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Current Research
in Dental Sciences

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Research Article *Araştırma Makalesi* DOI: 10.17567/currresdentsci.1618860

Gender Classification with Hand-Wrist Radiographs Using the Deep Learning Method

Derin Öğrenme Yöntemi Kullanılarak El-Bilek Radyografileri ile Cinsiyet Sınıflandırma

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ABSTRACT

Objective: Before dental procedures, hand-wrist radiographs are used to plan treatment time and determine skeletal maturity. This study aims to determine gender from hand-wrist radiographs using different deep-learning methods.
Methods: The left hand-wrist radiographs of 1044 individuals (534 males and 510 females) were pre-processed to clarify the image and adjust the contrast. In the gender classification problem, AlexNet, VGG16 and VGG19 transfer learning methods were both used as separate classifiers, and the features taken from these methods were combined and given to the support vector machine (SVM) classifier.
Results: The results revealed that image analysis and deep learning techniques provided 91.1% accuracy in gender determination.
Conclusion: Hand-wrist radiographs exhibited sexual dimorphism and could be used in gender prediction.
Keywords: Deep learning; İmage analysis; Hand-wrist radiographs; Gender determination

ÖZ
Amaç: Dental işlemler öncesinde tedavi zamanının planlanması ve iskeletsel olgunluğun saptanması amacıyla el-bilek radyografilerinden yararlanılır. Bu çalışmanın amacı, farklı derin öğrenme yöntemleri kullanılarak el-bilek grafilerinden cinsiyet tayini yapmaktır.
Yöntemler: Bu amaçla 1044 bireye ait (534 erkek ve 510 kadın) sol el-bilek radyografisi görüntüyü netleştirme ve kontrastı ayarlama amacıyla ön işleme tabi tutuldu. Cinsiyet sınıflandırma probleminde AlexNet, VGG16 ve VGG19 transfer öğrenme metotları hem ayrı ayrı sınıflandırıcı olarak kullanıldı, hem de bu yöntemlerden alınan öznitelikler birleştirilerek SVM sınıflandırıcısına verildi.
Bulgular: Sonuçlar, görüntü analizi ve derin öğrenme tekniklerinin cinsiyet tayininde %91,1 oranında doğruluk gösterdiğini ortaya koydu.
Sonuç: Yapılan bu çalışmada el-bilek grafilerin cinsel dimorfizm sergilediği ve cinsiyet tahmininde kullanılabilirliği belirlendi.
Anahtar Kelimeler: derin öğrenme; görüntü analizi; el-bilek radyografileri; cinsiyet tayini

INTRODUCTION

The determination of gender by skeletal structures is a fundamental step in estimating an individual's profile and determining its identity.[1] Many parts of the skeleton are used for gender analysis and some discriminative techniques are developed. There are studies in the literature to predict gender from vertebrae, skull, pelvis, and long bones. Among these, the highest accuracy rate for gender determination was obtained with the cranium and pelvis. In the studies conducted on these skeletal structures, gender differences have been revealed through linear and angular measurements.[2]

Knowing the differences between genders has considerable importance in anthropometry, forensic anthropology, and forensic medicine. Gender differences also have profound effects on human skeletal features and dimensions.[3] Differences in the shape, size, and appearance of bones by gender occur in response to sex hormones during the development and puberty. Bone maturation is closely related to sexual development. Determining individuals' skeletal maturity shows their biological development more accurately than their chronological ages. For this purpose, hand and wrist radiographs taken before dental treatments are the most common method used to determine skeletal maturity, timing and planning of the treatment. However, hand-wrist radiographs taken by radiologists are based on interpreting the patient's bone age, and gender-specific parameters cannot be determined with these radiographs. In the relevant

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studies, there is no conventional technique to determine gender using hand-wrist radiographs. Skeletal maturity and its relationship with gender are examined using a representative atlas using the Greulich-Pyle method.[4] However, this method is time-dependent and an expert radiologist is needed to evaluate bone age and gender in detail using the hand atlas as a reference. For this reason, the results may vary depending on the experts making the evaluation. However, using the deep learning method with a considerable number of data appears to be a technique that experts consider difficult to achieve gender classification.[5] In our study, the only images fed to the artificial neural network are left hand wrist X-rays. The effectiveness of the neural network in predicting gender without any instructions or pre-existing knowledge regarding gender dimorphic anatomy is aimed. In traditional methods, the first pre-processing is performed on left hand-wrist x-ray images. These images are determined by taking into account various conditions such as the length of the bones, their distance from each other, and the number of bones found. Gender classification is realized. error rates are compared by expert radiologists. Therefore, new methods are needed that will reduce the subjectivity of the observer and provide measurable tools to assist the expert in the decision-making process. Model running in deep learning methods; Features: Since it is achieved by self-learning in a short time with minimum training, more effective results are obtained and the need for an expert is reduced.[6,7] The application of deep learning methodologies is of great importance in modern dentistry. These methodologies can provide effective, accurate, and reliable tools for interpretation. As a result, they facilitate early diagnosis, planning, and monitoring of patient outcomes. In addition, these automatic systems can significantly reduce the workload of dental professionals, reduce the risk of human error, and increase the efficiency of dental health services.[8] In this study, a deep learning method was developed that analyzes the hand-wrist radiographs of 1044 individuals between the ages of 5-18 and can predict their genders.

METHODS

Data Set

The Atatürk University Faculty of Dentistry's Research Ethics Committee accepted the study, and all procedures were followed in accordance with the Declaration of Helsinki's principles (Decision No. 04/20.01.2021).

In this study, hand-wrist radiographs that are routinely taken from patients for diagnosis and treatment planning before orthodontic treatment, available in the archives of Atatürk University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, were retrospectively evaluated. Patients who did not have any known systemic disease, anomaly, or syndrome, had no malformation, pathology, or trauma history in the hand-wrist region, and had no artifacts or distortions in the relevant radiographs were included in the study. The data set of the study consists of left hand-wrist radiographs of 1044 individuals (534 males and 510 females) between the ages of 5-18 (Figure 1).

Method

Within the scope of the study, a gender classification was performed using artificial intelligence-based techniques on 1044 hand-wrist radiographs. In this study, two approaches were examined in terms of both data and method.

In the first category of the data, while the radiographs were classified with their original versions without any pre-processing, the second category was based on cropping only the hand-wrist part of the images and enhancing them with the contrast limited adaptive histogram equalization (CLAHE) technique,[9-11] which provides positive enhancement in these images. While the purpose of cropping the image is to prevent artificial intelligence models from focusing on unnecessary areas, the purpose of histogram equalization is to increase the differentiation in gray-level radiographs (Figure 2).

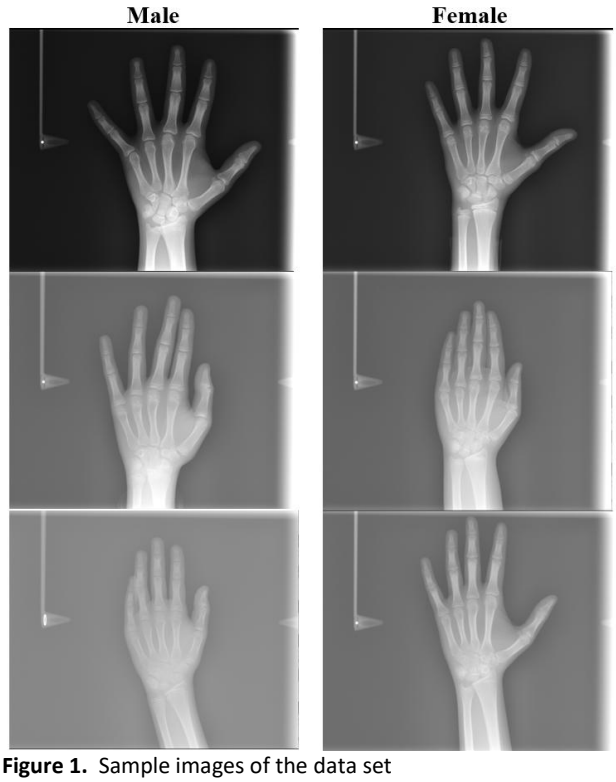

Figure 1. Sample images of the data set

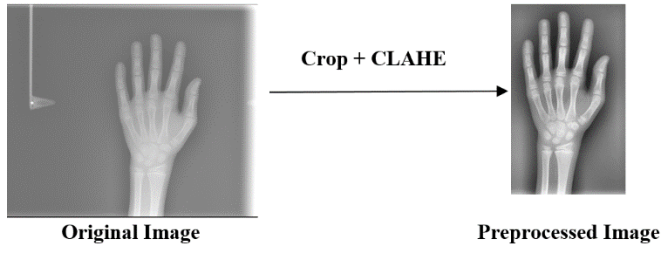

Figure 2. Preprocessing

On the basis of the method, in the first place, classification was realized with the transfer learning approach using AlexNet,[12] VGG16,[13] and VGG19,[13] which are popular CNN (Convolutional Neural Network) - based deep learning models with high performance in classification. In the second stage, AlexNet, VGG16, VGG19 models were used as feature extractors and the CNN+SVM (Support Vector Machine) hybrid method was proposed by giving these features to the SVM classifier[14] (Figure 3).

With the AlexNet network they designed, Alex Krizhevesky and others[12] won the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) competition in 2012, which involved a challenging visual object recognition task. The architecture they proposed was a significant breakthrough in the field of computer vision and rapidly increased interest in deep learning. AlexNet's Input image resolution is 227x227x3 pixels and has 11 main layers consisting of 5 convolutional, 3 pooling and 3 fully connected layers.

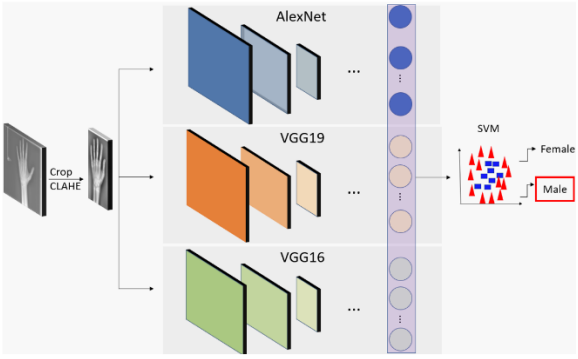

Figure 3. Proposed CNN+SVM hybrid method

The Visual Geometry Group (VGG), which graduated at ILSVRC in 2014, described the depth of a network as the critical component to achieve satisfactory classification performance.[13] The input image resolution of VGG16 and VGG19 is 224×224x3 pixels. VGG16; It consists of 21 main layers, including 13 convolutional, 5 pooling and 3 fully connected layers, while the VGG19 architecture has a total of 24 main layers, including 16 convolutional, 5 pooling and 3 fully connected layers. While training AlexNet, VGG16 and VGG19 models, the number of epochs was 50, batch size was 16, learning rate was 10^{-4} and stochastic gradient descent (SGD) was preferred as the optimization algorithm. No data augmentation technique was used

From CNN networks, 50 features were extracted for three models from the fully connected layer before the classifier layer. Finally, the new feature matrix of 1044x150 was fed to the SVM classifier as the input. SVM is a supervised learning method often used in classification problems. It draws a line to separate points placed on a plane. This line is intended to be the maximum distance for points of both classes.

A large number of interconnected experiments were performed with the setups in which the parameters changed in SVM. In the proposed CNN+SVM hybrid model, the highest performance is observed when the C (box constrait) parameter is 4 and the kernel scale is 256 in the linear kernel function.

All the experiments were carried out with the k-fold cross-validation approach by selecting the k parameter as 10 to better evaluate the model performance.[15] With this approach, the data set is divided into 10 parts and these parts are repeated 10 times. In each iteration, 9 parts are used for training and 1 part is used for testing. Final performance is found by averaging over 10 test pieces (Figure 4).

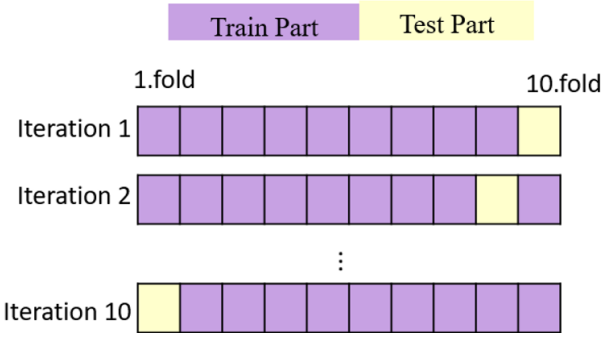

Figure 4. 10-fold cross-validation

Performance Metrics

The performance of the experimental studies was measured through accuracy, precision, recall, and F1 score metrics, which are frequently used in classification problems (Equation 1, Equation 2, Equation 3, Equation 4).[15] The parameters in the equations are shown on the representative confusion matrix (Figure 5).

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \quad \text{Equation 1}$$

$$Precision = \frac{TP}{TP + FP} \quad \text{Equation 2}$$

$$Recall = \frac{TP}{TP + FN} \quad \text{Equation 3}$$

$$F1\ score = 2 * \frac{precision * recall}{precision + recall} \quad \text{Equation 4}$$

		Positive	**Negative**
Output Class	**Positive**	True Positive (TP)	False Positive (FP)
	Negative	False Negative (FN)	True Negative (TN)
		Target Class	

Figure 5. Abbreviations in performance metrics on the confusion matrix

In Figure 5, TP indicates that both the actual value and the predicted value are positive (i.e. female if the gender is female, male if the gender is male), FP indicates that the actual value is negative and the predicted value is positive - FN indicates that the actual value is positive and the predicted value is negative (i.e. the label that is actually female is predicted to be male or label that is male is predicted to be female), TN indicates that both are negative (label that is not female is found to be non-female, label that is not male is found to be non-male). TP and TN are the areas that the model predicts correctly, while FP and FN are the areas that the model predicts incorrectly.

Accuracy value is calculated by the ratio of the areas we predicted correctly in the model to the total data set. Accuracy is a metric that is frequently used to measure the success of a model, but is not sufficient on its own. Precision is a measure of how many of the values predicted as positive are actually predicted as positive. Recall shows how many of the labels that should have been predicted as positive were predicted as positive. F1 Score value indicates the harmonic average of precision and recall values.

RESULTS

It was seen that hand-wrist radiographs exhibited sexual dimorphism and could be used in gender estimation.

While the achievement of artificial intelligence-based gender classification in left-hand-wrist radiographs was 54.58%, 58.14%, 55.37% and 51.1% for AlexNet, VGG16, VGG19 and hybrid models, respectively, without image enhancement, the classification success on the pre-processed data was 85.6%, 88.48%, 87.8%, and 91.1% for AlexNet, VGG16, VGG19, and the proposed hybrid model, respectively.

When the results of the original image and the preprocessed image were examined on the models, it was seen that the preprocessing made

significant enhancement (30%-40%) (Figure 6). If the models alone showed high success in the classification process, as in the preprocessed image, the hybrid model approach would have positively contributed to the performance. In the original image, it was seen that since the models could not adequately learn alone, using them together reduced the performance. The hybrid method was compared with the CNN-based transfer learning methods encompassing AlexNet, VGG16, and VGG19 in terms of different performance metrics such as accuracy, precision, recall, and F1 score (Figure 7). The confusion matrix for the CNN+SVM hybrid model based on the pre-processed image proposed within the scope of this study is shown in Figure 8.

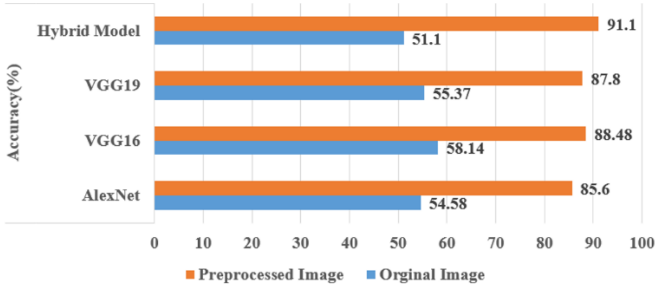

Figure 6: Preprocessing evaluation chart

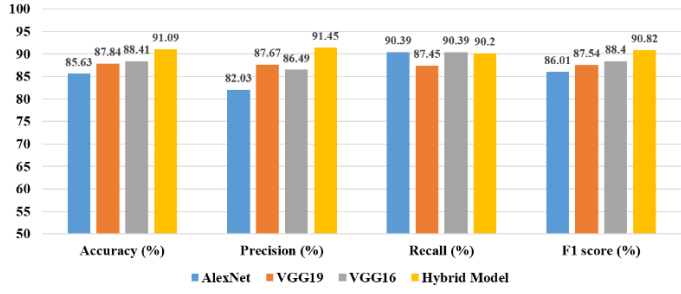

Figure 7. Comparison of preprocessed images and models through different performance metrics

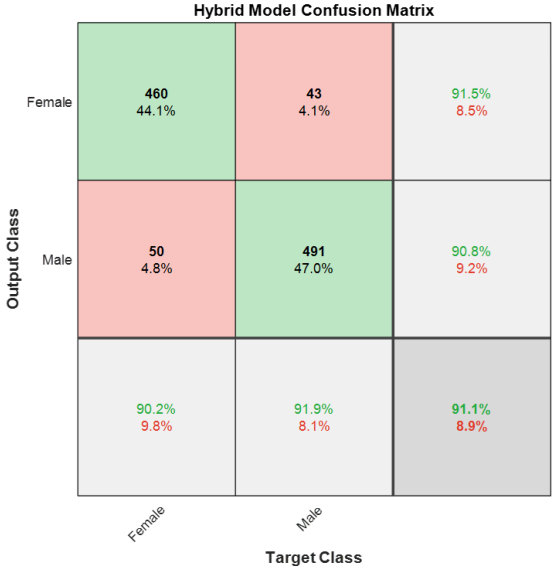

Figure 8. Hybrid model gender classification confusion matrix

DISCUSSION

The adequate enamel-bracket bonding strength is one of the This study showed that it is possible to predict gender by developing a deep learning method that can accurately and repetitively identify gender through hand-wrist radiographs. In the studies examining the relationship between skeletal structures and gender, it has been argued that there are morphological differences between different genders and that this varies depending on age. Male bones are morphologically larger and denser than females. Cortical bone loss in males due to aging is less than in females. The skeletal differences between genders are assumed to occur mostly during adolescence.[16]

In the studies using advanced imaging methods, some automatic gender estimation methods have been developed in adults through primarily pelvis imaging and the three-dimensional imaging of the skull as the second reliable method.[17,18] Thomas Radulesco et al.[19] used 103 CT images to investigate how to determine the gender of individuals by Maxillary Sinus Volumes (MSV). They identified MSV with 3D reconstructions. According to their results, they suggested that MSV could be useful in determining the gender of individuals.

Automatic methods are also being developed for the evaluation of hand-wrist radiographs, which reduce inter-rater variability compared to manual methods. However, the high dose of radiation and cost in these methods restrict the use of computed tomography in gender determination. In addition, researchers performing gender determination using radiographic methods have certain disadvantages such as subjective perception and low repeatability in visual evaluation of the morphological features. Research has shown that the most significant gender difference in the skeletal structure of the hand and wrist is the difference in the size and volume of the bones. In particular, it has been revealed that the size of the carpal bones in males is larger than in females.[20] In another study, digital right-hand radiographs were examined using these skeletal differences, and a 91% accuracy in gender determination was obtained.[21] Ibrahim et al.[22] researched the length and width of the hands of 600 people. They also investigated the relationship between the index and ring fingers. In their results, they claimed that the ratio of index and ring fingers was higher in women than in men.

Aboul Hagag et al.[23] among the Egyptians, he determined gender by calculating hand size, index finger and ring finger ratio. The dataset consisted of 250 men and 250 women. All subjects were adults over the age of 18. In their results, they claimed that the average male hand is 1.3 cm larger than women's.

There are no parameters in the literature that can reliably classify gender. Better-performing models have been recently obtained by combining the powers of CNN-based deep learning approaches at various stages for classification problems.[24-26] In this study, after the image enhancement with the CLAHE approach by cropping the left hand-wrist images, three separate deep learning methods (AlexNet-VGG16-VGG19) were trained using transfer learning, then taking the features from the fully connected layer, their powers were combined with the early fusion approach, and the features were classified with SVM. In light of the results obtained, it was seen that pre-processing and CNN+SVM hybrid models provided higher performance for gender classification than the classification performance of the models alone.

In 2019, Sarić and his colleagues[27]evaluated gender and bone age using the Deep Convolutional Neural Network (DCNN) algorithm. As a result, it was observed that the results were faster than classical methods.

Bewes et al.[28] investigated gender prediction from adult skeletal remains by training a deep convolutional neural network with images of

900 skulls obtained from computed tomography scans. When tested on previously unseen images, the deep network showed 95% accuracy. Yang et al.[29] use a six-variable method consisting of multilayer sensors to estimate gender from cranial measurement. They tested their approach on 267 skull ct scans (153 women and 114 men) from the Uyghur ethnic group in Northern China (women aged 18-88 and men aged 20-84). An accuracy of over 94% was reported in all cases.

Afifi[30] used CNN to determine the gender of individuals through biometric features on the hands. They used palms and back images of hands on both sides. They claimed that good accuracy was achieved not only on the palm but also on the back of the hand.

Darmawan et al.[31] used a Hybrid Particle Artificial Neural Network technique to determine the gender of individuals, which is the most relevant study to our research. They used left hand X-RAY images of the Asian population as a dataset. Their results show different accuracy for different age groups. The datasets were small and they did not mention the area they paid attention to in their work. A limitation of this study is that only left-hand radiographs were included. Although this study focused on the ability of a deep learning model to discover an unidentified pattern, including only left-hand images may limit the use of the model in clinical practices and other research studies. Although it is a standard procedure to use the left hand for bone age assessment, some studies argue that sex differences in finger ratio are more profound in the right hand. Further studies involving the right hand for testing and development can create a more comprehensive model to be clinically used.[11]

Another limitation of the study is the manual cropping of the region containing the hand and wrist from the original image. Within the scope of future studies, using cropped images by automatically segmenting the hand-wrist region with deep learning methods in the pre-processing stage is aimed to perform. At the output of high-performance segmentation models for cropping, the data will be subjected to the CLAHE procedure and the gender determination from the hand-wrist radiographs will be implemented with the end-to-end artificial intelligence.

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Evaluation of Dental Students' Sociodemographic Characteristics and Perspectives on Dentistry

Diş Hekimliği Fakültesi Öğrencilerinin Sosyodemografik Özelliklerinin ve Mesleğe Yönelik Perspektiflerin Değerlendirilmesi

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ABSTRACT

Objective: There are numerous factors that play a role in a student's selection of a profession, including examinations that need to be passed before being admitted into a programme such as dentistry. The aim of this study was to investigate the sociodemographic characteristics of the students admitted to the Pamukkale University Faculty of Dentistry based on their Student Selection and Placement Examination score, to determine their reasons for entering dental school and to examine their expectations from the dental profession.

Methods: We administered a questionnaire to the first-, second-, and third-year students of the Pamukkale University Faculty of Dentistry. The questionnaire collected the students' gender, type of high school they graduated from, the region of Turkey they were from, their reasons for selecting dental school and their expectations about dentistry.

Results: Overall, 69.5% of the students entered the faculty of dentistry voluntarily. In addition, 70.3% of the students stated that would still enter dental school if they were to take the placement examination again. The majority of students stated that it is important for a dentist to be helpful to people. Moreover, a significant proportion of the students planned to continue with dental specialisation after graduating from dental school.

Conclusion: Willingly choosing to attend dental school and to become a dentist would help students cope with the myriad challenges they will experience in their education and professional lives. In addition, the fact that students' financial gain expectations when they become dentists remain in the background will ensure that more attention is paid to professional ethics.

Keywords: Dentistry, Students, Specialisation

ÖZ

Amaç: Diş hekimliği gibi bir programa kabul edilmeden önce kazanılması gereken sınavlar da dahil olmak üzere, öğrencinin meslek seçiminde rol oynayan çok sayıda faktör vardır. Bu çalışmanın amacı, Pamukkale Üniversitesi Diş Hekimliği Fakültesi'ni Öğrenci Seçme ve Yerleştirme sınavında kazanan öğrencilerin sosyo-demografik özelliklerini araştırmak ve öğrencilerin diş hekimliği eğitimini tercih etmelerini etkileyen nedenleri ve meslekten beklentilerini belirlemektir.

Yöntemler: Bu amaçla Pamukkale Üniversitesi Diş Hekimliği Fakültesindeki 1., 2. ve 3. sınıf öğrencilerine bir anket uguladık. Anket öğrencilerin cinsiyeti, yaşadıkları bölge, mezun oldukları okul, diş hekimliği fakültesini seçim nedeni ve diş hekimliği mesleğine ilişkin beklentilerini içermektedir.

Bulgular: Genel olarak, öğrencilerin %69,5'inin diş hekimliği fakültesini gönüllü olarak tercih etmiştir. Ayrıca öğrencilerin %70,3'ü tekrar sınava girselerdi diş hekimliği fakültesini tercih edeceklerini belirtti. Öğrencilerin büyük bir kısmı insanlara faydalı olmanın önemli olduğunu belirtmişlerdir. Ayrıca öğrencilerin önemli bir bölümünün uzmanlık eğitimini planladığı görülmüştür.

Sonuç: Dişhekimliği fakültesini ve diş hekimi olmayı isteyerek seçmek, öğrencilerin eğitim ve mesleki yaşamlarında karşılaşacakları sayısız zorlukla başa çıkmalarına yardımcı olacaktır. Aynı şekilde öğrencilerin maddi kazanımla ilgili beklentilerinin arka planda olması meslek etiğine daha fazla ilgi gösterilmesine yardımcı olacaktır.

Anahtar Kelimeler: Diş Hekimliği, Öğrenciler, Uzmanlık.

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INTRODUCTION

A profession is defined as a paid occupation that requires knowledge and skills acquired by a rigorous, formal education. A professional receives respect from society and has a high place in it.[1,2] People prefer a job that aligns with their abilities and desires. When their job aligns with these factors, their level of happiness in their life could increase. However, when there is mismatch, or when people do not care, they might be subjected to unhappiness and excessive stress.[1] Therefore, willing choosing a career plays a key role in a person's life.

Dentistry is a branch of medicine that involves the diagnosis, prevention and treatment of the oral area and maxillofacial diseases.[3] Dentistry represents a moral contract supported by a set of values, behaviours and relationships between dentists and society.[4] Hence, professional responsibility and accountability are critical parts of dentistry.[5] Students who select dentistry as their profession have various career and business opportunities: they can be a general practitioner or receive additional training to specialise in specific areas.[6] In Turkey, there are eight dental specialties: periodontology; orthodontics; oral, dental and maxillofacial surgery; pedodontics; prosthodontics; endodontics; restorative dentistry; and oral, dental and maxillofacial radiology.[7] Dental education and practice are difficult for both dental students and professionals.[3] Various factors cause stress in dentistry such as the limited treatment time for each patient, non-cooperation from patients, financial matters and the highly technical and intensive nature of the profession.[8]

Based on the high level of stress associated with dentistry, it is crucial for students to willingly choose dentistry as their profession. Otherwise, they will be exposed to excessive stress and anxiety. In present study, we evaluated the socio-demographic characteristics of the dental students admitted to the Pamukkale University Faculty of Dentistry based on their high score on the Student Selection and Placement Examination. We also examined the reasons why students preferred to start dental education and their expectations from the dental profession.

METHODS

We performed a cross-sectional and descriptive study. We included first-, second- and third-year students of the Pamukkale University Faculty of Dentistry (the only available classes of the Pamukkale University Faculty of Dentistry in 2019). This study was approved by Pamukkale University Non-Invasive Clinical Research Ethics Committe (22/01/2019-02). This study was approved by the University Non-Invasive Clinical Research Ethics Committee (22/01/2019-02). Note that we previously presented the results from this study as an oral presentation at 2nd International Meandros Dental Congress.

The above-mentioned classes comprised 260 students, each of whom received a questionnaire of 15 questions divided into two parts. The first part consisted of 10 social demographic questions that asked the students to provide their gender, the type of high school they attended, the region where they lived prior to entering dental school, their reasons for choosing dentistry, their expectations from dentistry after graduating from dental school and their views on dentistry. The second part asked for the student's opinions regarding the dental profession, each rated on a 5-point Likert scale.

Participation was voluntary and anonymous. Participants were informed of the aim and benefits of the survey. Before the study was started, written permissions were obtained from the students who participated in the study.

Statistical Analysis

The results for the first part of the questionnaire (the first 10 questions) are presented as percentages. We analysed the results from the second part of the questionnaire by using the chi-square test. We considered $P < .05$ to be statistically significant. We used SPSS Statistics for Windows Version 23 (IBM Corp., Armonk, NY, USA) for the analysis.

RESULTS

Each student answered all the questions. Of the participants, 60% are women and 40% are men. The first-year class comprised 39.6% of the participants, the second-year class comprised 34.2% of the participants and the third-year class comprised 26.2% of the participants. Considering the high school from which the students graduated, 32.2% graduated from a science high school, 41.5% graduated from an Anatolian high school, 16.1% graduated from a private high school and 10.2% graduated from other high schools. The regions from which the students came included Aegean (52.5%), Marmara (14.4%), Central Anatolia (11%), Mediterranean (10.2%), Black Sea (4.2%), South East Anatolia (4.2%) and Eastern Anatolia (3.4%).

The majority (69.5%) of the students stated that they entered the faculty of dentistry voluntarily; on the other hand, 30.5% of the students expressed that they entered unintentionally. Additionally, 70.3% said that if they were to pass the entrance exam again, they would still choose to attend dental school. The other 29.7% said they would not attend dental school even if they passed the exam.

About three quarters of the students (74.5%) reported that they planned to take the Specialisation Education in Dentistry Entrance Examination after graduating from dental school. The remaining students stated they planned to continue their career as a general practitioner (Table 1).

In addition, the students reported a desire for an academic career (25.4%), professional satisfaction (24.6%), social status, interest in a specialty (16.9%) and financial security (10.2%) as the reasons to seek specialised education (Table 2).

Table 1. The expectations from the professions.

Expectations	Percentage(%)
Pass the Dentistry Entrance Exam immediately	52.5
Pass the Dentistry Entrance Exam after studying for a certain time	22.0
Gain Money immediately	11.9
Be a good researcher	6.8
Be a good general practitioner	1.7
Other	5.1
Total	100

Table 2. The reasons of pass the Dentistry Entrance Exam.

The reasons	Percentage(%)
Academic career request	25.4
Professional satisfaction	24.6
Social statue	16.9
An interest in a specialty	16.9
Income satisfaction	10.2
Other	5.9
Total	100

Regarding the student's opinions about dentistry (Table 3), more than three fourths of the students expressed that they care about helping people. Although more students from the first-year class thought being helpful was the most important part of the dental

profession, there was no significant difference between the classes (*P* = .272). More students in the first-year class expressed that they cared about respectability more than other classes, but there was no significant difference between the classes (*P* = .263). Only 0.8% of students stated that respectability was not important to them. Financial gain was very important for 42.4% of the students, with no significant difference between the classes (*P* = .214). Job guarantee after completing dental school was a main factor for 61.9% of the students. without a significant difference between the classes (*P* = 0.895). Half of the students stated that being able to work independently is very important to them. Although this seemed to be important to the second-year students, there was no significant difference between the classes (*P* = .224).

Table 3. Students' thoughts about the medical profession**.**

Questions	Answers	First class	Second class	Third class	*p* value
			n(%)		
Be helpful to people	The most important	30 (75)	27 (67.5)	27 (71.1)	.272
	Important	7(17.5)	13(32.5)	10 (26.3)	
	Indecisive	2 (5)	0 (0)	0 (0)	
	Not important	1 (2.5)	0 (0)	0 (0)	
	It is nothing	0 (0)	0 (0)	1 (2.6)	
Financial gain	The most important	22 (55)	17 (42.5)	11 (28.9)	.216
	Important	15 (37.5)	21 (52.5)	21 (55.3)	
	Indecisive	3 (7.5)	2 (5	5 (13.2)	
	Not important	0 (0)	0 (0)	1 (2.6)	
Independent working opportunity	The most important	22 (55)	25(62.5)	12(31.6)	.224
	Important	13 (32.5)	11 (27.5)	18(47.4)	
	Indecisive	3 (7.5)	3(7.5)	6(15.8)	
	Not important	1(2.5)	1(2.5)	2(5.3)	
	It is nothing	1(2.5)	0(0)	0(0)	
Job guarantee	The most important	26 (65)	26(65)	21(55.3)	.895
	Important	12(30)	12(30)	15(39.5)	
	Indecisive	2(5.0)	2(5)	2(5.3)	
Respectability	The most important	24(60)	18(45)	19(50)	.263
	Important	13(32.5)	21(52.5)	15(39.5)	
	Indecisive	3(7.5)	0(0)	3(7.9)	
	Not important	0(0)	1(2.5)	0(0)	
	It is nothing	0(0)	0(0)	1(2.6)	

P<.05 was considered statistically significant

DISCUSSION

There have been only a few studies focused on student views regarding their career choice and professional expectations.[9] To address this lacuna, we aimed to evaluate how Turkish dental students view their career choice and the dental profession.

In Turkey, students must pass the Higher Education Institutions Exam before entering a university. The students have to score highly to enrol in medical and dental faculties. A previous study in Turkey indicated that there was a higher ratio of students who graduated from scientific and Anatolian high schools who chose the Uludağ University Faculty of Medicine.[10] Köşker and Kaya[1] reported that students who graduated from scientific and Anatolian high schools scored higher on the university entrance exam. Moreover, according to the Assessment, Selection and Placement Centre data, students who graduate from scientific high schools are more successful on the university entrance exam than students who graduate from other high schools.[11] We found that the most of students admitted to the Pamukkale University Faculty of Dentistry graduated from scientific and Anatolian high schools compared with other high schools, a finding consistent with earlier reports.[1,10] These results indicate that scientific and Anatolian high schools provide a high-quality education that allow to perform well on the entrance exam and to attend enter rigorous professional programmes.

There have been a few studies regarding the regions from which Turkish students come from before entering a university. Alper and Özdemir[10] found that the most students enrolled in the Uludağ University Faculty of Medicine came from the Marmara and Aegean regions. Likewise, Köşker and Kaya[1] reported that the close to half of students enrolled in the Ege University Faculty of Dentistry came from the Aegean region.[1] In our study, more than half of students came from the Aegean region.[1,10] These results suggest that students generally prefer to attend a university that is close to where they grew up.

The dental profession is the most stressful compared with the other health care professions.[12] Dental school puts high stress and pressure on students due to the tough curriculum. Indeed, a study showed that dental students are exposed to higher stress levels than other medical students.[13] Henzi et al.[14] indicated that fourth-year students have a higher stress level than first-year students. For these reasons, students should voluntarily choose to attend dental school and be fully aware that they will be challenged academically and subjected to a high stress level. Hallissey et al.[15] reported that two out of three of students voluntarily chose medicine and dentistry. In another study, Dogan et al.[9] reported that most medical and dental students willingly chose to attend medical and dental school. Similarly, most of the students who participated in the present study willingly chose to attend dental school, consistent with the aforementioned studies.[9,15] When a student voluntarily enters a high-stress situation like dental school, they are more likely to be able to deal with the stress they will face during their education and professional life.

Over the past decades, more dental students have continued with specialised education after graduating from dental school. Since 2012, Turkish dental students have to pass Specialisation Education in Dentistry Entrance Examination to continue with specialisation after graduating. Küçükeşmen and Kirzioğlu[16] evaluated the opinions of students about this exam and reported that the overwhelming majority of students would like to pass the exam to begin specialised education.[16] Consistently, the vast majority of our students expressed that they would like to continue with dental specialisation. Various factors such as academic career, professional satisfaction, social status and interest in the specialised department play a role in the students' choice. These results suggest that the dentistry specialty exam affects the students' opinions about their career options.

Several studies have investigated dental students' views about the dental profession. Dogan et al.[9] reported that most of the students chose the dentistry not because they wanted to be a medical doctor or dentist, but because their university entrance exam score allowed them to enrol in dental school. There are many other factors including working conditions, financial security, status in society, the nature of the occupation, working with people, the use of personal or manual skills and interest in science and research that may influence a student's career choice.[17-19] Toit et al.[20] reported that assisting people and flexible hours are motivations for dental students. Çapan et al.[21] found that 78.2% of dental students chose dentistry because the profession will continue to grow. Barnabea et al.[22] reported that economic, professional and family reasons are mostly included in choosing a profession. In our study, the vast majority of students expressed that social status, financial input, respectability, flexible working hours and job guarantee are critical for their career choice; these factors are consistent with previous reports.[17-22] These results suggest that dental students consider a myriad of factors when plotting their career path.

There are some limitations to this study. We were only able to evaluate three classes of students, and we have not evaluated how the students' views may change as they progress in their dental education. Therefore, additional studies are needed to evaluate whether the students opinion about dentistry change during their education.

To conclude, dentistry is a profession that has a long and difficult education process. Students who select dentistry should be very aware of its challenges so they can manage its associated stress. This study provides information the opinions of students about dentistry and the reasons for their choice career.

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Evaluation of Dentists' Awareness Level About Dental Implant Failures in Early Period

Erken Dönem Dental İmplant Kaybında Diş Hekimlerinin Farkındalık Düzeyinin Değerlendirilmesi

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ABSTRACT

Objective: To determine the awareness levels of dentists about possible risk factors in order to prevent early implant losses.
Methods: The questionnaire form was directed to the participants online. Statistical analyzes were made with frequency analysis and Chi-square test.
Results: Majority of the participants usually (68.4%) prescribe amoxicillin (postoperatively 1 g 2x1) to patients in implant surgeries. While the rate of those who thought that prophylactic antibiotic therapy was mostly and always effective in preventing early implant loss was 17.6%, this rate was 42.7% for postoperative antibiotherapy applications. The highest rate of thinking that prophylactic antibiotherapy is effective in preventing early implant loss was found in the periodontology specialist (20.5%) group. Periodontology specialists (23.3%) were the group who thought that the effectiveness of postoperative antibiotherapy was the least in this regard. History of periodontitis (76.3%) and postoperative complication development (73.1%), diabetes (92.4%), smoking (89.8%) and osteoporosis (78.7%) were evaluated as the factors that have the most impact on early implant loss.
Conclusion: It is thought that the general knowledge level of the dentists participating in the survey about early implant loss is sufficient. We believe that it would be beneficial to organize postgraduate vocational training programs in order to eliminate the differences between the knowledge levels of dentists.
Keywords: Awarenes Level, Early Implant Failure, Implant Complications

ÖZ

Amaç: Erken dönem implant kayıplarının önüne geçebilmek adına diş hekimlerinin olası risk faktörleri hakkındaki farkındalık düzeylerini saptamaktır.
Yöntem: Katılımcılara; online olarak anket formu yöneltildi. İstatistiksel analizler, frekans analizi ve Ki Kare testi ile yapıldı.
Bulgular: Katılımcıların çoğunluğu implant cerrahilerinde hastalara genellikle (%68,4) amoksisilin (işlem sonrası 1g 2x1) reçete etmektedirler. Profilaktik antibiyoterapi uygulanmasının erken dönem implant kaybını önlemede çoğunlukla ve her zaman etkili olduğunu düşünenlerin oranları %17,6 iken postoperatif antibiyoterapi uygulamaları için bu oran %42,7 idi. Profilaktik antibiyoterapinin erken dönem implant kaybını önlemede etkili olduğunu düşünme oranı en yüksek periodontoloji uzmanı hekim (%20,5) grubunda saptandı. Postoperatif antibiyoterapinin bu konudaki etkinliğinin en az olduğunu düşünen grup yine periodontoloji uzmanları (%23,3) idi. Periodontitis öyküsü (%76,3) ve postoperatif komplikasyon gelişimi (%73,1), diyabet (%92,4), sigara kullanımı (%89,8) ve osteoporoz (%78,7) erken dönem implant kaybında en fazla etkisi olan faktörler olarak değerlendirilmiştir.
Sonuç: Ankete katılan diş hekimlerinin erken dönem implant kaybı ile ilgili genel bilgi düzeylerinin yeterli olduğu düşünülmektedir. Diş hekimlerinin bilgi düzeyleri arasındaki farklılıkları giderebilmek için mezuniyet sonrası mesleki eğitim programlarının düzenlenmesinin faydalı olabileceği kanaatindeyiz.
Anahtar Kelimeler: Farkındalık Düzeyi, Erken Dönem İmplant Kaybı, İmplant Komplikasyonları

INTRODUCTION

Tooth loss can be corrected with prosthetic restorations in partially or completely edentulous patients. Although it is known that partially edentulous patients function well with fixed dental prostheses, the majority of patients have difficulty in adapting to removable dental prostheses.[1] Compared to natural teeth, patients using removable dental prostheses were found to have low performance in functional tests. Even with optimal dental prostheses, many oral functions may not be realised at the desired level.[1]

This study was presented orally at the 26th International Dentistry Congress of the Turkish Dental Association.

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Among the treatment options applied to edentulous patients, the most preferred approach is full-arch implant-supported fixed dental prostheses.[2] However, implant applications are complex processes involving surgical and prosthetic stages. Besides, many factors such as age, general health status, socio-cultural characteristics, financial possibilities, intraoral findings are highly influential on the success of implant applications.[3]

Although dental implant treatments have long-term clinical success, biological, biomechanical and aesthetic complications can be seen in some cases. Implant losses can be categorised as early or late failures, depending on the period of occurrence, either before prosthetic abutment placement (early) or after prosthetic loading (late).[4] Early implant losses occur as a result of the formation of a fibrous scar tissue between the bone and the implant surface instead of a normal wound healing with bone apposition on the implant surface.[5]

Dentists undoubtedly have a great role in preventing or reducing implant losses. This study aimed to determine the level of awareness of dentists about the possible causes of early implant losses in order to prevent early implant losses.

METHODS

Location of the Study and Permissions

Necessary permissions were obtained from the Hatay Mustafa Kemal University Non-invasive Research Ethics Committee for our prospective survey study. (Approval number 32 dated 16.06.2021). Informed consents were obtained from the participants before they started to fill in the survey form. The informed consent form is attached.

Data Collection Tools

The survey forms prepared to obtain data were made available online to the participants between July 2021 and May 2022.

The survey form was delivered online to 342 participants. The survey includes 23 questions, 5 for demographic and professional data and 18 for opinions on early implant loss.

Statistical Analysis

In the power analysis of our study, with 5% acceptable error and 95% confidence level, it was seen that at least 330 people should participate among 34045 people (the number of dentists in our country in 2021 according to Turkish Dental Association data).

SPSS software version 25.0 (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analysis of the data. Data for continuous measurements are given as mean ± standard deviation. Chi-square test was used for the comparison of categorical variables and the statistical significance level was determined as 0.05 for all tests

RESULTS

Demographic Data

It was determined that 36.3% (124) of the dentists participating in our study were female and 63.7% (218) were male. The mean age of the participants was 35.6 ± 8.8 years.

It was observed that 13.5% (46) of the participants worked in an oral dental health centre, 27.2% (93) in a university, 59.1% (202) in a private polyclinic/private practice and 0.3% (1) in other institutions. When the distribution of the speciality areas of the participants was examined, it was seen that 21.3% (73) of the physicians were periodontology specialists and 20.5% (70) were maxillofacial surgery specialists. All other demographic data are shown in Table 1.

Table 1. Professional data of the physicians participating in the study

Parameters	All Participants (n=342)
The organization we have studied, n (%)	
Oral dental health center	46 (13.5)
University	93 (27.2)
Private polyclinic/private practice	202 (59.1)
Other	1 (0.3)
Area of specialization, n (%)	
Periodontology	73 (21.3)
Maxillofacial Surgery	70 (20.5)
Other areas of specialization	30 (8.8)
No specialization	169 (49.4)
Implant application experience, n (%)	
0-5 years	155 (45.3)
5-10 years	80 (23.4)
10-15 years	71 (20.8)
15-20 years	29 (8.5)
Over 20 years	7 (2.0)

Analysing the Relationships between Variables

According to the answers given to the question "How often do you encounter early implant loss?", it was observed that dentists rarely (75.1%) encountered early implant loss. According to the answers given to the question "Do you think that patient gender is effective in early implant loss?", it was seen that the majority of the participants (70.2%) thought that patient gender was not effective in early implant loss. According to the answers given to the question "Do you think that patient age is effective in early implant loss?", approximately half of the dentists (46.2%) reported that patient age was not effective in early implant loss. When the distribution of the responses of the participating dentists to the question "Do you prescribe antibiotics to patients during implant surgery?" was analysed, it was observed that the majority of dentists (68.4%) applied Amoxicillin (1 g 2x1 postoperatively) treatment protocol to patients during implant surgery (Table 2).

Table 2. Participants' responses 1

Questions	All Participants (n=342) n (%)
How often do you encounter early implant loss?	
Never	17 (5)
Rarely	257 (75.1)
Sometimes	64 (18.7)
Mostly	4 (1.2)
Do you think patient gender has an impact on early implant loss (EIL)?	
Not effective	240 (70.2)
I see more early implant loss in male patients	49 (14.3)
I see more early implant loss in female patients	53 (15.5)
Do you think patient age has an impact on early implant loss (EIL)?	
Not effective	158 (46.2)
I see early implant loss more in the 20-40 age range	9 (2.6)
I see early implant loss more in the 40-60 age range	56 (16.4)
Over the age of 60, I see early implant loss more often	119 (34.8)
Do you prescribe antibiotics to patients in implant surgeries?	
I do not prescribe	18 (5.3)
Amoxicillin (3 g loading before the procedure)	3 (0.9)
Amoxicillin (2 g loading before the procedure)	12 (3.5)
Amoxicillin (1 g loading before the procedure)	11 (3.2)
Amoxicillin (2 g loading before the procedure and 1 g 2x1 after the procedure)	43 (12.6)
Amoxicillin (2 g loading before the procedure and 500 mg 2x1 after the procedure)	8 (2.3)
Amoxicillin (1 g 2x1 after the procedure)	234 (68.4)
Other	13 (3.8)

The answers of the physicians participating in the study to the questions asked about the possible risk factors of early implant loss are shown in Table 3. It was observed that the majority of physicians thought that postoperative antibiotherapy was more effective than prophylactic antibiotherapy in early implant loss (Table 3).

The most common factors causing early implant loss were thought to be a history of periodontitis and the development of postoperative complications by the majority of participants (Table 3).

Table 3. Participants' responses 2

	Never n (%)	Rarely n (%)	Sometimes n (%)	Mostly n (%)	Always n (%)
Prophylactic antibiotic administration	91 (26.6)	113 (33)	78 (22.8)	56 (16.4)	4 (1.2)
Postoperative antibiotic administration	42 (12.3)	81 (23.7)	73 (21.3)	116 (33.9)	30 (8.8)
One-stage surgery	35 (10.2)	120 (35.1)	126 (36.8)	57 (16.7)	4 (1.2)
Use of short implants	102 (29.8)	115 (33.6)	70 (20.5)	50 (14.6)	5 (1.5)
Use of narrow diameter implants	105 (30.7)	121 (35.4)	65 (19)	49 (14.3)	2 (0.6)
Periodontitis history	5 (1.5)	25 (7.3)	51 (14.9)	206 (60.2)	55 (16.1)
Presence of adjacent teeth	92 (26.9)	147 (43)	78 (22.8)	25 (7.3)	0 (0)
Development of postoperative complications	3 (0.9)	26 (7.6)	63 (18.4)	231 (67.5)	19 (5.6)
Segmentation applied to the surgical site	27 (7.9)	153 (44.7)	108 (31.6)	53 (15.5)	1 (0.3)
Immediate implant application	35 (10.2)	147 (43)	105 (30.7)	53 (15.5)	2 (0.6)

The responses to the survey questions were also evaluated by classifying them according to their areas of expertise. It was found that antibiotic applications in the postoperative period were preferred more frequently by dentists belonging to other specialities and dentists with no speciality (Table 4).

Table 4. Distribution of participants' opinions on the role of antibiotherapy in preventing early implant loss according to their specialty

	Periodontology (n=73) n(%)	Maxillofacial Surgery (n=70) n(%)	Other areas of specialization (n=30) n(%)	Dentists without specialization (n=169) n(%)	*P*
Prophylactic antibiotic administration					.703
Never - Rarely - Sometimes	58 (79.5)	60 (85.7)	26 (86.7)	138 (81.7)	
Mostly - Always	15 (20.5)	10 (14.3)	4 (13.3)	31 (18.3)	
Postoperative antibiotic administration					**.001**
Never - Rarely - Sometimes	56 (76,7)[a]	49 (70)[a]	18 (60)[a, b]	73 (43,2)[b]	
Mostly - Always	17 (23,3)[a]	21 (30)[a]	12 (40)[a, b]	96 (56,8)[b]	

* Letters indicate which groups the statistical significance is between

In addition, other factors that were statistically different between specialities were the use of narrow diameter implants and periodontitis history. Dentists from other specialities believe that the use of narrow-diameter implants causes early implant loss more frequently. The rates of thinking that periodontitis usually and always caused early implant loss were found to be 89% in periodontology specialists, 77.5% in dentists with no speciality, 76.7% in dentists with other specialities and 60% in maxillofacial surgery specialists, respectively (Table 5). When the effect of systemic conditions on early implant loss was questioned, similar results were obtained for all specialities. The most common systemic conditions thought to cause implant loss were diabetes mellitus (92.4%), smoking (89.8%) and osteoporosis (78.7%), respectively (Table 6).

When the effect of surgical site and bone quality-quantity on early implant loss was questioned, 55.3% of the participants stated that they encountered early implant loss more frequently in the maxilla posterior and 73.7% of the participants stated that they encountered early implant loss more frequently in D4 bone structure (Table 6).

Table 5. Distribution of participants' responses according to their areas of specialization 1

	Periodontology (n=73) n(%)	Maxillofacial Surgery (n=70) n (%)	Other areas of specialization (n=30) n (%)	Dentists without specialization (n=169) n (%)	*P*
One-stage surgery					
Never - Rarely - Sometimes - Mostly - Always	59 (80.8) / 14 (19.2)	62 (88.6) / 8 (11.4)	24 (80) / 6 (20)	136 (80.5) / 33 (19.5)	.480
Use of short implants					
Never - Rarely - Sometimes - Mostly - Always	61 (83.6) / 12 (16.4)	61 (87.1) / 9 (12.9)	23 (76.7) / 7 (23.3)	142 (84) / 27 (16)	.633
Use of narrow diameter implants					
Never - Rarely - Sometimes - Mostly - Always	59 (80,8)[a] / 14 (19,2)[a]	64 (91,4)[a] / 6 (8,6)[a]	18 (60)[b] / 12 (40)[b]	150 (88,8)[a] / 19 (11,2)[a]	**.001**
Periodontitis history					
Never - Rarely - Sometimes - Mostly - Always	8 (11)[a] / 65 (89)[a]	28 (40)[b] / 42 (60)[b]	7 (23,3)[a, b, c] / 23 (76,7)[a, b, c]	38 (22,5)[c] / 131 (77,5)[c]	**.001**
Presence of adjacent teeth					
Never - Rarely - Sometimes - Mostly - Always	68 (93.2) / 5 (6.8)	61 (87.1) / 9 (12.9)	26 (86.7) / 4 (13.3)	162 (95.9) / 7 (4.1)	.063
Postoperative complications					
Never - Rarely - Sometimes - Mostly - Always	18 (24.7) / 55 (75.3)	21 (30) / 49 (70)	8 (26.7) / 22 (73.3)	45 (26.6) / 124 (73.4)	.911
Segmentation applied to the surgical site					
Never - Rarely - Sometimes - Mostly - Always	63 (86.3) / 10 (13.7)	61 (87.1) / 9 (12.9)	24 (80) / 6 (20)	140 (82.8) / 29 (17.2)	.722
Immediate implant application					
Never - Rarely - Sometimes - Mostly - Always	59 (80.8) / 14 (19.2)	64 (91.4) / 6 (8.6)	22 (73.3) / 8 (26.7)	142 (84) / 27 (16)	.115

* Letters indicate which groups the statistical significance is between

Table 6. Distribution of participants' responses according to their areas of specialization 2

	Periodontology (n=73) n (%)	Maxillofacial Surgery (n=70) n (%)	Other areas of specialization (n=30) n (%)	Dentists without specialization (n=169) n (%)	All participants (n=342) n (%)
Surgical site					
Surgical site has no effect	22 (30.1)	15 (21.4)	2 (6.7)	33 (19.5)	72 (21.1)
Maxilla anterior	6 (8,2)	9 (12.9)	6 (20)	40 (23.7)	61 (17.8)
Maxilla posterior	36 (49.3)	40 (57.1)	20 (66.7)	93 (55)	189(55.3)
Mandibula anterio	9 (12.3)	13 (18.6)	7 (23.3)	29 (17.2)	58 (17)
Mandibula posterior	13 (17.8)	7 (10)	2 (6.7)	23 (13.6)	45 (13.2)
Bone quality and quantity					
Not effective	5 (6.8)	6 (8.6)	1 (3.3)	16 (9.5)	28 (8,2)
D1 bone	30 (41.1)	28 (40)	7 (23.3)	57 (33.7)	122(35.7)
D2 bone	3 (4.1)	0 (0)	2 (6.7)	7 (4.1)	12 (3.5)
D3 bone	11 (15.1)	7 (10)	5 (16.7)	24 (14.2)	47 (13.7)
D4 bone	52 (71.2)	57 (81.4)	18 (60)	125 (74)	252(73.7)
Systemic conditions					
Smoking	68 (93.2)	66 (94.3)	26 (86.7)	147 (87)	307(89.8)
Alcohol	23 (31.5)	27 (38.6)	17 (56.7)	89 (52.7)	156(45.6)
Hypertension	6 (8,2)	4 (5.7)	9 (30)	20 (11.8)	39 (11.4)
Diabetes	67 (91.8)	67 (95.7)	28 (93.3)	154 (91.1)	316(92.4)
Obesity	13 (17.8)	12 (17.1)	8 (26.7)	22 (13)	55 (16.1)
Cholesterol	10 (13.7)	8 (11.4)	7 (23.3)	14 (8.3)	39 (11.4)
Serum Vitamin D level	24 (32.9)	40 (57.1)	10 (33.3)	40 (23.7)	114(33.3)
Osteoporosis	57 (78.1)	61 (87.1)	25 (83.3)	126 (74.6)	269(78.7)
Menopause	19 (26)	21 (30)	15 (50)	48 (28.4)	103(30.1)

DISCUSSION

The aim of the study was to determine the awareness levels of dentists working in Turkey about the factors that may cause early implant loss and to reveal how these awareness levels vary according to their specialties.

Implant loss can occur at different time frames during treatment or follow-up. Traditionally, implants lost before prosthetic loading are classified as early losses.[6,7] In the study by Alsaadi et al.[8] a total of 2004 patients and 6946 implant applications were evaluated for implant loss. In this study, 8.9% of patients experienced early implant loss. Early implant loss was observed in 3.6% of the implants. A recent meta-analysis that reviewed the entire literature on this topic presented data from 50 different studies examining early implant loss.[9] In this meta-analysis by Tomasi et al.,[9] the proportion of patients who experienced early implant loss varied between 0% and 15%. Similarly, the rate of early implant loss varies between 0 and 5.8% per implant. The fact that these rates are so variable shows that many factors can be effective on early implant loss. In our study, when the frequency of early implant loss was questioned, 75.1% of the participants stated that they rarely encountered it. The rate of those who stated that they mostly encounter this problem was 1.2%.

There are some reports that gender is associated with early implant loss. Olmedo-Gaya et al.[10] showed that early implant loss was more common in male patients. The higher prevalence of this condition in men has been attributed to the higher prevalence of smoking.[10] However, in another study, gender was not found to be a risk factor.[9] In our study, when the opinions about the effect of gender on early implant loss were questioned, the rate of those who thought that the gender factor was ineffective was 70.2%. While the rate of those who had more frequent early implant loss in men was 14.3%, this rate was 15.5% in women. The opinions of the dentists included in our study regarding the effect of gender on early implant loss were found to be adequate and generally consistent with the literature.

Many studies showing a relationship between age and early implant loss, show that early implant loss is more common over the age of 60. However, there are conflicting publications on this issue. Noguerol et al.[11] showed that old age was protective for early implant loss in their study. Lin et al.[12] compiled the results of more than 30,000 implant applications and showed that being over 60 years of age is a risk factor for early implant loss. In our study, when the relationship between age factor and early implant loss was questioned, the rate of those who thought that age was not effective was 46.2%. The proportion of dentists who generally observed early implant loss in individuals over the age of 60 was found to be 34.8%. Considering the conflicting data on age in the literature, it is not possible to state a definite consensus on this issue.

In a study questioning antibiotic prescribing habits in implant applications, 217 dentists working in the United States were surveyed.[13] Overall, 51.6% of the participants prescribed antibiotics before surgery. Again, 71.4% of the surveyed dentists prescribed antibiotics after routine dental implant surgery. The most commonly used preoperative regimen was 2 g amoxicillin given 1 hour before the procedure (32%). The most commonly preferred postoperative regimen was 500 mg amoxicillin given 3 times daily for 5 days (53%).[13] Canullo et al.[14] found that prophylactic antibiotic administration helped prevent early implant loss in healthy patients. Romandini et al.[15] concluded in their study with 1,693 patients that although the most commonly used prescription was a single dose of 2 g amoxicillin preoperatively, the most successful results were obtained with a single dose of 3 g amoxicillin preoperatively. When the antibiotic use habits of the participants were evaluated in our study, it was observed that 5.3% of the dentists did not prescribe antibiotics. The rate of physicians who applied various antibiotherapy protocols for prophylaxis in the preoperative period was 22.5%. It was observed that the majority of the participants (68.4%) applied the amoxicillin 2x1 g protocol postoperatively. When the role of antibiotic administration in preventing early implant loss was questioned, the rate of those who thought that prophylactic antibiotic administration was mostly and always effective in preventing early implant loss was 17.6%, while this rate was 42.7% for postoperative antibiotic administration. According to their specialty, 20.5% of periodontology specialists thought that prophylactic antibiotherapy could prevent early implant loss. Among all specialties, that consider prophylactic antibiotic therapy to be the most effective has been identified as periodontology. Among all specialties, that consider postoperative antibiotic therapy to be the least effective has been identified as periodontology. (23.3%). It was observed that the group who thought that postoperative antibiotic administration was effective in this regard the most was dentists without specialization (56.8%) and this difference was statistically significant. There was no statistically significant difference in the level of awareness regarding the effect of prophylactic antibiotic use on early implant loss. As seen in international studies, prophylactic applications are performed less frequently than postoperative applications worldwide.[14,15] In our study, there were different practices regarding antibiotherapy and different approaches even among specialties.

The relationship between single-stage surgery and early implant loss is not yet fully understood. Studies on this subject are limited. In a meta-analysis, Troiano et al.[16] compiled data from 13 different studies. The study reported that single-stage surgery may cause a higher rate of early implant loss. However, this was found to be relatively significant. It is stated that the level of evidence of the results obtained is quite low. In our study, when the participants were questioned about the effect of single-stage surgery on early implant loss, the rate of those who mostly and always thought that this factor could cause early implant loss was 17.9%. According to specialties, maxillofacial surgeons (11.4%) were the group who thought that single-stage surgery had the least effect on this issue. Approximately 20% of all other groups thought that single-stage surgery could often and always cause early implant loss. As a result of the analysis, it was observed that there was no statistically significant difference between the awareness levels of physicians regarding single-stage surgery.

There are many studies showing that short and narrow diameter implants can cause early implant loss. Alsaadi et al.[8] found that narrow diameter implants are a significant risk factor for early implant loss. Da Rocha Costa Coelho et al.[17] evaluated 594 patients and 2,537 dental implant applications in their study. In this study, early loss rate was found to be significantly higher in implants with diameters shorter than 8.5 mm and narrower than 3.75 mm. However, there are many other studies not confirming these results.[11,12,18,19] In the study by Derks et al.[19] in the Swedish population, it was shown that narrow implants are not a risk factor, instead short implants may be a more important risk factor. Lin et al.[12] showed that short implants rather than narrow implants are an important risk factor. However, there are many studies not confirming these results either.[18,20] When the effect of short and narrow implant use among the factors that may be effective in early implant loss was questioned among the participants, the rate of those who thought that short implant use was mostly and always effective was 16.1% and the rate of those who thought that narrow implant use was mostly and always effective was 14.9%. When the participants were evaluated according to their specialties, the rates of thinking that the use of short implants was effective were found to be similar between specialties. The rate of dentists who thought that narrow-diameter

implants were effective on early implant loss was 40% among dentists from other specialties. This rate was statistically significantly higher than the other groups. Such short and narrow diameter implants are used in some special patient groups. Especially this group of patients with insufficient bone tissue is already at risk for early implant loss. Therefore, it is not yet clear whether early implant loss is caused by short and narrow diameter implants or by other risk factors. Dentists with no specialization and other specialties may prefer short and narrow diameter implant applications rather than potentially complex augmentation procedures in these patient groups with insufficient bone tissue. The dentists participating in our study also generally think that short and narrow diameter implants are not a significant risk factor for early implant loss. Only a statistically significantly higher proportion of dentists from other specialties (40%) consider this factor to be influential in early implant loss.

A meta-analysis by Sgolastra et al.[21] compiled data from 16 different studies and as a result, it was found that having periodontitis had significant effects on early implant loss. The rate of those who thought that periodontitis could often and always cause early implant loss was 76.3%. Among specialties, the rates of thinking that periodontitis often and always causes early implant loss are 89% in periodontology specialists, 77.5% in dentists without specialization, 76.7% in dentists with other specialties and 60% in maxillofacial surgery specialists, respectively. It was observed that maxillofacial surgery specialists thought that this factor was less effective in early implant loss compared to other specialties and this difference was statistically significant.

Theoretically, it has been suggested that the presence of adjacent teeth may cause implant loss,[22] however, there is no clear study on this subject. It is thought that the implant may damage the neighboring tooth, making it devital and may cause implant loss with the infection that may develop. In our study, the presence of adjacent teeth was the factor least likely to cause early implant loss (7.3%). It was found that there was no statistically significant difference in the opinions about the effect of the presence of adjacent teeth on early implant loss between the specialties. However, periodontologists and non-specialized dentists considered the presence of adjacent teeth to be less influential (6.8% and 4.1%, respectively). Rare complications such as loss of vitality of the adjacent tooth and early implant loss are not considered as clear risk factors. The dentists included in our study generally think similarly.

Some postoperative complications may cause early implant loss. Da Rocha Costa Coelho et al.[17] showed that early implant loss may be observed more frequently after implant surgery if postoperative complications such as wound dehiscence, pus flow, infection and pain develop. In our study, the second factor thought to be most effective on early implant loss was the development of postoperative complications. The rate of those who thought that the development of postoperative complications was mostly and always caused by early implant loss was 73.1%. In each of the specialties, it was thought that the development of postoperative complications could cause early implant loss in approximately 70-75% of cases. The development of complications such as infection and wound dehiscence in the postoperative period is an important risk factor for early implant loss.[17] The dentists participating in our study were also found to have a high and sufficient level of awareness on this issue.

Olmedo-Gaya et al.[10] found that the application of augmentation procedure for the surgical site was a risk factor for early implant loss. However, these patients with insufficient bone tissue already have other risk factors for early implant loss, making it difficult to determine which factor is more effective. In our study, the rate of those who thought that augmentation of the implant site was mostly and always effective in early implant loss was 15.8%. This opinion was found to be similar between specialties and no statistically significant difference was observed. In general, the participants did not consider the fact that augmentation had been performed as a risk factor. There is not much literature data on this subject and there is no consensus.

Jemt et al.[23] found that immediate implant placement after tooth extraction is a risk factor for early implant loss. However, there are not many studies on this factor. Randomized controlled trials and meta-analyses are needed on this subject. In our study, the rate of those who thought that immediate implant application was mostly and always effective in early implant loss was 16.1%. When evaluated according to specialties, the rate of thinking that immediate application is mostly and always effective in early implant loss was 8.6% among maxillofacial surgeons. This rate was the lowest among other specialization groups. However, no statistically significant difference was found between specialties. According to the data we obtained in our study, participants do not think that this practice is an important risk factor. Personal experience comes to the fore in these issues where there is not much literature data.

The surgical site has always been considered an important risk factor for early implant loss. Many studies have shown that implant placement in the maxilla is an important risk factor for early implant loss.[24] Rosenberg et al.[24] reported that the risk was higher in the posterior region of the maxilla. Similarly, Alsaadi et al.[8] found a high risk in the posterior maxilla. However, a large cohort study by Lin et al.[12] revealed that the anterior region of the mandible is a more important risk factor. In our study, when the opinions of the participants about the surgical site factor, which was evaluated among the effective factors in implant loss, were questioned, in general, all specialties reported that early implant loss is most common in the posterior region of the maxilla. However, approximately 1 in 3 (30.1%) periodontologists think that the surgical site has no effect. Many studies have emphasized the importance of the surgical site for early implant loss.[8,12] According to literature data, caution and awareness should be kept high in terms of early implant loss, especially in posterior maxilla applications.

In a study by Nicolielo et al.[25] evaluating bone quality and quantity, a higher rate of early implant loss was observed in D4 bone structure. When the answers of the participants to the question about the effect of bone quality and quantity on implant loss were analyzed in our study, all dentists reported that a high proportion (73.7%) of them thought that the D4 bone structure caused implant loss. Among periodontologists, this rate was 71.2%. It is known that the D4 bone structure is mostly located in the posterior part of the maxilla.[25] It was found that it is well known that early implant loss is more common in D4 bone structure and awareness on this issue is high.

A Japanese study on implant loss in smokers showed that smoking increases the risk of early implant loss.[26] In addition, this study showed that smoking after the surgical procedure was effective in early implant loss, independent of smoking duration. The effect of smoking and alcohol use on implant survival was examined in the study by Galindo-Moreno et al.[27] In this study, smoking and alcohol consumption of more than 10 grams per day were shown to have significant effects on periimplant marginal bone loss. However, no data on early implant loss has been presented.[27] Many other studies have also shown that smoking is a significant risk factor for early implant loss.[9] In our study, the rate of thinking that smoking caused implant loss was 89.8%, while the same rate for alcohol was 45.6%. These rates were similar among all specialty groups. While the awareness of the dentists participating in our study about smoking is at an adequate level, no clear conclusion could be reached at the level of awareness about alcohol consumption. More

studies on the relationship between alcohol consumption and early implant loss are needed.

Diabetes is thought to be closely associated with early implant loss.[28,29] Many experimental studies have shown the negative effects of diabetes on implant healing. Diabetes mellitus impairs wound healing and increases susceptibility to infection.[28,29] Moy et al.[29] found that diabetic patients had more than twice the risk of implant failure. Morris et al.[28] found a very small increase in risk in patients with diabetes (6.8% vs. 7.8%). However, in some human studies, the relationship between the presence of diabetes and early implant loss has not been clearly demonstrated.[8,30] Hypertension is also suspicious for the risk of early implant loss. However, this relationship has not been demonstrated in any study.[31] In our study, participants in all specialty groups reported that diabetes was the most common systemic factor causing implant loss (92.4%). The presence of hypertension (11.4%) was one of the factors least likely to cause implant loss in all specialty groups. Systemic factors may be overlooked by many dentists or not questioned sufficiently before the procedure. However, in our study, it was shown that the awareness level of all dentists was very good in terms of the relationship of diabetes with early implant loss. Although the results cannot be shown conclusively, it is an important requirement for dentists to have a high awareness of systemic disease.

A recent meta-analysis by Monteiro et al.[32] compiled the results of 6 different studies and concluded that there was no significant relationship between obesity and implant complications. A cohort study in Italy, which evaluated 277 patients, showed no association between high cholesterol levels and implant losses.[33] Obesity (16.1%) and high cholesterol (11.4%) were the systemic factors least likely to cause early implant loss in our study. Studies have not shown a relationship between these factors and early implant loss. The majority of dentists working in our country think that these factors are ineffective, in line with the data in the literature.

The relationship between vitamin D levels and early implant loss has long been a focus of interest for researchers. This is mainly due to the effects of Vitamin D levels on bone metabolism. Guido Mangano et al.[34] found no relationship between serum vitamin D levels and early implant loss. There are also many studies questioning the relationship between early implant loss and osteoporosis. Alsaadi et al.[8] showed that osteoporosis is one of the most influential factors on early implant loss. A meta-analysis by Medeiros et al.[35] concluded that there was no significant relationship between osteoporosis and implant survival. Much more randomized controlled clinical trials are needed to clarify this issue. In our study, 78.7% of the participants thought that there was a relationship between osteoporosis and early implant loss and this rate was similar among all specialty groups. The rate of those who thought that serum vitamin D levels were important for early implant loss was 33.3%. More than half of maxillofacial surgeons (57.1%) consider vitamin D to be an important risk factor for early implant loss. Rates are similar in other specialties. Although there are no definitive results in terms of both vitamin D levels and osteoporosis, osteoporosis is considered to be an important risk factor for early implant loss by the dentists participating in our study. Although it has not been conclusively proven, it is important to be aware of the patient's systemic conditions and to be careful in these patients in terms of early implant loss.

Oral hygiene, surgical experience of the operator, implant surface, and bisphosphonate use are among the factors that draw attention when we look at the answers given to the open-ended question. Since patients with poor oral hygiene are likely to develop postoperative complications, this factor was already indirectly assessed in the questionnaire. The surgical experience of the operator is important in terms of factors to be considered during the procedure. Implant surgery is an important treatment protocol that requires knowledge, experience and attention. Today, it is difficult to say that there is a definite relationship between implant surface and early implant loss.[25]

CONCLUSION

According to the results we obtained in our study, it was determined that the level of knowledge of dentists about early implant loss is sufficient in general. It is noteworthy that postoperative antibiotic use is much more intensive than prophylactic antibiotic use. The fact that there are many studies showing the effectiveness of prophylactic antibiotherapy in preventing early implant loss reveals the need to increase the level of awareness of the situation. Regarding some factors, differences were found in the awareness levels of specialist physicians in terms of level of knowledge. Therefore, we believe that it would be important to review and standardize dental implant curricula across institutions to eliminate the differences between specialties.

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The Effect of Preheating on Fissure Sealant Viscosity

Ön Isıtmanın Fissür Örtücü Viskozitesine Etkisi

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ABSTRACT

Objective: Fissure sealant application is used for the prevention of caries. The viscosity of the fissure sealant directly affects the retention of the material to the tooth. Heating resin-containing materials before polymerization decrease the viscosity of the material. The purpose of this study was to examine the fluidity levels of four different fissure sealants containing resin with different filling ratios at different temperatures before polymerization and to evaluate the obtained data by comparing them.

Methods: The study of four different fissure sealant materials with resin content with different filler ratios (0%, 30%, 55%, and 70%) were heated at different temperatures (4ºC, 23ºC, 39ºC, and 55ºC) before polymerization. With the fluidity measurement between the two glasses, 20 fluidity measurement values were obtained at each temperature value, and a total of 320 measurements were made. The data were statistically evaluated with a two-way robust ANOVA analysis.

Results: The study it was determined that the fluidity values of the fissure sealants increased with the heating process before polymerization. The best result in terms of fluidity in the fissure sealants without filler was obtained at a temperature of at least 23ºC. In the fissure sealants containing 30% and 55% filler, there was a significant difference in fluidity values when the temperature difference was large.

Conclusion: It is thought that the filling ratio and temperature affect the fluidity in fissure sealants and that the appropriate temperature should be selected by considering the filling ratios to obtain the best result in terms of fluidity.

Keywords: fluidity, viscosity, preheating, fissure sealant, the heating device.

ÖZ

Amaç: Çürüklerin önlenmesi için fissür örtücü uygulaması kullanılmaktadır. Fissür örtücünün viskozitesi materyalin dişe retansiyonunu doğrudan etkilemektedir. Rezin içerikli materyallerin polimerizasyon öncesi ısıtılması materyalin viskozitesini azaltmaktadır. Bu çalışmanın amacı; farklı doldurucu oranlarına sahip rezin içerikli dört farklı fissür örtücünün polimerizasyon öncesi farklı sıcaklıklarda olması sağlanarak, akışkanlık düzeylerinin in vitro koşullarda incelenmesi ve elde edilen verilerin karşılaştırılarak değerlendirilmesidir.

Yöntemler: Çalışmada, farklı doldurucu oranlarına sahip (%0, %30, %55 ve %70) rezin içerikli dört farklı fissür örtücü materyali polimerizasyon öncesi farklı sıcaklıklarda (4ºC, 23ºC, 39ºC ve 55ºC) ısıtıldı. İki cam arasında akışkanlık ölçümü ile, her bir sıcaklık değerinde 20'şer akışkanlık ölçüm değeri elde edilerek toplam 320 ölçüm yapıldı. Veriler iki yönlü robust ANOVA analiziyle istatiksel olarak değerlendirildi.

Bulgular: Çalışmada polimerizasyon öncesi ısıtma işlemiyle fissür örtücülerin akışkanlık değerlerinde artış olduğu, doldurucu içermeyen fissür örtücülerde akışkanlık açısından en iyi sonucun en az 23ºC sıcaklıkta elde edildiği, %30 ve %55 doldurucu içeren fissür örtücülerde ise sıcaklık dereceleri arasındaki fark fazla olduğunda akışkanlık değerlerinde anlamlı fark gösterdiği saptandı.

Sonuç: Fissür örtücülerde doldurucu oranı ve sıcaklığın akışkanlık üzerinde etkili olduğu, akışkanlık açısından en iyi sonucun elde edilebilmesi için doldurucu oranları dikkate alınarak uygun sıcaklığın seçilmesi gerektiği düşünülmektedir.

Anahtar Sözcükler: akışkanlık, viskozite, ön ısıtma, fissür örtücü, ısıtma cihazı

INTRODUCTION

Dental caries is an infectious disease that is common in all age groups.[1] It occurs when the acid released as a result of the usage of fermentable carbohydrates by microorganisms destroys the calcified tissues of the tooth.[2] The types of caries are categorized based on their location and include pit-fissure caries, root surface caries, and flat surface caries. Pit-fissure caries are the most common types of caries lesions.[3]

Although dental caries are largely preventable, it remains a common disease across the globe. One of the various protective applications for the prevention of dental caries is fissure sealant applications [4]. Fissure sealants prevent tooth decay by closing the pits and fissures of the teeth and preventing the accumulation of bacteria and bacterial nutrients in the area.[5] Retention is the most important factor in the successful application of fissure sealants. Retention directly affects the adaptation and adhesion of the fissure sealant

to the tooth surface, thus facilitating its success and longevity.[6] The viscosity of fissure sealants is another factor that affects the retention of the sealant to the tooth. The viscosity of the fissure sealant directly affects the adhesion of the material to the tooth.[7] Studies have reported that the lower the viscosity value, the better the penetration of the tooth into the fissures and the more effective the retention [8]. The filling ratio of fissure sealants containing resin affects the viscosity of the material. Fissure sealants with a low filling ratio have lower viscosity and higher fluidity.[5]

Temperature is another factor affecting viscosity. Increasing the temperature of resin-containing materials increases the mobility of free radicals and decreases the viscosity of the material. The decrease in viscosity allows the material to better penetrate the tooth, resulting in higher retention [9]. Fissure sealants can more effectively penetrate the pits and fissures on the tooth surface when the viscosity value is reduced. In this way, the fissure sealant can successfully penetrate the enamel surface and the formation of caries in the tooth can be prevented.[10]

Most of the research on the effectiveness and success of fissure sealants addressed retention and microleakage, but studies evaluating the viscosity or fluidity of fissure sealants and heating fissure sealants are very limited. In light of this information, the present study aimed to examine the viscosity levels of four different fissure sealants containing resin with different filling ratios at different temperatures before polymerization and to evaluate the obtained data by comparing them.

METHODS

In the study, four different fissure sealants containing resin with different filler ratios (0%, 30%, 55%, 70%) were used (Table 1). Each type of fissure sealant was evaluated by heating at four different temperatures (4ºC, 23ºC, 39ºC, and 55ºC) before polymerization. According to the power analysis performed before the study, the number of measurement values required for each temperature of each fissure sealant was suggested as 6, with 95% test power (1-β), 95% confidence (1-α), f = 1.045 effect size. In this study, 20 fluidity measurement values were obtained for each of the four types of fissure sealants used at each temperature value; thus, a total of 320 measurements were obtained. The fissure sealants were stored in a refrigerator for 48 hours to reach a temperature of 4ºC. To reach 23ºC room temperature, the fissure sealants were kept at room temperature for 48 hours. A composite heating device (Micerium, S.p.a., Avegno GE, Italy) was used to heat the fissure sealants to 39ºC and 55ºC.

For each measurement, 0.05 ml of fissure sealant was placed on the glass layer. To ensure standardization in all measurements, 20 insulin syringes for each temperature of each fissure sealant were prepared with 0.05 ml of fissure sealant in each syringe. The insulin syringes were placed in the heating device. After each type of fissure sealant in the prepared insulin syringes reached the desired temperature, it was placed in the middle of a pre-prepared glass layer (100mmx100mmx 4mm) without decreasing its temperature. Then, a second glass layer weighing 100 g was placed over the fissure sealant. Afterwards, another 500 g weight was placed on the glass and a total of 600 g of weight was applied on the fissure sealant for 300 seconds. Then, the 500 g weight on the glass was removed. For a single measurement value, the diameter of the fissure sealant spread between two layers of glass was measured using a digital caliper from three different points in millimeters, and the average of these three measurement values was calculated and recorded.

Statistical Analysis

Data analysis were done with the R Project version 2021.09.0 (A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria). The conformity to the normal distribution was examined using the Shapiro Wilk test. A two-way robust ANOVA test was performed using the WRS2 package for 2-way comparison of the non-normally distributed fluidity values according to group and degree. The quantitative data values were given by finding the mean ± standard deviation value and the median (minimum - maximum) value. The significance level of the analysis was taken as $P<.05$.

RESULTS

A statistically significant difference was observed between the median fluidity values of each fissure sealant group at four different temperatures (Table 2). The highest fluidity median value was found in the group without filler and the lowest fluidity median value was found in the group containing 55% filler. However, no statistically significant difference was observed between the group containing 55% filler and the group containing 70% filler (Table 3).

No significant difference was observed between the fluidity values of the group without filler at 23ºC, 39ºC, and 55ºC. However, a significant difference was found between the fluidity values at 4ºC and the fluidity values at the other temperatures (Table 4).

Table 1. Fissure sealants used in the study and their chemical contents

Trade name	Chemical content	Manufacturer	Filler ratio
Teethmate F1 (Resin-containing)	TEGDMA, HEMA, MDP-F, colloidal silica, camphoroquinone, methacryloyl-fluoride-methyl methacrylate copolymer, accelerators, initiator, pigment and dye, hydrophobic dimethacrylates	Kuraray, Osaka, Japan	0%
Dyract seal (Compomer-containing)	DGDMA, hydrated silicon dioxide, strontium alumino-fluoro-silicate glass, phosphoric acid modified methacrylate resin ammonium salt, camphoroquinone, carboxylic acid modified macromonomer, ethyl-4-dimethyl amino benzoate, BHT, titanium dioxide	Dentsply, Konstanz, Germany	30%
Fissured fx (Resin-containing)	BIS-GMA, TEGDMA, UDMA, Bis-EMA, inorganic and glass ionomer filler (maximum 10 µm), 2% NaF	Voco, Cuxhaven, Germany	55%
Grandio Seal (Resin-containing)	Bis-GMA, TEGDMA, Inorganic Nanohybrid Fillers	Voco, Cuxhaven, Germany	70%

Table 2. Comparison of the fissure sealant and fluidity values according to temperature degree

	Test Statistic	P^a
Fissure sealant	925.3141	**.001**
Degree	444.7368	**.001**
Fissure sealant * Degree	214.657	**.001**

[a] Robust 2-way ANOVA

Table 3. Median values of the fluidity values of the fissure sealants at four different temperatures

Fissure Sealant	Mean ± S. Deviation	Median (Min. - Max.)
Without Filler Fissure Sealant	57.9 ± 6.0	58.7 [c] (45.1 – 68.2)
Fissure Sealant Containing 30% Filler	45.1 ± 2.4	45.5 [b] (40.1 – 49.3)
Fissure Sealant Containing 55% Filler	42.7 ± 4.4	41.3 [a] (36.2 – 50.2)
Fissure Sealant Containing 70% Filler	42.1 ± 2.0	42.4 [a] (36.8 – 47.1)

[a-c] There is no difference between the main effects with the same letter ($P < .05$).

Table 4. The flowability values of the fissure sealants evaluated at different temperatures

Fissure Sealant	Degree	Mean ± S. Deviation	Median (Min. - Max.)
Without Filler Fissure Sealant	4 ºC	50.8 ± 3.7	50.6 [G] (45.1 – 58.9)
	23 ºC	58.9 ± 4.7	58.8 [F] (52.2 – 68.2)
	39 ºC	59.2 ± 4.9	59.1 [F] (50.0 – 67.1)
	55 ºC	62.9 ± 3.1	64.1 [F] (55.8 – 68.1)
Fissure Sealant Containing 30% Filler	4 ºC	42.8 ± 2.0	42.5 [AE] (40.4 – 47.3)
	23 ºC	44.4 ± 2.0	44.3 [DE] (40.1 – 48.8)
	39 ºC	46.0 ± 1.6	46.1 [BD] (41.3 – 48.4)
	55 ºC	47.0 ± 1.5	47.2 [B] (42.5 – 49.3)
Fissure Sealant Containing 55% Filler	4 ºC	38.7 ± 1.7	38.0 [C] (36.2 – 42.2)
	23 ºC	39.2 ± 1.2	39.4 [C] (37.2 – 40.9)
	39 ºC	46.0 ± 3.0	46.6 [BD] (37.2 – 50.2)
	55 ºC	46.8 ± 2.7	47.3 [BG] (41.5 – 50.1)
Fissure Sealant Containing 70% Filler	4 ºC	41.6 ± 1.5	41.9 [A] (39.0 – 45.3)
	23 ºC	40.8 ± 2.3	41.8 [AC] (36.8 – 44.2)
	39 ºC	43.0 ± 1.3	43.1 [AE] (39.8 – 44.9)
	55 ºC	43.1 ± 1.8	42.6 [AE] (39.4 – 47.1)

[A-G] There is no difference between interactions with the same letter ($P < .05$).

Table 5. The flowability values and comparative results at four different temperatures, independent of the fissure sealant groups

Group	Degree	Mean ± S. Deviation	Median (Min. - Max.)
Total	4 ºC	43.5 ± 5.1	42.2 [c] (36.2 – 58.9)
	23 ºC	45.8 ± 8.3	42.9 [bc] (36.8 – 68.2)
	39 ºC	48.5 ± 7.0	46.3 [ab] (37.2 – 67.1)
	55 ºC	50.0 ± 8.0	47.2 [a] (39.4 – 68.1)
	Total	46.9 ± 7.6	45.0 (36.2 – 68.2)

[a-c] There is no difference between the main effects with the same letter ($P < .05$).

There was no statistically significant difference between the viscosity values of the group containing 30% filler at 4ºC and 23ºC, 23ºC and 39ºC, 39ºC and 55ºC. However, a statistically significant difference was found between the fluidity values at the other temperatures (Table 4).

No statistically significant difference was found between the fluidity values of the group containing 55% filler at 4ºC and 23ºC and 39ºC and 55ºC. However, a statistically significant difference was observed between the fluidity values at the other temperatures (Table 4).

There was no statistically significant difference between the fluidity values of the group containing 70% filler at 4ºC, 23ºC, 39ºC, and 55ºC (Table 4).

When analyzed independently of the material groups, no statistically significant difference was found between the fluidity values at 4ºC and 23ºC, 23ºC and 39ºC, and 39ºC and 55ºC. However, a statistically significant difference was observed between the fluidity values at 4ºC and 39ºC, 4ºC and 55ºC, and 23ºC and 55ºC (Table 5).

There was no significant difference between the fluidity values of the group containing 30% filler at 4ºC and the group containing 70% filler. A significant difference was found between the other groups at 4ºC (Table 4).

There was no significant difference between the fluidity values of the group containing 55% filler and the group containing 70% filler at 23ºC. A significant difference was found between the other groups at 23ºC (Table 4).

There was no significant difference between the fluidity values of the group containing 30% filler and the group containing 55% filler at 39ºC and 55ºC. A significant difference was found between the other groups at 39ºC and 55ºC (Table 4).

When the fluidity values were compared regardless of the material groups and temperatures, the highest median fluidity value was obtained at 55ºC in the group without filler and the lowest median fluidity value was obtained at 4ºC in the group containing 55% filler (Table 4).

DISCUSSION

Fissure sealant application is the method most frequently used to prevent caries on the occlusal surfaces of teeth.[11] Today, resin-based fissure sealants and glass ionomer-based are most commonly used as pit and fissure sealants. Many studies have reported that resin-based fissure sealants are the most successful fissure sealants.[5, 7] Most of the research on the efficacy and success of fissure sealant materials addressed retention and microleakage. Few studies have evaluated the viscosity or fluidity of fissure sealants. It is thought that the limited number of studies examining the fluidity of fissure sealants may be due to the assumption that less viscous materials show better flow resulting in better penetration into pit and fissure cavities.[10]

Viscosity is the resistance of a liquid to flow. This resistance is controlled by the internal frictional forces in the fluid. A liquid with a high viscosity flows slowly. Higher viscosity causes poor adaptation of the sealant to the tooth and incomplete penetration while reducing the retention of the sealant to the tooth. A low-viscosity sealant has a higher potential to spread and more quickly penetrate the tooth surface.[12] The depth of penetration is an important factor that can increase the life, durability, and adaptation of the fissure sealant. The low fluidity of the fissure sealant can lead to a decrease in the flow of the fissure sealant to the base of the fissures, resulting in incomplete penetration depth, especially in the case of narrow and deep fissures, such as IK-type and I-type. Moreover, less penetration depth reduces the retention of the fissure sealant.[13]

The polymerization of resin-containing fissure sealants is carried out with light. For the restoration to be healthier, the degree of polymerization must be high. When the degree of polymerization increases, the amount of residual monomer decreases, and the physical properties of the material increase.[14] If the polymerization of the material is not sufficient, microleakage, discoloration in the restoration, secondary caries formation, and retention problems can be observed. Many factors affect the depth of polymerization, including the power of the light source, the particle size, the color of the resin, and the temperature.[9, 15] Increasing the temperature of resin-containing materials increases the degree of polymerization. The rise in temperature increases the mobility of free radicals; accordingly, the viscosity of the resin decreases and additional polymerization occurs, resulting in better chemical and physical properties of the material.[9, 16] The adaptation of the resin-containing material to the cavity walls increases as the viscosity of the resin-containing materials decreases, and the fluidity increase with the heat application process before polymerization. The increase in the adaptation of the material increases the retention between the tooth and the restoration, thus reducing

secondary caries and post-operative sensitivity. Moreover, heat application before polymerization shortens the amount of time needed for the resin-containing material to harden.[9, 16]

The use of the heating process has increased in popularity in recent years, but the heating process is generally used in dentistry for composite materials and canal filling pastes.[17] To date, few studies have focused on the heating of fissure sealants. In the study conducted by Gorseta et al., it was found that the application of preheating to glass ionomer cement, which can be used as pit and fissure sealants, improves the mechanical properties of the fissure sealants.[18] In another study by Gorseta et al., it was reported that when the fissure sealant containing glass ionomer is heated, microleakage decreases, and marginal adaptation improves.[19] Borges et al. [20] reported that fissure sealants heated to 68ºC with a preheating process showed better marginal adaptation in comparison to those used at room temperature, and less space was formed between the fissure sealant and the tooth.

In a study by Knight et al., three different composite materials were preheated. That study found that the heating process reduces the film thickness of the material and reduces its viscosity.[21] In a study in which the composite material was preheated, it was reported that the fluidity of six different restorative composite resins that were heated to 60ºC before polymerization increased in comparison to the materials used at 23ºC room temperature [16]. In another study, it was reported that preheating of composites increased the microhardness of the samples and decreased their viscosity.[22] Marcondes et al. [23] applied the heating process to apply to 10 different composites; they reported that the viscosity of the composites decreased between 47% and 92% with the preheating process. Loumprinis et al.[24] reported that preheating causes a 30–82% decrease in the viscosity of composites. Al-Ahdal et al.[25]reported that the increase in temperature decreased the viscosity of all the studied composites by 40% to 90%. Davari et al. heated two different composites at 4°C, 23°C, and 37°C to evaluate the micro-tensile bond strength of the composite to dentin; they reported that heating increased the bond to dentin.[26] Similar to these results, in our study, when the fluidity values of the four different fissure sealants at four different temperatures were examined, the highest median fluidity value for each fissure sealant was found at 55ºC and the lowest median value was found at 4ºC. Similar to the studies performed with resin-containing materials, the present study observed that the fluidity values increase with the increase in temperature in fissure sealant materials.

The viscosity of a resin-containing material is affected by both organic and inorganic compounds. The type and amount of each monomer used are directly responsible for the viscosity of the organic matrix. The amount, shape, and size of the filler particles in resin materials also directly affect the viscosity.[27] It is thought that a fissure sealant that does not contain filler will penetrate deeper into the enamel surface and provide better adhesion.[5]

In our study, there was no significant difference between the fluidity values at 23ºC, 39ºC, and 55ºC in the group without filler; however, a significant difference was found between the fluidity values at 4ºC and 23ºC and 39ºC and 55ºC. Thus, the fluidity value of the group without filler is significantly lower at 4ºC than at the other temperatures, but there was no significant increase in the fluidity value of the material at temperatures higher than 23ºC. Our study results suggest that instead of using filler-free fissure sealants at a temperature of 4ºC, bringing them to a temperature of at least 23ºC would be the best way to use them in terms of fluidity of the material. Similar to the results of our study, Papacchini et al.[28] compared the bond strengths of three different composites heated before polymerization at 4ºC, 23ºC, and 37ºC and reported that the temperature had a significant effect on the bond strength by reducing the viscosity. The bond strength of two different composites increased significantly when the temperature was increased from 4°C to 23°C, but no significant difference was found between 23ºC and 37ºC.[28]

In our study, when comparing the groups with fillers at different temperatures, there was no significant difference between the fluidity values of the group containing 30% filler at 4ºC and 23ºC, 23ºC and 39ºC, and 39ºC and 55ºC when the temperature difference increased, a significant difference was found between the fluidity values between 4ºC and 39ºC, 4ºC and 55ºC, and 23ºC and 55ºC. There was no statistically significant difference between the fluidity values of the group containing 55% filler when compared at 4ºC and 23ºC and at 39ºC and 55ºC. However, a significant difference was found between the fluidity values at other temperatures. These results suggest that in order to create a significant difference in the fluidity values between the two temperatures of the 30% filler group and the 55% filler group, the difference between the temperatures should be great. It has been reported that the fluidity values of fissure sealants increase as the temperature difference increases. Choudhary et al.[29] evaluated the viscosity and adaptation rates of two different composites at 23ºC, 37ºC, and 54ºC. They observed better adaptation and less total void space formation at 54°C in comparison to 23°C and 37°C, which is similar to our study, and no significant difference was found between 23°C and 37°C. In the study by Dionysopoulo, the film thickness of the material was evaluated by heating the composite material at 23ºC, 54ºC, and 60ºC. They reported that there was no significant difference in film thickness between the groups heated to 54ºC and 60°C.[30] In the study by Davari et al.,[26] two different composites were heated at 4°C, 23°C, and 37°C, and the microtensile bond strength of the composite was evaluated; there was no significant difference between the microtensile bond strengths in the dentin of the two composites at 4°C and 23°C. The viscosity of conventional and flowable composites was evaluated by Loumprinis et al. at five different temperatures (23°C, 30°C, 37°C, 45°C, and 54°C). In that study, a significant difference was found between 23°C and 54°C for all composite types, but no significant difference was found between all the materials at the other temperature values.[24] These results support the finding in our study that the difference between the temperatures should be large in order to observe a significant difference in the fluidity values of the groups containing 30% and 55% filler.

In our study, no statistically significant difference was observed between the fluidity values of the group containing 70% filler at 4ºC, 23ºC, 39ºC, and 55ºC. This result demonstrates that there is no significant difference in the fluidity value when the heating process is applied to fissure sealants with a high filling ratio. When all the results were evaluated, as the filling ratio of the fissure sealant increased, the effect of the heating process on the fluidity of the material decreased. This result suggests that the structure that causes the change of fluidity by heating the resin-containing materials is the organic matrix structure, not the filler content of the material. Blalock et al. evaluated two composite materials with similar filler contents (77% and 60%) heated to 54ºC; they reported that there is a more than two-fold difference between the film thicknesses of the two materials brought to the desired temperature [31]. The heating process does not directly affect the ceramic-containing inorganic particle. The heating process before polymerization increases the fluidity of the material by affecting the ease of movement of the filler particle in the heated resin matrix, so the organic matrix structure of the resin materials can affect the fluidity. Blalock et al. [31] explained that the difference in film thickness between these two materials with close filler contents is very high due to the difference in the organic matrix structure of the materials. Lee et al. [32] investigated the viscosity changes by increasing the temperature according to the organic matrix composition of resin-containing materials When the temperature was increased from 25ºC to 35ºC, the viscosity decreased

significantly and the material with an organic matrix structure with high Bis-pheno A glycidyl metakrilat (Bis-GMA) content became more fluid as the temperature increased in comparison to the material with high Trietilen Glikol Dimetakrilat (TEGDMA) content. That study shows that the organic matrix structure is also effective in changing the fluidity value of resin-containing materials with a temperature increase.[32]

In our study, when the fluidity values were compared regardless of the material groups and the different temperatures, the highest fluidity median value was obtained at 55ºC in the group without filler and the lowest fluidity median value was found at 4ºC in the group containing 55% filler. Since the organic matrix ratio was higher in the filler-free group than in the other filler-containing groups, the highest fluidity value was reached at 55ºC, that is, at the highest temperature. When the filling ratio of the fissure sealant is the highest, the organic matrix ratio is the lowest and the effect of the heating process on the fluidity value decreases. Supporting this, the lowest fluidity value was found in the group containing high filler: 55% at 4ºC. Loumprinis et al. measured the fluidity values of composites at five different temperatures, and the highest fluidity value was measured in the composite with the lowest filler ratio and at the highest temperature of 54ºC.[24] Marcondes et al. [23] evaluated the viscosity of 10 restorative resin composites by heating them to 39ºC and 68ºC; it was determined that the lowest viscosity value was found at 68ºC and in the group with the lowest filler ratio. In these studies, similar to our study, it was reported that when the filling ratio of the material decreased and the heating process was applied, the fluidity decreased.

CONCLUSION

As a result of our study, it is thought that the filler ratio and temperature have an effect on the fluidity of fissure sealants. Thus, to ensure best fluidity, the appropriate temperature should be selected by considering the filler ratios. Since there are very few studies in the literature on this subject, the findings of this study need to be supported by in vitro and in vivo studies.

Etik Komite Onayı: Bu çalışma in vitro materyal değerlendirmesi olduğundan Etik Kurul Onayı gerektirmemektedir.
Hasta Onamı: İn vitro çalışma olduğundan onam formu alınmamıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir – EHB; Tasarım - EHB; Denetim - EHB; Kaynaklar -İSÇ; Malzemeler -İSÇ; Veri Toplanması ve/veya İşlemesi -İSÇ; Analiz ve/veya Yorum - İSÇ; Literatür Taraması – EHB, İSÇ; Makaleyi Yazan - İSÇ; Eleştirel İnceleme - EHB; Diğer –EHB, İSÇ.
Çıkar Çatışması: Yazarlar, çıkar çatışması olmadığını beyan etmiştir.
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Ethics Committee Approval: This study is an in vitro material evaluation and therefore does not require an Ethics Committee
Informed Consent: Since it was an in vitro study, no consent form was taken
Peer-review: Externally peer-reviewed.
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Comparison of Edgefile X3-One Curve File Systems and Cold Lateral Condensation-Single Cone Filling Techniques in Monoblocks With Simulated Curved Root Canals

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Tasarlanmış Eğimli Kök Kanallarına Sahip Monobloklarda Edgefile X3-One Curve Eğe Sistemleri ve Soğuk Lateral Kondensasyon-Tek Kon Dolum Tekniklerinin Karşılaştırılması

ABSTRACT

Objective: The present study aimed to compare the effects of EdgeFile X3 and One Curve files on the angle of curvature and the effectiveness of cold lateral condensation and single-cone filling techniques in monoblocks with curved root canals.

Methods: One hundred and eight monoblocks were divided into three main groups according to the curvature angle**.** Main group I had curvature angle of 5° at a distance of 6 mm from the root apex; main group II had curvature angle of 20° at the same distance from the root apex; and main group III had curvature angle of 20° at the same distance and curvature angle of 30° at a distance of 12 mm from the root apex. The main groups were divided into sub and end groups according to the use of Edgefile X3, One Curve, cold lateral condensation and single-cone techniques.

Results: With the One Curve, more straightening was observed in the curvature angle of the root canals in main group III. In main group III, there was a significant negative correlation between the change in apical and coronal curvature angles and the gutta-percha ratio and a significant positive correlation with the canal sealer ratio for both techniques.

Conclusions: With the Edgefile X3 file system, the shaping process took less time and the angular change was less. It was concluded that the main determinant of higher gutta-percha ratio was the filling technique used and the single-cone filling technique was more successful.

Keywords: Transportation, Resin block, EdgeFile X3, One Curve, Single-cone, Cold lateral condensation

ÖZ

Amaç: Bu çalışmanın amacı, eğimli kök kanallarına sahip monobloklarda EdgeFile X3 ve One Curve eğe sistemlerinin eğim açısı üzerindeki etkileri ile soğuk lateral kondensasyon ve tek kon dolum tekniklerinin etkinliğini karşılaştırmaktır.

Yöntemler: Yüz sekiz monoblok eğim açısına göre üç ana gruba ayrıldı. Ana grup I, kök apeksinden 6 mm uzaklıkta 5° eğim açısına sahipti; ana grup II, kök apeksinden aynı uzaklıkta 20° eğim açısına sahipti; ve ana grup III,aynı uzaklıkta 20° eğim açısına, kök apeksinden 12 mm uzaklıkta ise 30° eğim açısına sahipti. Ana gruplar Edgefile X3, One Curve, soğuk lateral kondensasyon ve tek kon tekniklerinin kullanımına göre alt ve uç gruplara ayrıldı.

Bulgular: One Curve ile ana grup III'teki kök kanallarının eğim açılarında daha fazla düzleşme gözlendi. Ana grup III'te her iki teknik için de apikal ve koronal eğim açılarındaki değişim ile guta-perka oranı arasında anlamlı negatif korelasyon ve kanal dolgu patı oranı arasında ise anlamlı pozitif korelasyon mevcuttu.

Sonuç: Edgefile X3 eğe sistemi ile şekillendirme işlemi daha az zaman aldı ve açısal değişim daha azdı. Guta-perka oranının yüksek olmasının temel belirleyicisinin kullanılan dolum tekniği olduğu ve tek kon dolum tekniğinin daha başarılı olduğu sonucuna varıldı.

Anahtar Kelimeler: Transportasyon, Rezin blok, EdgeFile X3, One Curve, Tek kon, Soğuk lateral kondensasyon

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INTRODUCTION

Curved root canals are frequently encountered in clinical practice. It is well established that root canals curve in almost all directions and canals that appear radiographically straight contain curvatures and irregularities in the apical third.[1] The aforementioned curvatures may not be detected on periapical radiographs and frequently lead to incorrect shaping and difficulties in root canal obturation.[1] As the curvature angle in the root canal increases, root canal treatment becomes more difficult and the risk of complications increases. Some of these complications are loss of root canal working length, step formation in the root canal, apical zip and elbow formation in the root canal, root canal transportation, perforation in the root canal and instrument breakage.[2]

The various root canal morphologies of extracted human teeth complicate efforts to standardise relevant studies.[3] Transparent resin blocks with simulated root canals that can be produced with preset diameter, shape and curvature can be used for standardisation when comparing the effectiveness of filling techniques and shaping capabilities of nickel–titanium (Ni-Ti) rotary file systems.[4] Furthermore, resin blocks with simulated root canals are important for research on S-shaped canals, especially since it is almost impossible to obtain natural teeth containing S-shaped canals along with a sufficient number of standard features.[5,6]

One Curve (OC) and EdgeFile X3 (EF) file systems are made of heat-treated Ni–Ti alloy. The OC file system consists of a single file, whereas the EF is a complete line of rotary file systems.[7,8] The EF file system is manufactured using a proprietary heat treatment process called FireWire. This heat treatment method was reported to provide the files with greater flexibility, increased resistance to cyclic fatigue, and higher torque endurance compared to the conventional Ni–Ti files, as well as better canal tracking and centring ability.[8] The OC file system is manufactured using the C-Wire technology. C-Wire technology provides the file with greater blade flexibility and fracture resistance.[9]

The aims of this study about curved root canals are to determine which file system causes greater angular change, to determine which filling technique provides more effective filling and to show the effect of angular changes on filling success. Resin blocks containing root canals designed with different degrees of curvatures were used with the aim of comparing the duration of shaping with the EF and OC file systems and the resulting changes in curvature angles. The degree of improvement of the effectiveness of the cold lateral condensation (CLC) and single-cone (SC) techniques were also compared when used in appropriately-shaped root canals.

METHODS

This article does not contain any studies with human or animal participants. Therefore, ethics committee approval and informed consent were not required.

Design of Resin Blocks and Setting the Experimental Groups

In the present study, 108 transparent resin blocks were divided into three main groups (n = 36) based on their curvature angles. The curvature angles of the root canals in the blocks were set as follows: main group I had curvature angle of 5° and radius of curvature of 3.5 mm at a distance of 6 mm from the root apex; main group II had curvature angle of 20° and radius of curvature of 4.5 mm at a distance of 6 mm from the root apex; and main group III had curvature angle of 20° and radius of curvature of 4.5 mm at a distance of 6 mm and curvature angle of 30° and radius of curvature of 5 mm at a distance of 12 mm from the root apex. Subsequently, the resin blocks were produced with apical diameter of 0.15 mm and taper of 0.02 (ARG Medikal, Isparta, Türkiye). The blocks were divided into two sub-groups based on the angle of curvature and shaped with either the EF (Edge Endo, Albuquerque, United States of America) (n = 18) or the OC (Micro-Mega SA, Besançon, France) file system (n = 18). The above sub-groups were further subdivided into end groups for obturation with the CLC (n = 9) or SC filling techniques (n = 9).

Shaping Resin Blocks

All the blocks used in the study were shaped by the same researcher. During the shaping procedure, the blocks were covered with aluminium foil and held in place by a setup mechanism. For both file systems, the resin residues inside the grooves left during shaping were cleaned with gauze dampened with distilled water. Recapitulation was performed with a 0.02 tapered #10 Ni–Ti K-type file by turning a quarter turn counterclockwise at the working length after each use. The above-mentioned procedures were repeated until the coronal–apical working length was achieved. Four different root canals were shaped with each file. During root canal preparation, a chronometer was used to determine the duration of shaping for each block. In order to comply with clinical practice, the irrigation time, recapitulation, removal of resin residues on the rotary file and file replacement times were all included in the study duration.

Shaping the resin blocks in the EF groups: Files C1 (20/0.06) and C2 (25/0.06) were used with the X-Smart Plus (Dentsply, Maillefer, Ballaigues, Switzerland) endodontic motor at 350 rpm speed and 3 Ncm torque as recommended by the manufacturer, with movements in the apicocoronal direction at a working length of 1 mm from the apical foramen.

In the OC groups: The 25/0.06 OC files were used with the X-Smart Plus endodontic motor at 300 rpm speed and 2.5 Ncm torque as recommended by the manufacturer, with movements in the apicocoronal direction at a working length of 1 mm from the apical foramen.

Detection of Angular Changes in the Shaped Root Canal

The images of all the shaped resin blocks were recorded using a surgical microscope (Leica, Vienna, Austria) in a fixed position. The root canal curvature angle measurements were performed on the basis of the long-axis technique using the angle function in ImageJ 1.53c software (National Institutes of Health and the Laboratory for Optical and Computational Instrumentation [LOCI, University of Wisconsin], United States of America) (Figure 1). In this technique, a line is drawn parallel to the long axis of the tooth. Then, another line is drawn between the root apex and the point where the slope ends. The acute angle at the intersection of two lines gives the root canal curvature angle.[10] Measurements were made blindly by three independent observers. Accordingly, angles prior to shaping and angular changes after filing were calculated. The final result was determined by taking the average of the measurements.

Obturation of Root Canals

AH Plus Root Canal Sealer (CS; Dentsply, Konstanz, Germany) was used for both filling techniques. In the end groups filled with the SC and CLC techniques, the 0.06 taper #25 gutta-percha (GP) cones (PearlEndo, Ho Chi Minh, Vietnam) and 0.02 taper #25 main GP cones (PearlEndo, Ho Chi Minh, Vietnam) were used, respectively. The condensation procedure was applied using the #25 Ni–Ti finger spreader in the CLC technique. In the resultant cavity, GP cones (0.02 taper) covered with root CS and one size smaller than the spreader were emplaced.

Figure 1. Determination of angular change after shaping

Sectioning the Resin Blocks and Analysis of Sections

The resin blocks were kept in an oven with constant humidity and temperature for 7 days to allow the CS to harden sufficiently. The blocks were cut at 3-, 6-, and 12-mm intervals from the root apex using a precision cutting device (Brillant 220, QATM, Mammelzen, Germany), which was a 0.3 mm thick cutting disc rotating at 2500 rpm under water cooling. The coronal faces of the parts were examined using a stereo microscope (50× magnification) (Zeiss Stemi 508, Jena, Germany). The sectional images were analysed using ImageJ 1.53c software to determine the percentages of GP, CS and empty spaces in the root canal lumen. The area percentages were calculated using the pixel-counting method. First, the number of pixels in the entire root canal lumen was determined (Figure 2). Then, the number of pixels for GP, CS and empty spaces were determined, and their respective percentages were calculated (Figure 3). The measurements were made blindly by three different observers. The final result was the average of the measurements.

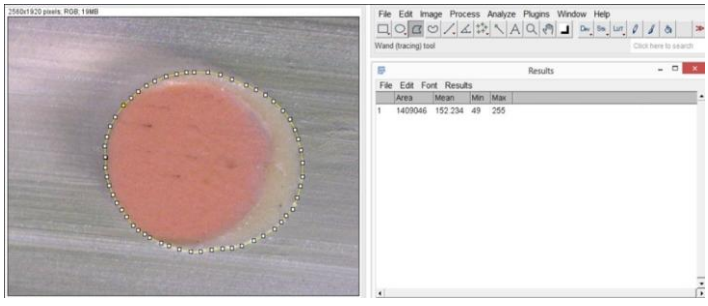

Figure 2. Determination of the number of pixels in the entire root canal lumen

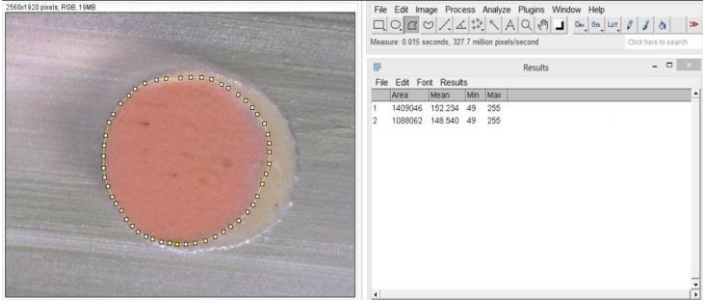

Figure 3. Determination of the number of pixels in the area filled with gutta-percha

Statistical Analysis

The Statistical Package for the Social Sciences Version 23 software (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analyses. Prior to statistical analyses, necessary controls were established to avoid data entry errors and to ensure that the parameters were within the expected ranges. The normal distribution hypothesis for continuous variables was tested using the Kolmogorov–Smirnov test, while variance homogeneity was tested using Levene's test. Mean and standard deviation values were used to present the descriptive statistics for continuous variables. The *t*-test and one-way analysis of variance were used to compare two groups and three or more groups, respectively, if the data met the normal distribution hypothesis, whereas the Mann–Whitney U test and Kruskal-Wallis test were used for comparing two groups and three or more groups, respectively, if the data did not have normal distribution. Pearson and Spearman (Spearman's Rho) correlation analyses were used to test the relationships between continuous variables. A *p* value of <.05 was considered statistically significant for all analyses.

RESULTS

In all three groups, shaping with the EF file system took significantly less time compared to shaping with the OC file system (Table 1).

Following the shaping procedure, there was an angular decrease in the curvature of all blocks. In terms of the angle of curvature of the blocks in main group III at a distance of 12 mm from the root apex, those shaped with the OC file system had statistically significantly higher angular change than those shaped with the EF file system (*P* <.05) (Table 2).

Table 1. Descriptive statistics about the duration of root canal shaping procedures

	EdgeFile X3			One Curve			*P*
	n	Mean±SD	Min-Max	n	Mean±SD	Min-Max	
Main Group I	18	171.94±7.19	162-189	18	196.67±19.89	164-225	***<.05****
Main Group II	18	172.17±8.87	159-190	18	197.22±15.45	172-221	***<.05****
Main Group III	18	278.89±16.26	252-306	18	295.78±9.02	280-311	***<.05****
All Blocks	54	207.67±52.07	159-306	54	229.89±49.41	164-311	

***:** Statistically significant *p* values
n, number of blocks in each group; SD, standard deviation; Min, minimum; Max, maximum

Table 2. Angular changes at curvature points after shaping

		EdgeFile X3			One Curve			*P*
		n	Mean±SD	Min-Max	n	Mean±SD	Min-Max	
Main Group I	**6 mm**	18	0.66±0.5	0.0-1.78	18	0.71±0.45	0.0-1.60	*>.05*
Main Group II	**6 mm**	18	1.37±0.54	0.7-2.35	18	1.41±0.50	0.80-2.40	*>.05*
Main Group III	**6 mm**	18	1.43±0.63	0.38-2.40	18	1.82±0.76	0.6-2.83	*>.05*
	12 mm	18	4.03±0.87	3.15-5.73	18	4.89±1.31	3.10-7.15	***<.05****

*: Statistically significant *p* values
n, number of blocks in each group; SD, standard deviation; Min, minimum; Max, maximum

Based on the comparison for only the filling technique used, regardless of the shaping system, there were statistically significantly higher GP rates and lower CS rates for the SC technique than for the CLC technique in all sections, except those taken 3 mm from the root apex in the blocks from main group I (Table 3).

Table 3. Comparison of filling techniques used, regardless of the file system, in terms of canal filling material ratios in sections taken at 3 mm, 6 mm and 12 mm distances from the root apex

			Cold Lateral Condensation			Single-Cone			*P*
			Mean±SD	Min	Max	Mean±SD	Min	Max	
Main Group I	3 mm	GP	75.98±6.34	69.20	91.33	76.43±4.79	67.21	84.18	*>.05*
		CS	21.90±6.81	8.67	29.82	21.86±4.43	15.45	29.61	*>.05*
		Emp	2.12±2.95	0.00	12.99	1.71±1.13	0.00	3.20	*>.05*
	6 mm	GP	50.22±9.13	37.73	69.27	76.79±6.35	66.59	88.18	***<.05****
		CS	47.35±9.21	28.31	60.67	21.24±6.23	10.72	33.41	***<.05****
		Emp	2.44±1.19	0.00	4.22	1.97±1.66	0.00	4.56	*>.05*
	12 mm	GP	75.53±5.91	67.20	86.07	80.54±3.74	72.70	87.91	***<.05****
		CS	24.42±6.45	8.45	30.77	17.63±3.43	11.07	24.68	***<.05****
		Emp	2.06±1.33	0.00	5.48	1.83±1.54	0.00	4.30	*>.05*
Main Group II	3 mm	GP	72.90±7.52	64.73	97.92	77.72±4.86	69.25	87.93	***<.05****
		CS	25.08±7.16	1.34	33.93	19.82±4.75	9.84	28.65	***<.05****
		Emp	2.02±0.70	0.74	3.12	2.46±3.01	0.00	12.70	*>.05*
	6 mm	GP	50.78±12.91	36.20	81.84	76.45±6.69	67.94	89.12	***<.05****
		CS	46.15±12.07	17.12	61.40	21.50±6.38	8.84	30.72	***<.05****
		Emp	3.06±1.64	1.04	6.20	2.06±1.15	0.00	4.12	*>.05*
	12 mm	GP	73.52±5.79	64.18	86.07	79.92±5.07	69.24	87.16	***<.05****
		CS	24.33±5.69	8.45	31.47	18.26±4.30	11.58	28.35	***<.05****
		Emp	2.15±1.64	0.00	5.62	1.83±1.59	0.00	4.75	*>.05*
Main Group III	3 mm	GP	57.52±6.12	45.42	68.54	64.20±7.04	50.18	78.28	***<.05****
		CS	37.27±6.20	20.33	49.70	31.75±7.87	11.25	46.02	***<.05****
		Emp	5.22±4.58	0.00	18.26	4.05±3.41	0.00	14.08	*>.05*
	6 mm	GP	50.33±4.43	42.05	56.47	64.40±5.11	56.72	75.40	***<.05****
		CS	45.04±6.82	24.87	55.64	31.40±5.50	21.65	40.95	***<.05****
		Emp	4.63±4.23	1.25	18.73	4.20±3.93	0.94	15.95	*>.05*
	12 mm	GP	64.46±6.15	57.15	83.12	70.63±6.90	53.83	82.26	***<.05****
		CS	31.29±6.10	16.88	38.55	26.74±6.30	17.74	44.55	***<.05****
		Emp	4.25±4.26	0.00	17.75	2.63±1.52	0.00	4.63	*>.05*

*: Statistically significant *p* values

SD, standard deviation; Min, minimum; Max, maximum; GP, gutta-percha; CS, canal sealer; Emp, empty

In the comparison based on both shaping system and filling technique combined, the mean GP ratios were significantly higher and mean CS ratios were significantly lower in the combinations using the SC technique compared to combinations using the CLC technique for block sections at a distance of 6 mm and 12 mm from the root apex in main groups I and II and for block sections at a distance of 6 mm from the root apex in main group III (Table 4).

The correlation analyses, which sought to investigate the relationship between the angular change in curvature at 6 mm distance from the root apex and the filling ratios of the section at the same level, revealed a statistically significant, positive and moderate correlation between the change in curvature angle and the ratio of empty spaces in the blocks in main group II filled using the CLC technique. For both filling techniques, there was a statistically significant, negative and very high correlation between the angular change in curvature and the GP ratios in blocks from the main group III; however, there was a statistically significant, positive and high correlation between the angular change in curvature and CS rates (Table 5).

There was a statistically significant, positive and moderate correlation between the angular change in curvature 12 mm from the root apex and CS in main group III blocks filled using the CLC technique. There was a statistically significant, negative, and high correlation between the angular changes in curvature at the same level in the blocks included in the same group and filled using the SC technique and the GP ratio; however, there was a statistically significant, positive and high correlation between the angular change in curvature and CS (Table 6).

Table 4. Comparison of file system and filling technique combinations in terms of canal filling material ratios in sections taken at 3 mm, 6 mm and 12 mm distances from the root apex

			Mean±SD				*P*
			EF+CLC	EF+SC	OC+CLC	OC+SC	
Main Group I	3 mm	GP	75.53±6.82	76.75±4.03	76.44±6.20	76.11±5.67	*>.05*
		CS	22.00±7.65	21.46±4.13	21.80±6.34	22.26±4.94	*>.05*
		Emp	2.47±4.08	1.78±1.17	1.77±1.24	1.64±1.15	*>.05*
	6 mm	GP	49.87±8.60	77.11±6.96	50.57±10.13	76.47±6.07	***<.05****
		CS	47.67±8.65	20.93±7.61	47.02±10.25	21.55±4.93	***<.05****
		Emp	2.47±1.24	1.96±1.66	2.41±1.22	1.98±1.76	*>.05*
	12 mm	GP	73.04±6.37	81.10±3.96	74.00±5.76	79.98±3.65	***<.05****
		CS	24.93±7.20	17.08±3.64	23.90±6.01	18.18±3.34	***<.05****
		Emp	2.02±1.65	1.81±1.59	2.10±1.01	1.84±1.59	*>.05*
Main Group II	3 mm	GP	73.39±9.82	77.57±6.15	72.42±4.84	77.87±3.51	*>.05*
		CS	24.71±9.43	19.75±6.02	25.44±4.42	19.90±3.42	*>.05*
		Emp	1.90±0.65	2.68±3.94	2.14±0.77	2.23±1.90	*>.05*
	6 mm	GP	51.14±12.87	77.21±7.18	50.43±13.72	75.69±6.49	***<.05****
		CS	45.84±11.97	20.80±7.27	46.46±12.89	22.21±5.71	***<.05****
		Emp	3.01±1.83	2.01±1.12	3.11±1.55	2.10±1.23	*>.05*
	12 mm	GP	73.50±5.37	80.01±4.08	73.54±6.52	79.82±6.17	***<.05****
		CS	24.35±6.36	18.17±3.79	24.32±5.32	18.34±5.01	***<.05****
		Emp	2.15±1.67	1.82±1.70	2.14±1.71	1.84±1.58	*>.05*
Main Group III	3 mm	GP	57.54±7.54	64.87±8.20	57.50±4.75	63.54±6.08	***<.05***
		CS	37.23±8.04	31.06±9.79	37.31±4.15	32.43±5.90	*>.05*
		Emp	5.23±5.97	4.07±4.04	5.20±2.99	4.03±2.90	*>.05*
	6 mm	GP	51.19±5.05	64.03±5.09	49.47±4.94	64.77±5.40	***<.05****
		CS	44.07±8.50	31.83±5.99	46.01±4.94	30.97±5.30	***<.05****
		Emp	4.74±5.33	4.13±4.63	4.52±3.09	4.26±3.37	*>.05*
	12 mm	GP	64.40±4.84	70.40±7.13	64.51±7.55	70.85±7.09	*>.05*
		CS	31.44±4.68	26.96±7.01	31.14±7.56	26.53±5.93	*>.05*
		Emp	4.15±3.30	2.64±1.71	4.35±5.26	2.62±1.40	*>.05*

*: Statistically significant *p* values

SD, standard deviation; Min, minimum; Max, maximum; GP, gutta-percha; CS, canal sealer; Emp, empty; EF, EdgeFile X3; OC, One Curve; CLC, cold lateral condensation; SC, single-cone

Table 5. Relationship between the change in curvature angle during shaping and the gutta-percha, canal sealer and empty spaces ratios in the sections taken at a distance of 6 mm from the root apex

				Filling Technique	
				Cold Lateral Condensation	Single-Cone
Sections taken from 6 mm distance from root apex	Main Group I	GP	R	0.032	-0.040
			P	*>.05*	*>.05*
		CS	R	0.005	-0.007
			P	*>.05*	*>.05*
		Emp	R	-0.279	0.179
			P	*>.05*	*>.05*
	Main Group II	GP	R	*-0.441*	*0.029*
			P	*>.05*	*>.05*
		CS	R	*0.406*	*-0.005*
			P	*>.05*	*>.05*
		Emp	R	*0.482*	*-0.143*
			P	***<.05****	*>.05*
	Main Group III	GP	R	*-0.852*	*-0.812*
			P	***<.05****	***<.05****
		CS	R	*0.625*	*0.671*
			P	***<.05****	***<.05****
		Emp	R	*-0.115*	*0.116*
			P	*>.05*	*>.05*

*: Statistically significant *p* values

GP, gutta-percha; CS, canal sealer; Emp, empty

Table 6. Relationship between the change in curvature angle during shaping and the gutta-percha, canal sealer and empty spaces ratios in a section taken at a distance of 12 mm from the root apex in main group III blocks

			Filling Technique	
			Cold Lateral Condensation	Single-Cone
Sections taken from 12 mm distance from root apex	GP	R	-0.445	-0.696
		P	*>.05*	***<.05****
	CS	R	0.504	0.684
		P	***<.05****	***<.05****
	Emp	R	-0.079	0.327
		P	*>.05*	*>.05*

*: Statistically significant *p* values

GP, gutta-percha; CS, canal sealer; Emp, empty

DISCUSSION

The duration of the root canal shaping procedure is determined by the root canal shaping technique used, the number of files used, and the operator's experience. Certain factors, including the operator's experience and technique, complicate standardisation efforts. Therefore, even in studies using the same file systems, extremely different results may be obtained.[3,5] The results of the present study suggest that the shaping procedure with the EF file system takes a statistically significantly shorter time than the OC file system for all three main groups. In both file systems, the S-shaped root canals in main group III took a significantly longer time to be shaped. Despite double files being used in the EF file system, the file system's production characteristics and cross-sectional design, as well as speed and torque values recommended by the manufacturer, may have accounted for the completion of the shaping procedure in a comparatively shorter period of time. According to a study, the EF file system was more flexible and more resistant to cyclic fatigue compared to the OC file system.[11] The above-mentioned flexibility might have contributed to shortening the shaping procedure duration in curved root canals. Furthermore, starting the shaping procedure with a smaller-sized C1 file may have facilitated the movement of canal tools in curved canals, resulting in a faster shaping procedure with the EF file system, which includes the C1 and C2 files. Furthermore, the manufacturer-recommended speed and torque values were higher for the EF file system. The high speed and torque might have accelerated the shaping procedure. Because the OC file system recommends a lower maximum torque value, the likelihood of more frequent bounce backs in the root canal, especially at the curvature points, may have prolonged the procedure.

Based on a comprehensive literature review, there is no study that examined the OC and EF file systems in combination, the angular change in the root canals after shaping; and the associated transportation. The results of studies that compared different file systems could have been affected by certain factors, including the file system, the use of tooth or resin block, and the degree of curvature of the root canal. The angular changes in the present study favoured root canal straightening. In the present study, the OC file system produced significantly greater angular changes in the curvature 12 mm from the root apex of the S-shaped, double-curved blocks in main group III during the shaping procedure than the EF file system. A previous study suggested that the EF file system was more flexible compared to the OC file system, which may account for less angular change in EF cases. The file's flexibility enabled it to more successfully adapt to curvature points.[11] The respective manufacturers report that the OC file system has triangular cross-sections at the tip and S-shaped cross-sections on the body, while the EF file system has a parabolic cross-section design. It was further claimed that the variable cross-sectional structure, which is unique to the OC file system, also preserved the original anatomy of the root canal and provided a centring ability in the apical third. Moreover, the variable cross-sectional structure provided higher cutting efficiency in the middle and coronal thirds.[5] The differences in production technology and design between the two file systems might explain why the OC file system induced a higher rate of angular change than the EF system. Previous studies on different file systems reported that metallurgical properties and production techniques were effective on transportation.[12,13] Furthermore, higher straightening of the coronal curvature caused by the OC file system in main group III, where there was a significant difference in angular change, could be because of higher cutting efficiency in the middle and coronal thirds due to the variable cross-sectional structure.[5] It is well established that increased cutting efficiency of the files paves the way for transportation.[14] The difference in angular change could also be explained by the fact that the shaping procedure was performed with a single file in the OC file system and with two files in the EF file system. According to relevant studies that tested different file systems, the use of less conical and more flexible files in multi-file systems reduced the amount of transportation.[13,15] Because of the lack of a pre-widening step, the grooves on single-file systems could become clogged more easily, resulting in more torque and pressure on the file. This would increase canal transportation.[16]

The mean angular change in main group III was greater than in main group II, and the mean angular change in main group II was greater than in main group I. Accordingly, increased angular change may be associated with increased difficulty of root canal anatomy. A previous study supports the above conclusion.[12] The coronal curvature of the blocks in main group III showed the highest mean angular change. The blocks in main group III with the highest curvature angle in the study may have caused this. Furthermore, similar to the results of the present study, previous studies using different file systems reported that transportation occurred more frequently in the coronal section.[5,6] It was suggested that the cause of this could be the tapering of Ni–Ti systems.[5] We believe that the same reason leads to higher rates of coronal transportation.

Root canal filling is affected by the degree of root canal curvature.[17] To ensure standardisation and to avoid the likelihood of angled GP cones specifically produced for the EF and OC file systems interfering with the comparison of filling techniques in blocks filed with different file systems, 0.06 taper #25 GP cones were used instead of angled SC GPs. This has been the preferred method in a number of studies.[17,18] The percentage of GP in root canal cross-sections is a frequently used method for investigating the success of obturation.[19-21] While GPs are stable in size, they may shrink and dissolve as the sealant hardens, and thus their sizes may change over time.[22,23] Higher GP and lower CS rates should be targeted to ensure successful outcomes from the root canal obturation procedure.[18,20,21] It is well established that filling the root canals without gaps is associated with higher rate of success in root canal treatment.[24]

Alim et al.[17] reported that the most successful technique for 2 and 5 mm distances was CLC in their study, in which they filled the mandibular first molars with a root canal curvature degree of >25° using CLC, SC, continuous-wave obturation and core carrier techniques. They investigated the filling success using micro-computed tomography on sections at 2, 5 and 8 mm distances. Furthermore, the SC technique had the lowest GP percentage of all the filling techniques in that study. The coronal part of all teeth included in the study had the most successful filling, while the apical part had the least successful. A number of factors might have caused the discrepancy with the present study's findings. The main differences in the study by Alim et al.[17] were the use of extracted teeth, the fact that the curvature points and angles in those teeth were not constant, the shaping size was not the same between the groups, the CS ratio was not included in the assessment, and the use of micro-computed tomography. Schafer et al.[19] used SC, CLC and warm vertical condensation techniques to fill extracted teeth with root canal curvatures ranging from 25° to 35°. They took sections at 2, 3, 4, 6 and 8 mm distances from the root apex and investigated the GP, CS and empty space ratios under a stereo microscope. Accordingly, similar to our study, there was no significant difference between the techniques in terms of empty space ratio. Simultaneously, teeth filled with the SC technique had a higher rate of CS and a lower rate of GP than other techniques at all levels.[19] The extracted teeth in the above-mentioned study were similar to those of Alim et al.[19] and no information about the location of the curvature points was provided. We believe that such

differences might have affected the results of the study. Romania et al.[25] used the CLC and SC techniques to fill mandibular premolar teeth with straight canals and examined the sections under a stereo microscope. They found that GP and CS percentages were similar. Tasdemir et al.[26] filled mandibular premolar teeth using SC and CLC techniques and reported a significantly higher rate of GP with the SC filling technique, which is similar to our study. Gordon et al.[27] filled resin blocks with curvature angles of 30° and 58° and the mesiobuccal canals of maxillary first molars with curvature angles of 25.6° ± 19.7° using the SC and CLC techniques and investigated sections taken at certain distances from the apical foramen for GP, CS and empty space ratios under a stereo microscope. Accordingly, the SC technique had higher area covered with GP in the apical part of resin blocks compared to the CLC technique. In the same study, there was no difference between the methods in terms of the curved mesiobuccal canals of the maxillary first molars.[27] This study suggests that the success of filling techniques may differ between extracted teeth and standard resin blocks. We believe that the differences in results between the present study and other studies of extracted teeth are because of the variable root canal anatomy of extracted teeth. A different study found that anatomical variations and oval or round shape of the canals might affect the success of the filling technique.[20] The canal must be circularly enlarged with a sufficient taper for GP to fit into the root canals when using the SC technique, which uses GPs compatible with rotary Ni–Ti canal instruments. This method will be more effective for the mesial and distal roots of the upper molars, as well as the mesial roots of the lower molars. A number of studies reported that the SC technique was more suitable for round-shaped canals.[24,27,28] In contrast, it was suggested that the GP cone was not suitable for root canals with oval and large diameters because of the inability to adapt to the root canal.[27] We believe that the higher GP rates with the SC technique compared to the CLC technique in the present study were because of the use of resin blocks with round root canals.

GP ratios in S-shaped canals in main group III were lower in both techniques when compared to the other main groups. The correlation between the angular change in the curvature of the blocks in main group III and the GP and CS ratios in the sections taken from the curvature points was also remarkable. The curvature points of the root canal are sections taken at 6 mm and 12 mm distances from the root apex, and at these points, the root canal loses its rounded structure owing to transportation and becomes oval, and the curvature angle changes in favour of straightening. As reported in other studies, this causes the GP used in the SC technique to be unable to effectively fill the root canal at those distances, increasing the percentages of empty space and CS.[17,27] In the CLC technique, this may be due to the spreader used to attach the auxiliary cones not being able to be placed within 1–2 mm of the apical working length.[29] Furthermore, even if the spreader is placed at the desired distance, there may be areas without GP owing to the inability to place the auxiliary cones in the space created by the spreader.[4] Previous studies reported that when using the CLC method, spreaders and endodontic pluggers might not reach all the way apical in excessively-curved root canals and may become stuck at the beginning of the curvature.[4,17] Moreover, a different study suggested that transportation negatively affected the success and impermeability of root canal filling.[30] We believe that the difficult anatomy of the S-shaped canals in main group III resulted in lower GP ratios with both techniques, especially at the curvature points, as a result of the mechanisms discussed above.

The most important limitation of our study is the use of resin blocks instead of extracted teeth. Other limitations are that only sectioned areas were evaluated and no radiological examination was performed. Extracted teeth with the same curvature angle are difficult to obtain. Similarly, it is almost impossible to obtain bi-curved teeth with a standard angle of curvature. This challenge was overcome by using resin blocks. This is the most important factor supporting the strength of our study. These results obtained with resin blocks should be supported by further studies on extracted teeth.

In conclusion, when compared to the OC, the shaping procedure with EF took significantly less time. In double-curved S-shaped canals, the sub-group shaped with OC had significantly more straightening at the angle of curvature in the coronal curvature compared to the sub-group shaped with EF. It was concluded that the main determinant of higher GP ratios was the filling technique used and that the SC filling technique was more successful. It was observed that as the extent of straightening upon shaping increased in main group III, so did the extent of CS in the sections corresponding to the curvature point.

Etik Komite Onayı: Bu makale, insan veya hayvan katılımcılar ile yapılan herhangi bir araştırma içermemektedir.
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Evaluating the Color Stability of 3D Printed Temporary and Permanent Composite Resins After Exposure to Common Beverages

3D Baskı Geçici ve Kalıcı Kompozit Reçinelerin Genel İçeceklere Maruz Kalma Sonrası Renk Stabilitesinin Değerlendirilmesi

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ABSTRACT

Objective: This study aimed to evaluate the color stability of 3D printed permanent and temporary composite-based restorative materials by assessing their stainability after immersion in tea, coffee, and water.

Methods: The composite resins used included Temp Ultra (TU) and Custom Composite Resin (CR) (for temporary restorations) and Crowntec (for permanent restorations). Specimens were 3D printed, post-polymerized, and polished. They were then immersed in tea, coffee, or water at 37°C for 7 days. Color changes were measured using the CIE Lab* system and analyzed using IBM SPSS 26, with ΔE00 values compared to clinical thresholds.

Results: After 7 days, the greatest color change (ΔE00) was observed in all coffee-immersed groups, with the TU + coffee group showing the highest ΔE00 value (2.38 ± 0.21), exceeding the clinically acceptable threshold of 2.25. The CR + water group exhibited the least color change (0.16 ± 0.05). Color changes in tea-immersed groups were statistically significant, with CR showing reduced color change (1.97 ± 0.15). Only the coffee-exposed groups exceeded the acceptable ΔE00 value.

Conclusion: The study found that the type of composite material significantly affects color stability, with Temp Ultra showing the most color change in coffee. The results suggest that while these materials demonstrate acceptable color stability.

Keywords: 3D Printing, Composite Resins, Color Stability, Staining, CAD/CAM Technology

ÖZ

Amaç: Bu çalışma, 3D baskılı kalıcı ve geçici kompozit bazlı restoratif materyallerin çay, kahve ve suya batırıldıktan sonra lekelenebilirliklerini değerlendirerek renk stabilitesini değerlendirmeyi amaçladı.

Yöntemler: Kullanılan kompozit reçineler arasında Temp Ultra ve Custom Composite Resin (geçici restorasyonlar için) ve Crowntec (kalıcı restorasyonlar için) yer aldı. Numuneler 3D olarak basıldı, polimerize edildi ve cilalandı. Daha sonra 7 gün boyunca 37°C'deki çay, kahve veya suya batırıldılar. Renk değişiklikleri CIE Lab* sistemi kullanılarak ölçülmüş ve IBM SPSS 26 ile klinik eşik değerlerine kıyasla ΔE00 değerleri ile analiz edilmiştir.

Bulgular: 7 gün sonra en büyük renk değişimi (ΔE00) kahveye batırılan tüm gruplarda gözlemlendi; TU + Kahve grubu en yüksek ΔE00 değerini (2,38 ± 0,21) göstererek klinik olarak kabul edilebilir eşik olan 2,25'i aştı. CR + Su grubu en az renk değişimini sergiledi (0,16 ± 0,05). Çaya batırılan gruplardaki renk değişiklikleri istatistiksel olarak anlamlıydı; CR, renk değişiminde azalma gösterdi (1,97 ± 0,15). Yalnızca kahveye maruz kalan gruplar kabul edilebilir ΔE00 değerini aştı.

Sonuç: Çalışma, kompozit malzeme türünün renk stabilitesini önemli ölçüde etkilediğini, Temp Ultra'nın kahvede en fazla renk değişimini gösterdiğini buldu. Sonuçlar, çalışmada kullanılan materyaller kabul edilebilir renk stabilitesi göstermişlerdir.

Anahtar Kelimeler: 3D Baskı, Kompozit Reçineler, Renk Stabilitesi, Renkleşme, CAD/CAM Teknolojisi

INTRODUCTION

Restorative dentistry focuses on rebuilding natural tooth structures with an emphasis on both aesthetics and functionality. The growing demand for restorations that combine excellent aesthetics with higher durability has driven the development of new material solutions for indirect restorations, including veneers, inlays, onlays, and crowns.[1]The advancements in digital technology, particularly the integration

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of computer-aided design and computer-aided manufacturing (CAD/CAM) systems, have become commonplace in the production of dental restorations.[2]

CAD/CAM systems offer numerous benefits such as freeform design, customized manufacturing, reduced chair time, enhanced infection control by eliminating certain laboratory processes, and exceptional accuracy. Digital technology is increasingly used in various dental fields, including surgical, restorative, endodontic, prosthetic, and orthodontic dentistry. Technological advancements have led to the development of new materials for CAD/CAM restorations, including glass ceramics, zirconia, and composites, which provide a range of mechanical and optical properties.[3]

Previously, CAD/CAM technology was primarily associated with subtractive manufacturing or milling. However, restorations can now also be produced using additive manufacturing or three-dimensional (3D) printing technology. Both CAD/CAM techniques are based on the principle that restorations are digitally designed using a CAD software program with patient data, saved as standard tessellation language (STL) files. In the milling technique, these files are transferred to a computer-controlled machine that produces the restorations from blocks using milling tools. Conversely, the 3D printing method builds restorations layer by layer from the transferred STL file data. Various 3D printing technologies are employed in dental restoration production, with stereolithography (SLA) and direct light processing (DLP) being particularly popular.[4] An SLA 3D printer uses an ultraviolet laser light source to polymerize photosensitive resin layer by layer. Although similar to SLA, DLP technology uses digital micro-mirrors beneath the resin tank, polymerizing all layers in a single exposure, thus making DLP faster than SLA.[5] However, Masked Stereolithography Apparatus (MSLA) 3D printers are also available today. Unlike SLA, which reflects UV light from a single point, MSLA can illuminate the entire surface simultaneously. This capability allows MSLA printers to print multiple models at once, regardless of the layer surface area, without increasing the print time.[6]

3D printing technology offers cost-effectiveness, minimal resin material waste, and the ability to produce more complex structures compared to milling.[7] Recent developments in 3D printing technologies and materials have introduced new printable permanent composite resins for indirect restorations. Color stability is crucial for patient satisfaction and the aesthetic appearance of composite resins in the dynamic oral environment. However, composite materials face challenges such as water absorption, inadequate polymerization, absorption of food or beverages, poor oral hygiene, and thermal processes in the oral environment.[8]

Current studies often compare the color stability of composite-based restorative materials produced by subtractive manufacturing techniques.[9,10] Although 3D printing technology and materials are increasingly used for permanent composite restorations, these materials are relatively new, necessitating further laboratory and clinical data. Studies examining the color stability of 3D printed permanent materials are limited. Thus, this study aims to compare the color stability of 3D printed permanent and temporary composite resin after immersion in tea, coffee and water. The null hypothesis is that the stainability of the 3D printed composite resin restorative materials tested will remain unaffected by the type of material after being stored in either tea, coffee or water.

METHODS

Specimen Preparation

The printable composite resins used in our study are detailed in Table 1. Temp Ultra (Arma Dental, Kocaeli, Turkey) and Custom Composite Resin (CRSCAM Teknoloji AŞ., Antalya, Turkey) are utilized for temporary restorations, whereas Crowntec (SAREMCO Dental AG, Rebstein, Switzerland) is suitable for use as a permanent composite restoration. The 3D models for cylindrical specimens (10 mm × 2 mm) were designed using Fusion 360 CAD software (Autodesk, San Rafael, CA, USA). These digital designs were exported as STL files for specimen production. Thirty specimens were produced for each 3D printed material. The SC specimens were printed using an MSLA-based 3D printer (Sonic Mini 8K, Phrozen Tech Co, Hsinchu, Taiwan) with a layer thickness of 50 µm and a build orientation of 90 degrees. Following the printing process, the specimens were cleaned with a cloth soaked in 96% alcohol and then underwent post-polymerization using a wash and cure machine (Anycubic Wash & Cure Plus, Anycubic, Shenzhen, China) according to the manufacturer's recommendations. After cooling, the support structures were removed from the specimens using low-speed rotary instruments. All specimens were then stored in distilled water at 37°C for 24 hours. Post-polymerization, the specimens were polished with aluminum oxide-coated discs (Sof-Lex XT, 3M, St. Paul, MN, USA). Standardization was ensured by measuring the thickness of the specimens with a digital caliper (Ultra-Cal V, Fowler Corp., Newton, MA, USA).

Table 1. Materials used in this study.

Group	Material Name	Purpose of usage	Manufactorer
CR	Crowntec	Permanent	SAREMCO Dental AG, Rebstein, Switzerland
TU	Temp Ultra	Temporary	Arma Dental, Kocaeli, Turkey
CCR	Custom Composit Resin	Temporary	CRSCAM Teknoloji AŞ., Antalya, Turkey

Color Measurement

In this study, color values were assessed using the Commission International de l'Eclairage (CIE) Lab* system with a spectrophotometer (VitaEasyshade V, Vita Zahnfabrik, Bad Säckingen, Germany) on a neutral gray background (L*=64.1; a*=0.3; b*=−3.4), with measurements taken under D65 standard lighting conditions after calibrating the spectrophotometer according to the manufacturer's recommendations.

Initial color measurements (L0, a0, b0) of the specimens were taken after storing them in distilled water at 37°C for 24 hours. The specimens were then divided into three groups according to the type of resin (n=30). Thirty randomly selected specimens were immersed in tea (Lipton Yellow Label Tea, Unilever, Istanbul, Turkey), 30 in coffee (Nescafe Classic, Nestle, Vevey, Switzerland), and 30 in water, all stored in an incubator at 37°C for 7 days. The solutions were prepared and refreshed daily. Color measurements were then taken at the end of the 1st and 7th days as previously described. The color change levels in the specimens were calculated using the following CIEDE2000 formulation: [11]

$$\Delta E_{00} = \left[\left(\frac{\Delta L'}{K_L S_L} \right)^2 + \left(\frac{\Delta C'}{K_C S_C} \right)^2 + \left(\frac{\Delta H'}{K_H S_H} \right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C} \right) \left(\frac{\Delta H'}{K_H S_H} \right) \right]^{\frac{1}{2}}$$

Statistical Analysis

Statistical analysis was conducted using IBM SPSS 26 (IBM Corp., Armonk, NY, USA). Normality of data was evaluated by using the Shapiro-Wilk test. Post-hoc Tukey test was used to make multiple comparisons. ΔE00 values were compared with one-way ANOVA. (P.<05)

In this study, the parametric factors for the ΔE00 were set to 1. The threshold for clinical perceptibility was established at ΔE00 ≤ 1.30, while the threshold for clinical acceptability was set at ΔE00 ≤ 2.25. [12]

RESULTS

According to the data presented in Table 2, after 7 days, the greatest ΔE was recorded in all groups immersed in coffee. Color changes were noted across all groups exposed to tea and coffee, with the most significant color change observed in the TU + Coffee group (2.38 ± 0.21). Conversely, the least color change was observed in the CR + Water group (0.16 ± 0.05). The color change in the groups exposed to tea was statistically significant, with the CR group (*P*.<05) demonstrating a reduced color change (1.97 ± 0.15). Color change exceeded the acceptable value only in the coffee-exposed groups.

Table 2. Mean ΔE00 values ± standard deviations of printable resins after 7 days of immersion in solutions.

ΔE	Temp Ultra	Custom Composite Resin	Crowntec
Tea	2,22 ± 0,18^{aA}	2,13± 0,25^{aC}	1,97 ± 0,15^{bE}
Coffee	2,38 ± 0,21^{cA}	2,36 ± 0,44^{cC}	2,28 ± 0,23^{cE}
Water	0,26 ± 0,07^{dB}	0,35 ± 0,04^{dD}	0,16 ± 0,05^{dF}

*Lowercase letters indicate differences in the column, uppercase letters indicate differences in the row

DISCUSSION

The current study evaluated the stainability of permanent and temporary composite-based restorative materials that were produced additively by testing their color stability after being submerged in water, tea, and coffee. The results showed that the kind of material had a substantial impact on the color stability of the studied restorations, confirming the rejection of null hypothesis.

The popularity of 3D printed tooth-colored restorations among clinicians has recently increased. Given their advantages, 3D printed materials could potentially replace CAD/CAM milled materials and serve as alternatives to feldspathic ceramics, which, despite their aesthetic appeal, are prone to fragility.[13] The current study aimed to address the lack of literature on critical properties, such as color stability, that are essential for the longevity of these materials.

The study's results demonstrated that the Temp Ultra with coffee group exhibited the highest mean ΔE00 values, surpassing the clinically acceptable threshold of 2.25. In contrast, other tested solution groups maintained ΔE00 values below the acceptable threshold.

According to Aguiar et al.,[14] the low filler content caused increased water absorption at the filler-matrix interface, and more discolouration was seen as a result of the absorbed water separating the filler and matrix or causing hydrolytic breakdown of the filler. The hydrophilic/hydrophobic nature of composite resin materials influences discolouration and directly impacts the level of water absorption. The reduced filler ratio may be the cause of the temporary 3D printed material's increased discolouration.

The color stability of resin-based composites is influenced by the hydrophobic or hydrophilic characteristics of the resin matrix, which affects water absorption. For instance, the Bis-EMA matrix monomer in CR has lower hydrophilicity compared to TEGDMA. Contrary to the current study's findings, Çakmak et al.[15] found that Saremco Crowntec exhibited similar color stability to milled composite and was more stable than other 3D printed resins after 10,000 coffee thermocyclings. Similarly, some studies reported higher color change values for another 3D printed composite resin compared to milled composite material after immersion in coffee.[13,16,17] A prior study on the color stability of 3D printed interim resin materials indicated that the production technology impacts color stability, with permanent resins generally showing better stability than temporary ones.

The quantity of residual monomer created as a result of the slow polymerization rate is another aspect to take into account. Prior studies have indicated that following the curing process, the polymerization rate of materials produced through 3D printing decreases.[18]

Differences in the production technology of 3D printed materials may have influenced the color stability observed in this study. Additionally, unreacted residual monomers, which are addressed through post-polymerization, may also contribute to color changes.[19] Among the materials tested, CR showed the lowest mean ΔE00 values after immersion in tea and coffee. However, the temporary resin groups demonstrated statistically significant color changes, possibly due to their microstructural properties and water absorption capacity. But as Berli et al.[20] also demonstrated, one of the investigated 3D printed resin materials had less water absorption than the PMMA resin in their study. Although water absorption cannot completely explain low color stability, the scientists pointed out that different materials can exhibit different properties even when utilizing the same 3D printing procedure.

Coffee and tea solutions are commonly used for staining due to their high colorant absorption potential. A one-week immersion period was selected based on previous research indicating significant color changes within the first week, to evaluate the long-term color stability of composite materials.[21] A cup of coffee takes 15 minutes on average to make, and coffee drinkers have 3.2 cups on a daily average, according to Guler et al.[22] As a result, the samples' 24-hour immersion in coffee is equal to a month's worth of coffee consumption. Moreover, Shin et al.[17] have pointed out that the color measurements acquired in this investigation following a month-long immersion of the samples in the solution are equivalent to 2.5 years of coffee intake.

This in vitro study has limitations, including the lack of simulation of clinical factors such as occlusal forces, saliva interactions, and mouth rinsing or brushing. Additionally, the flat surfaces of the specimens and absence of anatomical features did not fully replicate clinical conditions. Further investigation into other optical properties, such as translucency, and the use of different staining media may be warranted. Moreover, the VITA Easyshade V spectrophotometer, primarily a clinical device, may not be ideal for laboratory evaluations. Future research should focus on enhancing the color stability of 3D printed permanent composite resins produced using various techniques to ensure their suitability for long-term use in indirect restorations.

Etik Komite Onayı: Bu çalışmada deney gruplarında uygulanan çözümler herhangi bir hayvan veya insandan elde edilen hiçbir materyale uygulanmamıştır. Diş hekimliğinde kullanılan restorasyon malzemelerinin çay, kahve ve suya batırılması sonucu oluşabilecek renk değişikliklerinin değerlendirildiği bu çalışmada etik kurul onayı gerekmemektedir.
Hasta Onamı: Çalışmada hasta onamı gerekmemektedir.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir - M.D.; Tasarım - Doktora; Denetleme - Doktora; Kaynaklar - MD; Malzemeler - M.D.; Veri Toplanması ve/veya İşleme - Doktora; Analiz ve/veya Yorum - Doktora; Literatür Taraması - M.D.; Makaleyi Yazan - M.D.; Eleştirel İnceleme - Doktora; Diğer – M.D..
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Comparison of Apical Debris Extrusion Using EDDY, EndoActivator, Ultrasonic Irrigation and Manual Dynamic Agitation

EDDY, Endoaktivatör, Ultrasonik İrrigasyon ve Manuel Dinamik Aktivasyonun Apikalden Çıkan Debris Miktarına Etkisi

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ABSTRACT

Objective: This study was aimed to determine the amount of apically extruded debris using different final irrigation activation techniques.

Methods: The mesial roots of 70 extracted mandibular molar teeth were included. The mesiobuccal roots were instrumented to size 40/.06 with a reciprocal system file and divided into five groups according to the final irrigation activation technique used: EDDY, EndoActivator (EA), passive ultrasonic irrigation (PUI), manual dynamic agitation (MDA) or needle irrigation (NI). The extruded debris was collected in Eppendorf tubes and stored in an incubator at 70°C for 5 days. The results were analysed using the Kruskal–Wallis test (*P*=.05).

Results: EDDY and the EA caused significantly more apical debris extrusion ($P < .05$). There were no statistically significant differences between EDDY and the EA ($P > .05$). NI caused less extrusion, but there were no statistically significant differences between PUI, MDA and NI ($P > .05$).

Conclusion: EDDY and the EA were associated with significantly higher apical extrusion debris extrusion.

Keywords: debris extrusion, EDDY, Endoactivator, irrigation activation, manual dynamic agitation, ultrasonic irrigation.

ÖZ

Amaç: Bu çalışmanın amacı, farklı irrigasyon aktivasyon tekniklerinin apikalden ekstrüze olan debris miktarına etkisini incelemektir.

Yöntemler: Yetmiş adet çekilmiş mandibular molar dişin mesial kökleri çalışmaya dahil edildi. Mesiobukkal kökler, resiprokal hareketle çalışan eğe sistemi ile 40/.06 boyutunda prepare edildi ve final irrigasyon aktivasyon tekniklerine göre beş gruba ayrıldı: EDDY, Endoaktivatör (EA), ultrasonik irrigasyon (UI), manuel dinamik aktivasyon (MDA) ve iğneli irrigasyon (NI). Ekstrüze debris Eppendorf tüplerine toplandı ve eppendorf tüpleri beş gün boyunca 70 °C'de bir inkübatörde bekletildi. İstatistiksel analiz için Kruskal-Wallis testi kullanıldı. ($P = ,05$).

Bulgular: EDDY ve EA, diğer aktivasyon tekniklerine göre önemli ölçüde daha fazla debris ekstrüzyonuna neden oldu ($P < ,05$). EDDY ve EA arasında istatistiksel olarak anlamlı bir fark yoktu ($P > ,05$). En az debris ekstrüzyonu NI'da gözlendi ancak PUI, MDA ve NI arasında istatistiksel bir fark yoktu ($P > ,05$).

Sonuç: EDDY ve EA, diğer gruplara göre daha yüksek derecede apikal debris ekstrüzyonuna neden oldu.

Anahtar Kelimeler: debris ektrüzyonu, EDDY, Endoaktivatör, irrigasyon aktivasyonu, manuel dinamik aktivasyon, ultrasonic irrigasyon.

INTRODUCTION

The success of root canal treatment depends on the effective elimination of microorganisms and byproducts from the root canal system. Despite the development of endodontic instruments for this task, it is known that mechanical preparation is still not sufficient for root canal cleaning. It has been shown that untouched areas remain on the root canal surface when mechanical preparation is used on its own.[1] Needle irrigation (NI) is the basic technique for root canal irrigation, and the level of needle tip placementin the canal is the most dominating factor for solution extrusion.[2] NI does not provide adequate disinfection, especially in the apical third of the root. Therefore, activation of the irrigating agent has been recommended for effective root canal irrigation.[3]

During the irrigation activation procedure, residual tissues, bacteria and byproducts within the canal may extrude through the apical foramen into the periradicular area. This is an undesirable situation and is considered the main cause of postoperative pain following endodontic treatment.[4] For this reason, selecting an irrigation activation procedure that can reduce the risk of debris extrusion is important for postoperative pain.[5]

This study has been presented as an oral presentation at the 9th International Scientific Symposium of the Turkish Endodontic Society.

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Passive ultrasonic irrigation (PUI) cleans dentin through acoustic streaming and cavitation.[6] It has been shown that increased fluid dynamics results in greater penetration of the irrigation solution and removal of the smear layer, especially in the apical third and untouched areas of the root.[7,8] Manual dynamic agitation (MDA) is performed by moving a gutta-percha main thread compatible with the preformed canal up and down in the canal with short, gentle strokes of 2 to 3 mm. An effective hydrodynamic effect can be produced with this technique.[9]

The EndoActivator (EA, Medium, Dentsply Sirona), a sonically powered canal irrigation system, is a portable handpiece with disposable flexible polymer tips in various sizes that do not sever root dentin.[10] It was shown that this technique can thoroughly debride the complex root canal anatomy and remove the smear layer and biofilm.[11] EDDY (VDW, Munich, Germany), another sonic device with a non- cutting disposable polyamide tip (#25, taper 0.04), is powered by an air scaler at a rate of approximately 6,000 Hz.[12] The disposable non-cutting tip moves in three dimensions and enhances the cavitation and acoustic flow effect of the irrigation solution through high-amplitude oscillation.[13]

Previous studies have shown that irrigation techniques and file systems can cause apical debris extrusion, depending on the type of technique and the kinematics of the files.[14,15] However, there are no studies comparing the effects of EDDY, EA, PUI, MDA and NI on apical debris extrusion. Therefore, the purpose of this experimental study was to compare the effects on apical debris extrusion of EDDY, the EA, PUI, MDA and NI. The null hypothesis was that altering the irrigation activation techniques used would not affect the amount extruded.

METHODS

Tooth Selection

This study was conducted according to the Preferred Reporting Items for Laboratory studies (PRILE) 2021 guidelines.[16] The study was approved by The Ethics Committee of the Faculty of Dentistry, Atatürk University (Decision Date/Number: 26.01.2022 / 2022-03-22). Extracted mandibular molars were obtained from surgeries undertaken to address periodontal or orthodontic issues. All teeth had two different apical foramens with two mesial canals. Roots with apical diameters greater than the #15K file size were not included. Teeth with calcification, crack formation or resorption were also excluded. The curvature of each root canal was determined according to the Schneider method using digital radiographs which were taken in buccolingual and mesiodistal directions.[17] The mesial roots of 70 mandibular molars with canal curvatures ranging from 10 to 20 degrees were included. An access cavity was prepared, and a #10K file (Dentsply, Sirona, Switzerland) was placed until it was visible through the apical foramen. Glide path preparation was performed with a ProGlider (#0.16) rotary file according to manufacturer recommendation (300 rpm / 2 Ncm). Working length was determined by subtracting 0.5 mm from this length. The mesial roots of the teeth were removed from the cementoenamel junction. The working length (WL) was then standardised to 16 mm.

According to power analysis software (G*Power 3.1.Universitat, Düsseldorf, Germany), the sample size of 11 samples per group was determined from a previous study at an alpha error probability of 0.05 and power of 95% (effect size = 0.642).[18] To enhance the statistical power of the study, 14 teeth were enrolled in each group. The specimens were numbered and randomly allocated to four groups (n = 14) using a web programme (www.randomizer.org).

Myers and Montgomery's[19] method was followed to carry out the experimental procedures. Eppendorf tubes were preweighed three times on a 10^{-4} precision scale (Precisa XB 220A, Precisa Instruments, Dietikon, Switzerland), and the average weight was recorded as the tube weight. The Eppendorf tubes were placed in glass bottles, and a round hole was created in each of their stoppers. The teeth were inserted into the stopper up to the cementoenamel junction and fixed with cyanoacrylate (Pattex Super Glue; T€urk Henkel, Inc., Istanbul, Turkey) to prevent leakage of the irrigants. A needle was inserted into each stopper to balance the internal and external air pressure, and a rubber dam was used to prevent the operator from observing the root apex during root canal preparation and irrigation. All procedures were performed by the same specialist. The experimental model is as shown in Figure 1.

A Reciproc Silver endodontic motor (VDW, Munich, Germany) was set to 'RECIPROC ALL' mode. Reciproc R25 files (size 25, 0.08 taper; VDW) and R40 files (size 40, 0.06 taper; VDW) were used, and the crown-down shaping procedure was followed. For irrigation during the instrumentation procedures, 2.5 mL of distilled water was used. In the final irrigation, the following irrigation activation protocols with distilled water were applied (n = 14 in each group): EDDY, EA, PUI, MDA and NI.

Experimental Groups

EDDY

The irrigant was activated with a frequency of 6,000 Hz and an amplitude of 160 mm using an air scaler (KaVo SONICflex, KaVo) according to the manufacturer's recommendations. The root canal was filled with distilled water (2 ml). The EDDY's tip was then positioned 2 mm short of the WL, and an up and-down motion was repeated with 5-mm movements for 30 s.

Endoactivator

2 ml of irrigant were filled into the root canal, and the EA's tip (size #25/0.04) was positioned at a distance of 2 mm from the WL. The tip was moved up and-down motion, and the distilled water was agitated for 30 seconds using 5 mm vertical strokes.

Passive Ultrasonic Irrigation

A size 20 Irrisafe tip (Acteon Satelec, France) with a power setting of 3 was mounted on a VDW Ultra ultrasonic device and the irrigant was activated as recommended by the manufacturer with a frequency of 28,000 Hz. Two millilitres of distilled water were filled into the root canal. The tip was positioned two millimetres below the WL, and an up-and-down motion at 5 mm amplitudes was executed for 30 s.

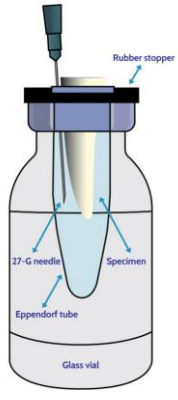
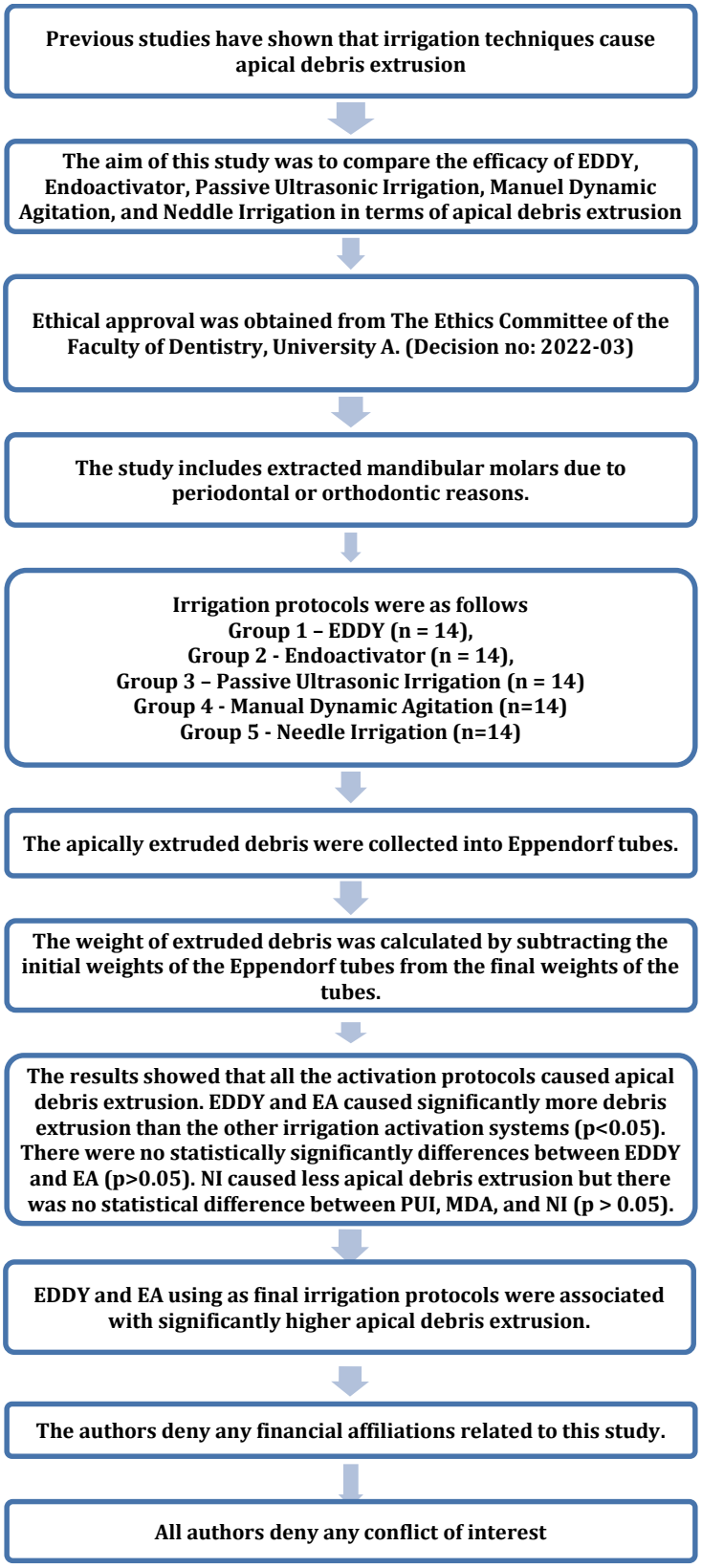


Figure 1. A schematic illustration of the experimental model.



**From: Nagendrababu V, Murray PE, Ordinola-Zapata R, Peters OA, Rôças IN, Siqueira JF Jr, Priya E, Jayaraman J, Pulikkotil SJ, Camilleri J, Boutsioukis C, Rossi-Fedele G, Dummer PMH (2021) PRILE 2021 guidelines for reporting laboratory studies in Endodontology: a consensus-based development. International Endodontic Journal May 3. doi: 10.1111/iej.13542. https://onlinelibrary.wiley.com/doi/abs/10.1111/iej.13542.*
For further details visit: http://pride-endodonticguidelines.org/prile

Figure 2. PRILE 2021 flowchart

Manual Dynamic Agitation

A 2 mL of distilled water was inserted into the canal, and the irrigant was agitated using the MDA approach. A gutta-percha master cone that fit well was placed in the canal and gently moved up and down 100 times in 5 mm strokes for one minute.

Needle Irrigation

A 30 G needle (Ultradent Products Inc) was placed into the canal 2 millimetres short of the WL. Irrigation solution (2 ml) was placed into the root canal, and for 30 seconds, 5 mm movements were used to agitate the distilled water in an up-and-down motion.

All methods of final irrigation activation procedures with distilled water were repeated twice. Following the instrumentation of the root canal, the Eppendorf tubes were taken out of the vials. Each tooth's apex was flushed with 1 mm of distilled water to collect the apically extruded debris that had adhered to the root apex. The Eppendorf tubes were stored in an incubator (Binder, Tuttlingen, Germany) at 70° for 5 days so the irrigant could evaporate. An electronic balance (Precisa XB 220 A) was used to measure the weight of each Eppendorf tube three times. The mean values of extruded debris were recorded. The normality distribution of the data was determined using the Shapiro–Wilk test, and a nonparametric one- way analysis (the Kruskal–Wallis H test) was conducted to compare the amounts of debris. IBM SPSS 22.0 software (IBM, Armonk, NY, USA) was used to analyse the data, with the level of statistical significance set at 0.05.

RESULTS

A PRILE 2021 flowchart is presented in Figure 2. The median, minimum and maximum, and mean rank values are listed in Table 1. The results demonstrate that apical debris extrusion was caused by all the activation protocols tested. EDDY and the EA considerably increased the amount of debris extruded compared to the other irrigation activation methods ($P < .05$). No statistically significantly differences in debris extrusion were observed between EDDY and the EA ($P > .05$). NI caused less extrusion, but there were no significant differences between PUI, MDA and NI ($P > .05$).

Table 1. Different lowercase means significant difference among the groups ($P < .05$).

	n	Median	Min	Max	Mean Rank
EDDY	14[a]	0,0175	0,0126	0,0308	55,00
Endoactivator	14[a]	0,0159	0,0122	0,0314	52,43
PUI	14[b]	0,01	0,0005	0,0234	30,50
MDA	14[b]	0,0074	0,0002	0,0122	20,54
NI	14[b]	0,0005	0,0006	0,0129	19,04

DISCUSSION

Although irrigation protocols are essential for successful root canal treatment, increased positive apical pressure can cause extruded debris.[20] In turn, periapical inflammation, postoperative discomfort and flare-ups are caused by apical debris extrusion.[21] There is limited research on differences in apical debris extrusion using of EDDY under various experimental conditions.[22–24] In this study, we investigated the quantity of apical debris extrusion using EDDY, EA, PUI, MDA and NI. The results show that EA and EDDY caused significantly more debris extrusion. Thus, the null hypothesis was rejected.

Ince-Yusufoglu et al.[22] assessed the effects of various irrigation activation systems – EDDY, PUI and PIPS – on debris extrusion and showed that EDDY causes debris extrusion at a statistically significant level. According to a different investigation, PUI produced significantly

less apical irrigant pressure than the EDDY technique.[23] Ada et al.[20] investigated debris extrusion using the EA, UI, MDA and NI, and they found that the EA produced the most debris. These results are supported by the present findings. During sonic activation, increasing the flow rate while delivering irrigation chemicals throughout the root canal system improves their efficacy.[25] PUI generate the ultrasonic vibration energy and oscillating movement that allows a lateral flow towards the root canal wall.[6] The 3D motion of the sonic system, along with its frequency and flexible tips, induces a substantial quantity of debris extrusion.[22] This may explain the greater extrusion yielded by EDDY and the EA in the current study.

There was no significant difference in the quantity of debris extruded using the MDA, NI and PUI techniques in the current study. There is no significant difference in the volume of irrigation liquid that extrudes from the apex when using ultrasonic tips rather than conventional needle irrigation when the file is placed 1 or 3 mm beyond the WL.[26] İnce-Yusufoglu et al.[22] reported that PUI caused less apical debris extrusion (by weight) than MI, but there was no statistically significant difference between the amount of debris extruded following MI and PUI application. A previous study comparing the EndoVac, EA, Rispisonic and PUI techniques found that the EA sonic device caused less apical debris extrusion than PUI.[14] Another spectrophotometry-based study that assessed the efficacy of PUI, the EA and MI found that PUI and the EA produced more debris than MI, while no statistical difference was detected between PUI and the EA.[5] Tambe et al.[27] reported that PUI caused less debris extrusion than MI. However, in this study, irrigation solution was activated for 20 seconds. Some methodological factors, such as the using different irrigation solution[14] (such as NaOCl), measurement method of extruded debris[5], agitation time[27] or apical preparation size[23] may have contributed to the inconsistency between previous findings and our results.

The three most popular activation methods are SI, PUI and MDA.[25] İnce-Yusufoğlu et al.[28] examined postoperative pain levels following EDDY and MDA application and recorded statistically significantly higher postoperative pain scores in the EDDY group after 12, 24 and 48 hours. This may be attributed to the inflammation that develops in the periapical tissues as a result of the large amount of debris extruded. The fact that automated techniques produce frequency more efficiently than the manual push–pull action of gutta-percha may account for the difference between MDA and sonic systems.[20]

During the incubation procedure (70°C for 5 days), the irrigants into the canals should be evaporated. If NaOCl or other irrigants was used for irrigation procedures, crystals of these irrigants are likely to remain which might adversely affect the reliability of the study. Sodium crystals that cannot be separated from extruded debris may cause effect of the results.[29,30] Therefore, we used distilled water as the irrigation solution rather than sodium hypochlorite in our study.

Previous research on debris extrusion has focused on floral foam and agar gel techniques.[31,32] It is believed that periapical tissues can be mimicked using these techniques. However, these studies' findings were directly impacted by the foam's absorption of extruded irrigants and challenges in modifying the agar gel's thickness. For this reason, we used Tanalp and Güngör's technique in the current investigation to provide group standardisation.[29]

The use of single and straight roots in this in vitro study was one of its limitations. Karataşlıoğlu et al.[33] reported that the amount of apical debris extruded increases in accordance with the increase in the degree of canal curvature in the teeth. Also, for the real extrusion measurement, it is necessary to use irrigants as in the clinical practice and the periapical tissue resistant must take into consideration. Results may also differ depending on normal or pathological tissues. In clinical applications, in teeth with resorption, perforation defects, or immature roots with open apex, the higher amount of apical extrusion should also be taken into account when using the ajitation techniques with a caustic irrigation agent such as NaOCl or EDTA.[34] The resistance of periapical tissues has an inhibiting effect on apical extrusion of irrigant. Briefly, the observed results should not be generalized to teeth with shorter or longer root length.[35]

CONCLUSION

Within the limitations of this study, using EDDY and the EA as final irrigation protocols produced a significantly higher apical extrusion of debris.

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Effect of Different Beverages and Polishing Systems on Color Stability and Surface Roughness of a Smart Chromatic Composite Resin and Methacrylate Composites

Farklı İçecek ve Parlatma Sistemlerinin Akıllı Kromatik Kompozit Rezin ve Metakrilat Kompozitlerin Renk Stabilitesi ve Yüzey Pürüzlülüğü Üzerine Etkisi

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ABSTRACT

Objective: The purpose of the study is to evaluate the color stability and surface roughness of smart chromatic composite resin and methacrylate composite resins with applying different polishing systems and stored in different solutions.

Methods: In the study, 120 disc-shaped specimens were prepared from a smart chromatic composite, a nanofill composite, and a nanohybrid composite. The specimens were separated into 12 groups with a specimen size of 10, and the two different polishing systems were utilized. The initial color values of the specimens were measured with a spectrophotometer and the surface roughness values were measured with a profilometer. Then, the specimens were stored in two different beverage solutions, and color and roughness measurements were repeated. The mean color change values of the specimens were calculated in ΔE, and the surface roughness values were recorded in Ra. Statistical analysis of the data was performed using One-way ANOVA and post hoc Tukey test (*P* =.05).

Results: Statistically significant variations were observed in the mean color change values among the groups, as a consequence of the utilization of various polishing systems and exposure to different solutions (*P*.05). Although no significant variations were observed in the mean surface roughness values of the specimens due to exposure to different solutions (*P* >.05), significant distinctions were identified among the groups to which different polishing systems were employed (*P* <.05).

Conclusion: The application of different polishing systems and exposure to various solutions can result in variations in color and surface roughness values for composite resins, owing to their inherent structural characteristics.

Keywords: Color Change, Composite Resin, Profilometer, Smart Chromatic Composite, Surface Roughness

ÖZ

Amaç: Çalışmanın amacı akıllı kromatik kompozit reçine ve metakrilat kompozit reçinelerin farklı cila sistemleri uygulanarak ve farklı solüsyonlarda saklanarak renk stabilitesi ve yüzey pürüzlülüğünün değerlendirilmesidir.

Yöntemler: Çalışmada akıllı kromatik kompozit, nano dolgu kompozit ve nano hibrit kompozitten 120 adet disk şeklinde örnek hazırlandı. Numuneler 10 numune büyüklüğünde 12 gruba ayrıldı ve iki farklı cilalama sistemi kullanıldı. Numunelerin başlangıç renk değerleri spektrofotometre ile, yüzey pürüzlülük değerleri ise profilometre ile ölçülmüştür. Daha sonra örnekler iki farklı içecek solüsyonunda saklanarak renk ve pürüzlülük ölçümleri tekrarlandı. Numunelerin ortalama renk değişim değerleri ΔE olarak hesaplandı ve yüzey pürüzlülük değerleri Ra olarak kaydedildi. Verilerin istatistiksel analizi One-way ANOVA ve post hoc Tukey testi kullanılarak yapıldı (*P* =,05).

Bulgular: Çeşitli cila sistemlerinin kullanılması ve farklı solüsyonlara maruz kalınması sonucunda gruplar arasında ortalama renk değişimi değerlerinde istatistiksel olarak anlamlı farklılıklar gözlendi (*P* <,05). Numunelerin ortalama yüzey pürüzlülük değerlerinde farklı solüsyonlara maruz kalmaya bağlı olarak anlamlı bir değişiklik görülmemekle birlikte (*P* >,05), farklı cila sistemlerinin kullanıldığı gruplar arasında anlamlı farklılıklar tespit edildi (*P* <,05).

Sonuç: Farklı cilalama sistemlerinin uygulanması ve çeşitli solüsyonlara maruz bırakılması, kompozit reçinelerin doğal yapısal özellikleri nedeniyle renk ve yüzey pürüzlülük değerlerinde farklılıklara neden olabilir.

Anahtar Kelimeler: Renk Değişimi, Kompozit Reçine, Profilometre, Akıllı Kromatik Kompozit, Yüzey Pürüzlülüğü

This study was presented orally at the 26th International Dentistry Congress of the Turkish Dental Association.

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INTRODUCTION

The increasing demand for aesthetic dentistry has led to a rise in the popularity of cosmetic dentistry, as individuals seek to not only maintain oral health but also achieve a pleasing appearance of their teeth.[1] Composite resin restorations have become a popular choice among dental clinicians, as they can be used in a variety of indications and offer a more conservative alternative to traditional ceramic restorations.[2] To effectively imitate these properties, it is essential to have a comprehensive understanding of the optical, anatomical, and functional characteristics of natural teeth. Furthermore, the success of composite resin restorations in providing both function and aesthetics for prolonged periods of time is highly dependent on the clinician's expertise, the appropriate indication, and the use of high-quality materials.[3]

The replication of natural tooth aesthetics through composite resin restorations can be a challenging task due to the polychromatic and varied optical properties of natural teeth. The successful imitation of these properties is crucial for achieving optimal aesthetic outcomes in dental restorations. In addition, the development of layering techniques and the use of high-quality materials enable clinicians to perform complex restorations in a single session, utilizing direct techniques that result in superior aesthetic and clinical outcomes. However, it is important to note that the success of these restorations also depends on the practitioner's expertise and the appropriate indication for their use.[4,5]

The preservation of color stability in dental restorations is a crucial factor in achieving optimal aesthetic outcomes and ensuring the longevity of the restoration. Discoloration, which is a common cause of failure in anterior composite resin restorations, can be influenced by a variety of factors including personal oral hygiene habits, diet and oral habits. Additionally, the structural properties of the restoration, such as the degree of polymerization and surface roughness, can also impact the susceptibility to discoloration through water absorption.[6-8] Research has shown that the color stability of composite resins can be influenced by external factors, the composition of the material, and the shape and size of the filler particles. It has been demonstrated that efficient polishing and finishing techniques can reduce the surface roughness and discoloration of composite resins.[9]

The finishing and polishing of composite resin restorations is a critical aspect of achieving optimal aesthetic outcomes. A variety of tools and techniques are utilized in these processes, including the use of diamond or carbide burs, polishing discs, diamond-containing rubber spirals, silicon carbide brushes, and polishing pastes. These systems, which may involve one or multiple steps in the finishing and polishing process, vary in terms of composition, type, and abrasive particle hardness. The properties of the surface of composite resin restorations are directly impacted by the polishing systems used, and thus represent a significant factor in the overall success of the restoration.[10]

Recently, a new generation of smart chromatic composite resins has been developed that eliminates the need for color selection during composite resin restoration by mimicking the color of the dental tissues from which it is made.[11] While manufacturers claim that these composites exhibit good color compatibility, polishing and color stability with natural tooth tissues, there is a lack of research in the literature investigating the effect of different polishing systems on the surface properties and color of these composites. Furthermore, the effect of exposure to various beverages in the oral environment on the surface roughness and color of composite resins is an important topic that requires further investigation. To address these gaps in knowledge, the objective of this study is to examine the impact of two current polishing systems and different storage conditions on the surface roughness and coloration of a new generation smart chromatic composite and traditional methacrylate-based composites used in anterior restorations. The null hypothesis is that "different polishing systems and storage conditions have no effect on the color change (1) and surface roughness (2) of composite resin restorations."

METHODS

The materials utilized in this study are detailed in Table 1, which includes information on their composition, filler particle sizes and structures, and corresponding lot numbers.

Table 1. Resin-based composite materials and polishing materials used in the study.

Material/Manufacturer	Particle size	Content	Lot
Omnichroma Tokuyama Dental, Tokyo, Japan	260 nm spherical SiO_2-ZrO_2	UDMA, TEGDMA, Uniform size supra-nano spherical filler (spherical SiO_2-ZrO_2) Filling content by weight 70%	022E12
Filtek Ultimate (A2B) 3M ESPE, St. Paul, MN, USA	Silica particles (20 nm), zirconium particles (4–11 nm)	Bis-GMA, UDMA, TEGDMA, PEGDMA, Bis-EMA, silica, zirconium Filling content by weight 78.5%	645560
Estelite Asteria (A2B) Tokuyama Dental, Tokyo, Japan	200 nm spherical SiO_2-ZrO_2	Bis-GMA, UDMA, TEGDMA, Bis-MPEPP, supra-nano spherical filler (spherical SiO_2-ZrO_2) Filling content by weight 82%	W220
Material/Manufacturer	**Abrasive particle**	**Content**	**Lot**
Twist Dia Kuraray, Noritake, Germany	Pre-polisher: 25-35 µm High shine polisher: 4-8 µm	Diamond coated flexible silicone spirals	404817
3M Sof-lex 3M ESPE, St Paul, MN, USA	46 µm aluminum oxide particles 36 µm diamond particles	Spiral 1: Aluminum oxide coated spiral Spiral 2: Diamond elastomer coated spiral	N513708

Bis-GMA: *Bis-phenol A diglycidylmethacrylate,* ***Bis-MPEPP:*** *Bisphenol A polyethyl methacrylate,* ***Bis-EMA:*** *Bisphenol A ethoxylate dimethacrylate,* ***TEGDMA:*** *Triethylene glycol dimethacrylate,* ***UDMA:*** *Urethane dimethacrylate,* ***PEGDMA:*** *Polyethylene glycol.*

Preparation of Resin Specimens

In this study, three different composite resin materials were utilized (Omnichroma [smart chromatic composite; Tokuyama Dental, Tokyo, Japan], Filtek Ultimate [nanofill composite; 3M ESPE, St. Paul, MN, USA], Estelite Asteria [nanohybrid composite; Tokuyama Dental, Tokyo, Japan]). In total, 120 specimens were fabricated, each measuring 6 mm in diameter and 2 mm in thickness. Based on power analysis, it was determined that a minimum of 8 specimens per group should be prepared with 95% confidence (1-α), 80% test power (1-β) and f=0.4 effect size. Therefore, the number of specimens was set to 10. The 120 specimens were randomly divided into 12 subgroups based on the polishing system and staining solution. The composite resin was placed in a teflon mold (6 mm in diameter and 2 mm in height) between two cement glasses and polymerized by covering the composite surface with a transparent matrix tape, similar to a previous study on specimen preparation.[12] In the polymerization process of the specimens, a LED (light emitting diode) curing unit (Valo LCU; 1000 mW/cm^2, Ultradent Products Inc, South Jordan, USA) was utilized on the upper and lower surfaces of the specimens for a duration of 20 seconds. To ensure accuracy, the power of the light device was measured using a radiometer (Curing Radiometer; Kerr Corp., Orange, USA) and calibrated in all three specimens. The prepared specimens were then left to store in distilled water for 24 hours to complete the polymerization process. Subsequently, both surfaces of the specimens were polished five times

using 600-800 grit abrasive SIC (silicon carbide) abrasive papers to ensure initial surface standardization.

Study Groups

In the study, there are 6 different groups according to the composite resin and polishing spiral used in restorations, and they are divided into two subgroups according to the staining solutions (Figure 1).

Group 1: Omnichroma composite - Twist Dia spiral polishing disc (O-TD)
Group 2: Omnichroma composite - Soflex spiral polishing disc (O-S)
Group 3: Filtek Ultimate composite - Twist Dia spiral polishing disc (F-TD)
Group 4: Filtek Ultimate composite - Soflex spiral polishing disc (F-S)
Group 5: Estelite Asteria composite - Twist Dia spiral polishing disc (E-TD)
Group 6: Estelite Asteria composite - Soflex spiral polishing disc (E-S)

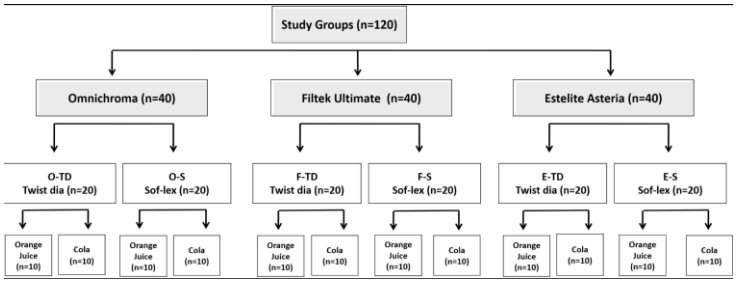

Figure 1. Systematic representation of study groups. **O-TD:** Omnichroma - Twist Dia, **O-S:** Omnichroma – Soflex, **F-TD:** Filtek Ultimate - Twist Dia, **F-S:** Filtek Ultimate – Soflex, **E-TD:** Estelite Asteria - Twist Dia, **E-S:** Estelite Asteria – Soflex

Polishing protocol

The surfaces of the composite specimens in the Twist Dia groups were polished using a 2-step diamond particle-impregnated polishing system (Twist Dia, Kuraray Noritake, Germany). The coarse-grained (14µ) spiral rubber was applied for 20 seconds in a counter-clockwise direction at 5.000 revolutions, followed by the fine-grained (10µ) spiral rubber applied to the composite resin surfaces for an additional 20 seconds in a counter-clockwise direction at 2.000 cycles.

The surfaces of the composite specimens in the groups using the Soflex Spiral Disk were polished using a 2- step polishing system (Soflex Spiral Disk, 3M ESPE, St. Paul, MN, USA). The system comprised the application of Al_2O_3-coated fine-grain polishing spirals followed by super fine-grain polishing spirals with diamond particles. Both were applied in a counter-clockwise direction for 20 seconds at a speed of 5.000 revolutions. Polishing systems were applied to the specimens under water.

Evaluation of Color Stability

After the polishing process, the specimens in all groups were exposed to staining solutions (orange juice [Dimes, Turkey], cola [Coca-Cola, Atlanta, USA]) to evaluate their color stability. According to previous in vitro studies using coffee as a staining solution, it was found that a cup of coffee is typically consumed within 15 minutes and the mean daily coffee consumption is 3.5 cups. Additionally, to replicate the oral environment, a constant temperature of 37°C was maintained during the study.[13,14] Before using the beverages for staining in this study, the pH of the beverages was measured using a pH meter (distilled water pH=5.56, orange juice pH=3.38, and cola pH=2.64). The specimens were immersed in the staining solutions at intervals of 8 hours, three times a day, and stored at 37°C. The staining solutions were renewed every 8 hours until the experimental period was completed. By maintaining this exposure regimen for a total of 12 days (288 hours), it approximated to a 12-month period of beverage consumption for an individual who consumes 2-3 cups of beverage daily, each consumed within 15 minutes.[7]

Color measurements of the prepared composite resin specimens were performed using a spectrophotometer device (SpectroShade Micro II, SpectroShade, CA, USA). The initial color measurements were taken after the specimens were stored in distilled water at 37°C for 24 hours and the data was recorded in the CIE L*a*b* color spectrum. Mean values were obtained by repeating the measurements three times on a standard white background. Before each measurement, the device was calibrated in accordance with the manufacturer's instructions. Subsequent color measurements were conducted after the specimens were removed from the staining solutions, washed with distilled water for 10 seconds, and dried slightly.[14] Color measurements of the specimens were taken at the initial step and after 288 hours of exposure to the staining solutions. All color measurements were repeated three times on a standard white background to obtain mean values, and the data was recorded. The color change (ΔE) values were calculated using the following formula:

$$\Delta E^* = [(L1^* - L0^*)2 + (a1^* - a0^*)2 + (b1^* - b0^*)2]1/2$$

The CIE L * a * b * values pertaining to the specimens after being immersed in the staining solutions are represented by the L1, a1, and b1 values, respectively. The CIE L * a * b * values measured during the initial step are represented by the L0, a0, and b0 values, respectively. A ΔE value of 3.3 was considered as a clinically acceptable level of color change.[14]

Evaluation of Surface Roughness

The initial surface roughness measurements of the composite resin specimens after polishing were conducted by measuring the specimen surfaces at three different points using a profilometer device (SJ-101 Mitutuyo Surfest, Kanagawa, Japan). The measuring length of the device was set at 0.8 mm and the working speed was set at 0.05 mm/s. The surfaces of the specimens on which the roughness measurements were made were marked and then exposed to staining solutions of orange juice and cola for 12 days. To determine the surface roughness values of the specimens after staining, three distinct points on the designated surface of each specimen were measured, and the average of these measurements was calculated. Additionally, surface roughness was evaluated qualitatively using a scanning electron microscope [SEM, (LEO-440, Zeiss, Cambridge, England)].

Statistical analysis

The collected data was analyzed using the SPSS statistical software to evaluate the results (SPSS 22, IBM, Chicago, Illinois, USA). The normality of the data was evaluated using the Shapiro-Wilks test to ensure the data met the assumptions of the statistical tests. Surface roughness and color stability assessments were performed using One Way ANOVA and the post hoc Tukey test (P=.05).

RESULTS

The findings of the CIE L*a*b* color spectrum for the resin composite resins and polishing systems evaluated in the study are presented in Table 2, and the color stability findings are presented in Table 3. A statistically significant variation was identified in the mean color change values between the groups exposed to different staining solutions (P<,05). Among the groups exposed to orange juice, the lowest color stability was observed in the O-S and E-S groups (P<,05). The lowest color stability was observed in the O-S, F-S, and E-S groups among the groups exposed to cola (P<,05). After storing in orange juice and cola, color change findings above the clinically acceptable threshold value were obtained in all resin composite resins. In general, the mean color change values were found to be higher in the specimens polished with the Soflex system.

The results of the surface roughness measurements for the composite resin specimens used in the study are presented in Table 4. An examination of the effect of the staining solutions on the surface roughness of the specimens indicated that the beverages that were tested did not significantly impact the surface roughness (*P*>,05). In general, it was observed that the mean surface roughness values of specimens stored in cola were higher than those stored in orange juice. Statistical significance was found between the application of different polishing systems to various composite resin specimens and the surface roughness values of the specimens (*P*<,05). The mean surface roughness values were found to be statistically significantly higher in the O-S and E-S groups (*P*<,05). Representative SEM images following exposure to the different beverages can be found in Figure 2.

Table 2. The mean L*, a*, b* values and standard deviation of the specimens at the initially and after the storing in the solutions

Group	Index	Initially (Distilled water)	Orange Juice	Cola
		Mean ± SD	Mean ± SD	Mean ± SD
O-TD	L*	82.81 ± 3.51	71.12 ± 3.64	62.24 ± 3.68
	a*	1.07 ± 1.37	1.03 ± 1.25	0.83 ± 1.11
	b*	21.36 ± 1.87	20.60 ± 1.30	20.31 ± 2.14
O-S	L*	83.14 ± 2.18	70.85 ± 3.14	59.26 ± 2.58
	a*	1.55 ± 0.81	1.47 ± 1.53	1.27 ± 1.36
	b*	22.931 ± 2.2	21.84 ± 1.75	21.60 ± 1.21
F-TD	L*	80.43 ± 2.45	71.31 ± 3.74	63.23 ± 2.75
	a*	1.29 ± 1.35	0.97 ± 0.84	1.12 ± 0.79
	b*	23.70 ± 2.57	21.21 ± 1.47	19.52 ± 3.28
F-S	L*	78.95 ± 2.78	70.73 ± 2.42	63.50 ± 3.71
	a*	1.18 ± 1.71	1.56 ± 1.62	1.58 ± 1.34
	b*	22.74 ± 2.51	21.41 ± 2.63	20.36 ± 2.98
E-TD	L*	81.42 ± 3.47	70.59 ± 2.72	65.42 ± 3.15
	a*	0.87 ± 1.63	1.23 ± 1.78	1.53 ± 1.46
	b*	19.59 ± 2.81	21.33 ± 2.18	22.41± 3.12
E-S	L*	82.75 ± 3.78	71.84 ± 2.36	60.42 ± 3.31
	a*	1.28 ± 1.51	2.06 ± 1.42	1.54 ± 1.13
	b*	21.51 ± 2.41	21.41 ± 1.67	20.33 ± 1.74

O-TD: *Omnichroma - Twist Dia,* ***O-S:*** *Omnichroma – Soflex,* ***F-TD:*** *Filtek Ultimate - Twist Dia,* ***F-S:*** *Filtek Ultimate – Soflex,* ***E-TD:*** *Estelite Asteria - Twist Dia,* ***E-S:*** *Estelite Asteria - Soflex*

Table 3. Mean ΔE values and standard deviation of specimens after storing in solutions

Group	ΔE-P	ΔE-K	*P*
	Mean ± SD	Mean ± SD	
O-TD	5.62 (± 1.06)^{Aa}	7.91 (± 1.37)^{Cb}	**<.001**
O-S	6.92 (± 1.37)^{Ba}	9.71 (± 1.48)^{Db}	**<.001**
F-TD	5.51 (± 0.95)^{Aa}	7.84 (± 1.05)^{Cb}	**<.001**
F-S	5.78 (± 1.04)^{Aa}	8.98 (± 1.16)^{Eb}	**<.001**
E-TD	5.73 (± 1.18)^{Aa}	8.19 (± 1.25)^{Cb}	**<.001**
E-S	6.23 (± 0.98)^{Ba}	9.45 (± 1.27)^{Db}	**<.001**
P	**<,001**	**<,001**	

** The same uppercase indicates statistical differences in the same column, same lowercase letters indicate statistical differences in the same row (P <,05).*

ΔE-P: *Initially – 12 days orange juice,* ***ΔE-K:*** *Initially – 12 days cola, O-****TD:*** *Omnichroma - Twist Dia,* ***O-S:*** *Omnichroma – Soflex,* ***F-TD:*** *Filtek Ultimate - Twist Dia,* ***F-S:*** *Filtek Ultimate – Soflex,* ***E-TD:*** *Estelite Asteria - Twist Dia,* ***E-S:*** *Estelite Asteria – Soflex*

Table 4. The mean Ra (μm) values and standard deviation of the specimens at the initially and after the storing in the solutions

Group	Initially (Distilled water)	Orange Juice	Cola	*P*
	Mean ± SD	Mean ± SD	Mean ± SD	
O-TD	0.19 (± 0.09)^{A}	0.19 (± 0.11)^{A}	0.21 (± 0.08)^{A}	.24
O-S	0.35 (± 0.11)^{B}	0.37 (± 0.09)^{B}	0.38 (± 0.11)^{B}	.93
F-TD	0.19 (± 0.10)^{A}	0.22 (± 0.07)^{A}	0.25 (± 0.13)^{A}	.37
F-S	0.16 (± 0.08)^{A}	0.17 (± 0.10)^{A}	0.19 (± 0.10)^{A}	.08
E-TD	0.18 (± 0.09)^{A}	0.18 (± 0.12)^{A}	0.19 (± 0.09)^{A}	.85
E-S	0.29 (± 0.11)^{C}	0.31 (± 0.09)^{C}	0.37 (±0.10)^{BC}	.42
p	**<0.001**	**<0.001**	**<0.001**	

** Same uppercase indicates statistical differences in the same column (P<,05).*

O-TD: *Omnichroma - Twist Dia,* ***O-S:*** *Omnichroma – Soflex,* ***F-TD:*** *Filtek Ultimate - Twist Dia,* ***F-S:*** *Filtek Ultimate – Soflex,* ***E-TD:*** *Estelite Asteria - Twist Dia,* ***E-S:*** *Estelite Asteria - Soflex*

DISCUSSION

In the present study, the color change and surface roughness of a smart chromatic composite resin and two different methacrylate-based composite resins were evaluated by exposing them to different polishing systems and solutions. The color of an object is defined as the reflection and absorption of light from the object and the sensation it creates in the eye, which is dependent on its own structure.[15] Color matching and color stability are critical parameters in aesthetic restorations. Different methods have been reported in the literature for assessing the color characteristics of restorative materials, however, spectrophotometers are commonly used due to their ease of use and ability to evaluate using different scales. In this study, we utilized a digital spectrophotometer for color measurement and recorded the data in the CIE L*a*b* color coordinates, which are widely used in the mathematical formulation of color values and are frequently preferred in dentistry with their ease of calculation and evaluation of data.[16] ΔE values were calculated by exposing the specimens to different polishing systems and solutions.

In the present study, the color change of composite resin specimens was evaluated by measuring their ΔE values after being stored in different polishing systems and staining solutions. Stober et al.[17] have shown that prolonged exposure to staining solutions can result in the discoloration of composite resins due to the penetration of color pigments into their surfaces. In this study, although keeping in orange juice caused a color change, it was determined that this effect was more in the specimens stored in cola. Similar to this study, Meenakshi et al. [18] found that the specimens stored in cola showed higher color change values than the specimens stored in orange juice. Researchers determined that cola caused more surface deterioration in composite resin specimens and stated that it could cause more color change with a high color-pigment ratio. This situation, which is stated in the literature, may cause more color changes in the specimens stored in cola in our study. In the present study, ΔE values in all specimens stored in different solutions were found to be higher than the clinically accepted value of 3.3. This is an indication that long-term exposure to both solutions may cause surface discoloration in composite resins.

In the current study, it was established that the polishing and structural characteristics of the resin have a significant impact on the composite resin's ability to resist discoloration. Specifically, it was observed that the better the surface of the composite resin is polished, the greater its resistance to discoloration. The use of polishing systems containing small-sized (10-14μm) diamond particles and flexible silicon structures, such as the Twist Dia system utilized in this study, was found to result in lower mean ΔE values for all composite resin specimens. These systems can improve surface brightness and, as a result, better resist discoloration.[19]

Studies in the literature have demonstrated that the organic matrix structure, filler content, and amount of composite resin play a role in resisting color change by influencing properties such as water absorption and degree of polymerization.[17,20] It was observed in the present study that the nanofill composite resin specimens (Filtek Ultimate) exhibited lower mean color change values than the smart chromatic composite resin and nanohybrid composite resin specimens. The small filler particle size (20 nm), filler content comprising zirconium particles, and the resin matrix structure of the nanofill composite resin may have contributed to the lower mean color change values observed.

The introduction of smart chromatic composite resins in dentistry has been met with great interest as they utilize an additive color mixing system to reflect the color of the supporting tooth tissues, mimicking the natural tooth appearance. This system aims to create a tooth- staining

image by reflecting light from natural tooth structures instead of relying on dominant color pigments, allowing for the imitation of various tooth shades with a single composite resin.[11,21] In this study, smart chromatic composite resin specimens displayed lower mean ΔE values than nanohybrid composite resin specimens, despite being exposed to solutions containing intense color pigments for an extended period. However, the mean color change values were higher than nanofill composites. Similar to our study, Aydın et al.[22] determined that smart chromatic composite resin specimens showed more color change than nanofill composites. Researchers claimed that this situation may be due to water absorption depending on the monomer content of the composite resin. The high color change in this study may be due to the matrix structure, monomer content of the composite resin, and water absorption during the storage process. These color change values were found to be above the clinically acceptable threshold. As a result, our first null hypothesis that "different polishing systems and storage conditions have no effect on the color change of composite resin restorations" was rejected.

In the present study, the surface roughness of composite resin restorations was evaluated using a profilometer device, which is widely used in dentistry due to its ease of use, suitability for the materials, and ability to provide sensitive results. The Ra value, which is calculated by averaging the absolute values of the positive and negative elevation and trough values of the line passing through the center of the specimen, was used as a measure of surface roughness. The higher the Ra value, the higher the surface roughness.[23] The clinically accepted threshold value for surface roughness, in terms of the absence of plaque retention and discoloration, is 0.2 µm. Additionally, a SEM was used in our study for qualitative evaluation of the surface roughness of the specimens. The findings of this study suggest that the finishing and polishing processes can influence the surface roughness of composite resin restorations, which may have an effect on the restoration's long-term clinical performance. Factors such as plaque and bacterial uptake, food accumulation, microleakage, and secondary caries formation, may be influenced by the surface roughness of the restoration.[24,25]

In this study, the mean surface roughness values of composite resin specimens maintained in various beverages showed no significant variation (*P*>,05). Storing composite resins in solutions with low pH values may result in an increase in surface roughness. Ertas et al.[26] also found that acidic beverages may increase the roughness of composite resin restorations by causing surface deterioration. In the present study, it was observed that the mean surface roughness values of the specimens stored in cola, which has a relatively lower pH compared to orange juice, were found to be higher. In spite of orange juice's acidic pH (pH=3.38), our study indicated that specimens stored in it had lower mean surface roughness values than specimens stored in cola (pH=2.64).

The results of this study indicate that the filler content and particle size, resin matrix structure, and degree of polymerization of composite resins can affect the surface roughness.[27] The smart chromatic composite resin specimens had the greatest mean surface roughness values, whereas nanofill composite resin specimens had the lowest mean values. In general, the mean surface roughness values of nanofill composite resin specimens were found to be below the clinically acceptable limit of 0.2 µm. The low particle size and high filler content (78.5% wt.) of the nanofill composite resin may have contributed to the smoothness of the restored surface. Aytaç et al.[28] found that composite resins with lower filler sizes showed lower surface roughness and color change. Similarly, Moda et al.[29] found that nanofill composites showed lower surface roughness values than hybrid composites. In this study, the higher filler particle size, lower filler volume, and resin matrix structure of the smart chromatic composite resin specimens may have led to higher surface roughness. The effectiveness of polishing procedures is a critical factor in determining surface roughness. Studies have reported that Twist Dia and Soflex spiral polishing discs, which are current and effective polishing systems for polishing, increase the success of composite resin restorations by decreasing the surface roughness of the composite resin and increasing the surface hardness.[30,31] According to the results of this study, the surface roughness values of the O-S and E-S groups polished with the Soflex spiral polishing disc were found to be higher than the other groups. The reason for these results may be that the particle sizes of the Soflex polishing spiral (46 - 36 µm) are larger than the Twist Dia polishing spiral (35 - 4 µm). Gömleksiz et al.[32] in their study with Bulk Fill composites, they found higher surface roughness in the groups polished with the Soflex spiral disc than in the groups polished with Twist dia. Similarly, Degirmenci et al.[33] obtained high roughness values in the Soflex polishing system group, depending on the composite type used in their studies using different composite resin and polish systems. The results of this study are consistent with similar studies in the literature. Based on the results, our second null hypothesis, which states that "different polishing systems and storage conditions have no effect on the surface roughness of composite resin restorations," was partially rejected.

The present study aimed to investigate the color change and surface roughness of composite resin restorations under different polishing systems and storage conditions. While the results revealed significant differences in color change and surface roughness between the composite resins and polishing systems tested, there are also limitations to the study. Firstly, the study was limited to a small number of composite resins, and further research could benefit from the inclusion of a wider range of composite resin types, such as microhybrid and microfill. Secondly, the study focused on color change and surface roughness as evaluation criteria; however, there are many other tests and parameters that could be used to assess the physical and mechanical properties of composite resins.[21] Thirdly, although the solutions were applied for a simulated period in an in vitro setting, further clinical studies are necessary to evaluate the color change and surface roughness of restorations under oral conditions. This study should be considered as a pilot study and further researches are needed to confirm the findings and to investigate the potential impact on clinical practice.

Despite the limitations of this study, the results indicate that storage in orange juice and cola may affect the color change and increase the surface roughness of smart chromatic composite resins and methacrylate composite resins. These effects may be influenced by factors such as the matrix structure of the composite resin, the filler particle structure and amount, the chemical composition, and the environment to which it is exposed. Clinicians should consider these factors, including the patient's diet, the structural characteristics of the applied composite resin, and the effectiveness of the polishing systems, in their treatment protocols. Further studies involving a larger number of composite resins and a broader range of parameters are needed to fully understand the impact of these variables on the long-term clinical success of composite resin restorations.

Etik Komite Onayı: Bu çalışma in vitro bir çalışma olduğundan etik kurul onayına tabi değildir.
Hasta Onamı: Bu çalışma in vitro bir çalışma olduğundan hasta onamı bulunmamaktadır.
Hakem Değerlendirmesi: Dış bağımsız.

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Evaluation the Effects of Different Silica Coating Methods and Silane Types on the Bond Strength Between Polyamide and Polymethylmethacrylate

Farklı Silika Kaplama Yöntemleri ve Silan Tiplerinin Poliamid ve Polimetilmetakrilat Arasındaki Bağlanma Dayanımına Etkisinin Değerlendirilmesi

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ABSTRACT

Objectives: The aim of this study is to evaluate the effect of different silica coating methods and silane applications on the bond strength between polyamide and polymethylmethacrylate (PMMA).
Methods: Forty-five polyamide specimens were divided into two main groups based on the coating method applied: sol-gel silica coating (S) and tribochemical silica coating (T). Each main group was further divided into two subgroups based on the type of silane used: Bisco Porcelain Primer (BPP) and Clearfil Primer Plus (CPP) (n=9). The control group (C) received no silica coating or silane application. PMMA was then bonded to all specimens, and shear bond strength was evaluated.
Results: The highest shear bond strength was observed in group T with BPP application, while the lowest value was recorded in group C. Statistically significant differences were found between S-T and T-C groups (*P<.05*). Although BPP application in group T resulted in higher bond strength than CPP, the opposite trend was observed in group S.
Conclusion: The shear bond strength between polyamide and PMMA can be enhanced by applying silane after silica coating using either the tribochemical or sol-gel method.
Keywords: Polyamide, Polymethylmethacrylate, Silica

ÖZ

Amaç: Bu çalışmanın amacı, farklı silika kaplama yöntemleri ve silan uygulamalarının poliamid ile polimetilmetakrilat (PMMA) arasındaki bağlanma dayanımı üzerindeki etkisini değerlendirmektir.
Yöntemler: 45 poliamid örneği uygulanacak kaplama yöntemine (Sol-jel silika kaplama (S) ve tribokimyasal silika kaplama (T)) göre iki ana gruba ayrılmıştır. Her ana grup ise uygulanan farklı silan türlerine (Bisco Porcelain Primer (BPP) ve Clearfil Primer Plus (CPP)) göre iki alt gruba ayrılmıştır (n=9). Kontrol grubu (C) için ise herhangi bir silika kaplama veya silan uygulaması yapılmamıştır. Ardından hazırlanan tüm örneklere PMMA bağlanarak makaslama bağlanma dayanımı değerlendirilmiştir.
Bulgular: En yüksek makaslama bağlanma dayanımı grup T'de BPP uygulanan örneklerde bulunurken, en düşük değer grup C'de gözlenmiştir. Gruplar arasında S-T ve T-C arasında istatistiksel olarak anlamlı fark bulunmuştur (*P<,05*). Grup T'de BPP uygulanan örneklerin makaslama bağlanmadayanımı CPP uygulanan örneklerden daha yüksek olmasına rağmen, bu durum grup S'te ters yönde izlenmiştir.
Sonuç: Poliamid ile PMMA arasındaki makaslama bağlanma dayanımı, tribokimyasal silika kaplama veya sol-jel yöntemiyle silika kaplama sonrası silan uygulaması ile artırılabilir.
Anahtar kelimeler: Poliamid, Polimetilmetakrilat, Silika.

INTRODUCTION

Dental treatments of the geriatric patients are generally aimed at the prosthetic rehabilitation of their missing teeth with partial or complete dentures, for which many materials and manufacturing techniques are used in the construction of these dentures.[1] Currently, patients demand that their prosthetic restorations perform an excellent aesthetics in addition to good function.[2] Polyamide polymer denture bases, also described as nylon, were used for the first time in 1950 and became one of the remarkable denture base materials due to their advantages such as sufficient strength, high elasticity, no residual monomer and aesthetic appearance.[3-7] In addition to the many advantages of polyamide-based prostheses, the weak bond strength to autopolymerizing resins is one of the ongoing problems. [8-10] Denture fractures may develop due to temporary and large force such as an accident or repetitive and small forces

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during chewing and in such cases, the repair of polyamide prostheses is more difficult than polymethylmethacrylate dentures. Fixing a broken tooth or clasp, repairing a denture fracture or relining a denture with polyamide materials is difficult and expensive. Sometimes making a new denture is a more appropriate approach than repairing the old one.[6,11] Unlike polymethylmethacrylate (PMMA), polyamide materials are resistant to chemicals due to their dense crystalline content. Therefore, it is difficult for polyamides to react and repair with chemical binders. The bond strenght between polyamide and ohter materials can be increased with some surface preparations.[12] While many surface improvement methods have emerged and proven to be effective, in order to provide compatibility and repair between conventional heat-polymerizing resins and autopolymerizing resins, which are routinely used in prosthetic treatments today, a few studies have aimed to develop polyamide bases.[8,13] There is a need for scientific studies on repair and strengthening of these prostheses, which have exhibiting better features compared to traditional dentures, in order to avoid the burden of time and cost by making them again in case of any failure. For these reasons, it was decided to conduct such a study.

METHODS

Since the relevant study is a material research, there is no need for an ethics committee decision. Table 1 shows the composition of the materials used in this experiment. Table 2 shows the experimental and control groups.

Table 1. Materials used in the study

Material	Chemical content	Brand-Manufacturer
Polyamide base	Poliamid	Deflex Nuxen S.R.L Buenos Aries, Argentina
Autopolymerizing acrylic resin	Polimetilmetakrilat	Blau Cryl, Efes Dental Bursa,Turkey
Silane coupling agent	3 Trimethyloxysyl propyl-2 Methyl propenoic acid	Bisco Porcelain Primer, Bisco, Schaumburg II, USA
Silane coupling agent	3Trimethyloxyylpropyl methacrylate 10-Methacryloyloxydecyl dihydrogen phosphate	Clearfil-Primer, Kuraray, Osaka, Japan
Silica-containing sand	Silica and 30 µm Al_2O_3	Cojet Sand, 3M ESPE, Seefeld, Germany
Cylindrical tube with an inner diameter of 17 mm, an outer diameter of 25 mm and a height of 30 mm		
Cylindrical tube with an inner ring diameter of 4mm and a height of 2mm		
#100, #400, #600, #800 and #1000grid size silicone carbide abrasive papers	Silicone carbide	Waterproof silicon carbide paper, UK

Table 2. Experimental and control groups in the study

Polyamide samples (n=45)		
T:Tribochemical silica coating group (n=18)	**S:Sol-gel silica coating group (n=18)**	**C:Control group (n=9)**
TC: Clearfil Primer Plus (CPP) group (n=9)	SC: Clearfil Primer Plus (CPP) group (n=9)	No silica or silane coupling agent was applied
TB: Bisco Porcelain Primer (BPP) group (n=9)	SB: Bisco Porcelain Primer (BPP) group (n=9)	

Preparation of polyamide samples

For use in the study, 45 disc-shaped polyamide samples with a diameter of 10 mm and a thickness of 2 mm were manufactured from injection molded thermoplastic polyamide resin (Deflex, Nuxen SRL, Argentina). The formed polyamide samples were fixed in previously prepared plastic pipes (Inner diameter of 12 mm, outer diameter of 24 mm and a height of 30 mm. cylinder shaped) with the help of autopoly-merizing acrylic (BLAU CRYL, Efes Dental, BURSA). Fixed samples were polished under water using #100, #400, #600, #800 and #1000 grid size silicone carbide abrasive papers. The prepared samples were kept in an ultrasonic cleaner (VEVOR, China) for 10 minutes at 25°C. The samples were removed from the ultrasonic cleaner and dried with air.

Dividing the samples into groups according to the surface treatment to be applied

The samples were divided into two main groups (n=18) to apply sol-gel silica coating (S) and tribochemical silica coating (T) treatment, and each main group was divided into two subgroups (n=9) to apply different silane material. No silica coating or silane application was applied for the control group (C).

Silica coated group with sol-gel (S)

Sol solution was prepared by acid-catalyzed hydrolysis of tetraethylorthosilicate (TEOS). TEOS was dissolved in ethanol and deionized water, then acetic acid was added until a molar ratio of 1 TEOS: 30 ethanol: 5 water: 2 acetic acid was reached. This reaction mixture was stirred continuously for 2 hours until a clear and homogeneous solution was obtained and finally the solution was aged at 20 to 25°C for 24 hours. The samples were immersed in this prepared TEOS sol and UV irradiation was carried out under O2 environment and approximately 1 cm below the light source for 30 min. TEOS coated samples were divided into two subgroups (n=9) and silane coupling agent with different chemical content was applied to each subgroup. 1st group (SB): 3-(Trimethoxysilyl) propyl-2-Methyl-2-Propenoic Acid containing silane (Bisco Porcelain Primer, Bisco, Shaumburg II, USA), 2nd group (SC): 3-trimethoxysilylpropyl methacrylate, 10-Methacry-loyloxydecyl dihydrogen phosphatic silane (Clearfil-Primer, Kuraray, Osaka, Japan) was applied.

Tribochemical silica coated group (T)

The samples in this group (n=18) were sandblasted by containing silica and 30 µm Al2O3 particles (Cojet Sand, 3M ESPE, Seefeld, Germany) at 4.2 psi pressure from 10 mm. Distance for 15 s with an intraoral blasting device (Prophy-neo Partner, Liang ya Dental, China). Sandblasted samples were divided into two subgroups (n=9) and a different silane coupling agent was applied to each subgroup. 1st group (TB): 3-(Trimethoxysilyl) propyl-2-Methyl-2- Propenoic Acid containing silane (Bisco Porcelain Primer, Bisco, Shaumburg II, USA), 2nd group (TC): 3-trimethoxysilylpropyl methacrylate, 10-Methacryloyloxydecyl dihydrogen phosphatic silane (Clearfil-Primer, Kuraray, Osaka, Japan) was applied.

Connecting polyamide and autopolymerizing resin

A cylindrical tube with an inner circle diameter of 4 mm and height of 2 mm will be placed in the center of the polyamide discs for the standard application of autopolymerizing acrylic and this tube will be expected to be polymerized by placing autopolymerizing acrylic with a brush inside. After polymerization, the pipe around the autopolymerized acrylic was cut vertically with the help of a scalpel and removed precisely.

Thermal cycle application

All of the samples (n=45) were kept in an automatic thermal cycle device (Mod Dental, Ankara, Turkey) for 20 seconds at each temperature (5-55°C) and for 5 seconds between two temperatures for 1000 cycles.

Measuring shear bond strength

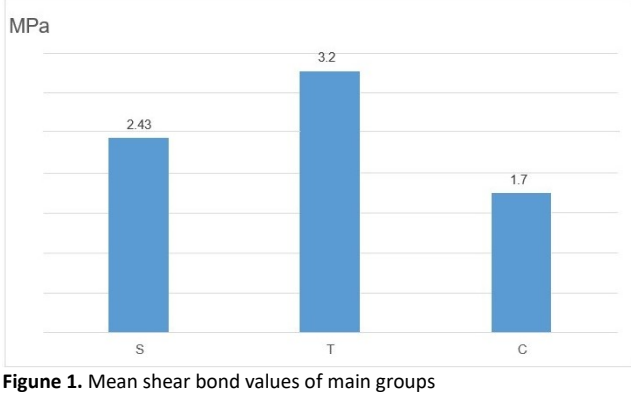
Acrylic molds are fixed to the test device in such a way that they do not move and the breaking apparatus comes into contact with the polyamide discs and the autopolymerizing acrylic junction at a right angle. Shear tests were performed with a 0.5 mm/min approach speed using a universal test device (Mod dental, Ankara, Turkey) and the test was monitored as tension and percent elongation graphs on the computer screen. The test was stopped automatically when separation occurred and the results were calculated by the computer in MPa.

Statistical analysis

In the statistical analysis of the study SPSS V25. (IBM SPSS Corp., Armonk, NY, USA) package program was used. Descriptive statistics of categorical variables in the study; descriptive statistics for frequency and percentage and continuous variables; are given with mean, standard deviation, median, minimum and maximum values. The conformity of continuous variables to the normal distribution was examined using the Shapiro Wilk test. The Oneway Anova Test was used to compare groupings with more than two options with normal distribution. In the 3-group comparisons of continuous variables that do not show normal distribution; Kruskal Wallis test and Mann-Whitney U tests were used in comparison of two groups. Relationships between continuous variables were examined by Spearman correlation analysis. In all statistical comparisons in the study, comparisons with a *p* value below 0.05 were considered statistically significant.

RESULTS

The results of the shear bond test for the main and subgroups are shown in Figure 1 and 2, respectively. The results of the Kruskal Wallis test performed to compare the main groups are given in the Table 2. According to the analysis results, there was a statistically significant difference between the main groups (*P<.05*). Bonferroni Corrected Mann Whitney test results show that there was a statistically significant difference between groups S-T and T-C. Shear bond values of the subgroups are given in Table 3, according to the table, the highest bond strength was found in group TB and the lowest bond strength is in control group. The results of the Kruskal Wallis test performed to compare the average shear bond strengths of the subgroups are given in Table 4. According to the analysis results, there was a statistically significant difference between the groups. Bonferroni Corrected Mann Whitney test results show that the difference between the SB group and the TB group and the difference between the TB and C groups were statistically significant. Mann Whitney test results are given in table 5 in order to compare all groups directly with each other. According to the results of the analysis, there were statistically significant differences between SC-TB, SB-TC, SB- TB, TC-C and TB-C.



Figune 1. Mean shear bond values of main groups

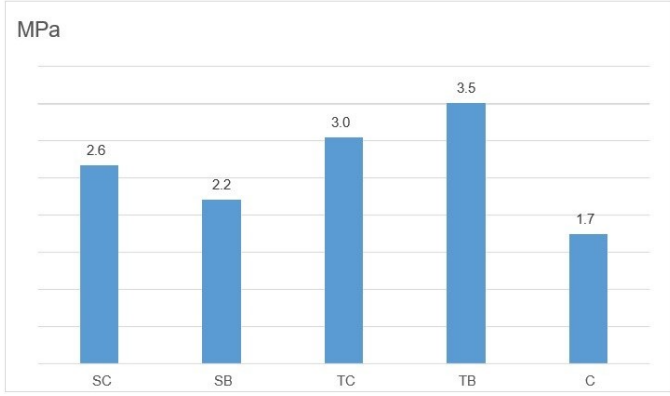


Figure 2. Mean shear bond values of subgroups

Table 3. Comparison of shear bonding values of main groups with Mann-Whitney U test with Bonferroni Correction

	Min	Max	X	ss	Median	X^2	*P*	Differnce
S	0.45	7.39	2.43	1.45	2.22			
T	1.98	4.50	3.27	0.70	3.22	15.359	<.01	T-C, S-T
C	0.55	3.84	1.74	1.11	1.08			

*Statistical significance

S: Silica-coated group with sol-gel, T: Tribochemical silica-coated group, C: Control group

Table 4. Comparison of shear bonding values of main groups with Mann-Whitney U test with Bonferroni Correction

	Min	Max	X	ss	Median	X^2	*P*	Differnce
SC	0.45	7.39	2.66	1.94	2.17			
SB	0.58	3.01	2.20	0.77	2.33			
TC	1.98	4.50	3.04	0.74	3.09	16.262	<.01 *	SB-TB, TB-C
TB	2.72	4.31	3.50	0.60	3.62			
C	0.55	3.84	1.74	1.11	1.08			

*Statistical significance

SB: Group coated with silica by sol-gel method followed by Bisco Porcelain Primer, SC: Group coated with silica by sol-gel method followed by Clearfil-Primer, TB: Group with tribochemical silica coating followed by Bisco Porcelain Primer, TC: Group with tribochemical silica coating followed by Clearfil-Primer, C: Control group, Min: Minimum, Max: Maximum, SD: Standard deviation

Table 5. Direct comparison of the mean shear bonding values of all subgroups with each other

	Min	Max	X	ss	Median	Mann-Whitney U Test (*P <.05*)
SC	0.45	7.39	2.66	1.94	2.17	SC-TB
SB	0.58	3.01	2.20	0.77	2.33	SB-TC
TC	1.98	4.50	3.04	0.74	3.09	SB-TB
TB	2.72	4.31	3.50	0.60	3.62	TC-C
C	0.55	3.84	1.74	1.11	1.08	TB-C

SB: Group coated with silica by sol-gel method followed by Bisco Porcelain Primer, SC: Group coated with silica by sol-gel method followed by Clearfil-Primer, TB: Group with tribochemical silica coating followed by Bisco Porcelain Primer, TC: Group with tribochemical silica coating followed by Clearfil-Primer, C: Control group, Min: Minimum, Max: Maximum, SD: Standard deviation

DISCUSSION

This study was conducted to repair polyamide-based prostheses, which are superior to PMMA prostheses in terms of aesthetics, biocompatibility, and mechanical properties. While PMMA-based prostheses applied today have an acceptable repair application with fast

and inexpensive methods when they fail mechanically for several reasons, this is not the case for polyamide prostheses. This is because polyamide-based dentures resist chemical substances due to their dense crystalline content.[12]

PMMA-based materials are applied with increasing interest in prosthetic treatments due to their simple manipulation technique, low toxicity, low water absorption and solubility, repairability and aesthetic appearance.[14] In addition to these advantages, dentures have disadvantages, such as insufficient surface hardness, weak brittleness, and low fracture toughness.[15] To repair the PMMA dentures, heat-polymerized, auto polymerized or light-polymerized acrylic resins can be used.[16] The prosthesis is exposed to repetitive bending due to the chewing function in the mouth, and cracks or fractures may occur in the denture base due to fatigue developed. To reduce this, dentures must have high bending strength and resistance.[17] Polyamide-based dentures have high flexibility capacity and high impact strength, but when some mechanical problems develop in polyamide dentures, repairing these prostheses is more complicated than PMMA.[6,18]

Silica, found in two main types crystalline and amorphous, is the final product formed by the polymerisation of silicon dioxide monomers.[19] There are various silica coating methods, such as tribochemical silica coating or silica coating with sol-gel, to increase the bonding of dental materials. Studies show that the silica-containing layer increases the reactivity of the polyamide material without impairing its mechanical properties.[13,20] Tribochemical silica coating, a chemical bonding method with mechanical energy, is frequently used in the laboratory or clinic to provide the surface roughness of dental materials. In this method, silica-coated Al_2O_3 particles with an average particle size of 30 or 110 µm are used for 15 seconds at a pressure of 280 kPa (2.8 bar) and from a distance of 10 mm. With the high heat energy generated, a rough area up to 15 µm in size occurs within the material. The next step after roughening is silanisation. The aim is to form a thin layer of silica-containing enough free hydroxyl groups to bond with the resin. To increase the bond of the roughened area with the resin, a silica layer containing free hydroxyl groups should be formed; for this purpose, silanisation should be provided after the tribochemical silica coating process.[21,22] Tetra alkoxysilane sol-gel polymerisation is a method used to synthesise amorphous silica gel that transforms into monolithic silica glass under hypercritical conditions.[13] In the literature, there are studies in which silica coating was applied to the polyamide surface by tribochemical or sol-gel method to increase the bond strength between polyamide and PMMA. In their study, Kumbuloglu et al. [23] concluded that the tribochemical silica coating applied to the surface of polyamide samples increased the bonding with autopolymerizing PMMA. Hamanaka et al.[24] in their study on the adhesion strength of autopolymerizing acrylic and injection moulded thermoplastic denture bases, concluded that the best surface improvement method was tribochemical silica coating and 4-META/MMA-TBB application. In their study, Hafezeqoran and Koodaryan reported that the repair strength between autopolymerizing acrylic and polyamide increased with the application of aminofunctional silica coating.[13] Although such studies are in the literature, studies comparing different silica coating methods or different silane types applied after silica coating have not been found. In this study, polyamide samples were divided into two main groups, tribochemical silica coating and sol-gel silica coating, and each main group was divided into two subgroups according to the type of silane to be applied to it. In the literature, autopolymerizing PMMA was used in a study on the transverse strength of polyamide-based prostheses and another study on the repair of polyamides.[25,26]

Autopolymerizing PMMA resin, used in repairing dental prostheses, was also used in our study. The thermal cycle process applies thermal changes in the intraoral region under in-vitro conditions.[27] ISO TR 11450 (1994) standards state that the thermal cycle applied with 500 cycles in water tanks with a temperature of 5-55 °C is appropriate; sometimes, this cycle number is not enough. To imitate the temperature in the oral environment, the polyamide specimens with autopolymerizing acrylic bonding were kept for 20 seconds at each temperature and 5 seconds between two temperatures (5-55 °C) for 1000 cycles by the literature.

The shear test, frequently used to measure the bond strength, is an in-vitro test method created by applying a force to the joint area at a speed of 0.5mm/min until the joint is separated between two bonded materials. The shear bond value is found by dividing the maximum force applied by the joint area.[28-30] The samples in which the thermal cycle process was completed were subjected to a shear bond strength test in the universal testing device as stated in the literature. The group with the lowest shear bond strength was found to be C, while the highest value belonged to the TB group. The reason for the lowest value in group C is that PMMA is attached to the surface of the polyamide samples without any surface preparation. Some surface treatments should be applied to polyamides, which are resistant to chemical substances due to their dense crystalline content, to increase their bond with other materials.[12] Another reason for the low shear bond value seen here is that PMMA and polyamide are polymers with different chemical contents. In the TB group treated with Bisco silane after tribochemical silica coating, the average shear bond value was 3.49 MPa. Hamanaka et al. [24] in their study in which they examined the bond strength between polyamide and autopolymerizing PMMA, applied ESPE Sil silane and 4-META/MMA-TBB to the samples after tribochemical silica coating and reported the average shear bonding value as 16.44 Mpa. The mean shear bond value was 13.41 MPa in the group where only tribochemical silica and ESPE silane were applied. These values are well above the highest shear bond value we found in our study, and this difference is thought to be due to the use of ESPE-Sil silane and 4-META/MMA-TBB-based resin cement after tribochemical silica coating. In the same study, the average shear bond value was found to be 0.44 MPa in the group that did not undergo any surface treatment; this value was 1.73 MPa on average in group C in our study, which did not undergo any surface treatment, and the values were more compatible with each other. In another study evaluating the bond strength between autopolymerized resin and polyamide base, the average shear bond strength of polyamide samples applied ESPE-Sil silane after tribochemical silica coating was 13.18 MPa.[8] This value was much higher than the average values found in our study; in this case, the reason might be the ESPE-Sil silane application. Kumbuloglu et al.[23] evaluated the bond strength of polyamide samples, on which ESPE-Sil silane applied to tribochemical silica coated samples, with two different autopolymerizing resins, found the bond strength value of the autopolymerizing resin in one group was 4.99MPa. In contrast, the bond strength in the other group was 3.27 MPa. In our study, in the TB group treated with Bisco silane after tribochemical silica coating, the average shear bond value was found to be 3.49 MPa. In comparison, the same value was found as 3.03 MPa in the group treated with Clearfil silane, and the values found agree with the results reported by Kumbuloglu et al.[23] When the literature is examined, reports state that applying tribochemical or sol-gel silica coating increases the bond strength between polyamide and autopolymerizing PMMA.[13,23,24] As a result of the study, shear bond values between autopolymerizing PMMA and polyamide samples coated with silica by tribochemical or sol-gel were higher than the

control group without any surface treatment. It is reported in the literature that the homogeneity and purity of sol-gel-derived silica film are comparable or even superior to surface coatings obtained by other methods. Hafezeqoran and Koodaryan, in their research to improve the adhesion of polyamides with autopolymerized resins, formed a double layer silica layer with aminosilane and tetraethylorthosilicate (TEOS) on polyamide surfaces by sol-gel method. As a result of the study, they found that the mean shear strength value of double-layer silica-coated polyamide bases with autopolymerized resin was 20.86 MPa.[13] In our study, the mean shear bond values of the silica-coated sol-gel groups were 2.20MPa for the SB group and 2.66MPa for the SC group. It can be thought that this situation is caused by the formation of a single-layer silica surface instead of two layers in our study and the chemical differences in the autopolymerizing resins used.

The silane forms a chemical bond with the silica-coated surface.[23] Silane application after silica coating improves the bond strength between non-silica-based and various materials.[20] In a study evaluating the bond strength of silica-coated titanium surfaces with adhesive cement, a total of five different silane groups were studied, and the group in which the Bisco porcelain primer was applied was one of the groups that showed the best bond strength.[31] In another study examining the bond strength of composite resins with zirconium and titanium, it was concluded that applying Clearfil Ceramic Primer on titanium and zirconium samples increased the bond strength with the composite.[32] In the study, silica-coated samples with either the tribochemical method or the sol-gel method were divided into different subgroups, and silane coupling agents with different chemical contents (Bisco Porcelain Primer and Clearfil-Primer), which were proven to have a positive effect on the bond strength of dental materials, were applied to each subgroup. In the tribochemical sandblasting group, the shear bond value of the TB subgroup was higher than the TC subgroup. In the sol-gel coating group, the shear bond value of the SC subgroup was higher than the SB subgroup, but the difference between them was not statistically significant. Htami et al.[33] in their study examining the bond strength between composite and zirconia, concluded that Bisco and Clearfil had a similar effect on bond strength.

Within the limitations of this study, the following conclusions and recommendations can be reached;

1. The bond strength between polyamide and polymethylmethacrylate can be increased by surface treatments.
2. The shear bond value between polyamide and polymethylmethacrylate was increased by tribochemical silica coating or silica coating with sol-gel followed by silane application.
3. Tribochemical silica coating and silane-applied polyamide samples were found to have higher shear bond strength with PMMA than sol-gel silica-coated, and silane-applied samples.
4. Although the shear bonding value of BPP-applied samples in group T was higher than the applied samples, this situation was opposite in group S.
5. In future studies, the bond strength between polyamide and polymethylmethacrylate can be evaluated with different silanes applied after different surface coating techniques.

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Effect of Gastric Acid on the Surface Properties of Different Composite Resin Restorative Materials: Scanning Electron Microscope (SEM) Evaluation

Gastrik Asitin Farklı Kompozit Rezin Restoratif Materyallerin Yüzey Özelliklerine Etkisi: Taramalı Elektron Mikroskobu (SEM) Değerlendirmesi

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of gastric acid on different resin-based composites with surface microhardness, surface roughness and scanning electron microscopy (SEM).
Methods: Three different composite resin restorative materials (Clearfil Majesty ES-2{Kuraray, Tokyo, Japan}, Beautifil II {Shofu, Ratingen, Germany}, Group Beautifil II LS {Shofu, Ratingen, Germany}) were used. Vickers microhardness and surface roughness measurements were evaluated at baseline, after 7 and 14 days of soaking in gastric acid. SEM images were obtained to examine the effects of gastric acid on the surface properties of the composites.
Results: When the difference in the microhardness values of the composite resins was compared, the time-dependent change in all composites was found to be statistically significant. The most surface roughness and hardness changes occurred in Beautifil II group (*P:0.000; P<.05*). According to SEM images, Beautifil II group was most affected by gastric acid, while Clearfil Majesty group was least affected.
Conclusion: In vitro conditions gastric acid increased the surface roughness of different composites while decreasing their microhardness. As a result, if these restorative materials are to be preferred in patients with reflux, they should be checked frequently. In the presence of an uncontrollable situation, the use of these restorative materials can be limited.
Keywords: Gastric acid, microhardness, surface roughness, SEM

ÖZ

Amaç: Bu çalışmanın amacı, farklı rezin esaslı kompozitlerin üzerine gastrik asitin etkisinin yüzey mikrosertliği, yüzey pürüzlülüğü ve taramalı elektron mikroskobu (SEM) ile değerlendirmektir.
Yöntemler: Üç farklı kompozit rezin restoratif materyal (Clearfil Majesty ES-2{Kuraray, Tokyo, Japonya}, Beautifil II {Shofu, Ratingen, Almanya}, Group Beautifil II LS {Shofu, Ratingen, Almanya}) kullanılmıştır. Vickers mikrosertliği ve yüzey pürüzlülüğü ölçümleri başlangıçta, gastrik asitde 7 ve 14 gün bekletildikten sonra değerlendirilmiştir. Kompozitlerin yüzey özelliklerindeki gastrik asitin etkilerini incelemek için SEM görüntüleri elde edildi.
Bulgular: Kompozit rezinlerin mikrosertlik değerlerindeki fark karşılaştırıldığında, tüm kompozitlerde zamana bağlı değişim istatistiksel olarak anlamlı bulunmuştur. En çok yüzey pürüzlülüğü ve sertlik değişimi Beautifil II grubunda gerçekleşmiştir (*P:,000; P <,05*). SEM görüntülerine göre Beautifil II grubu gastrik asitten en çok etkilenen grup iken, Clearfil Majesty grubu en az etkilenmiştir.
Sonuç: İn vitro koşullarda gastrik asit, farklı kompozitlerin yüzey pürüzlülüğünü arttırırken mikrosertliğini azaltmıştır. Bu verilere göre; reflü hastalarında bu restoratif materyaller tercih edilecekse sıklıkla kontrol edilmelidir. Kontrol edilemeyen bir durumun varlığında bu restoratif materyallerin kullanımı sınırlandırılabilir.
Anahtar Kelimeler: Gastrik asit, mikrosertlik, yüzey pürüzlülüğü, SEM

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INTRODUCTION

Dental erosion (DE) is the chemically irreversible loss of enamel and cement without bacteria.[1] Dental erosion is one of the important issues in dentistry, due to its high prevalence affecting 30% to 50% of primary teeth and 20% to 45% of permanent teeth.[2] DE can be etiologically 'external' and 'internal'. External etiological causes; Some medications such as food intake, chewable vitamin C tablets, antidepressants, asthma medications, and acid action through occupational factors.[3] A lifestyle with a more fruit-containing diet, increased intake of sports drinks and especially fruit juices are among the major exogenous causes of DE today.[4] Internal causes include recurrent vomiting and eating disorders, and gastroesophageal reflux

disease, which is defined as acidic stomach contents reaching the oral cavity.[5] In a study, it was determined that DE is 8.5 times more common in individuals with eating disorders.[6] Gastroesophageal reflux disease is defined as decreased involuntary muscle relaxation of the esophageal sphincter, which causes stomach acid to travel up the esophagus and into the oral cavity. Continuous return of stomach contents to the oropharynx is one of the risk factors for DE.[7]

Because of DE, tooth abrasions, sensitivity due to the exposure of the dentin surface owing to abrasion, loss of dental aesthetics and function may be encountered. Tooth surfaces exposed to DE may appear thinner, smoother, brighter and more yellow in color. At the same time, pits may form due to abrasion on the cutting edges and occlusal tubercles.[8] Composite resin restorations age and have degradation due to intermittent or continuous exposure to various chemicals in the oral cavity.[9] Güler et al.[10] Reported that solutions with various pH (Cola, Orange juice, Kefir, Artifical gastric acid and Artifical saliva) affected the surface features of different composite materials.

Today, the demand for composite resins and indirect ceramics has increased due to the increase in aesthetic expectations. Composite resin restorative materials are preferred due to their tooth color, aesthetics and good mechanical properties. Nanohybrid composite resin restorative materials have the lowest organic matrix content, a larger percentage of filler content, and show less polymerization shrinkage.[11]

The content of giomers, which are fluorine-releasing restorative materials, is different from conventional composite resin restorative materials. The combination of composites and glass ionomers where the acid-base reaction takes place is called giomer.[12] In addition to their appropriate aesthetics, they are preferred for their easy polishing and fluoride charging potential. At the same time, these materials have antibacterial effects due to fluoride release.[13]

Restorations made with resin-containing materials may fail in the long and short term for various reasons.[12] The presence of gastric acid in the oral cavity in individuals with reflux may cause various effects on the surface and mechanical properties of resin-containing materials. Studies on this subject are limited[10, 14] and more research is required. The aim of this study was to evaluate the effect of gastric acid on the surface roughness and microhardness of different resin-based materials.

The first null hypothesis is that the surface microhardness values of composite and giomers do not change with exposure to gastric acid simulation. The second null hypothesis is that the roughness values of composite material and giomers do not change with exposure to gastric acid simulation. Finally, the third null hypothesis is that there is a correlation between exposure to gastric acid simulation and surface microhardness and roughness values of two distinct giomers.

METHODS

Ethics committee approval was not obtained as human or animal sources were not used in this study.

Since human resources were not used in this study, informed consent was not obtained.

Preparation of Composite Resin Specimens

In this study, the effect of gastric acid on three distinct composite resin restorative materials with different filler ratio and monomer structure was investigated. The technical properties of the composite materials evaluated in the study are shown in Table 1.

Table 1. Contents of composite resins used in the study

Material	Manufacturer	Composition/ Particle Size	Filling Ratio (%wt-%vol)	Lot Number
CLEARFIL MAJESTY ES-2	Kuraray Medical Inc., Okayama, Japan	Bis-GMA, Silane barium glass filler, 0.37-1.5µm (%Wt)	78%- 40%	320084
BEAUTIFIL II	Shofu Inc., Kyoto, Japan	Bis-GMA, TEGDMA, S-PRG, Fluoroboroaluminosilicate glass, 0.8 µm (%Wt)	83.3%-69%	61938
BEAUTIFIL II-LS	Shofu Inc., Kyoto, Japan	Bis-GMA, TEGDMA, S-PRG	83%-68%	11925

Bis-GMA: Bisphenol A-Glycidyl Methacrylate; TEGDMA: Triethylene glycol dimethacrylate; S-PRG: Surface pre-reacted glass-ionomer

In the preparation of the composite resin specimens, plexiglass molds with a 5 mm diameter and a 2 mm depth were used. While the composite resin specimens were being prepared, restorative materials were placed in the molds, first the transparent band and then the glass surfaces were positioned with light pressure on both surfaces and polymerized with a LED light curing unit (D-Light Pro, GC, Tokyo, Japan) with a light intensity of 1,200 mW/cm^2 in accordance with the manufacturer's recommendations. The composite resin specimens were finished and polished with polishing discs in order from coarse to fine grained (Super-Snap, Shofu Inc., Kyoto, Japan). After each disc application, it was washed for 10 seconds and dried with light air for 5 seconds.

Gastric Acid Cycle

The composite resin specimens obtained from composite resin restorative materials were treated for 18 hours in gastric acid solution and 6 hours in deionized water for 14 days. The composite resin specimens kept in gastric acid were washed with distilled water at the end of 18 hours and left in deionized water. The gastric acid solution content was prepared fresh every day in Gazi University Faculty of Dentistry, with Hydrochloric acid (HCl) 0.06 M (Aklar Kimya, Ankara, Turkey) 0.113% deionized water solution and pH 1.2[10]. It was stored for 14 days at 37°C in 100% humidity.

24 hours after preparation of composite resin specimens from composite resin restorative materials, 7. and measurements were made on the 14th day. Measurements were made after the composite resin specimens were washed with distilled water and dried with air-water spray.

Measurement of Surface Hardness

Microhardness values of composite resin specimens were measured with a digital surface microhardness device (HMV-700 Microhardness Tester, Shimadzu, Japan) with Vickers surface hardness test under 490µN load for 15 seconds. Three different measurements were made from different parts of each 24 hours after preparation of composite resin specimens from composite resin restorative materials, and the average value was calculated.

Measurement of Roughness

An area of 100*100 µm^2 was determined with the surface roughness meter (Surftest SJ-301-Mitutoyo, Illinois, USA) and a 0.25 mm line scan was performed across the surface of the composite resin specimens. The profilometer was calibrated with 0.25 mm cut off, 1.25 mm reading

length and 0.5 mm/s speed, and the average surface profile was evaluated accordingly. After the preparation of composite resin samples from composite resin restorative materials, three different measurements were made from different parts every 24 hours and the average value was calculated.

The evaluation of Scanning Electron Microscope (SEM) images

SEM images were taken from the composite resin specimens prepared from each group at baseline, 7th and 14th days. The composite resin specimens were gold plated (Leica EM ACE 200, Leica Microsystems, Danaher Corporation, Washington DC, USA) and evaluated by SEM (Hitachi SU5000 FE-SEM,). The entire surface of these composite resin specimens was scanned and photographs were obtained at 10,000x magnification from the areas showing surface structure changes.

Statistical Assessment

These study data were evaluated using the IBM SPSS Statistics 22 program. The compatibility of the data with normal distribution was determined by Kolmogorov-Smirnov and Shapiro Wilks tests. While evaluating the study data, the One Way Anova test was used to compare the data between groups, and the Tukey HDS test was used to determine which group the difference originated from. Analysis of variance in repeated measurements and Bonferroni test as post hoc test were used to compare the data within the group. Significance was evaluated at the *p>.05* level.

RESULTS

Evaluation of Surface Roughness

When the initial roughness levels were evaluated, the post hoc Tukey HSD test was used to determine which group caused the statistically significant difference between the groups. While the initial roughness of the Clearfil Majesty ES-2 composite group was significantly lower than the Beautiful II and Beautiful II LS groups (*P<.05*), there was no statistically significant difference between the Beautiful II and Beautiful II LS groups (*p>.05*) (Table 2).

Table 2. Evaluation of surface roughness (Ra)

Surface Roughness (Ra) Composite Resins	Initial	Day 7	Day 14
Clearfil Majesty ES-2 (Mean±SD)	0.05±0.01[a]	0.27±0.07[a]	0.35±0.09[a]
Beautiful II (Mean±SD)	0,09±0.02[b]	0.33±0.11[a]	0.64±0.11[b]
Beautiful II LS(Mean±SD)	0.08±0.02[b]	0.31±0.10[a]	0.55±0.12[b]
[1]*P*	0.000*	0.320	0.000*

[1]Oneway ANOVA posthoc Bonferroni Test **P<.05*

[a,b]Different letters in the lines indicate the difference between groups.

When the surface roughness levels were evaluated on the 7th day, there was no statistically significant difference between the groups (*P: .032*).

When the 14th day roughness levels were evaluated, a statistically significant difference was found between the groups (*P<.05*) and the 14th day surface roughness of the Clearfil group was found to be significantly lower than the Beautiful II and Beautiful II LS groups (*P<.05*). There was no statistically significant difference between Beautiful II and Beautiful II LS groups in terms of roughness on day 14 (*P>.05*).

In the Clearfil Majesty group; Statistically significant difference was found when baseline, 7th day and 14th day surface roughness levels were evaluated (*P<.05*). The increases observed on the 7th and 14th days according to the initial surface roughness were statistically significant (*P<.05*). The increase in the roughness of the 14th day compared to the 7th day was also statistically significant (*P<.05*).

In the group Beautiful II; There was a statistically significant difference between the surface roughness levels at baseline, 7th day and 14th day (*P<.05*). The increases observed on the 7th and 14th days according to the initial surface roughness were statistically significant (*P<.05*). The increase in the roughness of the 14th day compared to the 7th day was also statistically significant (*P<.05*).

Beautiful II LS group; There was a statistically significant difference between the surface roughness levels at baseline, 7th day and 14th day (*P<.05*). The increases observed on the 7th and 14th days according to the initial surface roughness were statistically significant (*P<.05*). The increase in the roughness of the 14th day compared to the 7th day was also statistically significant (*P<.05*).

Evaluation of Surface Hardness

When the initial surface hardness levels were evaluated, the post hoc Tukey HSD test was used to determine which group caused the statistically significant difference between the groups. The initial surface hardness of the Clearfil Majesty ES-2 composite group was significantly higher than the Beautiful II and Beautiful II LS groups (*P<.05*). There was no statistically significant difference between the Beautiful II and Beautiful II LS groups in terms of initial surface hardness (*P>.05*).

While the 7th day hardness values of the Clearfil Majesty ES-2 composite group were found to be significantly higher than the Beautiful II and Beautiful II LS groups (*P<.05*), there was no statistically significant difference between the Beautiful II and Beautiful II LS groups in terms of the 7th day surface hardness values (*P>.05*).

The 14th day hardness values of the Clearfil Majesty ES-2 composite group were significantly higher than the Beautiful II and Beautiful II LS groups (*P<.05*). There was no statistically significant difference between Beautiful II and Beautiful II LS groups in terms of surface hardness values on day 14 (*P>.05*).

In all three groups; Statistically significant difference was found between initial, 7th day and 14th day surface hardness values (*P<.05*). While the decreases observed in the 7th and 14th days compared to the initial surface hardness were statistically significant, the decrease in the 14th day surface hardness compared to the 7th day was also statistically significant (*P<.05*).

Scanning Electron Microscope (SEM) Investigations

SEM images were obtained at 10,000x (Figure 1) magnification from the **composite resin specimens** obtained as a result of initial, 7th and 14th day gastric acid exposure of all groups in the study. For all groups; When the surface examinations were examined on the 7th day (Figure 1-B/E/H) in SEM imaging, it was observed that the surface roughness increased compared to the baseline (Figure 1-A/D/G) and pits were formed. Likewise, similar results were seen at day 14 (Figure 1-C/F/I). According to SEM data, Beautifil II group (Figure 1-E/F) was most affected by gastric acid, while Clearfil Majesty ES-2 group (Figure 1-B/C) was least affected.

Table 3. Evaluation of surface hardness (kg/mm^2)

Surface Hardness (kg/mm^2) Composite Resins	Initial	Day 7	Day 14
Clearfil Majesty ES-2 (Mean±SD)	102.6±6.37^a	95.92±6.17^a	92.50±5.33^a
Beautiful II (Mean±SD)	73.88±2.91^b	56.52±2.16^b	33.25±4.73^b
Beautiful II LS(Mean±SD)	71.65±4.18^b	59.71±4.14^b	36.03±7.09^b
^1P	0.000*	0.000*	0.000*

[1]Oneway ANOVA posthoc Bonferroni Test **P<.05*

[a,b]Different letters in the lines indicate the difference between groups.

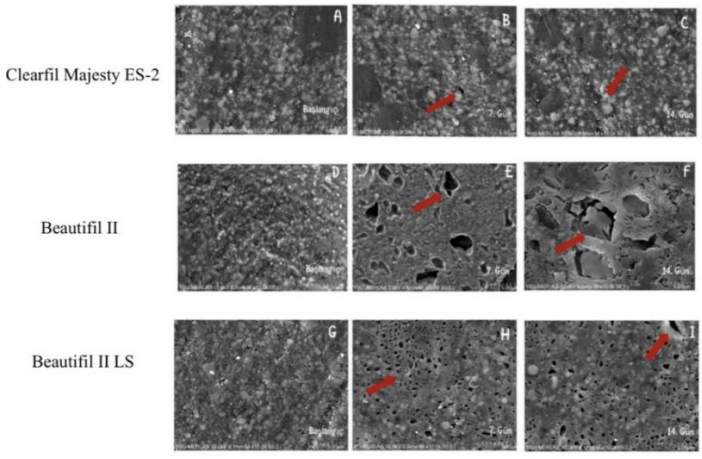

Figure 1. SEM images at 10,000x magnification; (A): Clearfil Majesty ES-2 initial SEM image (B): Clearfil Majesty ES-2 day 7 SEM image (C): Clearfil Majesty ES-2 day 14 SEM image (D): Beautifil II initial SEM image (E): Beautifil II day 7 SEM image (F): Beautifil II day 14 SEM image (G): Beautifil II LS initial SEM image (H): Beautifil II LS day 7 SEM image (I): Beautifil II LS 14th day SEM image

DISCUSSION

When the prevalence of dental erosion resulting in loss of dental hard tissues is examined, gastroesophageal reflux disease (GERD) is seen in 17 percent of patients (range 21-83%).[15] According to studies, 40 percent of the adult population has been reported to have GERD symptoms at some point in their lives.[7] Clinical symptoms may occur as a result of demineralization of dental hard tissues as a result of diseases such as GERD and repeated exposure of the oral cavity to gastric acid.[16] The aim of this study is to examine the effect of pH change, which causes damage to dental hard tissues, on dental restorative materials.

In this study, the effect of a nanohybrid composite resin restorative material and two giomers, claimed to exhibit low polymerization shrinkage (Beautifil II LS), on the roughness and surface microhardness of the materials in a time span of 13 years of gastric acid were tested. Measurements were made at baseline (T0), after 7 days (T1), and after 14 days (T2). SEM images were taken from composite resin specimens at T0, T1 and T2 stages. Exposure to low pH caused a statistically significant increase in roughness and hardness in all three groups. Based on the data obtained from this study, the first and second null hypotheses were rejected. Surface hardness and roughness increased after gastric acid cycle in all three materials compared to baseline. The last null hypothesis that there is a correlation between exposure to gastric acid simulation and microhardness and surface roughness values of two different giomers was also rejected. There is a difference in microhardness and surface roughness values between the two giomers. Changes in all these surface properties can be supported by SEM images.

Different immersion times have been planned in studies examining the effect of different acidity liquids on the mechanical and physical properties of dental restorative materials. Different immersion periods were used in some studies ranging from 1 day to 1 month[17-19], and in some studies from 1 month to 1 year.[20-23] There are studies in the literature reporting that the 14-day test period simulates the intraoral environment of approximately 13 years to evaluate the effect of various beverages on dental restorations.[10,22] In this study; a 7-day and 14-day immersion period (18 hours per day in gastric acid and 6 hours in distilled water) was planned to achieve a reasonable immersion time representative of the intraoral environment.[14] Since the tested composite resin specimens were not exposed to a mechanical force factor, the changes in surface hardness and roughness, which were also observed in SEM images, were caused by a chemical reaction or dissolution that developed depending on the Ph level of gastric acid.

The most commonly used microhardness tests in dentistry in the literatüre are the Knoop and Vickers microhardness tests. Vickers hardness test, which is also accepted as an indicator of the degree of polymerization of composite resin restorative materials, is widely used in the literature.[24, 25] In this study, Vickers microhardness test was preferred. The Vickers microhardness value reflects the resistance of materials to deformation and wear resistance.[26] There are several factors that can affect the hardness of resin-containing restorative materials. The filler size, filler content and resin monomer type are considered within these factors.[27] Surface roughness is generally associated with filler size in restorative materials.[28, 29] In the literature, it has been observed that smoother surfaces are obtained in materials with smaller filler size.[29, 30]

Clearfil Majesty ES-2 is a nanohybrid composite resin containing Bis-GMA. BisGMA is an essential component in the composite resin matrix, but one of its drawbacks is its high viscosity. Strong molecular interactions driven by the H bond are effective in this viscosity.[31] High viscosity weakens the mechanical properties of the composite and reduces its lifetime.[31] This content of the material may explain the increase in surface hardness and roughness in acidic environment. For Clearfil Majesty ES-2 group; When the surface examinations on the 7th day (Figure 1-B) and 14th day (Figure 1-C) were examined in SEM imaging, it was observed that the roughness increased and pits were formed compared to the baseline (Figure 1-A). This finding supports the surface roughness data.

In addition to conventional composite resins, materials with fluorine release in giomer structure are used in restorative dentistry. Giomers exhibit similar aesthetic and physical properties to composite resin restorative materials, superior to other fluorine-releasing conventional glass ionomers and resin modified glass ionomer cements (RMGIC). Many studies in the literature have shown that acid attacks in the oral cavity cause fluoride removal from glass ionomer restorative materials.[32,33] Beautifil II and Beautifil II LS release fluoride from its surface in acidic environment due to its giomer structure. It is thought that fluoride release is the reason for the increase in surface roughness and decrease in microhardness values in these groups after gastric acid exposure.

The giomers have a conventional bis-GMA matrix and contain bioactive glass fillers.[34] S-PRG (surface pre-reacted glass-ionomer) filler particles in giomers have been reported to act as a fluoride reservoir.[34] TEGDMA provides fluidity, flexibility and heterogeneity to the material it is in. The heterogeneity in the matrix allows for the formation of larger micropores between the polymers.[34]

According to the results of the study, the surface roughness of Beautifil II and Beautifil II LS groups, which are in gionomer structure, showed a statistically significant increase. In this case, it is thought that the fluoride content has an effect as well as the TEGDMA content in their structure. Although there is no statistically significant difference in surface roughness between Beautifil II and Beautifil II LS groups, the Beautifil II group has a higher surface roughness than the Beautifil II LS group, and SEM images have shown results that support this. With a particle size of 0.8 µm, Beautifil II group is the group that shows the most variation in surface roughness. Likewise, the fluoride content separated from the surface by the effect of gastric acid also explains the decrease in microhardness. Another reason for the decrease in surface hardness is the softening of bisphenol-A-glycidyl methacrylate (Bis-GMA) based polymers in the structure of composite resins exposed to gastric acid.[35] For Beautifil II and Beautifil II LS groups; When the surface examinations on the 7th day (Figure 1-E/H) and 14th day (Figure 1-F/I) were examined in SEM imaging, it was observed that the roughness increased and pits were formed compared to the baseline (Figure 1-D/G). According to SEM data, while materials with giomer structure were affected more by gastric acid, the most surface change was observed in Beautifil II group (Figure 1-E/F).

In support of this study; In their study, Guler and Unal reported that various acidic liquids, including gastric acid, increase the roughness on the surface of resin-containing materials and cause color change in the restorative material[15]. In the presence of factors affecting erosion such as gastroesophageal reflux in patients, physicians should be careful in the selection of restorative materials to be preferred and patients should be informed about this issue. Limitations of this study include deficiencies in mimicking the complex oral environment and ignoring the effects of temperature change and the buffering effect of saliva. Further research can examine the in vivo effects of gastric acid on different restorative materials with different evaluation methods (Atomic force microscopy (AFM), Knoop surface hardness test). Although the complex does not fully reflect the oral environment in this study, it does confirm the corrosive potential of gastric acid on restorative materials.

CONCLUSION

According to this study, gastric acid was found to be effective on the surface hardness and roughness of restorative materials.

- A decrease in surface hardness was observed in restorative materials after exposure to gastric acid.
- The surface roughness of the restorative materials also increased after gastric acid exposure.
- As a result, the choice of dental material is very important in patients with reflux.
- If the dental materials evaluated in this study are to be preferred, patients should be checked more frequently considering the results of the study.
- The use of these dental materials may be limited in the presence of a situation where case follow-up cannot be performed.

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Knowledge and Attitudes About Obstructive Sleep Apnea Among Dental Students: A Cross-Sectional Study

Diş Hekimliği Öğrencileri Arasında Obstrüktif Uyku Apnesi Hakkında Bilgi ve Tutum: Kesitsel Bir Çalışma

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ABSTRACT

Objective: Dental sleep medicine is an increasingly recognized medical specialty, but obstructive sleep apnea (OSA) frequently progresses undetected. Dentists are often the first health-care professionals to assess signs and symptoms of OSA and therefore have a key role in OSA diagnosis. The purpose of the study was to assess the knowledge and attitudes about OSA among dental students.
Methods: The OSA knowledge and attitude questionnaire was completed by dental students between April 2023 and June 2023. The questionnaire includes 18 knowledge and 5 attitude items on OSA. Chi-square tests and Student's t-tests were used to compare the differences between individual items and mean scores of the participants. Differences were considered significant at $P < .05$.
Results: A total of 351 dental students participated in the study. The total knowledge scores of the students were poor with a mean knowledge score for all students of 51% (9.18 ± 2.89). While 67.6% of participants considered OSA to be of clinical importance, only 18.2% were confident in their ability to manage OSA.
Conclusion: There are some deficiencies in the OSA education provided to dental students. Additional courses on dental sleep medicine are needed, and relevant updates should be made to the dentistry curriculum.
Keywords: Knowledge, attitude, dental education, dental student, obstructive sleep apnea

ÖZ

Amaç: Dental uyku tıbbı, pek tanınmayan bir tıbbi uzmanlık alanıdır ve obstrüktif uyku apnesi (OUA) genellikle fark edilmeden ilerleyebilir. Diş hekimleri hastanın tıbbı öyküsünü ilk alan ve OUA'nın teşhisinde kritik role sahiptirler. Bu çalışmanın amacı, diş hekimliği öğrencilerinin obstrüktif uyku apnesi ile ilgili bilgi ve tutumlarını değerlendirmektir.
Yöntemler: Bu çalışma Ocak-Nisan 2023 tarih aralığında planlanmıştır. Katılımcıların bilgi ve tutum seviyelerinin değerlendirilmesi için OSA bilgi ve tutum (OSAKA) anketi kullanılmıştır. Katılımcıların bireysel maddeler ve ortalama puanları arasındaki farkları karşılaştırmak için sırasıyla Ki-Kare testi ve bağımsız örneklemler Student t-testi kullanıldı. İstatistiksel anlamlılık düzeyi $P <,05$ olarak kabul edilmiştir.
Bulgular: Araştırmaya toplam 351 diş hekimliği öğrencisi katılmıştır. Öğrencilerin toplam bilgi puanı her iki grupta da zayıf olup tüm öğrencilerin ortalama bilgi puanı (9,18 ± 2,89) olarak gözlenmiştir. Ankete katılanların çoğu, OSA hakkında güçlü olumlu tutumlar gösterdi. Ancak çoğunun OUA hastalarının yönetiminde kendilerine güvenleri düşük bulunmuştur.
Sonuç: Diş hekimliği öğrencilerinin eğitim sürecinde obstrüktif uyku apnesi ile ilgili bilgi ve tutumuna ilişkin bazı eksiklikler bulunmaktadır. Bu sebeple diş hekimliği eğitimine uyku diş hekimliği ile ilgili ek dersler konulmalı ve eğitim müfredatında güncellemeler yapılmalıdır.
Anahtar Kelimeler: Bilgi, tutum, diş hekimliği eğitimi, diş hekimliği öğrencisi, obstrüktif uyku apnesi

INTRODUCTION

Sleep disorders are a public health problem that has been noticed in recent years that causes serious problems in the short and long term. Obstructive sleep apnea syndrome (OSAS) is a very widespread cause of sleep disorders and is the most common type of sleep breathing disorders.[1] Obstructive sleep apnea (OSA) is a medical condition which frequent respiratory pauses due to sleep-related muscle tone changes leading to partial or complete upper airway collapse. The prevalence of obstructive sleep apnea has been reported to be approximately 15% in the general population.[2] It has been reported that women are less affected than men and the prevalence varies among 0.5%-9% and 1%-24%, respectively. OSA is not only related with daytime sleepiness and poor quality of life. [2,3] It has been found to be associated with 7% of motor vehicle accidents in individuals with untreated OSA.[4]

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The diagnosis of OSA is made by the presence of a total of 5 apneas and hypopneas per hour, accompanied by daytime sleepiness, sleep sighs, sleep interruptions, daytime fatigue, and concentration disorders.[5] Common risk factors for the development of OSA are considered to be obesity, male gender, old age, hormonal changes in menopause, increased fluid retention, presence of adenotonsillar hypertrophy and smoking.[6] Also hypertension has been found to be related with OSA. Various cardiovascular disorders and diabetes mellitus have been stated to can be associated with OSA, although it is not clear.[6] In a meta-analysis, the prevalence of OSAS ranged from 9-38%, and it was stated that this condition increased with age and was more common in male gender and obese.[7] In a previous study, the prevalence of OSA in Turkey was found to be among 0.9-1.9%.[8]

Dental sleep medicine is can be identifed as a branch of dentistry that deals with the study of the oral and maxillofacial reasons and results of sleep-related disorders, including sleep-related breathing disorders such as OSA.[9] Physicians working in this topic must have very specialized medical knowledge. Particularly, there are some OSA related findings such as high arched or narrow hard palate, maxillo-mandibular relationships, enlarged or elongated uvula, tonsil hypertrophy, and lateral peritonsillar narrowing that general dental practitioners can observe during routine intraoral examination.[10] In addition, sleep bruxism (SB), a behavior often suspected and reported to share widespread clinical features with OSA, may also occur in OSA patients.[11] Furthermore, it is also quite common to have OSA and craniofacial pain together.[12] Due to the insufficient information about sleep medicine in the dentistry curriculum, sometimes treatment can be planned incorrectly, and the situations in which OSA patients should be referred for further investigation may be overlooked.

The gold standard in the diagnosis of obstructive sleep apnea is nocturnal polysomnography (PSG) in the sleep laboratory. However, several alternative portable diagnostic devices have also been developed, which have various advantages such as shorter waiting time and lower price.[13,14]

The first treatment option and the gold standard method in the treatment of OSA is the continuous positive airway pressure (CPAP).[15] The use of the CPAP device is difficult for the patients, their compliance with the treatment is generally not very good. Mandibular advancement device (MAD) is a type of oral appliance used as an alternative treatment to CPAP in the treatment of OSA.[16] Studies have reported that these appliances increase oxygenation during the night and improve the negative health and social results of OSA and snoring.[16,17] Mandibular advancement devices are generally recommended for use in patients with mild or moderate OSA and snoring, as well as in patients who are not compliant with CPAP use.[17] Therefore, dentists have a critical role in the treatment of OSA patients by using intraoral appliances.

The most important part of the dental clinical routine is to record the medical history patients before deciding the treatment on the examination. At this point, with a well-done clinical examination, many systemic conditions can be diagnosed and necessary referrals can be made.[18] Thus, dentists have a critical role in the diagnosis and diagnostic procedures of OSA, referral for advanced surgical procedures, and treatment with mandibular advancement devices.[19]

Hence, the aim of this study was to investigate the knowledge and attitudes about obstructive sleep apnea among dental students and thus to identify the need for revision of the dental educational curriculum on this subject.

METHODS

This study was designed as a cross-sectional study between April 2023 and June 2023 and it was conducted in accordance with the Principles of the Declaration of Helsinki and was approved by the Human Research of Ethics Commitees of Istinye University (Date: 12.04.2023; Protocol Number: 22-118) A total of 351 dentistry students 53,3% female and 46,7% male, were included in the study and an informed consent form was obtained from all of them. All of the participants met all of the inclusion criteria: being a dentistry student in 4th and 5th year, being between the ages of 18-30, volunteering to participate in the study, and answering the questions completely. A questionnaire form was created as a result of the literature review, including demographic characteristics such as age, gender, class of education, presence of chronic disease, and having OSAS in the family. Moreover, The Obstructive Sleep Apnea Knowledge Attitude (OSAKA) questionnaire developed by Schotland and Jeffe[20)] was used to evaluate OSAS knowledge and attitude. The OSAKA questionnaire is 23-item questionnaire that takes less than 10 minutes to be complete and consists of 18 knowledge assessment and 5 attitude assessment questions. Knowledge questions of OSAKA consist of true-false format and “do not know” option was also included as a third-response to minimise the effect of guessing. This option scored as an incorrect response during response rate calculations. Correct options were set as 1 point, and 0 points were given to the incorrect answers and “I don’t know”, which was accepted as an incorrect answer. Therefore, the total score that can be obtained varies between 0 and 18.[20]

The second part is about the OSAS attitude and consists of five items: two items to evaluate the importance of this situation as a clinical disorder and identifying OSAS, and three items assessing self-confidence in the management of OSAS. The answers to the attitude questions were calculated with a five-point Likert scale ranging from 1 to 5. (1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; and 5=strongly agree).

Statistical Analysis

Statistics analysis was performed using IBM SPSS Statistics (Version 22.0. Armonk, NY: IBM Corp.) The categorical data were expressed as numbers and percentages. The chi-square test and independent sample t-test were used to compare differences between categorical variables. Pearson correlation analysis was used to examine the relationship between the total knowledge score, total attitude score and each attitude subscale score in OSAKA, ages and years of education of participants. The statistical significance level was considered as $P < .05$.

RESULTS

It was seen that hand-wrist radiographs exhibited sexual A total of 351 dental students participated in the study and the mean age of students was 23.4±1.9 years. 39% (n=137) of the participants were 4th year, 61% (n=214) were 5th year dental students. 5.1% of the students have a systemic disease and the rate of those who use drugs was 4.3%. Additionally, 6.8% of the participants have a family history of obstructive sleep apnea syndrome. Table 1 presented the demographic characteristics of the students.

The total knowledge score of students was calculated and the mean knowledge score of all students was 9.18±2.89. While there was no statistically significant difference between OSAKA knowledge score and gender of dental students, a significant relationship was observed between age, education year, presence of OSAS in the family members

and presence of systemic diseases. The knowledge scores of students aged ≥24 years (9.65±2.57), 5th year dental students (10.20±2.59), systemic disease (11.56±2.50) and patients with a family history of OSAS (11.42±2.45) were higher (*P*<.05). (Table 2).

Table 1. Demographic characteristics of the dental students

		n	%
Gender	Female	187	53.3
	Male	164	46.7
Age	<24 years	209	59.5
	≥24 years	142	40.5
Years of dentistry education	4th year	137	39.0
	5th year	214	61.0
Presence of systemic diseases	No	333	94.9
	Yes	18	5.1
If yes, drug use related to these systemic diseases	No	336	95.7
	Yes	15	4.3
Presence of Obstructive Sleep Apnea Syndrome in the family	No	327	93.2
	Yes	24	6.8

Table 2. The relationship between the demographic characteristics of dental students and the OSAKA questionnaire knowledge items

		Mean	SD	*P*
Gender	Female	9.32	3.08	.330
	Male	9.02	2.68	
Age	<24 years	8.86	3.07	.012*
	≥24 years	9.65	2.57	
Years of dentistry education	4th year	7.59	2.63	.001*
	5th year	10.20	2.59	
Presence of systemic diseases	No	9.05	2.86	.001*
	Yes	11.56	2.50	
If yes, drug use related to these systemic diseases	No	9.03	2.85	.001*
	Yes	12.53	1.73	
Presence of Obstructive Sleep Apnea Syndrome in the family	No	9.02	2.86	.001*
	Yes	11.42	2.45	

The correct answer rates to the knowledge questions of the OSAKA questionnaire were shown in Table 3. None of the questions were answered correctly by all the participants. The question with the highest correct answer rate was the 4th question (The majority of patients with OSA snore) with 88.6% (n=311) and with 81.2% (n=285) the 11th question (A craniofacial and oropharyngeal examination is useful in the assessment of patients suspected with OSA) took the second place. However, the question with the lowest correct answer rate was the 8th question (Laser-assisted uvuloplasty is an appropriate treatment for severe OSA) with 6.6% (n=23) and the second question (Uvulopalatopharyngoplasty is curative for the majority of patients with OSA) with 9.4% (n=33) (Figure 1). 5th year students gave more correct answers to the majority of OSAKA knowledge questions compared to 4th year students and statistical significance was found in these answers (*P*<.05) (Table3).

Two of the attitude questions were associated with awareness of the importance of OSA, and three were associated with self-confidence in identifying and managing OSA. Importance subscale score, confidence subscale score and total attitude scores of the participants were found as 3.95±0.90, 2.68±0.96 and 3.19±0.93, respectively. Overall, 67.6% (n=237) of students considered OSA very important or extremely important as a clinical disorder. Similarly, 64.4% (n=226) considered identifying patients with OSA as very important or extremely important.

A very small proportion of participants (20.8%, n=73) agree or strongly agreed that they were confident in identifying patients with OSA. Only 18.2% agreed or strongly agreed that they were confident in their ability to manage OSA and only 17.1% (n=60) agreed or strongly agreed that they were confident in their ability to manage patients with CPAP therapy.

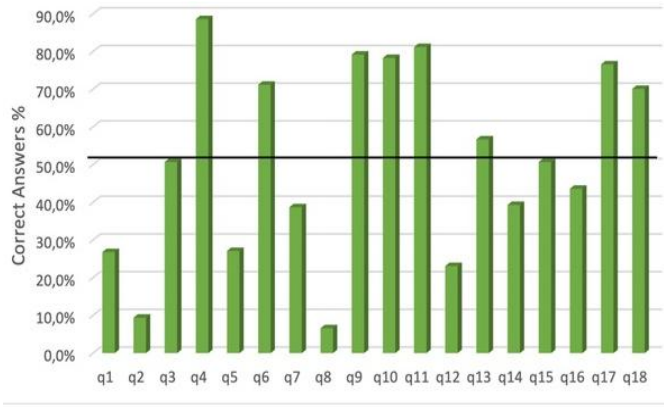

Figure 1. The rates of correct answers of obstructive sleep apnea knowledge and attitude knowledge questions

Table 3. Total and comparative scores of 4th and 5th year dental students knowledge items of OSAKA

Item on the knowledge section of OSAKA questionnaire (correct responses)	% Correct Answers			
	Total	**Years of dentistry education**		***P***
		4th year (n=137)	**5th year (n=214)**	
1. Women with OSA may present with fatigue alone (True)	94 (26.8%)	21 (15.3%)	73 (34.1%)	.001*
2. Uvulopalatopharyngoplasty is curative for the majority of patients with OSA (False)*	33 (9.4%)	4 (2.9%)	29 (13.6%)	.001*
3. The estimated prevalence of OSA amongst adults is between 2% and 10% (True)	178 (50.7%)	49 (35.8%)	129 (60.3%)	.001*
4. The majority of patients with OSA snore (True)*	311 (88.6%)	113 (82.5%)	198 (92.5%)	.004*
5. OSA is associated with hypertension (True)	95 (27.1%)	22 (16.1%)	73 (34.1%)	.001*
6. An overnight sleep study is the gold standard for diagnosing OSA (True)	250 (71.2%)	96 (70.1%)	154 (72.0%)	.703
7. Continuous positive airway pressure (CPAP) therapy may cause nasal congestion (True)	136 (38.7%)	49 (35.8%)	87 (40.7%)	.371
8. Laser-assisted uvuloplasty is an appropriate treatment for severe OSA (False)	23 (6.6%)	8 (5.8%)	15 (7.0%)	.666
9. The loss of upper airway muscle tone during sleep contributes to OSA (True)	278 (79.2%)	106 (77.4%)	172 (80.4%)	.499
10. The most common cause of OSA in children is the presence of large tonsils and adenoids (True)	275 (78.3%)	99 (72.3%)	176 (82.2%)	.027*
11. A craniofacial and oropharyngeal examination is useful in the assessment of patients suspected with OSA (True)	285 (81.2%)	93 (67.9%)	192 (89.7%)	.001*
12. Alcohol at bedtime improves OSA (False)	81 (23.1%)	30 (21.9%)	51 (23.8%)	.675
13. Untreated OSA is associated with a higher incidence of automobile crashes (True)	199 (56.7%)	50 (36.5%)	149 (69.6%)	.001*
14. In men, a collar size of 17 inches of greater is associated with OSA (True)	138 (39.3%)	16 (11.7%)	122 (57.0%)	.001*
15. OSA is more common in women than men (False)	178 (50.7%)	64 (46.7%)	114 (53.3%)	.231
16. CPAP is the first line therapy for severe OSA (True)	153 (43.6%)	31 (22.6%)	122 (57.0%)	.001*
17. Less than five apnoeas or hypopnoeas per hour is normal in adults (True)	269 (76.6%)	110 (80.3%)	159 (74.3%)	.196
18. Cardiac arrythmias may be associated with untreated OSA (True)	246 (70.1%)	79 (57.7%)	167 (78.0%)	.001*

There was a significant correlation between the total knowledge score, total attitude score (r=0.106, *P* <.001) and each attitude subscale score (r=0.382, *P* <.001), (r=0.291, *P* <.001). Moreover, the total knowledge score correlated significantly with the age of the participants (r=0.150, *P* <.001) and year of dentistry education (r=0.439, *P* <.001) (Table 4). The total attitude score correlated significantly with the year of dentistry education (r=0.106, *P* <.001), conversly no correlation was found between age of participants (r=0,083, *P* >.001). Importance subscale score shown no correlation neither age (r=0.005, *P* >.001) or year of dentistry education (r=0.086, *P* >.001). Additionally, while there was a positive relationship between the confidence subscale attitude score of the participants and their age (r=0.106, *P*<.001), no relationship was found between the years of dentistry education (r=0.080, *P* >.001,

Table 4. Pearson correlation coefficients between mean scores of total attitude questions, each attitude subscale, and total knowledge questions on the OSAKA

	a	b	c	d	e	f
Age (a)	1					
Years of dentistry education (b)	.278**	1				
Total knowledge score (c)	.150**	.439**	1			
Importance subscale score (d)	0.005	0.086	.382**	1		
Confidence subscale score (e)	.106*	0.080	.291**	.184**	1	
Total attitude score (f)	0.083	.106*	.421**	.661**	.859**	1

*P<.05, ** P <.001

DISCUSSION

This study represents the first attempt to evaluate the knowledge and attitudes among dental students regarding OSA. Dentists have a critical role in the initial detection and treatment of various clinical conditions. Such as, they are likely to be the first to be contacted to identify potential OSA or other sleep disorders, refer them to appropriate physicians, or treat them with oral appliance.[21] Therefore, dentists' knowledge, attitudes, and collaboration with other physicians regarding OSA and intraoral appliances are essential for managing OSA patients. This study provides data on the basic education of the dentistry, the competencies of future dentists on these issues and the requirements of curricular regulations.

Dental students' knowledge of OSA was limited with an average score of 51% in this study. It was determined that the average of the knowledge scores of the dentistry students in the study was lower than the study averages of Schotland and Jeffe[20] where OSAKA was developed, and the results of the studies that included many different groups (such as doctors, medical students, practitioners or dentists) in the literature.[22-24] This situation can be improved by factors such as increasing the diagnostic opportunities and training hours devoted to sleep medicine in dentistry faculties.

As for results, among dental students, the increased age and years of dental education were significantly associated with higher knowledge about OSA. Conversely no significant relationship between the knowledge scores of dental students and gender was found. There are studies in the literature reporting that there is a relationship between the age of physicians and their level of knowledge but in contrary to this study results older physicians have less knowledge about OSA.[20, 24] The reason for this is thought to be that young dentists receive a more up-to-date education and can access new information more easily by using technology.[24] Obtaining different results from the literature in this study may be due to the different study group. While general dental practitioners and specialist dentists took part in these studies, dental students participated in the present study. Moreover, it can be concluded that although the ages of the students are close to each other and their command of current information and technology is similar, the level of OSA knowledge is higher due to the fact that the 5th years students have more clinical experience.

The knowledge scores of students which presence systemic diseases (11.56±2.50) and patients with a family history of OSAS (11.42±2.45) were higher. Systemic hypertension, cardiovascular problems, type 2 diabetes, metabolic syndrome have been found to be associated with OSA.[6] Since the presence of OSAS in the individual or one of the family members will increase awareness about the subject, the high level of knowledge can be attributed to this.

In the study, the knowledge questions answered most correctly by the dental students were the 4th and 11th questions. These are the items regarding the role of sleep studies and craniofacial and oropharyngeal examination in the diagnosis of OSA, in which snoring is the most common symptom. This correct response rate indicates that dental students have a high level of awareness and knowledge of the diagnosis of OSA and associated symptoms. Conversely, the questions with the lowest knowledge scores of the students were the 2nd and 8th questions, and since these are questions related to the treatment approach and management, it shows that their awareness and knowledge of treatment is insufficient.

In accordance with previous studies, we concluded that the majority of the students had high awareness of the clinical definition of OSA and the importance of recognizing individuals at risk (79%).[24-27] However, it observed that students' self-confidence scores in managing OSA treatment were quite low (53.6%). At this point, educational deficiencies related to dental sleep medicine should also be taken into account in pre- and post-graduate education.[28] Similar to a previous studie, a positive significant correlation was found between knowledge scores and attitude scores in this study.[28] When the relationship between attitude scores and years of education and age was examined, no effect of age on attitude scores was observed, again related to the fact that the age distribution of students is very close to each other. However, it was observed that the average attitude scores increased as the years of education increased. In the education process, both the training received and the increase in the number of cases encountered positively affect the attitudes of the students. Considering all these, dental education and training curriculum should be supported with additional programs related to dental sleep medicine be more comprehensive studies should be carried out.

The limitations of this study are as follows; Firstly, this study was planned as a cross-sectional study and therefore causality cannot be inferred from any of the relationships we observed. furthermore, we cannot generalize the results of study to other countries where dental education on OSA may differ in significant ways.

In conclusion, the dental students in this study showed insufficient knowledge and attitudes towards the diagnosis, appropriate referral and treatment of OSA. The role of the dentist is very important in identifying OSA patients and directing them to medical care. It can be kept in mind as OSA may initially be suspected at a dentist visit. For this reason, the necessity of giving more place to dental sleep medicine in the dental education curriculum and increasing the level of OSA knowledge with postgraduate education should be taken into consideration.

Etik Komite Onayı: Bu çalışma için etik komite onayı İstinye Üniversitesi'nden (Tarih: 12.04.2023, Sayı: 22-118) alınmıştır.
Hasta Onamı: Çalışmaya katılan tüm diş hekimliği öğrencilerinden yazılı onam alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.

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Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstinye University (Date: 12.04.2023, Number: 22-118).
Informed Consent: Written informed consent was obtained from dental students who participated in this study.
Peer-review: Externally peer-reviewed.
Author Contributions: Concept G.,Y.; Design G.Y.; Supervision S.G.; Resources – S.G.; Materials – G.Y., S.G.; Data Collection and/or Processing – G.Y., S.G.; Analysis and/or Interpretation – G.Y.; Literature Search – G.Y., S.G.; Writing Manuscript – G.Y.; Critical Review – S.G.; Other – G.Y.
Conflict of Interest: The authors declare that they have no competing interest.
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Influence of Preheating Procedure and Polymerization Modes on Degree of Conversion of Contemporary Resin Composites

Ön Isıtma İşlemi ve Polimerizasyon Modlarının Güncel Rezin Kompozitlerin Dönüşüm Derecesi Üzerindeki Etkisi

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ABSTRACT

Objective: To evaluate the effects of preheating procedure and polymerization modes on degree of conversion (DC) of resin composites.

Methods: Three different types of composites - a conventional (GrandioSO - [GSO]), a bulkfill (GrandioSO x-tra - [GSX]), and a thermoviscous bulkfill (VisCalor bulk - [VCB]) - were investigated. Three specimens were prepared for each combination of the variables (composite type*preheating procedure*polymerization mode). Photo-polymerization was performed using an LED operated in standard (SM), high power plus (HM), and x-tra power (XM) modes. DC was measured with Fourier Transform Infrared Spectroscopy after 5 min and 24 h post-irradiation. Furthermore, three-way analysis of variance followed by a Tukey test at a significance level of $P < .05$ were performed to compare the DC values.

Results: Considering the DC values at two post-irradiation time, preheated VCB group polymerized with HM gave the highest DC value, while GSX cured with XM, regardless of the preheating exhibited the lowest one. Preheating application caused a statistically significant increase in the DC values of the VCB*SM, VCB*HM, and GSO*HM groups at both evaluation periods, and the GSX*SM group at 24h post-irradiation. Regarding the polymerization mode, the ranking depending on the significant differences among all preheated composites tested at both time intervals was HM > SM > XM.

Conclusion: Preheating generally exhibited favorable effects on the DC of all tested composites, with the most significant impact observed in VCB. Additionally, polymerization with x-tra power mode is not recommended to achieve a sufficient DC required for clinically acceptable restorations.

Keywords: bulk fill composite; degree of conversion; FTIR; polymerization mode; preheating; thermoviscousity.

ÖZ

Amaç: Bu çalışmanın amacı ön ısıtma işlemi ve polimerizasyon modlarının rezin kompozitlerin dönüşüm dereceleri üzerindeki etkilerini değerlendirmektir.

Yöntemler: Üç farklı kompozit türü - geleneksel (GrandioSO - [GSO]), bulkfill (GrandioSO x-tra - [GSX]) ve termovisköz bulkfill (VisCalor bulk - [VCB]) - incelendi. Değişkenlerin her bir kombinasyonu (kompozit türü*ön ısıtma işlemi*polimerizasyon modu) için üç örnek hazırlandı. Foto-polimerizasyon, standart (SM), yüksek güç (HM) ve x-tra güç (XM) modlarında çalışan bir LED kullanılarak gerçekleştirildi. Dönüşüm dereceleri, polimerizasyondan 5 dakika- ve 24 saat- sonra Fourier Dönüşümlü Kızılötesi Spektroskopisi ile ölçüldü. Ayrıca, dönüşüm derecesi değerlerini karşılaştırmak için $P < .05$ anlamlılık düzeyinde üç yönlü varyans analizi ve ardından Tukey testi uygulandı.

Bulgular: Polimerizasyon sonrası iki farklı zamanda elde edilen değerler göz önüne alındığında, ön ısıtma uygulanan VCB grubunun HM ile polimerize edildiğinde en yüksek değeri verdiği, ön ısıtma işleminden bağımsız olarak XM ile polimerize edilen GSX'in ise en düşük dönüşüm değerini sergilediği bulundu. Ön ısıtma uygulaması, her iki değerlendirme döneminde de VCB*SM, VCB*HM ve GSO*HM gruplarında, ayrıca polimerizasyondan 24 saat sonra GSX*SM grubunda dönüşüm derecesi değerlerinde istatistiksel olarak anlamlı bir artışa neden oldu. Polimerizasyon modu açısından, her iki zaman diliminde test edilen tüm ön ısıtma uygulanan kompozitler arasında anlamlı farklara bağlı sıralama HM> SM> XM olarak belirlendi.

Sonuç: Ön ısıtma, test edilen tüm kompozitlerin dönüşüm dereceleri üzerinde genel olarak olumlu etkiler göstermiş olup, en belirgin etki VCB'de gözlenmiştir. Ayrıca, klinik olarak kabul edilebilir restorasyonlar için gereken yeterli dönüşüm derecesine ulaşmak amacıyla x-tra güç moduyla polimerizasyon önerilmemektedir.

Anahtar Kelimeler: bulk fill kompozit; dönüşüm derecesi; FTIR; ön ısıtma; polimerizasyon modu; termoviskozite.

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INTRODUCTION

Restorative dentistry has witnessed substantial innovation in composite resins, resulting from advancements in their physico-mechanical properties and manufacturing technologies in recent years. As a result of these improvements, composite resins have been acknowledged as dependable materials for direct restoration.[1] With trends aiming at expediting the restoration process, bulk fill composites that can be placed and light-cured up to 4 or 5 mm without stratification were introduced to the dental profession.[2,3] These contemporary restorative materials are characterized by marked differences from their conventional counterparts in terms of various changes in the chemistry of the monomer, modified inorganic fillers, addition of new photoinitiators, and enhancement of translucency.[4,5]

A crucial parameter for resin-based materials is their degree of conversion (DC), which represents the ratio of unreacted carbon double bonds (C=C) in a polymerized specimen relative to the uncured material.[6] DC values for resin composites, which generally range between 50% and 75%, influence the rheological and mechanical features of the polymer, thereby affecting its clinical performance and functionality.[7,8] Although the minimum DC required for clinically admissible restoration has not yet been specified, DC values below 55% are usually not recommended for occlusal restorative layers.[9] Furthermore, DC is known to be considerably impacted by variables of the curing unit such as light intensity, wavelength, light curing method, curing time, light tip size, irradiation distance, and the chemistry of resin-based restorative materials comprising of the monomer composition, filler size and amount, and type of photo-initiators.[8,10-12]

There are a variety of methods for specifying the DC of light-cured materials. Recently, Fourier Transform Infra-Red Spectroscopy (FTIR) coupled with Attenuated Total Reflectance (ATR) accessories, which is able to quantify infrared light absorbance and transmittance, has emerged as the most widely used among vibrational spectroscopic methods for DC determination.[2,13-15] The rationale behind the ATR-FTIR technique relies on the measurement of alterations in the dipole moment of the bonds in molecules that exhibit vibrational patterns before, during, and after curing.[13]

Due to the increment thickness of bulk fill composites, the requirement for increased light transmission is of paramount importance for achieving adequate DC, which eventually ensures the longevity of the restorations.[16,17] In this regard, it is worth mentioning that polymerization reaction of composite resins is induced by light-curing devices at different energy densities and exposure durations.[18] As a consequence of the latest advancements in the field of light curing units (LCUs), light-emitting diodes (LED) characterized by higher irradiance within a short time interval, which anticipates increased polymerization efficiency and diminished chairside treatment duration, are currently available on the market.[19,20] Considering this context, it ought to be emphasized that, given the importance of their role in clinical applications, dental clinicians should further question characteristics and technical details of LCUs not to compromise patient's health and longevity of restorations.[21]

Preheating application prior to light-curing ensures reduction of material viscosity, enhancement of marginal adaptation, decrease in microleakage, and increases in both radical and monomer mobility, resulting in higher DC values and thereby better physical and mechanical properties of restorative material.[8,22-24] The aforementioned phenomenon may be elaborated as follows: the increased mobility of monomers by means of elevated temperature can lead to a delay in the auto-deceleration stage of the polymerization reaction, resulting in higher monomer conversion.[25-28] This preheating technique may be conducted by inserting syringes or compules of resin-based materials into commercially existing preheating devices set at a temperature range of 39–68 °C.[25] The present study uses VisCalor bulk (VOCO GmbH, Cuxhaven, Germany)—a bulk fill composite specifically designed for preheating—which is considered a noteworthy innovation in terms of dental materials science. Although the preheating procedure has been used in the field of restorative materials for many years, the available literature pertaining to the thermoviscous bulk fill composite is insufficient due to the recent introduction of the material to the dental market, and more investigation is needed to corroborate the effects of promising preheating application.

The present study aimed to investigate the effect of different polymerization modes and preheating application on the DC of novel resin composites. The null hypotheses tested in this study were that the DC is not impacted by 1) the resin composite type, 2) the preheating procedure, and 3) the polymerization mode at two different time intervals (5 min and 24 h post-irradiation).

METHODS

This *in vitro* study investigated three types of resin composites—a conventional universal nanohybrid (GSO; GrandioSO; VOCO GmbH, Cuxhaven, Germany), a nanohybrid bulk fill (GSX; GrandioSO x-tra; VOCO GmbH, Cuxhaven, Germany), and a thermoviscous bulk fill (VCB; VisCalor bulk; VOCO GmbH, Cuxhaven, Germany) (Table 1). Drawing on the results reported by Kincses et al.[26] and using analysis of variance (ANOVA: fixed effects, special, main effects and interactions, $\alpha = 0.05$, power $[1-\beta] = 0.95$, effect size = 0.639), the total sample size required for DC analysis was established as 53 (G*Power version 3.1; Heinrich-Heine-Universität Düsseldorf). Therefore, the experiment was conducted with n = 3 for each resin composite*preheating procedure*polymerization mode subgroup. Eighteen specimens of each resin composite, constituting a total of 54 specimens, as presented in Figure 1, were randomly separated into six subgroups (n = 3) in accordance with the preheating application (p+: with preheating/p-: without preheating) and polymerization mode (SM/HM/XM) interactions.

Table 1. Specifications of tested composite resins

Material	Type	Composition	Filler content %	Lot number	Manufacturer
GrandioSO [GSO]	Universal nanohybrid composite	**Matrix:** Bis-GMA, BisEMA, TEGDMA **Filler:** Glass ceramic, silicon dioxide	89 (w/w)	2108726	VOCO, Cuxhaven, Germany
GrandioSO x-tra [GSX]	Nanohybrid bulk fill composite	**Matrix:** Bis-GMA, BisEMA, aliphatic dimethacrylate **Filler:** Inorganic filler, organically modified silica	86 (w/w)	2112568	VOCO, Cuxhaven, Germany
VisCalor bulk [VCB]	Thermoviscous nanohybrid bulk fill composite	**Matrix:** Bis-GMA, aliphatic dimethacrylate **Filler:** Inorganic filler	83 (w/w)	2111548	VOCO, Cuxhaven, Germany

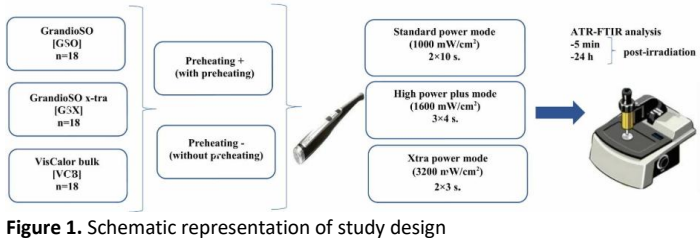

Figure 1. Schematic representation of study design

According to the manufacturer's instructions, a VisCalor Dispenser (VOCO GmbH, Cuxhaven, Germany) was used to preheat the composite compules by selecting setting 1 (for the VisCalor bulk, 30s) and setting 2 (for other studied composites, 70s) as required. In the non-preheated subgroups, the composite compules were maintained at room temperature (25 °C) with no preheating, and were included as a control group in this experiment. In each 'composite type*preheating procedure' subgroup, the uncured material was inserted into cylindrical stainless-steel molds of 8 mm × 4 mm and 8 mm × 2 mm for the bulk fills and their conventional counterparts, respectively.

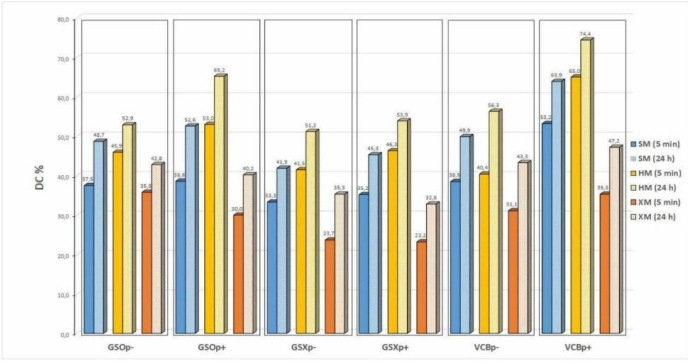

Figure 2. The mean DC of investigated materials according to the preheating procedure and polymerization mode at two-time intervals

Infrared spectra of the specimens' top surfaces were collected by employing Fourier Transformed Infrared Spectroscopy (FTIR, Nicolet iS50, Thermo Scientific, USA) equipped with a universal ATR accessory along with a diamond crystal (Thermo Fisher Scientific Co., Waltham, MA, USA) in absorbance mode. Subsequently, 32 scans at a resolution of 4 cm^{-1} within a wavelength spectrum of 4000–400 cm^{-1} were obtained. Furthermore, a background FTIR spectrum was recorded prior to each measurement. A preliminary readout of the uncured specimen was considered the unpolymerized reference. Photo-polymerization was performed using a LED unit VALO® Cordless (Ultradent Inc., South Jordan, UT, USA) operated in standard mode (1000 mW/cm^2 - [2 × 10s]), high power plus mode (1600 mW/cm^2 - [3 × 4s]), and x-tra power mode (3200 mW/cm^2 - [2 × 3s]). The specimens were stored in a lightproof oven within a desiccator with silica gel at 37°C for either 5 min or 24 h before DC measurement. Additional spectra of the cured specimens at 5 min and 24 h post-irradiation were obtained under the aforementioned conditions. Moreover, the crystal plate was cleaned cautiously with absorbent paper and ethyl alcohol between each sequence of monomer-polymer conversion.

Using a standard baseline technique,[29] the percentage of DC on the tested surfaces was calculated by determining the variation in the ratio of absorbance intensities (peak heights) of the aliphatic C=C stretching vibrations at 1636 cm^{-1} and aromatic C...C stretching vibrations at 1608 cm^{-1} using the following equation:

$$DC\ (\%) = (1 - \frac{(A_{1636} / A_{1608})after\ curing}{(A_{1636} / A_{1608})before\ curing}) x\ 100$$

Statistical Analysis

The data were analyzed with IBM SPSS version 23 (IBM Software Group, Chicago, IL, USA), while a Shapiro-Wilk test was implemented to examine the distribution normality. Furthermore, a three-way analysis of variance (ANOVA) (with resin composite type, preheating procedure, and polymerization mode as the main factors) followed by a Tukey test were used to examine the DC values among the experimental groups at two post-irradiation time. The significance level was established as $P<.05$.

RESULTS

The three-way ANOVA revealed significant effects of not only the three main factors but also the interactions of "resin composite* preheating procedure" as well as "preheating procedure* polymerization mode" at the two different time intervals, and interaction of "resin composite*polymerization mode" at 5 min post-irradiation (P <.001). Additionally, triple interaction was identified to be statistically significant at both 5 min and 24 h post-irradiation (in order of P =.001, P <.001). The results of the DC_{5min} and DC_{24h} values are presented in Table 2 and Table 3, respectively. Furthermore, Figure 2 depicts the DC values of each investigated variable in pairs, with reference to the two-time intervals. Considering the DC values at 5 min and 24 h post-irradiation separately, the highest DC value was observed in the preheated VCB group polymerized with HM, while the lowest degree of conversion was detected in the GSX cured with XM, regardless of the preheating procedure (P <.001). Preheating application caused a statistically significant increase in the DC values of the VCB*SM, VCB*HM, and GSO*HM groups at both evaluation periods, while that of the GSX*SM group exhibited statistical significance at 24 h post-irradiation (P <.001). Concerning the polymerization mode, their ranking based on the significant differences among all preheated composites tested at both time intervals was HM > SM > XM (P <.001).

Table 2. Mean degree of conversion (%) and standard deviation (mean ± SD) of each investigated variable at 5 min post-irradiation

Polymerization mode	Preheating procedure	Composite type		
		GSO	**GSX**	**VCB**
SM	**p-**	37.5 ± 0.7^{DEF}	33.3 ± 0.8^{FG}	38.5 ± 2.7^{DEF}
	p+	38.6 ± 1.2^{DEF}	35.2 ± 0.3^{EFG}	53.2 ± 4.0^{B}
HM	**p-**	45.9 ± 0.6^{C}	41.5 ± 0.7^{CD}	40.4 ± 2.6^{CDE}
	p+	53.0 ± 0.9^{B}	46.3 ± 0.3^{C}	65.0 ± 2.3^{A}
XM	**p-**	35.8 ± 1.1^{DEFG}	23.7 ± 1.1^{H}	31.1 ± 2.3^{G}
	p+	30.0 ± 0.9^{G}	23.2 ± 0.3^{H}	35.3 ± 4.5^{EFG}

Notes: A-H: There is no difference between the interactions (resin composite*preheating procedure*polymerization mode) with the same upper case letters.
Abbreviations: GSO, GrandioSO; GSX, GrandioSO x-tra; VCB, VisCalor bulk; SM, standard mode; HM, high power plus mode; XM, x-tra power mode; p-, without preheating; p+, with preheating.

Table 3. Mean degree of conversion (%) and standard deviation (mean ± SD) of each investigated variable at 24 h post-irradiation

Polymerization mode	Preheating procedure	Composite type		
		GSO	**GSX**	**VCB**
SM	**p-**	48.7±0.6^{EFG}	41.9±0.8^{IJ}	49.9±1.1^{DEF}
	p+	52.6±0.7^{CDE}	45.3±0.2^{GHI}	63.9±3.7^{B}
HM	**p-**	52.9±0.3^{CDE}	51.2±0.8^{DEF}	56.3±0.6^{C}
	p+	65.2±0.2^{B}	53.9±0.1^{CD}	74.4±3.4^{A}
XM	**p-**	42.8±1.1^{IJ}	35.3±1.2^{K}	43.3±1.2^{HIJ}
	p+	40.2±1.2^{J}	32.8±0.3^{K}	47.2±1.6^{FGH}

Notes: A-K: There is no difference between the interactions (resin composite*preheating procedure*polymerization mode) with the same upper case letters.
Abbreviations: GSO, GrandioSO; GSX, GrandioSO x-tra; VCB, VisCalor bulk; SM, standard mode; HM, high power plus mode; XM, x-tra power mode; p-, without preheating; p+, with preheating.

DISCUSSION

Effect of chemical composition on DC

Within the limits of this research, the first part of the null hypothesis was rejected since the current study confirmed that the DCs of the tested materials were impacted by the resin composite type. From a theoretical standpoint, DC (%) differences which are closely related with intricate polymerization process are expected as the monomer composition, inorganic filler characteristics vary on a large scale from material to material.[13] In a previous study, it was specified that increasing filler-matrix ratio proportionally reduces degree of conversion, because raised amounts of inorganic fillers are an impediment for polymeric chain propagation.[27] Taking into consideration of tested composites in this study, the ranking of the numerical values of DC was mostly VCB > GSO > GSX. In view of this, it is not surprising that VCB composites exhibited the highest DC values as a result of their lower filler loading (83% wt.). Notably, a discrepancy was noted between the DC values and the filler amounts of the GSO (89% wt.) and GSX (86% wt.) groups. The explanation for the higher DC values in the GSO may be attributed to its application at 2 mm increment thickness, and the presence of TEGDMA, which could have positively affected the DC in the monomer structure of the GSO.

Furthermore, the DC of composite resins is essentially impacted by the nature and quantity of each monomer in their composition.[6] Ultimately, the DC of the different monomer systems diminishes in the following order: TEGDMA > UDMA > Bis-EMA > Bis-GMA.[2] Unfortunately, the lack of data provided by the manufacturers in the package inserts and on their websites about the exact ratio of the assorted monomers, as they were proprietary, made the interpretation of the existing results an arduous task.

DC change depending on preheating

Preheating application is an innovative approach that could ameliorate the handling characteristics of dental materials, as well as their physical and mechanical properties.[30] Based on the effects of the preheating procedure on DC observed in the current study, the second null hypothesis was rejected. Our findings coincide with those of various studies[23,24,31,32] reporting that preheating causes increased molecular mobility, thereby allowing the system to attain higher level monomer conversion before vitrification. On the other hand, in several studies[15,28,33,34], it was emphasized that no significant effect was stated about the preheating procedure on monomer conversion. For instance, unlike the present study, Kincses et al.[26] specified that preheating had no beneficial impact on the DC of thermoviscous VisCalor bulk. Furthermore, a previous study that investigated the effects of pre-heating time and exposure duration on the post-irradiation properties of a thermoviscous resin composite declared that the DC did not alter with preheating application and time (no heat, T3-30 s, T3-3 min), since a reduction in the composite temperature was observed after its removal from the heating instrument.[8] This inconsistency between the findings of the current study and former investigation may have resulted from the use of different heating devices. It is important to mention that compules do not need to be removed from VisCalor Dispenser used in this study, and that's why this device can maintain increased temperature throughout the procedure as distinct from the other heating instruments.[26] In another study by Tauböck et al.[22] in which they evaluated influence of preheating on shrinkage force and monomer conversion of high-viscosity bulk fill resin composites, it was notified that preheating prior to photoactivation either maintains or increases the DC.

Influence of polymerization mode on DC

In spite of the fact that the polymerization reaction is completely chemical, dental practitioners are still regulating several momentous points of the reaction such as the curing time and radiant energy.[1] Comparisons of alternative polymerization protocols are generally made by changing the light activation time and irradiance while preserving stationary radiant exposure.[20] Considering the impact of polymerization modes in this study, especially in all the preheated groups, the high power plus mode presented a significantly higher DC than the standard mode and x-tra power modes, respectively. In line with the data obtained from the current study, the third part of the null hypothesis, which emphasizes that the DC is not affected by polymerization modes, was rejected.

In a previous study conducted by Sadeghyar et al. [3] who examined limited reciprocity in curing efficiency of bulk fill resin composites, three LCUs of rising radiant emittance capacity (1200, 2000 and 3200 mW/cm^2) were utilized. It was stated that irradiance for 10 s at 1200 mW/cm^2 displayed mostly better hardness values than by using LCUs of higher radiant emittance with reciprocally declined curing times, to sustain stationary dose of energy density. Furthermore, Ilie and Stark claimed that to preserve the mechanical features of resins in depth, the necessary energy density should be achieved at moderate irradiance coupled with enhanced exposure time.[4] A study that investigated the effect of light-curing protocols (standard and x-tra power modes) on the mechanical behavior of bulk fill resin composites reported that higher irradiance in a short period jeopardizes the mechanical properties of composite resins, leading to undesirable clinical outcomes.[5] As an explanation of the aforementioned finding, it could be pointed out that low power irradiance in a longer time duration ensures leisurely polymerization, which improves the mechanical behavior of composites, since extended chains with higher molecular weight are created in comparison with high power irradiance. The results of this investigation are consistent with those of Daugherty et al.[11] who stated that bulk fill composites polymerized with high irradiance*short/ultra-short curing time combinations may not provide a sufficient degree of polymerizetion, in turn, leading to undesirable clinical features. On the other hand, Atria et al. [35] have accentuated that different curing modes (High- 1200 mW/cm^2; Low- 650 mW/cm^2; Soft-start- [650-1200] mW/cm^2; and Turbo- 2000 mW/cm^2) with the same exposure time do not significantly impress the DC values of a composite resin. Drawing on the above observations, it is crucial to underline that dental professionals should have notice of technic elaborations and properties of LCUs by the side of the curing time and radiant irradiance suggested by the manufacturer of each dental material.[21]

For all composite resins analyzed in this study, the DC at 24 h post-irradiation was greater compared to those obtained immediately post-cure. This finding is in harmony with the studies conducted by Yang et al.[8,28] As corroborating with the literature, it was concluded that DC may not be optimized 5 min post-irradiation, and it should be anticipated for up to 24h in order to obtain eventual degree of post-polymerization conversion.[17]

A limitation of this experiment is that only one brand of composite resin was tested. Furthermore, the use of different specimens at the two time intervals (5 min and 24 h post-irradiation) may be preferred because removal of the cured specimens from the ATR crystal for re-evaluation at 24 h post-irradiation could be detrimental to the specimens, resulting in poor spectra recordings. Moreover, the outcomes of the current research should be corroborated with *in vivo* studies because they simulate intraoral environment conditions

completely and prevent erroneous prediction from the results of *in vitro* methodologies.

CONCLUSION

Within the limitations of this laboratory study, the following conclusions can be deduced:

1. VisCalor bulk indicated the highest degree of conversion in comparison with other tested composites when preheated as suggested.

2. Preheating procedure had generally favorable effects on DC of the tested composites, besides that the most significant impact was observed in VisCalor bulk group.

3. X-tra power mode, which has higher irradiance in a short time interval may not be recommended for adequate degree of conversion.

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Diagnostic Comparison of Different Methods for Detection of Occlusal Caries Lesions in New Erupted Permanent Teeth

Yeni Sürmüş Daimi Dişlerde Oklüzal Çürük Lezyonlarının Tespiti İçin Farklı Yöntemlerin Tanısal Karşılaştırması

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ABSTRACT

Objective: The aim of this study is to evaluate the effectiveness of the alternating current impedance spectroscopy device in the diagnosis of occlusal caries using visual and radiovisiography and determining the inter-researcher reliability of the device by repeating it with two different researchers. Materials and **Methods:** From thirty-five patients, a total of thirty-five new eruptive occlusal first molar teeth with intact or early decay were included. It was examined by visual, radiovisiography and CarieScan Pro (CP) device by two researchers with independent clinical experience.

Results: With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II (*P*<.005), no significant difference was found among other groups. A high inter observer agreement and moderately good kappa value were seen.

Conclusion: The ICDAS-II method alone appears to be sufficient for the diagnosis of occlusal caries. It was concluded that the CP technique showed a low ability to reveal occlusal carious lesions on enamel and/or dentin in newly erupted permanent molars.

Keywords: Caries Diagnosis, CarieScan Pro, ICDAS-II

ÖZ

Amaç: Bu çalışma amacı, oklüzal çürüklerin tanınmasında alternatif akım empedans spektroskopisi cihazının çalışmasını görsel ve radyovizyografi kullanarak değerlendirme ve bunu iki farklı araştırmacı ile tekrarlayarak cihazların birbirleriyle dayanıklılığını sağlamaktır.

Yöntemler: Otuz beş hastadan, sağlam veya erken çürüğe sahip toplam otuz beş yeni süreli oklüzal birinci azı dişinin bakımı dahil edildi. Dişler, bağımsız klinik deneyimlere sahip iki araştırmacı tarafından görsel, radyovizyografi ve CarieScan Pro (CP) cihazı ile incelendi.

Bulgular: İncelemeci 1 ve 2 için uyumluluk içi uyum bakış açısı, yalnızca CP ve ICDAS-II arasında anlamlı olarak fark varken (*P*<,005), diğer gruplar arasında anlamlı bir fark vardı. Yüksek bir güvenlikler arası uyum ve orta düzeyde iyi bir kappa değeri görüldü.

Sonuç: ICDAS-II yöntemiyle tek başına oklüzal çürüklerin tanısı için yeterli görülüyor. CP uzmanının yeni sürmüş daimi azı dişlerinde mine ve/veya dentin üzerindeki oklüzal çürük lezyonlarını ortaya çıkarmada düşük bir yeteneğe sahip olduğu için yetiştirildiği varılmıştır.

Anahtar Kelimeler: Çürük Tanısı, CarieScan Pro, ICDAS-II

INTRODUCTION

Tooth decay is a complex disease caused by a combination of many factors. Caries begin with the destruction of hard tooth tissues as a result of a combination of bacterial biofilms and foods that cause acid production on the tooth surface. Occlusal surfaces are the most suitable areas for caries formation due to the different morphology of pits and fissures and the plaque not being easily removed. [1]

The majority of cavities during childhood and adolescence, ranging from 75% to 92%, begin in the cracks on the occlusal surfaces of the teeth. [2] The early diagnosis of these cavities allows for treatment with preventive methods or minimal invasive restorations. Deep dental caries lesions may require local anesthesia or longer-term restorative treatment, which can particularly induce fear in the dental treatments of the younger age group of children and create difficulties in collaborating with the child during dental procedures. [3,4] Furthermore, early diagnosis of cavities can reduce cavity prevalence and socio-economic costs, while also reinforcing the fundamental principle of minimal invasive dentistry. [5]

Such situations further increase the importance of early diagnosis of initial enamel caries in children. Accurate and correct diagnosis of occlusal caries will be the first step in successful treatment. However, caries detection is difficult due to the anatomical structure of dental fissures and fossa and the diversity seen in this structure. The most common caries detection methods used by dentists are visual inspection,

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tactile use of an explorer and radiographs and although the specificity of visual examination (VE) alone is high, it has been reported to have a low sensitivity for the detection of early onset caries and based on clinicians' experience. [6]

The examination of caries by dental prob is criticized for the transfer of carious microorganisms from one place to another, as well as for irreversible traumatic defects in early caries lesions that can be remineralized. [7] Moreover, since caries is a dynamic and fluctuating process that involves demineralization and remineralization over a period of time, [8] radiography may inadequately estimate the depth of the carious lesion and offer a very low sensitivity rate, especially in the detection of incipient caries. [9,10]

These limitations in traditional methods have led to the development of new methods and devices for the detection of caries. [11] A device developed for caries detection is the CarieScan Pro (CP) device using alternating current impedance spectroscopy. In this method, it is aimed to evaluate mineral change in dental tissues by means of low voltage current applied to the surface of the tooth. The manufacturer recommends the use of this device for the diagnosis of caries without cavitation at the initial stage. [12]

The aim of this study is to evaluate the effectiveness of the alternating current impedance spectroscopy device in the diagnosis of occlusal caries using visual and radiovisiography and determining the inter-researcher reliability of the device by repeating it with two different researchers. The null hypothesis of this study was that there would be no difference in the inter-rater reliability of the device as a result of evaluating the effectiveness of the alternating current impedance spectroscopy device (CarieScan Pro) in diagnosing occlusal caries using visual and radiovisiography.

METHODS

Ethical approval for this study was obtained from the Cumhuriyet University Clinical Research Ethics Committee (Dat: 19.03.2019; Decision no.2019-03/06) and the study was conducted at the Faculty of Dentistry, Department of Pediatric Dentistry, Cumhuriyet University. The clinical procedure, associated risks, and benefits were fully explained to the parents of the participants and written consent form was obtained to participate before the procedure. Before the study begin, a detailed information was given to two researchers and they were calibrated.

Sample Size Calculation

A power analysis of the study was performed to determine the sample size and it was decided to take 35 teeth and the power of the test was found to be *P* = .80223. A total of thirty-five new eruptive occlusal first molars with intact or incipient caries from children aged 6-12 years who applied to Cumhuriyet University Faculty of Dentistry, Department of Pediatric Dentistry, were included in the study. Teeth with occlusal restoration and fissure sealant, hypoplastic pits and open occlusal cavitating teeth were excluded from the study. After the plaque or dental calculus was removed from the selected teeth, it was examined by visual, radiovisiography and CP device by two researchers with independent clinical experience.

The selected teeth were first air-dried and then determined under reflector light without using probes, according to the ICDAS-II' s VE scoring system by two independent researchers with different clinical experience.

Score 0: Healthy tooth surface (no signs of caries after air drying for 5 seconds)

Score 1: First visual changes in enamel (color change or opacity in pits and fissures, not visible when moist, but observed after tooth drying)

Score 2: Significant changes in enamel (color change or opacity in pits and fissures, which can be observed when both are moist and dry)

Score 3: Local enamel destruction due to caries that do not appear dentin (discoloration or opacity with a wider spread than pits and fissures observed when both are moist and dry)

Score 4: Dark shading observed from dentin (no enamel destruction)

Score 5: Visible cavity formation including dentin (demineralization and exposure of dentin to the naked eye)

Score 6: The condition of the caries will be diagnosed using the presence of a large cavity with more than half of the tooth showing dentin. [13-16]

After the VE, to ensure standardization for radiographic examination (RE), periapical radiographs were taken by the same technician each time using the parallel technique with the Planmeca ProX (Planmeca Oy, Helsinki, Finland) device. The images obtained were obtained from two independent clinical studies by Extrand et al. [17] the radiographic scoring criteria used in this study were modified according to our study and recorded by scoring as shown in Table 1.

Table 1. Scoring Criteria

	Code 0	Code 1	Code 2
RE	No radiolucency	Enamel has radiolucency	Radiolucency of the outer half of the dentin
ICDAS-II	ICDAS 0	ICDAS-II (I-II-III)	ICDAS-II (IV)
CP	0-20	21-90	91-100
VE	No caries	Caries in enamel	Caries in dentin

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

After VE and RE the teeth were measured with CP. CP was calibrated using a special ceramic piece. For occlusal surface evaluation, the tip of the target fissure probe was placed directly and parallel to the long axis of the tooth. After the tip remained on the tooth surface for about 3-5 seconds, a score ranging from 0 to 100 was determined. Score ranging from 0 to 50 indicates low caries; A score ranging from 51 to 90 indicates moderate caries, and a score ranging from 91 to 100 indicates high caries. Red, Yellow and Green LED pyramids are illuminated on the device in response to the numerical score. Accordingly, the green pyramid indicates 0-50, yellow 51-90 and 91-100 red. The instrument was scored between 0 and 100 with colored light depending on the presence of decalcification on the caries or tooth surface.

Statistical Analysis

The data were analyzed with the Statistical Package for Social Sciences (SPSS) for Windows software 22.0 (IBM SPSS Corp., Armonk, NY, USA) package program. Intra-observer reproducibility was analyzed by Cohen's Kappa (κ) for in vivo study observers. Comparison of distributions among tested groups was assessed by chi-square test. To compare the methods, sensitivity and specificity were calculated and a *P* value of <0.05 was considered statistically significant.

RESULTS

The distribution of ICDAS-II, RE, CP and cavity scores for each examiners are shown in Table 2. With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II (*P*<.001 and *P*<.002), no significant difference was found among other groups. According to radiographic evaluations, there was a significant p value but a decreased compatibility was seen between the observers. There was a high compatibility at code 1 level between the observers. According CP evaluations, there was no statistically differences between the observers but a decreased significance was seen. According to cavity scores evaluation, there was a statistically significance (Table 3).

A high inter observer agreement and moderately good kappa value (0.579) were seen. The table showed an increased kappa value (0.837) between the observers. ICDAS-II and CP showed increased sensitivity results and intermediate specificity scores were seen. According to statistical analysis, ICDAS-II and CP showed reliable results than other methods (Table 4).

Table 2. ICDAS-II, RE, CP and cavity scores for each examiners

	Scores	Examiner 1	Examiner 2
ICDAS-II	0	28	25
	1	7	10
RE	0	7	7
	1	17	15
	2	11	13
CP	0	6	5
	1	29	30
VE	0	5	6
	1	19	16
	2	11	13

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

Table 3. p- values of intra-observer agreement with regards to test methods

	Clinician 1				Clinician 2			
	ICDAS-II	RE	CP	VE	ICDAS-II	RE	CP	VE
ICDAS-II	-	.371	.001*	.491	-	.405	.002*	.739
RE		-	.028	.793		-	.033	.317
CP			-	.034			-	.011

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro
**P* <.05 was accepted as significance level.

Table 4. Sensitivity, specificity scores and kappa value of each method in terms of the presence of caries

	Sensitivity	Specificity	Kappa value
ICDAS-II	0.997	0.437	0.837
RE	0.421	0.435	0.145
CP	0.989	0.375	0.246
VE	0.896	0.467	0.579

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

DISCUSSION

The null hypothesis of the study was rejected. With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II, no significant difference was found among other groups.

This study investigated the performance of traditional caries diagnosis methods in new eruptive occlusal first molars with CP, which is based on electrical conduction differences between intact and decayed tissues.

According to the data of our study, it was shown that ICDAS-II had the highest validity and reproducibility for caries assessment compared to the other three systems; these results were similar to other researches. [1,18,19] Higher sensitivities than the specificities obtained from the detection methods used in this study were observed. However, Shoaib et al. [20] and Jablonski-Momeni et al. [21] specificity is higher than sensitivity. Both examiners in this study were inexperienced in the use of ICDAS-II, but in the Shoaib et al's[20] study, examiners had prior experience, training, and practice, which may have led to a tendency to better detect absence rather than presence of the initial lesion.

CP, one of the new caries detection methods in dentistry practice, was introduced and started to be used. Ari et al. [22] also determined in their study that ICDAS-II was superior to CP in the diagnosis of caries. Surme et al. [19] in their study, in which they evaluated occlusal caries detection methods in primary and permanent teeth, they reported that CP showed higher sensitivity than radiographic evaluation and VE in both dentitions. Popuri et al. [23] reported that CP showed higher sensitivity than traditional methods in their study in which they compared traditional methods and CP in caries detection. Despite this, Jablonski-Momeni et al. [21] reported in their study that CP is not suitable for use in primary teeth, since permanent molars have both deeper and more complex fissures than primary teeth. The use of CP, the age of the patients, the diameter of the dentinal tubules have a decisive importance in the interpretation of the measurement results. It contains less electrically conductive electrolyte due to reduced tubule diameters due to apposition with age, resulting in an overall higher resistance. [24,25] This may lead to different results regarding caries pro in studies.

The lowest sensitivity in our study was seen in the RE group. This was to be expected, as initial occlusal carious lesions in tissues were difficult to detect radiographically due to overlapping of buccal and lingual enamel. [26] Therefore, RE was not found suitable for the detection of occlusal enamel caries.

Reproducibility was evaluated by means of kappa values among all methods included in our study. In our study, the highest kappa value was obtained from ICDAS-II (0.837) and the lowest value was obtained from RE (0.145) and CP (0.246). Jablonski-Momeni et al. [21] also found CP to have a low kappa value among examiners. Neuhaus et al. [27] reported low values (0.23–0.35) for the three methods they evaluated in their study (VE, ICDAS-II, and RE), and reported that these methods depend on subjective aspects such as the background knowledge and individual clinical experience of the relevant examiners. [28,29] In addition, Rodrigues et al. [30] found a low kappa value for inter-rater reproducibility (0.19). The difference in results, the difference between kappa values for in-person reproducibility, and the subjective characteristics of the examiners may be the effect. Also, our findings of low reproducibility with the CP method may be due to the fact that the method is new to both examiners. However, before the research, the same preparatory training was given to the two examiners.

Ismail et al. [31] have reported excellent reliability of ICDAS-II, even when used by examiners without epidemiological dental examination experience. Chesters et al. [32] found that the new but trained examiners in clinical trials had a kappa value of over 0.80 over a long period of time. In our study, the validity and reliability of ICDAS-II was found to be high and the kappa value was found to be very good. These results support the literature.

CONCLUSION

The limitation of our in vivo study is that the methods used for the diagnosis of occlusal caries were evaluated only on newly erupted permanent molars. Within the limitations of the in vivo study, the ICDAS-II method alone appears to be sufficient for the diagnosis of occlusal caries. It was concluded that the CP technique showed a low ability to reveal occlusal carious lesions on enamel and/or dentin in newly erupted permanent molars. Clinicians should keep in mind that visual aids have the potential to improve early caries detection and clinical diagnostic performance in children. Further in vivo studies of occlusal caries detection are needed to better reflect the clinical situation.

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Evaluation of Knowledge and Attitudes of Dentists and Dental Students about Oral Cancer

Diş Hekimleri ve Diş Hekimliği Öğrencilerinin Ağız Kanserine İlişkin Bilgi ve Tutumlarının Değerlendirilmesi

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ABSTRACT

Objective: This study aimed to evaluate the knowledge and negative attitudes of dentists and 4th-grade and 5th-grade students of dentistry towards oral cancer (OC).

Methods: The study was conducted on 417 individuals consisting of 100 dentists, 186 5th-grade, and 131 4th-grade students. The questionnaire included questions on demographic characteristics, 10 questions measuring their knowledge about OC risk factors (knowledge-risk factors), 5 questions measuring their knowledge regarding the diagnosis of OC (knowledge-diagnostic procedures), and 11 questions assessing their attitudes towards OC (negative attitudes).

Results: While there is no significant difference between dentists and 5th-grade students in knowledge-risk factors and knowledge-diagnostic procedures total scores, the total score of the 4th-grade students was statistically significantly different from these groups (*P* =.001). Looking at the negative attitudes total score, there is no significant difference between 5th and 4th-grade students, while total score of dentists was observed a statistically significant difference (*P*=.001). While knowledge-risk factors and knowledge-diagnostic procedures total scores were significantly and positively correlated (r=.287, *P*<.05), negative attitudes total score showed a significant negative correlation with knowledge-risk factors total score (r=.103, *P*<.05). Deficiencies were observed regarding the clinical characteristics of the prior oral lesion among participants. The group who considered leukoplakia and erythroplakia most likely to become precancerous lesions were 5th-grade students by 81.7%. Most participants indicated their need for further training, especially on OC and screening.

Conclusion: In the study, deficiencies were observed in the groups about OC. Therefore, deficiencies should be assessed comprehensively at regional and national levels, and it should be addressed.

Keywords: Dental student, dentists, knowledge, mouth neoplasms, risk factors, squamous cell carcinoma.

ÖZ

Amaç: Bu çalışmada diş hekimleri ile diş hekimliği 4. ve 5. sınıf öğrencilerinin ağız kanserine (AK) yönelik bilgi ve olumsuz tutumlarının değerlendirilmesi amaçlandı.

Yöntemler: Araştırma 100'ü diş hekimi, 186'sı 5. sınıf ve 131'i 4. sınıf öğrencisi olmak üzere 417 kişi üzerinde gerçekleştirildi. Ankette demografik özelliklere ilişkin sorular, AK risk faktörleri (bilgi-risk faktörleri) hakkındaki bilgilerini ölçen 10 soru, AK tanısına (bilgi-teşhis prosedürleri) ilişkin bilgilerini ölçen 5 soru ve AK'ye yönelik tutumlarını (olumsuz tutumlar) değerlendiren 11 soru yer aldı.

Bulgular: Diş hekimleri ve 5. sınıf öğrencileri arasında bilgi-risk faktörleri ve bilgi-teşhis prosedürleri toplam puanları arasında anlamlı bir fark bulunmazken, 4. sınıf öğrencilerinin toplam puanları bu gruplardan istatistiksel olarak anlamlı derecede farklıydı (*P* =,001). Olumsuz tutumlar toplam puanına bakıldığında 5. ve 4. sınıf öğrencileri arasında anlamlı bir fark bulunmazken, diş hekimlerinin toplam puanları istatistiksel olarak anlamlı farklı idi (*P* =,001). Bilgi-risk faktörleri ve bilgi-teşhis prosedürleri toplam puanları anlamlı ve pozitif yönde korelasyon gösterirken (r=.287, *P*<,05), olumsuz tutumlar toplam puanı ile bilgi-risk faktörleri toplam puanı arasında anlamlı ve negatif korelasyon bulundu (r=.103, *P*< ,05). Katılımcılar arasında eski oral lezyonun klinik özelliklerine ilişkin eksiklikler gözlendi. Lökoplaki ve eritroplaki'nin kanser öncesi lezyonlara dönüşme olasılığını en fazla düşünen grup %81,7 ile 5. sınıf öğrencileri oldu. Katılımcıların çoğu, özellikle AK ve tarama konusunda daha fazla eğitime ihtiyaçları olduğunu belirtti.

Sonuç: Araştırmada gruplarda AK konusunda eksiklikler gözlendi. Bu nedenle eksiklikler bölgesel ve ulusal düzeyde kapsamlı bir şekilde değerlendirilmeli ve giderilmelidir.

Anahtar Kelimeler: Diş hekimliği öğrencisi, diş hekimi, bilgi, ağız neoplazmaları, risk faktörleri, yassı hücreli karsinom

INTRODUCTION

Oral cancer (OC) is defined as any malignant neoplasm of the lips and oral cavity and is referred to by the codes C00-C06 in the 10th revision of the International Classification of Diseases [ICD-10].[1, 2] The global

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incidence of three type of cancer (lip, oral cavity, and pharyngeal cancer), which accounts for 3.8% of all cancer cases, is projected to increase by 62% by 2035 due to possible changes in demographic characteristics.[3] In a review of studies limited to Asian populations, the prevalence of OC was reported as 8.5 per 100,000 people per year.[4] In most countries, mortality rates due to OC are estimated at 3-4 per 100,000 male and 1.5-2 per 100,000 female.[2] Squamous cell carcinoma (SCC), a particularly malignant type of this disease, accounts for more than 90% of oral malignancies in the upper respiratory-digestive tract.[2, 5] In this type of cancer, the annual incidence of secondary tumors was reported to be between 3% and 7%, an extremely high rate compared to several malignancies.[5] In addition, precancerous malignant diseases such as leukoplakia and erythroplakia are responsible for the increased risk of cancer development.[6]

Early diagnosis is critical in OC. A diagnosis delayed by more than one month significantly increases the risk of developing advanced OC.[7] This is because the likelihood of having advanced-stage cancer is 30% lower in patients diagnosed early compared to individuals with delayed diagnosis.[7] Insufficient knowledge about OC may also lead to delayed diagnosis. It was proven that the diagnostic ability of primary health care professionals is directly related to their knowledge regarding OC.[8] In this regard, dentists and dental students, who will be the future dental health workforce, play a vital role. Since they can easily access the oral cavity, they have an ideal advantage for opportunistic scans in diagnosing OC. Consequently, reducing the diagnostic delay in OC or precancerous lesions may be related to regular visits to dental clinics and opportunistic screening.[9] Nevertheless, negative attitudes and insufficient knowledge of the dentist may cause delayed diagnosis or underdiagnosis of OC.

Deficiencies were found in informing patients about the risk factors and symptoms of OC.[10] According to a recent study conducted among 130 dentists, more than half of the participants reported that they did not perform a special examination for identifying OC in asymptomatic patients aged 40 years and older.[11] The same participants reported that lack of training was a critical factor in performing a thorough OC examination.[11] In addition, the studies conducted with dental students and dental hygienists concluded that there were deficiencies in attitudes and awareness regarding OC, and training programs should be developed.[12-16] These results suggest that there is an alarming lack of awareness about OC.[2] Consequently, this study aimed to evaluate the knowledge and negative attitudes towards OC among dentists and 4th and 5th-grade dental students actively treating patients and identify the points considered insufficient. In this study, it was tried to determine the differences or deficiencies in the performances of dentistry and 4th and 5th- grade dentists regarding OC.

METHODS

Ethics committee approval of this study was obtained from Van Yuzuncu Yil University Non-Interventional Clinical Research Ethics Committee with decision number 2023/07-11 (14.07.2023). The study was designed as a joint study of the Periodontology departments of the Faculties of Dentistry at Van Yuzuncu Yil and Firat Universities. After the participants were informed about the purpose, scope, and method of the study, participants who agreed to participate in the face-to-face questionnaire were included. Dentists who did not agree to participate in the study, who responded to the questionnaire incompletely, or who did not actively treat patients for various reasons, and 1st, 2nd, and 3rd-year dental students were excluded.

The first part of the questionnaire included questions on demographic characteristics. The second part consisted of 10 questions measuring participants' knowledge about OC risk factors (knowledge-risk factors), the third part consisted of 5 questions measuring their knowledge of OC diagnosis procedures (knowledge-diagnosis procedures), and the final part consisted of 11 questions assessing participants' attitudes towards OC (negative attitude). The questions of the questionnaire were prepared from the questions used in previous studies.[10, 17-21] The study was initiated after 7 dentists and 12 dental students who were not included in the study read the questions, and the comprehensibility of the questionnaire was tested.

The questions regarding OC risk factors were answered as "yes, no, or don't know." The responses of each participant were evaluated separately, and the total score of the knowledge-risk factors was calculated. Each correct answer was scored 1 point.[22] The total score represented the total score of OC-risk knowledge for that participant (minimum 0, maximum 10 points). A higher score represented a higher level of knowledge-risk factors.

In the questions on OC diagnosis, the responses of each participant were evaluated separately, and the total score of the participant's diagnostic knowledge was calculated by assigning 1 point for each correct answer (minimum 0, maximum 5 points). A higher score represented a higher level of OC-diagnostic knowledge procedures.

The answers to the questions assessing attitudes about OC were given on a 5-point Likert-type scale, consisting of strongly agree, agree, undecided, disagree, and strongly disagree.[22] The total score for OC was calculated based on the following points: Strongly agree=1, agree=2, undecided=3, disagree=4, and strongly disagree=5 (minimum 11, maximum 55). Therefore, a high score expressed the negative attitudes of the participants about OC. A lower score represented a more positive attitude towards OC.

Statistical analysis

Descriptive statistics for the continuous variables were presented as mean, standard deviation, minimum and maximum values while count and percentages for categorical variables. One-way ANOVA was performed for the comparison of group means. Duncan multiple comparison test was also used to identify different groups. Pearson correlation analysis was carried out to examine linear relationships among the continuous variables while Chi-square test was performed to determine the relationship between categorical variables. In addition, Non-linear principal component analysis was performed to determine the configuration of the relationship between categories of variables in 2-dimensional space. Statistical significance level was considered as 5% and SPSS (ver: 21) statistical program was used for all statistical computations.

RESULTS

The study included 100 dentists (mean age 29.91 ± 5.485), 186 5th-grade students (mean age 23.24 ± 1.144), and 131 4th-grade students (mean age 22.46 ± 1.223), totalling 417 participants (Table 1). The length of experience was between 4.930 ± 5.481 years (minimum 1 year, maximum 35 years).

The data related to the mean total scores of knowledge-risk factors, knowledge-diagnostic procedures, and negative attitudes among the groups are presented in Table 1. Significant differences were found between the groups in terms of the mean total scores (*P*=.001). While there is no significant difference between dentists and 5th-grade

students in knowledge-risk factors and knowledge-diagnostic procedures total scores, the total score of the 4th-grade students was statistically significantly different from these groups. Accordingly, dentists and 5th-grade students achieved similar scores in knowledge-risk factors total score and knowledge-diagnostic procedures total score, while 4th-grade students scored lower. Looking at the negative attitudes total score, there is no significant difference between 5th and 4th-grade students, while total score of dentists was observed a statistically significant difference. Accordingly, 5th and 4th-grade students had similar total scores, while dentists scored significantly lower.

Table 1. The data related to the mean total scores of ages, knowledge-risk factors, knowledge-diagnostic procedures, and negative attitudes among the groups

		n	Mean	Std. Dev.	Min.	Max.	*P*
Age	Dentists	100	29.91 a	5.485	22	59	.001*
	5th grade students	186	23.24 b	1.144	21	28	
	4th grade students	131	22.46 b	1.223	20	28	
	Total	417	24.59	4.154	20	59	
Knowledge risk factors (Total score)	Dentists	100	8.05 a	1.175	4	10	.001*
	5th-grade students	186	7.96 a	1.438	0	10	
	4th-grade students	131	7.10 b	1.528	1	10	
	Total	417	7.71	1.467	0	10	
Knowledge diagnostic procedures (Total score)	Dentists	100	3.17 a	1.111	0	5	.001*
	5th-grade students	186	3.16 a	0.951	1	5	
	4th-grade students	131	1.80 b	1.286	0	5	
	Total	417	2.74	1.270	0	5	
Negative attitude (Total score)	Dentists	100	26.16 b	6.055	12	41	.001*
	5th-grade students	186	28.02 a	5.802	11	43	
	4th-grade students	131	27.82 a	6.119	13	49	
	Total	417	27.51	5.998	11	49	

a, b: Different lowercase represents statistically significant differences among the groups
Statistically significant difference at *P<.05

Categorical principal components analysis was conducted to determine the structure of the relationship between the variables (the explanatory value of the first dimension was 32.7% and the second dimension 18.96%. The two dimensions had a total explanatory value of 51.66%) (Figure 1). According to the first dimension, female dentists aged between 25 and 59 years tended to have lower negative attitudes total scores and higher knowledge-diagnostic procedures and knowledge-risk factors total scores. The 4th and 5th-grade dental students tended to have lower scores in knowledge-diagnostic procedures and knowledge-risk factors total scores and higher scores in terms of negative attitudes total scores. In the second dimension, the 4th and 5th-grade male dental students between 20 and 24 years of age were observed to have higher negative attitudes total scores.

While knowledge-risk factors and knowledge-diagnostic procedures total scores were significantly and positively correlated (r=0.287, *P*<.05), negative attitudes total score showed a significant negative correlation with knowledge-risk factors total score (r=0.103, *P*<.05) and a non-significant negative correlation with knowledge-diagnostic procedures total score (r=0.035, *P*>.05) (Table 2, Figure 1).

The data related to the comparison of age and mean total scores between genders within the group are presented in Table 3. As presented in the table, no significant difference was observed between genders among dentists regarding all three total scores. In 5th-grade students, a significant difference was found in the mean total scores of knowledge-diagnostic procedures and negative attitudes between genders (*P*=.026, *P*=.037, respectively). Accordingly, female scored higher in knowledge-diagnostic procedures and negative attitude total scores compared to male. In 4th-grade students, a significant difference between genders was found only in the mean total score of knowledge-diagnostic procedures (*P*=.001). Accordingly, female scored higher in knowledge-diagnostic procedures total score compared to male.

Table 2. Correlation between total score averages of knowledge-risk factors, knowledge-diagnostic procedures and negative attitude

	Knowledge-risk factors (Total score)	Knowledge-diagnostic procedures (Total score)	Negative attitude (Total score)
Knowledge-risk factors (Total score)	1		
Knowledge-diagnostic procedures (Total score)	.287**	1	
Negative attitude (Total score)	-.103*	-.035	1

Statistically significant difference at *P<.05

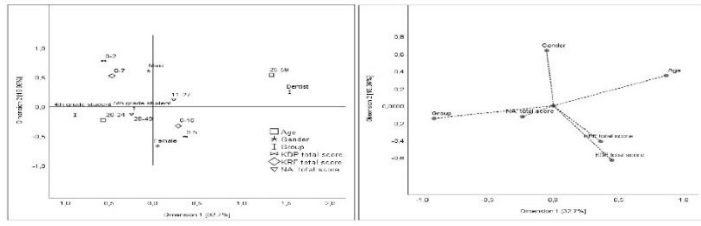

Figure 1. The relationship between the variables with categorical principal components analysis
(KDP: knowledge-diagnostic procedures, KRF: knowledge-risk factors, NA: negative attitude)

The responses to each question on knowledge-risk factors and comparisons between groups are presented in Table 4. No statistically significant difference was found between the groups in terms of responses to the questions on smoking, autoimmunity, obesity, prior oral cancer lesion, and chronic infection among OC risk factors. A statistically significant difference was determined between the groups in the responses to the questions about alcohol consumption, sun exposure, viral infection (e.g., HPV), nutrition diet (e.g., low consumption of fruits and vegetables), and advanced age (*P*<.05).

Responses regarding OC knowledge-diagnostic procedures and comparisons between groups are presented in Figures 2 and 3. The most common involvement sites of OC were reported as the floor of the mouth and under the tongue by 71% of dentists, 52.7% of 5th-grade students, and 34.4% of 4th-grade students. The group who considered leukoplakia and erythroplakia most likely to become precancerous lesions were the 5th-grade students by 81.7%. On the other hand, 49% of the 4th-grade students responded with "Don't know." While the majority of dentists (93%) and 5th-grade students (98.9%) responded to the most common type of OC as SCC, only 44.3% of the 4th-grade students responded the same, and 35.1% of the 4th-grade students responded with "Don't know." According to 68.3% of the 5th-grade students, the age group in which OC was most frequently diagnosed was

Table 3. The data related to the comparison of age and mean total scores between genders within the group

Dentists		n	Mean	Std. Dev.	Min.	Max.	*P*
Age	Female	55	29.91	5.264	22	46	.999
	Male	45	29.91	5.803	24	59	
	Total	100	29.91	5.485	22	59	
Knowledge-risk factors (Total score)	Female	55	7.96	1.217	5	10	.419
	Male	45	8.16	1.127	4	10	
	Total	100	8.05	1.175	4	10	
Knowledge-diagnostic procedures (Total score)	Female	55	3.07	1.136	0	5	.335
	Male	45	3.29	1.079	0	5	
	Total	100	3.17	1.111	0	5	
Negative attitude (Total score)	Female	55	26.13	6.034	12	38	.953
	Male	45	26.20	6.148	12	41	
	Total	100	26.16	6.055	12	41	
5th-grade students							
Age	Female	79	22.90	0.841	21	25	.001*
	Male	107	23.50	1.269	21	28	
	Total	186	23.24	1.144	21	28	
Knowledge-risk factors (Total score)	Female	79	8.16	1.213	5	10	.100
	Male	107	7.81	1.573	0	10	
	Total	186	7.96	1.438	0	10	
Knowledge-diagnostic procedures (Total score)	Female	79	3.34	0.861	1	5	.026*
	Male	107	3.03	0.995	1	5	
	Total	186	3.16	0.951	1	5	
Negative attitude (Total score)	Female	79	29.05	5.602	11	40	.037*
	Male	107	27.26	5.856	11	43	
	Total	186	28.02	5.802	11	43	
4th-grade students							
Age	Female	65	22.29	1.271	20	27	.124
	Male	66	22.62	1.160	21	28	
	Total	131	22.46	1.223	20	28	
Knowledge-risk factors (Total score)	Female	65	7.20	1.416	5	10	.456
	Male	66	7.00	1.636	1	10	
	Total	131	7.10	1.528	1	10	
Knowledge-diagnostic procedures (Total score)	Female	65	2.23	1.196	0	5	.001*
	Male	66	1.38	1.237	0	5	
	Total	131	1.80	1.286	0	5	
Negative attitude (Total score)	Female	65	28.03	5.291	17	41	.703
	Male	66	27.62	6.872	13	49	
	Total	131	27.82	6.119	13	49	

Statistically significant difference at **P*<.05

Table 4. The responses to each question on knowledge-risk factors and comparisons between groups

		Group n (%)		
		Dentists	5th-grade students	4th-grade students
Smoking	Yes	100 (100%)	184 (98.9%)	127 (96.9%)
	No	0 (0%)	2 (1.1%)	4 (3.1%)
	I don't know	0 (0%)	0 (0%)	0 (0%)
P= .133				
Alcohol	Yes	94 (94%)	168 (90.3%)	97 (74%)
	No	4 (4%)	13 (7%)	17 (13%)
	I don't know	2 (2%)	5 (2.7%)	17 (13%)
P= .001*				
Sun exposure	Yes	76 (76%)	144 (77.4%)	66 (50.4%)
	No	10 (10%)	12 (6.5%)	23 (17.6%)
	I don't know	14 (14%)	30 (16.1%)	42 (32.1%)
P= .001*				
Viral infection (e.g. HPV)	Yes	90 (90%)	170 (91.4%)	110 (84%)
	No	3 (3%)	11 (5.9%)	6 (4.6%)
	I don't know	7 (7%)	5 (2.7%)	15 (11.5%)
P=.028*				
Nutrition diet (e.g. low consumption of fruits and vegetables)	Yes	67 (67%)	149 (80.1%)	92 (70.2%)
	No	14 (14%)	20 (10.8%)	25 (19.1%)
	I don't know	19 (19%)	17 (9.1%)	14 (10.7%)
P=.025*				
Advanced age	Yes	80 (80%)	148 (79.6%)	73 (55.7%)
	No	11 (11%)	23 (12.4%)	26 (19.8%)
	I don't know	9 (9%)	15 (8.1%)	32 (24.4%)
P=.001*				
Autoimmune	Yes	92 (92%)	162 (87.1%)	110 (84%)
	No	6 (6%)	6 (3.2%)	6 (4.5%)
	I don't know	2 (2%)	18 (9.7%)	15 (11.5%)
P=.081				
Obesity	Yes	44 (44%)	101 (54.3%)	79 (60.3%)
	No	24 (24%)	40 (21.5%)	26 (19.8%)
	I don't know	32 (32%)	45 (24.2%)	26 (19.8%)
P=0.152				
Prior oral cancer lesion	Yes	98 (98%)	176 (94.6%)	127 (96.9%)
	No	0 (0%)	6 (3.2%)	0 (0%)
	I don't know	2 (2%)	4 (2.2%)	4 (3.1%)
P=.096				
Chronic infection	Yes	84 (84%)	143 (76.9%)	109 (83.2%)
	No	7 (7%)	19 (10.2%)	8 (6.1%)
	I don't know	9 (9%)	24 (12.9%)	14 (10.7%)
P=.506				

Statistically significant difference at * *P*<.05

Table 5. The responses regarding attitudes about oral cancer and comparisons between the groups

	Group	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
I report to my patients with suspicious oral lesions	Dentists	70 (70%)	28 (28%)	1 (1%)	1 (1%)	0 (%)
	5th-grade students	101 (54.3%)	70 (37.6%)	10 (5.4%)	5 (2.7%)	0 (%)
	4th-grade students	70 (53.4%)	50 (38.2%)	10 (7.6%)	1 (0.8%)	0 (%)
	P=.05					
I give my patients adequate information about oral cancer risk factors	Dentists	16 (16%)	30 (30%)	30 (30%)	24 (24%)	0 (%)
	5th-grade students	28 (15.1%)	63 (33.9%)	65 (34.9%)	27 (14.5%)	3 (1.6%)
	4th-grade students	30 (22.9%)	44 (33.6%)	34 (26%)	22 (16.8%)	1 (0.8%)
	P=.231					
I give my patients enough information about the signs and symptoms of oral cancer	Dentists	11 (11%)	29 (29%)	37 (37%)	23 (23%)	0 (0%)
	5th-grade students	20 (10.8%)	54 (29%)	70 (37.6%)	40 (21.5%)	2 (1.1%)
	4th-grade students	25 (19.1%)	43 (32.8%)	32 (24.4%)	28 (21.4%)	3 (2.3%)
	P=.145					
I have received sufficient training to perform an oral cancer examination	Dentists	12 (12%)	24 (24%)	33 (33%)	20 (20%)	11 (11%)
	5th-grade students	11 (5.9%)	22 (11.8%)	66 (35.5%)	63 (33.9%)	24 (12.9%)
	4th-grade students	4 (3.1%)	9 (6.9%)	39 (29.8%)	43 (32.8%)	36 (27.5%)
	P=.001*					
I received sufficient training for patient's lymph node palpation	Dentists	18 (18%)	37 (37%)	30 (30%)	8 (8%)	7 (7%)
	5th-grade students	12 (6.5%)	54 (29%)	51 (27.4%)	47 (25.3%)	22 (11.8%)
	4th grade students	5 (3.8%)	31 (23.7%)	34 (26%)	39 (29.8%)	22 (16.8%)
	P=.001*					
I request my patient for laboratory tests in case of suspicious lesions	Dentist	22 (22%)	28 (28%)	23 (23%)	19 (19%)	8 (8%)
	5th-grade students	14 (7.5%)	41 (22%)	46 (24.7%)	46 (24.7%)	39 (21%)
	4th-grade students	19 (14.5%)	46 (35.1%)	26 (19.8%)	28 (21.4%)	12 (9.2%)
	P=.001*					
I am knowledgeable about self-examination techniques for diagnosing oral cancer	Dentists	7 (7%)	22 (22%)	25 (25%)	34 (34%)	12 (12%)
	5th grade students	10 (5.4%)	40 (21.5%)	55 (29.6%)	54 (29%)	27 (14.5%)
	4th grade students	4 (3.1%)	19 (14.5%)	40 (30.5%)	42 (32.1%)	26 (19.8%)
	P= .439					
I examine my patients aged 40 and over for oral cancer or refer them to a specialist for this examination.	Dentist	10 (10%)	18 (18%)	28 (28%)	34 (34%)	10 (10%)
	5th-grade students	15 (8.1%)	39 (21%)	51 (27.4%)	67 (36%)	14 (7.5%)
	4th-grade students	13 (9.9%)	46 (35.1%)	29 (22.1%)	32 (24.4%)	11 (8.4%)
	P=.082					
I refer my patient with suspicious lesion to the oral and maxillofacial surgery department	Dentists	62 (62%)	28 (28%)	3 (3%)	5 (5%)	2 (2%)
	5th-grade students	82 (44.1%)	88 (47.3%)	6 (3.2%)	10 (5.4%)	0 (0%)
	4th-grade students	47 (35.9%)	63 (48.1%)	11 (8.4%)	8 (6.1%)	2 (1.5%)
	P=.002*					
I refer my patient with suspicious lesion to the periodontology department	Dentists	38 (38%)	30 (30%)	11 (11%)	15 (15%)	6 (6%)
	5th grade students	54 (29%)	94 (50.5%)	23 (12.4%)	14 (7.5%)	1 (0.5%)
	4th grade students	48 (36.6%)	64 (48.9%)	10 (7.6%)	6 (4.6%)	3 (2.3%)
	P=.001*					
Dentists need more education about and screening for oral cancer	Dentists	76 (76%)	21 (21%)	3 (3%)	0 (0%)	0 (0%)
	5th-grade students	134 (72%)	42 (22.6%)	6 (3.2%)	2 (1.1%)	2 (1.1%)
	4th-grade students	95 (72.5%)	29 (22.1%)	4 (3.1%)	1 (0.8%)	2 (1.5%)
	P=.951					

Statistically significant difference at * *P*<.05

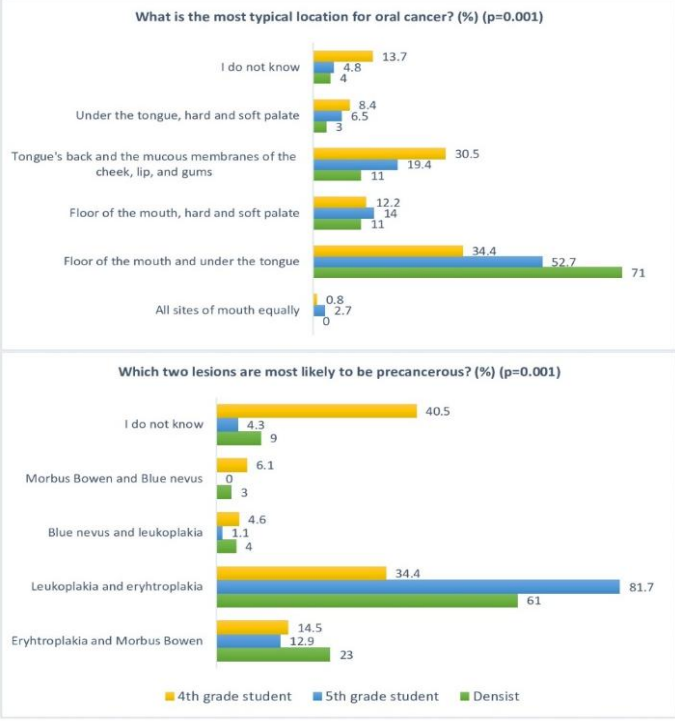

Figure 2. Responses regarding OC knowledge-diagnostic procedures and comparisons between groups

40-60 years, while this rate was 48.1% among the 4th-grade students and 61% among dentists. The clinical features of the prior OC lesion were described as a "small, painless, and red area" by 31% of the dentists, 16.7% of the 5th-grade students, and 18.3% of the 4th-grade students.

The responses regarding attitudes and comparisons between the groups are presented in Table 5. Among the participants, 33% of the dentists and 35.5% of the 5th-grade students responded to having received sufficient training for an OC examination with "undecided," while 32.8% of the 4th-grade students responded with "disagree." While 37% of dentists and 29% of the 5th-grade students agreed that they had sufficient training on lymph node palpation, 29.8% of the 4th-grade students disagreed. The most common response to requesting laboratory tests in case of suspicious lesions was 'agree' among dentists and the 4th-grade students, whereas it was 'undecided' and 'disagree' among the 5th-grade students. In all three groups, the majority of the participants responded with "strongly agree" to the need for further training.

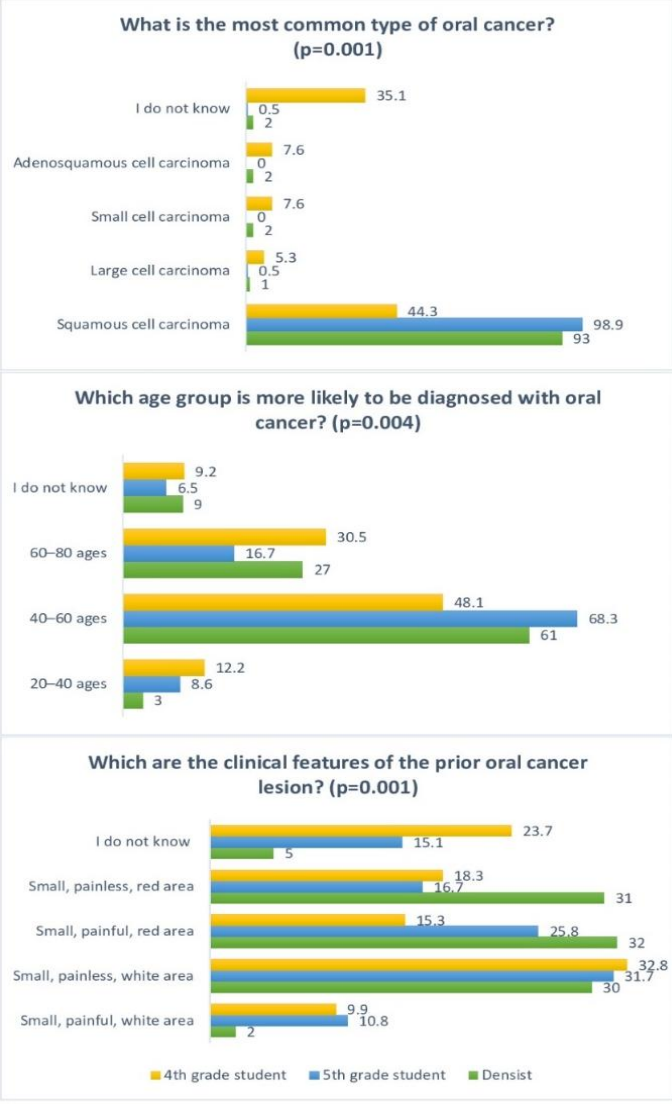

Figure 3. Responses regarding OC knowledge-diagnostic procedures and comparisons between groups

DISCUSSION

This study aimed to investigate the knowledge and attitudes of dentists and dental students about OC and identify the deficiencies. When the negative attitude total score was examined, it was observed that there was a statistically significant difference between the total score of dentists. The 4th-grade students were observed to be insufficient in questions about the risk factors and in terms of the total score. Insufficiency was observed in some responses. Most participants expressed the need for further training on OC and screening.

The risk factors regarding OC have been listed as smoking, alcohol consumption, human papillomavirus (HPV), and chronic inflammation.[5, 23] Autoimmune-related diseases have also been associated with an increased risk of OC.[24] Diet and nutrition have been reported to be associated with the risk of cancer development.[25] Frequent consumption of some fruits and vegetables has been associated with a reduced risk of OC and pharyngeal cancer.[25] Excessive sun ultraviolet (UV) light has been reported as a cause of lip cancer and actinic cheilitis, which can develop into oral SCCs.[25] In addition, OC has been reported to be more common in individuals over 40 years of age compared to younger individuals.[5] The practitioners' knowledge-risk factors about OC coincided with previous studies.[10,18] However, 4th-grade students were found to be incompetent in our study, particularly regarding the questions on risk factors and the total score.

The most common site prevalence of OC may vary according to countries, habits, and geographies. While the tongue accounts for 40-50% of OC in Europe and the USA, the buccal mucosa has been reported as the most common site of OC in Sri Lanka.[2] In this study, dentists reported the floor of the mouth and under the tongue as the most common sites of OC by 71%. This percentage was lower among dental students. It was determined as 37.1% by Kebabcioglu and Pekiner,[10] and 85% by Joseph et al.[20] among the dentists. On the other hand, Keser and Pekiner[18] reported this rate as 44.4% among the 5th-year students.

Leukoplakia and erythroplakia have been considered among the potential malignancy diseases of the oral mucosa.[6, 23] In a study conducted in Italy, 53.8% of dentists responded the same while,[26] Joseph et al.[20] reported as 93.2%. According to Clovis et al.,[27] 76% of participants reported that these two lesions were the most likely to be associated with OC, regardless of the rank order. In our study, 61% of the dentists and 81.7% of the 5th-grade students reported these two diseases as precancerous lesions. On the other hand, this rate was determined to be lower among the 4th-grade students.

SCC is the most common malignant type of cancer of the oral cavity.[5] Taneja et al.[28] reported this rate among dental graduates as 48%, Kebabcioglu and Pekiner as 64.7%,[10],Collela et.al.[26] as 50.5%, and Clovis et al.[27] as 83.4%. In our study, both in the dentists and the 5th-grade students, the majority responded correctly. Nevertheless, the rate of correct responses was 44.3% and responses with "Don't know" was 35.1% among the 4th-grade students.

According to the 2005-2017 records of a cancer center, the majority of patients diagnosed with OC were over 45 years of age.[29] In our study, the most common response to the age group in which OC was diagnosed most frequently was between 40 and 60 years of age in all three groups. It was also the most common response in the studies conducted by Kebabcioglu and Pekiner[10] and Keser and Pekiner.[18]

The diversity of responses in our study regarding the clinical features of the prior oral lesion was noteworthy. While the dentists responded with three different options, the most common response among the 4th and 5th-grade students was a "small, painless, and white area." Kebabcioglu and Pekiner[10] reached similar conclusions to our study. Clovis et al.[27] reported that the majority of the participants (77.3%) responded correctly to the emergence of early OC lesions as "small, painless, and red lesions."

In our study, the most common response to receiving sufficient training to perform OC examination was "undecided" among the dentists and the 5th-grade students, whereas it was "disagree" among the 4th-grade students. In a study conducted in our country, 69.3% of those who graduated before 2000 and 41.3% of those who graduated after 2000 reported as 'weak or very poor' for the education they received at university on OC.[30] According to these results, it can be expressed that participants need various arrangements regarding OC education.

The percentage of participants who agreed that the patient was sufficiently trained on lymph node palpation was high among the dentists and the 5th-grade students; however, the response with "disagree" was more common among the 4th-grade students. In a study involving intern dentistry students and academic staff, the majority of participants stated that they had received sufficient training for lymph examination.[31] The low number of participants in this study may have

caused a difference from our results. In additional, half of the dentists had positive attitudes (strongly agree and agree) towards requesting laboratory tests in case of doubt, while the rate of participants with positive attitudes was higher among the 4th-grade students compared to the 5th-grade students.

Most participants in this study indicated their need for further training, especially on OC and screening. Similar to our study, previous study can be cited.[32] Thus, it can be mentioned that training and courses on this subject should be held regularly.

Several limitations of our study, such as the lack of comparison between the specialties of dentists, the limited number of participants, the lack of visual data to test diagnostic skills, the limited number of questions to assess knowledge and attitudes, and the unknown prevalence of OC in the community, should be noted. Therefore, our results cannot be generalized, and further studies are necessary.

According to the results of our study, knowledge-risk factors and knowledge-diagnostic procedures total scores were positively correlated; however, both mean total scores were negatively correlated with the total score of the negative attitudes. The 4th-grade students were observed to be insufficient in questions about the risk factors and in terms of the total score. The group who considered leukoplakia and erythroplakia most likely to become precancerous lesions were the 5th-grade students. Deficiencies were observed regarding the clinical characteristics of the prior oral lesion. Most participants expressed the need for further training on OC and screening.

In conclusion, OC is a disease that increases the global burden of cancer; therefore, it should be assessed comprehensively at regional and national levels, and deficiencies should be addressed through effective planning. These deficiencies can be eliminated by focusing on this subject in the undergraduate curriculum and providing professional development courses.

Ethics Committee Approval: Ethics committee approval of this study was obtained from Van Yuzuncu Yil University Non-Interventional Clinical Research Ethics Committee with decision number 2023/07-11.

Informed Consent: The study was designed as a joint study of the Periodontology departments of the Faculties of Dentistry at Van Yuzuncu Yil and Firat Universities. After the participants were informed about the purpose, scope, and method of the study, participants who agreed to participate in the face-to-face questionnaire were included.

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Obstrüktif Uyku Apnesine Ortodontik Yaklaşım

Orthodontic Approach to Obstructive Sleep Apnea

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ÖZ

İnsan yaşamının büyük bir çoğunluğunu oluşturan uyku; kişinin fizyolojik, sosyal ve psikolojik durumunu önemli ölçüde etkilemektedir. Solunumla ilişkili uyku bozukluklarından en yaygın görüleni obstrüktif uyku apnesi sendromunda üst solunum yollarında hava akışı uyku boyunca aralıklı olarak kesilmektedir. Bunun sonucunda gün içinde aşırı uykulu olma hali, hormonal dengenin bozulması ve motor fonksiyonların azalması görülmektedir. Hastanın yaşam kalitesini önemli ölçüde düşüren ve çeşitli hastalıklara yatkınlığını arttıran obstrüktif uyku apnesinin tespiti oldukça mühimdir. Obstrüktif uyku apnesi tedavisinde ilk olarak bu hastalığa yol açan başlıca etkenlerin kaldırılması gerekmekte ve bunun için hastalığın predispozan faktörleri ve semptomlarının farkında olarak doğru teşhis konulması gerekmektedir. Bu çalışmanın amacı obstrüktif uyku apnesi sendromunun etiyolojisi, klinik tablosu ve tedavi seçeneklerinin değerlendirilmesidir. Pubmed, Dentistry&Oral Science, Medline ve Google Akademik veritabanları üzerinden "Apne, obstrüktif uyku apnesi sendromu, polisomnografi, oral apareyler, mandibulayı ilerletici aparey" anahtar kelimeleri kullanılarak kaynaklar incelendi.

Her geçen gün insidansı artmaya devam eden obstrüktif uyku apnesi önemli bir halk sağlığı problemi haline gelmekte ve multifaktöriyel bir etyolojiye sahip olduğu için obstrüktif uyku apnesi hastalarına multisipliner teşhis ve tedavi yaklaşımı uygulanması gerekmektedir.

Oral apareyler hafif-orta şiddetli obstrüktif uyku apnesi vakalarında yüksek başarı oranı göstermiştir. Etkin oral aparey tedavisi için hasta ve aparey tipi seçimi önem taşımaktadır.

Anahtar Kelimeler: Uyku apnesi, obstrüktif; horlama; ortodonti; polisomnografi; ortodontik aletler, hareketli aygıt; mandibula ilerletmek.

ABSTRACT

Sleep, that is one of the most critical factors for human life; affects the physiological, social and psychological condition of a person. In obstructive sleep apnea syndrome, which is the most common respiratory-related sleep disorder, air flow in the upper respiratory tract is intermittently interrupted during sleep. Thus, excessive daytime sleepiness deterioration of hormonal balance and decreased motor function are observed. Diagnosing the obstructive sleep apnea which significantly reduces the patients' quality of life and increases their susceptibility to various diseases, is highly critical. The main factor in the treatment of obstructive sleep apnea is to eleminate the etiological factor. Therefore, diagnosis should be made accurately based on the crticial evaluation of predisposing factors and symptoms of this disease. The aim of this study is to evaluate the etiology, clinical picture and treatment options of obstructive sleep apnea syndrome.

Resources were reviewed using the keywords "Apnea, obstructive sleep apnea syndrome, polysomnography, oral appliances, mandibular advancement splint" on Pubmed, Dentistry & Oral Science, Medline and Google Scholar databases.

The prevelance of obstructive sleep apnea has steadily increase. Therefore it has become an important public health problem. Obstructive sleep apnea has a multifactorial etiology, a multidisciplinary diagnosis and treatment approach should be applied to patients with obstructive sleep apnea.

Oral appliances have a high success rate in cases of mild to moderate obstructive sleep apnea. However, appropriate indication and appliance type selection is critical for effective treatment of obstructive sleep apnea.

Keywords: Sleep apnea, obstructive; snoring; orthodontics; polysomnography; orthodontic appliances, removable appliance; mandibular advancement

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GİRİŞ

Obstrüktif uyku apnesi (OUA) uyku sırasında tekrarlayan üst yolunum yolu tıkanmaları ile azalan hava akımı (hipopne) veya tamamen hava akımının kesilmesi (apne) ve bunun sonucunda kandaki oksijen satürasyonunun düşmesi ile karakterizedir. Apne-Hipopne İndeksi (AHİ) uyku süresince görülen apne ve

hipopnelerin her saat başına düşen sayısını ifade etmektedir. Obstrüktif uyku apnesi sendromu (OUAS) için tanı kriterleri, gece monitorizasyonu ile belirlenen 5 veya daha fazla AHİ ve yeterli gelmeyen uyku, gündüz uykululuğu veya diğer gündüz semptomlarını içermektedir. OUAS şiddeti AHİ'ye bağlı olarak; hafif şiddetli OUAS 5≤AHİ<15, orta şidddetli OUAS 15≤AHİ<30 ve şiddetli OUAS AHİ≥30 olarak üç grupta sınıflandırılmaktadır.[1,2]

OUAS prevelansı yaklaşık olarak erkeklerde %4, kadınlarda %2 oranında değişmekte ve obezitenin pandemik boyutta her geçen gün artmasıyla birlikte OUAS insidansı artış göstermektedir.[3,4]

OUAS için risk faktörleri

Obezite, erkek cinsiyeti, ileri yaş ve genetik OUA'nın toplumda görülme sıklığını arttıran başlıca faktörlerdendir. Özellikle boyunda, üst vücut ve abdominal bölgede yağ birikmesi ile karakterize santral obezite; OUAS ile en sık görülen obezite türü olduğu belirtilmiştir.[3]

Üst solunum yollarının yapısı, aktivitesi, kraniyofasiyal morfoloji ve yağ birikimi tipi iki cinsiyet arası farklılık göstermektedir. Önemli risk faktörlerinden olan alkol ve sigara kullanımının erkeklerde fazla olması nedeniyle prevelansın erkeklerde daha yüksek çıktığı düşünülmektedir. Ayrıca uyku ile ilişkili solunum bozukluklarının insidansı artan yaş ile artış göstermekte; bunun nedeninin ise yaş artışıyla birlikte hipoksiye verilen cevap sonucu solunum yolunun stabilitesi ve farengeal kasların aktivitesi azalmaktadır.[2,5]

OUA gelişimi ve şiddeti üst solunum yolu hacmini etkileyen kraniofasiyal yapıların ve farengeal yumuşak dokuların anatomisine bağlıdır. Boyun çevresi önemli bir risk faktörü olup kadınlarda 38 cm ve erkeklerde 43 cm üstü OUA gelişimi ve şiddetlenmesi için risk teşkil etmektedir.[6] Mallampati skoru 3-4, büyük uvula, adenoid hipertrofisi, makroglossi, yüksek maksiller ark, retrognati, mikrognati ve burun tıkanıklığına neden olan septum deviasyonu, polip, konka hipertrofisi gibi anomaliler üst hava yolu obstrüksiyonun anatomik nedenleridir.[7]

Alkol, sedatif ve hipnotik etkili ilaçlar üst solunum yolundaki farengeal dilatatör kasın nöromuskuler aktivitesini baskılayarak apne gelişme riskini arttırmakta ve tablonun ağırlaşmasına neden olmaktadır.[5] Sigara kullanan OUA hastalarında; sigara kullanmayan OUA hastalarına oranla uvula mukozasında kalınlaşma, ödem ve inflamasyonun daha belirgin olduğu ve çok sık sigara içen kişilerde horlamanın daha sık görüldüğü vurgulanmıştır.[8]

OUAS'ın sağlık üzerindeki majör etkileri

OUA yetişkinlerde ölüme yol açan hipertansiyon, kardiyovasküler ve serebrovasküler hastalıklarla ilişkili olduğu belirtilmiştir.[5] Hastalar gün içinde uykulu durumda olduğu için bilişsel fonksiyonlarının düşmesiyle birlikte trafikte ve iş yerlerinde birçok ciddi sakatlanma ve ölüm meydana gelebilmektedir.[9]

Kardiyovasküler hastalıklar

Birçok fizyolojik mekanizma OUA'ya akut ve kronik olarak hemodinamik bir yanıt vermektedir. OUA olgularında ortaya çıkan hipoksemi, sempatik sinir sisteminin aktivasyonu, kan basıncının yükselmesi, oksidatif stresin ve inflamasyonun artması gibi görülen fizyopatolojik olaylar kardiyovasküler hastalık riskini arttırmaktadır.[9] Apne bitiminde oksijen satürasyonu en düşük seviyedeyken taşikardi ve artmış kan basıncı ile birlikte miyokardial oksijen ihtiyacı doğması sonucunda disritmiler, koroner kalp rahatsızlığı, kalp yetmezliği, miyokard infarktüsü veya inme ile birlikte ani ölümler gerçekleşebilmektedir.[2,10]

Psikiyatrik hastalıklar

Tedavi edilmemiş OUA'nın, depresyon ve aksiyete gibi birçok psikiyatrik bozuklukla ilişkili olduğu ve OUA hastalarında sık görülen gün içi aşırı uykululuk hali mental hastalıklar için ana risk faktörü olduğu belirtilmiştir. Uykululuk hali, yorgunluk, asabiyet, uyku bölünmeleri, psikomotor becerilerde ve konsantrasyonda azalma depresyon ve OUA'nın ortak semptomlarıdır.[11]

Endokrin ve metabolik problemler

OUA'da uyku süresi ve kalitesi azaldığından dolayı metabolizma indirekt olarak etkilenmesiyle birlikte insülin direnci, sempatik aktivasyon, kortizol seviyeleri artmakta ve plazmadaki leptin-ghrelin hormonlarının seviyelerinin düşmesiyle de iştah artmaktadır. OUA hipoksi ve uyku bölünmelerine sebep olarak obezite ve diabetus mellitus tip 2'ye yol açabilmektedir.[2,12]

Trafik kazaları

OUA hastalarında aralıklı hipoksemi ve uyku yoksunluğuyla birlikte beyindeki prefrontal ve frontoparietal bölgelerinin aktivasyonu azalması sonucu yönetici işlevler bozulmakta, kognitif ve psikomotor performans düşmektedir. OUA'lı hastaların uykulu ve bitkinken araba kullanması durumunda dikkat, karar verme yeteneği ve atiklik düştüğü için direksiyon başında kaza yapma olasılığı arttığı belirtilmiştir.[13]

Yaşam kalitesinde azalma

Hipoksiyle birlikte görülen frontal lob disfonksiyonu sonucu motor beceriler, öğrenme, kısa ve uzun süreli bellek fonksiyonundaki bozulmalar sonucu birtakım kişilik değişiklikleri ortaya çıkabilmektedir. OUA hastaları aile bireyleri tarafından huysuzluk, asabiyet, anksiyete ve depresyon gibi karakter değişimleri gözlenmekle birlikte hastalar yaptıkları aktivitelerden zevk alamamaktadır.[14]

OUAS'ın Teşhisi

Anamnez ve klinik muayene

OUA'nın doğru, hızlı teşhisi ve erken tedavisi ile OUA'nın neden olduğu komplikasyonlardan kaçınmak mümkün olmaktadır. Diş hekiminin hastayı apne açısından şüpheli olarak tanımlayabilecek risk faktörlerini fark edebileceği; ayrıca dişle ilgili predispozan faktörlerin değerlendirmesine ve vakaya yönelik multidisipliner tedavi oluşturulmasına katkı sunabileceği için OUA vakalarının diş hekimi ile konsülte edilmesi gerekliliği vurgulanmıştır. Hasta polisomnografi (PSG) için konsülte edilmeden önce diş hekimleri klinik belirti ve semptomları değerlendirmeli ve OUA'nın ayırt edici özelliklerini sorgulamalıdır. Horlama, apne, ağız solunumu, konsantrasyon güçlüğü, performans düşüklüğü ve uyku bruksizmi hakkında sorular sorularak uyku durumuna ilişkin bilgiler elde edilmelidir.

OUA, prevelansı yüksek bir hastalık olduğu için hastalar genellikle uyku problemlerini normal karşılayarak herhangi bir hekime başvurmamaktadır. Uyku apnesinin bulguları ve semptomları olan horlama, tanık olunan apne, soluk kesilmesi, obezite, hipertansiyon, gün içi aşırı uyku hali, aile öyküsü, geçirilmiş tonsillektomi ve dinlendirmeyen uyku sorgulanmalıdır.[6,7,15] Anamnez alınırken hastanın partneriyle de görüşme yapılmalıdır. Çünkü hastalar genellikle gece boyunca horlama ve uyanmalarının farkında olmamakla birlikte uyurken solunumun durması partnerin sıklıkla şahit olduğu, uyku kliniğine esas başvuru sebebi olduğu belirtilmiştir. Hastalar uyku esnasında nefes darlığı ve boğulma hissiyle uyanmaktan şikayet edebilmektedir.[15,16]

Horlama, özellikle supin pozisyonda üst solunum yolunun kritik derecede daralmasıyla ortaya çıkmakta ve altta yatan hastalığın patofizyolojisini yansıttığı için önemli bir belirteç olduğu vurgulanmaktadır. OUA hastalarının %95'inde görülen horlama, apneye en sık eşlik eden semptomdur ve yaş, kilo artmasıyla birlikte toplumda görülme sıklığı artmaktadır. Fakat horlamanın OUA'ya spesifik olmadığı bildirilmiştir.[6,16]

Klinik muayeneyle birlikte obstrüksiyonun hangi seviyede meydana geldiği ve predizpozan faktörler tespit edilmektedir. Boy, kilo, VKİ, boyun çevresi ölçülerek; oral kavite muayenesiyle tonsil büyüklüğü, yumuşak damak, uvula uzunluğu, kalınlığı, dil büyüklüğü, mandibula ve oklüzyon incelenmelidir. Hasta dik pozisyondayken boyun çevresi ölçümü

yapılmalıdır. 48 cm'den geniş boyun çevresi OUA için yüksek risk faktörü olduğu vurgulanmıştır.[15,16]

Orofarinks muayenesiyle yumuşak doku büyümesi ve hava yolu genişliği kontrol edilmektedir. OUA hastalarında yumuşak damak kalın ve daha posteriorda konumlanmış; lateral duvarlar hacimli kıvrımlar şeklinde ve uvula kalın, uzun olarak görülebilmektedir. Tonsil ve Mallampati derecelendirmesinde sınıf arttıkça hava yolu volümü kaybı da artmakta ve sert damak yüksek, dar olabilmektedir.[15] Hasta profilinin maksillofasiyal gelişimsel bozukluklarının anlaşılması için incelenmesi gerekmektedir. Mandibular retrognati varlığı hasta dik otururken, Frankfort horizontal düzleminde iken incelenmektedir. Posterior hava lümenini daraltan retrognati gibi olguların varlığında sefalometrik ölçüm yapılarak daha ayrıntılı ve kesin bir sonuç elde edilebilmektedir.[17-19]

Sefalometrik değerlendirme

OUAS'da fiziksel muayeneye ek olarak solunum yolunun incelenmesi için fiberoptik faringoskop, ultrasonografi, bilgisayarlı tomografi, manyetik rezonans görüntüleme ve lateral sefalometri kullanılmaktadır. Lateral sefalometik radyografi dental, maksillofasiyal malformasyonlar ve üst solunum yolundaki obstrüksiyon nedeninin belirlenmesinde kullanılan bir görüntüleme yöntemi olmakla birlikte mandibula, maksillanın kranial kafa tabanına göre konumu, yumuşak doku durumu ve posterior havayolu boşluğu ölçülebilmektedir.[4,15]

Birçok OUA hastası farengeal yağ birikiminden dolayı dar üst solunum yoluna sahip olabilmektedir. Hyoid ile mandibula düzlemi ve 3. servikal vertebra (C3) arası uzaklık OUA hastalarında artmakta ve hyoidin aşağıda konumlanması sonucu dilin büyük bir bölümü hipofarengeal alanda toplanmakta ve obstrüksiyon daha kolay ortaya çıkmaktadır. Dili dışarı çıkarmak ve öne almak için daha fazla enerji harcanması durumu ağız açık uyumaya sebep olarak apneyi kötüleştirmektedir. Mandibuler retrognati OUA gelişimi ve şiddetinin artmasında bir risk faktörüdür.[4]

Sefalometri ile posterior farengeal duvar, yumuşak damak ve dilin tabanı gibi yumuşak dokular da incelenebilmektedir. Dilin tabanı ile posterior farengeal duvar arasındaki posterior solunum yolu boşluğu OUA hastalarında normale göre dar olduğu belirtilmektedir. Posterior nasal spinadan posteriora doğru takip edilerek yumuşak damağın uzunluğu saptanabilmekte; yumuşak damak uzunluğunun ise OUA hastalarında artmış olduğu görülmektedir. SNB açısı 78 dereceden az olduğunda gözlenebilen mandibular retrognati OUA gelişimi ve şiddetinin artmasında risk faktörü olarak belirtilmektedir. Posterior solunum yolu boşluğu OUA hastalarında farengeal yağ birikiminden dolayı normale göre dardır. Ayrıca OUA hastalarında yumuşak damak uzunluğu artmıştır.[4,17,18]

Endoskopik tanı

Üst solunum yolundaki kolaps farenksin birçok bölgesinde gerçekleşmesinden dolayı obstrüksiyonun meydana geldiği birden fazla bölgeden cerrahi müdahalenin yapılması gerekebilmektedir. Kollapsın meydana geldiği bölgeyi bulmak için KBB uzmanı tarafından fleksibl fiberoptik endoskopiyle birlikte Müller Manevrası kullanılmaktadır.[19]

Polisomnografi

Anamnez ve klinik muayene sonucu eğer OUA'dan şüpheleniliyorsa hasta göğüs hastalıkları uzmanı tarafından uyku laboratuvarına yönlendirilmektedir. OUAS tanısında altın standart olan polisomnografi diğer uyku bozukluklarının teşhisinde de kullanılabilmektedir. Polisomnogram, bir gece boyunca hasta uyurken fizyolojik verilerin eş zamanlı ve kesintisiz bir şekilde kaydedilmesinden elde edilmektedir. Elde edilen veriler temel olarak 3 gruba ayrılmaktadır: kardiyak aritmiyi tespit eden veri (elektrokardiyografi), uykuyu tespit etmeye yarayan veriler (elektrookulografi, elektromyografi ve elektroensefalografi) ve solunumu kayıt altına alan veriler (torako-abdominal efor, oksimetre ve burun ağız solunumu). PSG en az 3 saatlik uyku dahil olmak üzere en az 6 saat sürmektedir.[2,7,15,16] Polisomnografi testi süresince tespit edilen en az 10 sn süren hava akışı kesilmesi ile birlikte, hava akışında en az %30'luk bir düşüş ile ardından en az %4'lük bir oksihemoglobin desatürasyonu; veya hava akışında %30'luk düşüş ile oksijen satürasyonunda en az %3'lük bir düşüş veya bir arousal skoru apne olarak tanımlanmaktadır. Hastada apne veya hipopne süresi çok değişken olmakla birlikte dakikalarca sürebilmektedir.[1] AHİ skoruna bağlı olarak tıp hekimi hastayı ileri tedavi seçenekleri ve oral aparey açısından değerlendirilmesi için ortodontiste yönlendirmektedir.

OUAS'ın Tedavisi

OUA tedavisindeki asıl amaç uyku sırasında oluşan üst solunum yolu kollapsını azaltıp elimine etmektir. OUA'nın etkin tedavisi hastanın aldığı genel önlemler, medikal cihazlar, oral apareyler ve cerrahi yaklaşımlardan oluşmaktadır.[15,18]

Genel önlemler

OUA olan hastalar değerlendirildikten sonra hangi tedavinin tercih edileceği hastalığın şiddetine, hastanın klinik durumuna ve tercihlerine bağlı olarak değişmektedir. Genel önlemler ve yaşam tarzı değişiklikleri tüm hastalar tarafından benimsenmesi ve uygulanması gerekmektedir.[6,18]

Kilo vermeyle birlikte obez hastalarda AHİ skoru düşerek semptomlar azaldığından dolayı diyet ve düzenli egzersiz tüm kilolu apne hastalarına önerilmelidir.[2,6] Alkol, sigara, sakinleştirici ve kas gevşeticiler üst solunum yolu kaslarının tonusunu azalttığından dolayı hastaların bunlardan kaçınması gerekmektedir.[15] Supin pozisyonda yatmak üst solunum yolunu daraltarak apne şiddetini arttırabilmektedir. Bu nedenle sırt arkasına yastık konulması veya sırta tenis topu gibi bir engel bağlanması önerilmektedir.[2,6,15] Uyku hijyeninin sağlanması kaliteli ve yeterli uyku alınması için şarttır. Bunun için yatak rahat ve yatak odası ılık, sessiz ve karanlık olmalı ve hasta uykudan önce kafeinli içecek ve diğer uyarıcı maddeleri kullanmamalıdır.[15,20]

Pozitif hava yolu basıncı tedavisi (PAP)

Herhangi bir şiddetteki semptomatik OUA'nın altın standart tedavi yöntemi devamlı pozitif havayolu basıncıdır (Continuous positive airway pressure-CPAP).[2,6] CPAP tedavisinde üst solunum yoluna sıkıştırılmış hava pozitif basınçla devamlı olarak verilerek akciğer volümünün ve fonksiyonel rezidüel kapasitenin artması sağlanarak üst solunum yolu açık tutulmaktadır. Pozitif basınçlı hava burun veya hem burun hem ağzı içeren bir maske aracılığıyla verilmektedir. CPAP hastalığın şiddeti, üst solunum yolu kollapsının bölge ve kiloya bağlı olmaksızın çoğu hastada etkili olduğu belirtilmiştir. Elde edilen yarar hastanın tedaviyi devam ettirmesine bağlı olmakla birlikte mukozal kuruluk, burun tıkanması, irritasyon gibi nedenlerle hastaların yarısı bu tedaviyi tolere edememektedir.[4,21]

Oral apareyler

OUAS teşhisi konulmuş hastalar hem tıp hekimleri ve hem de ortodontistler tarafından multidisipliner bir değerlendirmeye tabi tutulmalıdır. Noninvaziv, düşük maliyetli ve geri dönüşümü olan bu oral apareyler horlama ve OUA tedavisinde kullanılmaktadır. [22]

Düşük-orta AHİ skorlu, CPAP tedavisine alışamamış, basit horlaması olan, genel önlemleri uygulayamamış ve vücut kitle indeksi düşük OUAS hastalarında oral aygıtlar endikedir.[2,23] Oral apareylerin kullanımı AHİ skorunu ve arousal sıklığını düşürmekte ve oksijen satürasyonunu arttırmaktadır. Fakat oral apareylere oranla CPAP ile OUA hastalarında iyileşme daha çok gerçekleştiğinden dolayı ilk tedavi yöntemi olarak CPAP denenmelidir.[24]

OUA tedavisinde çeşitli tiplerde oral apareyler kullanılmaktadır. Oral apareyler başlıca 3 gruba ayrılabilir. Bunlar yumuşak damak kaldırıcı, dil tutucu aparey ve mandibulayı ilerletici apareylerdir.[22]

Yumuşak damak kaldırıcı aparey (soft palate lifters- SPL)

SPL, uyku esnasında yumuşak damağı kaldırarak hava yolunda titreşmesini önlemektedir. Horlamaya karşı başarılı bulunsa da OUA tedavisinde yeterli başarıyı sağlayamamıştır. Bu nedenle günümüzde kullanımı olmadığı belirtilmiştir. [25]

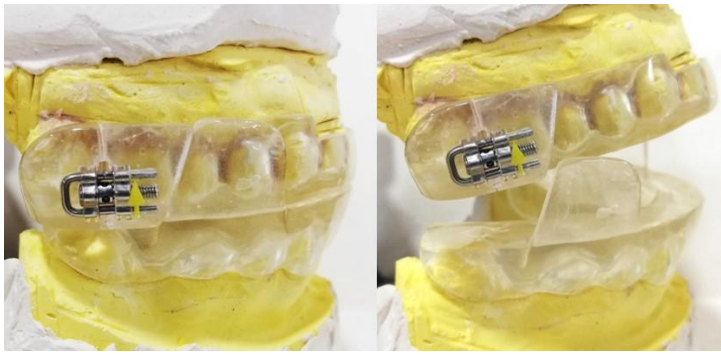
Dil tutucu apareyler (tongue retaining devices-TRD)

TRD mandibulayı anterior konuma almadan dili önde tutarak solunum yoluna kollapsını önlemekte ve böylece dilin farengeal alandan uzaklaşmasını sağlayarak üst solunum yolunu genişletmektedir. Anterior dişlerin arasından çıkan yuvarlak balon şekilli yumuşak tüpün içine dil yerleştirilmekte ve negatif basınç ile yüzey adezyonu sayesinde dil önde sabitlenmektedir. Ağız solunumu yapan hastalar için TRD kullanımı zor olabilmekte ve dil zamanla irrite olabilmektedir. Tek başına kullanımı önerilmemekle birlikte diğer tedaviler eşliğinde kullanılabilmektedir.[20,25,26]

Mandibulayı ilerletici apareyler (mandibular advancement devices-MAD)

MAD gece uykuda kullanılan, noninvaziv, uygun fiyatlı, hafif-orta şiddetli OUA tedavisinde pozitif etkileri olan ve CPAP tedavisini tolere edemeyen hastalara kullanılabilen alternatif bir tedavi yöntemidir.[2,20,24] MAD gece boyunca mandibulayı anterior pozisyonda tutarak orofarengeal ve hipofarengeal hava yolu boşluğunu arttırmakta ve dil ile yumuşak damağın posterior farengeal hava yoluna kollapsını engellemektedir.[25]

MAD maksiller ve mandibular arktan destek alır. Aparey kişiye özel, prefabrike, rijit veya aktive edilebilen olarak tasarlanabilmektedir.[27] MAD'ın kişiye özel ve aktive edilebilen şekilde tasarlanmış olması AASM tarafından önerilmektedir (Şekil 1).[23,28] Hastanın dentisyonu, sert ve yumuşak doku anatomisi apareyin dizaynında göz önüne alınmalıdır.[27]



Şekil 1. Aktive edilebilen MAD apareyi

Oral aparey kullanımına karar verilmeden önce hastanın ayrıntılı dental muayenesi yapılması gerektiği vurgulanmıştır. Öncelikle MAD kullanımı için hastanın her bir arkta 6-8 dişi olmalıdır.[27] Eğer hastanın 6'dan az dişi var ise zamanla aparey dişlerde hareket ve mobiliteye sebep olacaktır. Ayrıca gingivitis, periodontitis, çürük ve mobil dişler gibi aktif diş eti hastalıkları bulunmamalıdır. Şiddetli bruksizmle birlikte gece hastanın aşırı lateral çene hareketleri sonucu aparey ağızdan çıkabilir veya aparey zarar görebilmektedir. Aktif temporomandibuler eklem (TME) disfonk- siyonu aparey kullanımıyla kötüleşebilmektedir.[23,25] Bundan dolayı aparey kullanımına karar verilmeden önce hastanın TME bölgesinde klik ve krepitasyon sesi; çene açmada, kapamada ve protrüzyonda ağrı ve kısıtlama olup olmadığına bakılmalıdır. Anterior açık kapanışa sahip hastalar genellikle kısıtlı protrüzyon yapabilmekte; bu nedenle MAD kullanımı için uygun olmadıkları belirtilmektedir. Ayrıca şiddetli mikrog- nati hastaları ölçü alınırken ve aparey kullanımında zorluk yaşayabil- mektedir.[25]

Oral aparey kullanımı sonucu birtakım kısa ve uzun vadeli komplikasyonlar görülebilmektedir. Hastalar görülebilecek yan etkilere karşı bilgilendirilmelidir. Aparey kullanımının ilk 2 haftasında salivasyon miktarında artış görülebilmektedir. Dil için yeterli boşluk kalmadığı takdirde dilde ülserasyon ve irritasyonlar görülmektedir. Bir veya birkaç dişte ağrı hastaların %59'unda görülen bir komplikasyondur ve bu şikayetle gelen hastada apareyin dişlere kuvvet uyguladığı akla gelmeli ve aparey ilgili bölgeden aşındırılarak dişe gelen yük kaldırılmalıdır. MAD apareyinin mandibulayı gerekenden fazla protrüze etmesi sonucu altta var olan TME problemi şiddetlenmektedir. Hastaya nonsteroidal antiinflamatuar ilaç reçete edilerek eklem bölgesine sıcak kompres yapması önerilmelidir. Prefabrike apareyler insizörlere aşırı kuvvet uygulayabilmekte ve bunun sonucunda kesici dişlerin angulasyonu artmakta, overjet, overbite ve oklüzyon değişebilmektedir. Bunlara ek olarak bruksizm sonucu apareyin retansiyonu bozulabilmekte ve diş hareketlerine neden olabilmektedir.[25]

Tüm bu komplikasyonların önlenmesi için her 3-6 ayda bir düzenli diş hekimi kontrolleri önerilmektedir. Bu sayede ortaya çıkan yan etkiler kısa dönemde düzeltilebilmekte ve engellenebilmektedir.[25]

Cerrahi tedaviler

Orta-şiddetli OUA hastalarında CPAP tedavisi öncelikli olarak tercih edilmesine karşın; düşük uyum oranı nedeniyle hastalar MAD veya cerrahi operasyonlar gibi alternatif tedavi yöntemlerini tercih etmektedir. Cerrahi tedaviler, üst solunum yolu obstrüksiyonunda önemli rol oynayan, anatomik anomalileri olan hastalar için uygun bir alternatif tedavi yöntemidir.[28] Cerrahi tedavilerin amacı üst solunum yolunda obstrüksiyona neden olan yumuşak dokuların repozisyonunu sağlamak veya ortadan kaldırmaktır. Posterior farengeal bölgeden yumuşak doku eksizyonu (uvulopalatofaringeoplasti) ve maksillomandibular ilerletme (MMİ) cerrahisi ile posterior farengeal bölgenin hacmi arttırılmakta ve OUA tedavisinde yüksek başarı oranları elde edilmektedir. Üst solunum yoluna yapılan cerrahi tedavi başarısı hastalığın şiddeti, hasta seçimi ve cerrahi tipine bağlı olarak %24-86 oranında değişmektedir. Uvulopalatofaringoplasti (UPPP) sonrası MMİ cerrahisi gibi birbirini takip eden cerrahi uygulamalar sonucu başarı şansı daha yüksek olduğu belirtilmiştir.[30] Orta-şiddetli OUA genellikle çok seviyeli tıkanıklıklarla karakterize olduğundan dolayı sadece bir bölgeyi düzeltmeye yönelik cerrahi girişimler üst solunum yolundaki tüm tıkanıklıkları ortadan kaldıramamaktadır. OUA tedavisinde birden fazla seviyeyi hedefleyen MMİ'nin başarı oranı %86 bulunarak en etkili cerrahi tedavi olduğu bildirilmiştir.[29] Hipoplazik maksillomandibular kompleks, retrognati, dar üst solunum yolu görülen ve PAP tedavisini tolere edemeyen orta-şiddetli OUA hastaları MMİ için adaydır. Fakat anatomi, hastalık şiddeti ve hasta tercihindeki farklılıklar göz önüne alındığında OUA için genel olarak kabul edilmiş bir cerrahi prosedür kılavuzu olmamakla birlikte; kompleks veya birden fazla obstrüksiyon bölgesi görülen OUA vakalarında, cerrahi tedavinin endikasyonları ve takip edilecek protokoller belirsizliğini korumaktadır.[29]

MMİ cerrahisi; Le Fort 1 maksilla osteotomisi ve eşzamanlı bilateral sagittal split mandibula osteotomisini (BSSO) içermekte ve her iki çene maksimum derecede öne alınarak rijit olarak sabitlenmektedir. Farengeal hava yolu genişlemesiyle birlikte yumuşak doku gerilmesi MMİ cerrahisinin başlıca sonuçlarındandır. Çeneler ile birlikte yumuşak damak, dil, hyoid ve bağlantılı yumuşak dokular protrüze olmaktadır.[31] Mandibula ilerletmesi ile hyoid pozisyonu değişerek, supra ve infrahyoid kaslar ve dil tabanı kasları farklılaşarak farengeal havayolu boşluğu hacmi artmaktadır.[32] OUA hastalarında MMİ cerrahisi sonucunda AHİ skorun-

daki azalmanın üst solunum yolu çapının artmasına bağlı olmadığı; maksilla, yumuşak damak ve dilin hareketlerine bağlı olduğu bildirilmiştir.[33] MMİ cerrahisi sonucu hastaların yüksek memnuniyet duyduğu ve yaşam kalitelerinin arttığı; yüzde veya dilde uyuşukluk yaygın olarak görüldüğü bildirilmiştir.[34]

SONUÇ

OUAS toplumun genelini ilgilendiren ve insidansı artmaya devam eden önemli bir halk sağlığı problemidir. Multifaktöriyel etiyolojiye sahip olması nedeniyle OUA yönetimi erken tanı ve doğru bir tedavi planının yapılabilmesi için çok sayıda uzman ekip (KBB uzmanı, ortodonti uzmanı, nöroloji uzmanı vb) tarafından multidisipliner bir yaklaşım gerektirmektedir. Ortodonti uzmanı bu hastalığın temel etiyolojileri hakkında bilgi sahibi olmalı ve erken teşhis ile gerekli müdahaleleri multidisipliner tedavi yaklaşımları çerçevesinde gerçekleştirebilmelidir. Bu sayede ileride ortaya çıkacak olan hastanın genel sağlığını etkileyen sorunların ve dental problemlerin önüne geçilmesini de sağlayacaktır. Hafif-orta şiddetli OUAS hastalarında kullanılan oral apareyler yüksek başarı oranına ve iyi hasta kooperasyonuna sahip verimli ve geçerli bir tedavi yöntemidir. Oral aparey tedavisinin başarısı doğru hasta seçimi, ayrıntılı klinik muayene, doğru oral aparey tipi seçimi ve tedavi süresince vakanın yönetimine bağlıdır.

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Geleneksel Tam Protezlerden İmplant Üstü Overdenture Protezlere Geçişte Oklüzyon Değişiminin T-scan III Sistemi Kullanılarak Ölçülmesi

Measuring Occlusion Change in Transition from Traditional Complete Dentures to Implant supported Overdentures Using the T-scan III System

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ÖZ

Geleneksel total protez kullanan hastaların mevcut total protezlerinin ağız içinde implantlara bağlanarak implant üstü hareketli proteze geçişte oklüzal kuvvetlerin yer değişiminin kaydedilmesidir. 56 yaşındaki tam dişsiz erkek hasta alt çene ön bölgeye yapılan 3 implantın osseointegrasyonu için gerekli süre geçtikten sonra implant üstü hareketli protezini yaptırmak üzere kliniğimize başvurdu. Hastaya topuz başlı ataşman tutuculu implant üstü hareketli protez yapılması planlandı ve bunun üzerine yeni alt çene total protez hazırlandı. Oklüzal temasları düzenlenen total protez ağız içinde implantlara bağlanmadan önce ve bağlandıktan sonra T-Scan III sistemi kullanılarak oklüzal temasların dağılımı kaydedilmiştir. Bu çalışmada total protezin implantlara bağlamadan önceki ve sonraki oklüzal temaslarının dağılımının birbirine çok yakın değerler verdiği görülmüştür. Bu yüzden oklüzal temaslarının tekrardan düzenlenmesine ihtiyaç duyulmamıştır.
Anahtar Kelimeler: Oklüzyon, Overdenture, T-Scan III

ABSTRACT

Objective:: Recording of the change of the occlusal forces in the transition to the implant-supported removable prosthesis by connecting the existing complete denture prosthesis of the patients to the implants. A 56-year-old completely edentulous male patient applied to our clinic to have his removable prosthesis on the implant, after the required time for the osseointegration of 3 implants in the anterior region of the mandible. It was planned to make a removable prosthesis on the implant with ball-attachment retaining for the patient, and then a new mandibular complete denture prosthesis was prepared. The distribution of occlusal contact points was recorded using the T-Scan III system before and after attaching the complete denture to the new implants , whose occlusal contacts were fixed. In our study, the distribution rate of the occlusal contacts of the total prosthesis after attachment to the implants gave values very close to the state arranged before. Therefore, there was no need to rearrange the occlusal contacts.
Keywords: Occlusion, Overdenture, T-Scan III

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GİRİŞ

İnsanlarda oklüzyon algısı, propriyoseptörler aracılığıyla duyusal sinirlerden kaynaklanır.[1] Devital dişlerde bile, periodontal mekanoreseptörler ısırma kuvvetinin algılanmasında önemli bir rol oynadığından,[1] yüklenme üzerine doğal dişlere kıyasla benzer duyusal tepkiye sahiptir.[2] Dental oklüzyon sadece hastalar tarafından tespit edilemez, aynı zamanda çeşitli oklüzal göstergeler kullanılarak klinisyenler tarafından da incelenebilir.

Bazı yazarlar, statik ve dinamik oklüzal temasları kaydetmek için kullanılan dental materyallerin tarihçesi hakkında bir inceleme yayınlamışlar ve protezde kullanılan yaklaşık 17 yöntem bulmuşlar.[3] Protez tedavilerinde oklüzyonun doğru bir şekilde incelenmesi için, diş teması modellerini, malzemelerin özelliklerini ve bu diş temaslarını kaydetmek için kullanılan yöntemleri anlamak önemlidir.[3]

Oklüzyonun rutin muayenesi, hastanın algıları ile klinisyenin bir kombinasyonudur. Klinisyenler, artikülasyon kağıdın mürekkep izlerini, oklüzal kontağı olan iki diş arasında shim stok folyosunun çekme

kuvvetini ve oklüzal gösterge mumunun yarı saydam veya perforasyon alanını değerlendirerek diş oklüzyonunu belirlerler.[4] Bu geleneksel oklüzal göstergeler pratik olsa da, dental oklüzyonu ayırt etme becerisinin sınırlı olması nedeniyle sonuçları değişkendir. Sınırlamaların üstesinden gelmek için dijital oklüzal göstergeler (yani, T-Scan sistemi) geliştirilmiştir.

T-Scan III ile bilgisayarlı oklüzal analiz, tüm oklüzyonun gerçek zamanlı bir filmini oluşturur, dinamik ve statik oklüzyonun değerlendirilmesine izin verir.[5]

T-Scan III sistemi, dijital oklüzal göstergelerin iyi bir sürümüdür.[6] Oklüzyonu, 0.003 saniyelik artışlarla her diş temasının sıralaması, temas eden diş yüzeylerindeki kuvvet konumu, yüzde değerler olarak göreceli oklüzal kuvvet ve kuvvet merkezi yörüngesi bakımından analiz edebilir ve raporlayabilir.[6]

Geleneksel tam protez kullanan hastaların çiğneme performansını artırmak için iyi dağıtılmış oklüzal kuvvet ve oklüzal temas alanı sağlanmalıdır.[7] Bu yüzden tam protezlerde bilateral balanslı oklüzyonun sağlanması önerilmektedir.

Bilateral balanslı oklüzyon durumunda, dinamik oklüzyonda protez tabanının bile sıkıştırılmasına ve çiğneme sırasında optimal stabiliteye önemli bir rol düşer.[8] Bu tip oklüzyon yatay bir çiğneme modelini tercih ettiğinden, muhtemelen iki taraflı dengeli oklüzyon, hastaların yeni protezlerine uyum sağlamasına yardımcı olabilir.

Ama bilateral balanslı oklüzyonun sağlanması geleneksel tam protezler ile tedavi sırasındaki en önemli zorluklardan biridir.[9] Bu prosedürü etkileyebilecek en sık görülen engel, yarı ayarlanabilir artikülatörler gibi gelişmiş mekanik cihazlar kullanılmasına rağmen yumuşak doku esnekliğidir; bunlar sadece oklüzal fonksiyonel hareketlere yaklaşabilir.[10]

Modern teknoloji, bir hastanın ısırma kuvvetini, oklüzal kuvvet konumunu ve zamanlamasını kaydedebilen bir teşhis cihazı olan T-Scan bilgisayarlı oklüzal analiz sistemi ile bu soruna bir çözüm sunmaktadır.[11,12]

Diş hekimleri, implantları yirmi yılı aşkın süredir tam protezlerin tutuculuğunu ve stabilitesini iyileştirmek için dişsiz çenelerde başarıyla kullanmıştır. İmplantların takılması, protezlerin stabilitesini ve işlevini iyileştirir ve hasta memnuniyetini artırır. İmplant bağlantısının ayrıca nöromüsküler aktiviteyi ve adaptasyonu geliştirdiği ve böylece dişsiz hastalarda çiğneme fonksiyonunu önemli ölçüde geliştirdiği kaydedilmiştir.[13] İmplant tedavisi, geleneksel tam protezlerle elde edilenlere kıyasla maksimum ısırma kuvvetlerini neredeyse iki katına çıkarır ve çene kasları daha verimli bir şekilde kullanılır.[14,15]

Çeşitli çalışmalarda, implant üstü overdenture protezleri kullanan hastalarda, geleneksel tam protezlere göre daha iyi çiğneme işlevi ve önemli ölçüde daha yüksek genel memnuniyet bildirilmiştir.[16-18]

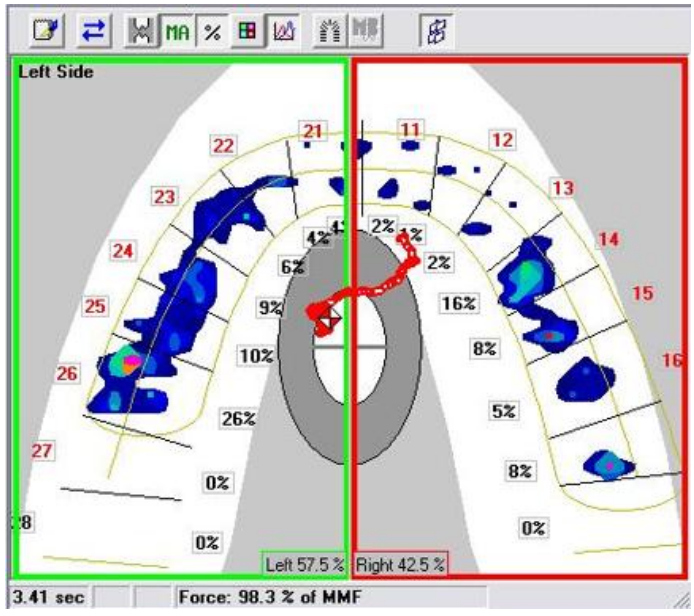
Mandibulada implant üstü overdenture protezler, sabit implant destekli protezler kadar iyi bir tedavi seçeneği olmasa da, tam protez kullananlara göre önemli derecede çiğneme ve yaşam kalitesinde iyileşme sağlar.[19,20]

Bu çalışmanın amacı, geleneksel total protez kullanan hastaların mevcut total protezlerinin ağız içinde implantlara bağlanarak implant üstü hareketli proteze geçişte oklüzal kuvvetlerin yer değişiminin kaydedilmesidir. Ağız içinde yapılan bu işlem sonrası hastanın alışmış olduğu oklüzyon değişebileceği için oklüzyonun tekrardan düzenlenme gerekliliği doğabilir. Bu farklılığa dikkat etmemek ball ataşman lastiklerinin kısa sürede bozulmasına ve protezin kullanım konforunun azalmasına sebep olabilir. Çalışmanın hipotezi ise bu oklüzal kuvvetlerin bileşkesinin anterior bölgeye doğru hareket edeceği yönündedir.

OLGU SUNUMU

56 yaşındaki tam dişsiz erkek hasta alt çene ön bölgeye yapılan 3 implantın osseointegrasyonu için gerekli süre geçtikten sonra implant üstü hareketli protezini yaptırmak üzere Atatürk Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi kliniğine başvurdu. Yapılan klinik ve radyografik muayene sonucu hastaya topuz başlı ataşman tutuculu implant üstü hareketli protez yapılması planlanmıştır.

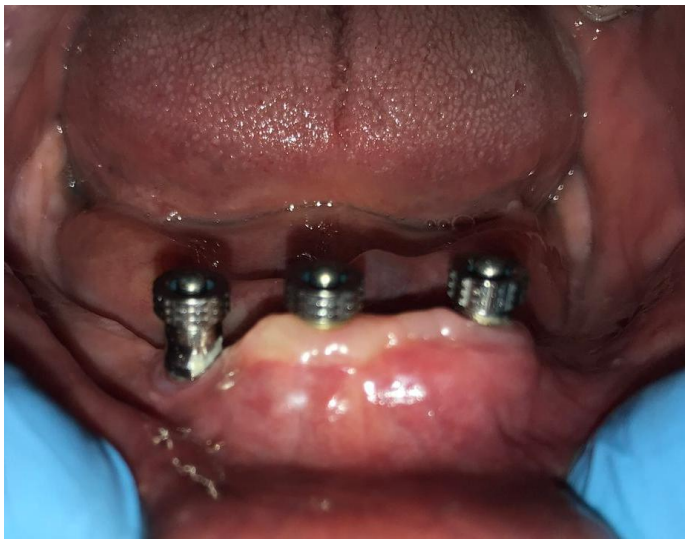
Hastaya yeni alt çene total protez hazırlanmıştır. Hastaya yapılan yeni total protezin oklüzyonu artikülasyon kağıdı ve T-Scan III (Tekscan, Boston, Massachusetts, Amerika Birleşik Devletleri) sistemi kullanılarak düzenlenmiştir. Oklüzal temaslar eşit şekilde dağıtılıp, primer kontaklar kaldırılmıştır. Oklüzal temasları düzenlenen total protez ağız içinde implantlara bağlanmadan önce T-Scan III sistemi kullanılarak oklüzal temasların dağılımı son kez kaydedilmiştir (Resim 1).



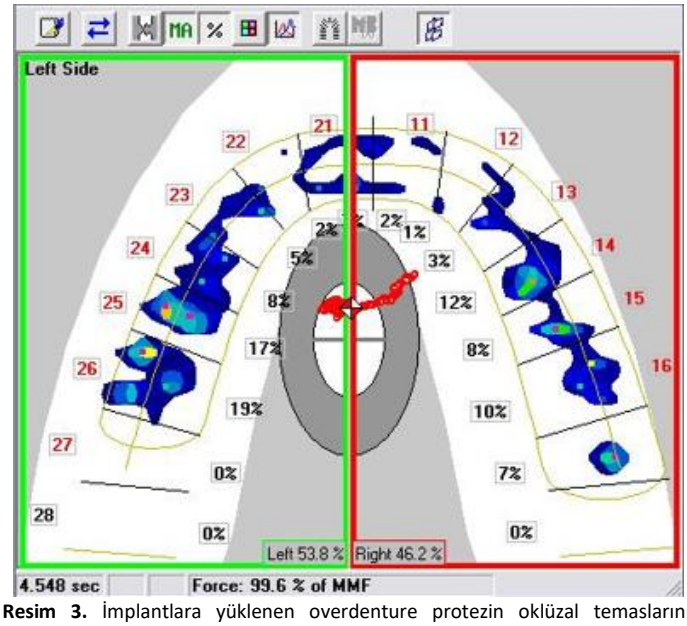
Resim 1. Total protezin implantlara bağlanmadan önceki oklüzal temas dağılımları

Ağız içinde diş eti yüksekliklerine göre topuz başlı ataşmanlar seçilmiştir ve protez içerisinde kalacak topuz başlı ataşman parçaları denenmiştir (Resim 2).

Hazırlanan alt total protezin implant bölgelerine, uygulanacak materyal için yeterli boşluk oluşturulmuştur. Topuz başlı ataşmanların etrafındaki yumuşak dokular teflon bant ile izole edilmiştir. Protez, pembe soğuk akrilik ile ağız içinde topuz başlı ataşmanlara bağlanmıştır. Taşan akrilik fazlalıklar möllenerek total protez kullanıma hazır hale getirilmiştir. İmplantlara yüklenen overdenture protezin oklüzal temaslarının dağılımı T-Scan III sistemi kullanılarak ölçülmüştür (Resim 3). Total protezin implantlara bağlanmasından sonraki oklüzal temaslarının dağılımı öncesinde düzenlenen haline çok yakın değerler vermistir. Bu yüzden oklüzal temaslarının tekrardan düzenlenmesine ihtiyaç duyulmamıştır.



Resim 2. Ağız içi topuz başlı ataşmanların görünümü



Resim 3. İmplantlara yüklenen overdenture protezin oklüzal temaslarının dağılımı

TARTIŞMA

Bu olguda olduğu gibi implant destekli protezler hem fonksiyonu hem de estetiği geliştirerek en iyi performans gösteren rehabilite edici çözüm gibi görünmektedir.

Çalışmanın hipotezi olan total protezin ağız içinde implantlara bağlanmadan önce ölçülen kuvvet dağılımının, bağlandıktan sonra anterior bölgeye doğru hareket edeceği yönündeki görüşümüz red edilmiştir.

Literatürden elde edilen mevcut kanıtlar, implant destekli overdenture'ların protezin sağlamlığı ve retansiyon sorunlarını önemli ölçüde azaltabileceğini ve alttaki yumuşak dokular üzerindeki basıncı azaltabileceğini göstermektedir.[21] Kemik içi implantlar tarafından garanti edilen protetik denge, çiğneme biyomekaniğini büyük ölçüde etkiler ve bu da eksantrik etkileşimlerin azalmasına, sentrik oklüzyonun stabilizasyonuna ve çiğneme kaslarının yoğunluğunun azalmasına yol açar. Bu fark, T-Scan III cihazının uygulanmasından elde edilen iki ve üç boyutlu planlarla iyi bir şekilde temsil edilmektedir. Bu bilgisayarlı kaydın, artikülasyon kağıtlarının kullanımıyla elde edilen geleneksel algılamaya kıyasla en büyük avantajı, temasların yoğunluğunun ve özellikle bunların hem statik (maksimum interkuspasyon veya sentrik ilişki) hem de dinamik durumdaki zamansal sırasının değerlendirilmesine izin vermesidir.[22]

Üç boyutlu histogramlar hem sağ hem de sol alanlar ve her diş için oklüzal yükler arasındaki farkı diğerlerinden daha fazla vurgulamaktadır.[22] Renk dağılımı, oklüzal yüklerin farklı yoğunluğunu gösterir: kırmızı, daha büyük bir yükü, mavi ise daha küçük bir yükü gösterir.

Oklüzal analiz, implant tedavisinin başarısı için önemli bir adımdır. Tam protezlerde uygun oklüzyon, tedavinin başarısını artırmak için çok önemli bir faktördür. Bilgisayarlı oklüzal analizin kullanılması, diş hekiminin oklüzal kuvveti ve oklüzal dağılımı tespit etmesine yardımcı olur ve diş hekiminin oklüzyonu doğru bir şekilde ayarlamasını sağlar.[23,24] Ayrıca geleneksel artikülasyon kağıdı ile birlikte kullanılır.[25]

Yapılan çalışmalar, iki veya dört implant üstü protez kullanmanın tam protezin işlevini arttırdığını göstermiştir.[26,27] Bu çalışmada, alt tam protezleri korumak için dental implantları kullanmadan önce ve sonra yapılan oklüzal analizi karşılaştırılmaktadır.

Oklüzyonla ilgili klinik araştırmalarda, interkuspal pozisyonda oklüzal temasların doğasını değerlendirmek için artikülasyon kağıdı, folyolar, mum, silikon vb. gibi çeşitli yöntemler kullanılmıştır.[28] Basit ve hızlı olmasına rağmen, bu yöntemlerle oklüzal interferenslerin varlığını ve lokasyonunu belirlemek zor olmuştur. Örneğin, Kerstein[3] oklüzal işaretlemenin boyutu ile kuvvet arasındaki güvenilirliğin sadece %21 olduğunu bildirmiştir. Kalın ürünler izlerin yüzey alanını arttırır ve ayrıca mandibulada sapmalara neden olabilen propriyoseptif reaksiyonları uyarabilir.[29] Ek olarak, tam protezlerde erken temaslar, oklüzyon sırasında protez pozisyonunu değiştirebilir, bu da esas olarak yanlış bir maksimum interkuspasyonda yanlış oklüzal temaslara yol açabilir.[30] Bu nedenle, tam protezlerde erken oklüzal temasların varlığını objektif olarak doğrulamak için, oklüzal temas sırasını değerlendirmek gereklidir. T-Scan'in doğruluğu ve tekrarlanabilirliği eleştirilmiştir.[31] Ancak Koos ve ark.,[32] T-Scan III ile yapılan oklüzal analizin kesin ve güvenilir olarak kabul edilebileceğini bildirmiştir. Koos ve ark.[32]'a göre, tüm uygulamaların %95'inde 1,96 kat ölçüm hatası, yani ölçülen ve gerçek değerler arasındaki fark %2'den azdır. Bu nedenle, maksimum interkuspasyonda oklüzal temas dağılımının analizi ve değerlendirilmesi için yöntem yeterince kesin ve güvenilir olarak kabul edilebilir.[31] Koos ve diğerleri[32] bu ekipmanın doğruluk seviyesinin kabul edilebilir olduğunu ve çalışmalarında folyodaki değişikliklerden veya tekrarlanan ölçümlerden kaynaklanan hiçbir interferensin tespit edilmediğini bildirmiştir. Ayrıca, dinamik oklüzyondaki erken temaslar ve interferensler tanımlanabilir.

Oklüzyonda üretilen kuvvet, zamanla değiştiği ve bir grafikte zamana karşı çizilebildiği için doğası gereği dinamiktir.

Sistemin yazılım programı, dental arkların daha iyi görüntülemesini sağlar,[32] bu da onu oklüzal temas kaydı için diğer yöntemlerden çok daha bilgilendirici hale getirir.[33] T-SCAN III, oklüzal-artikülasyon analizinin hızlı ve doğru bir şekilde kaydedilmesine ve analizine olanak tanır.[34]

Bilgisayarlı oklüzal analiz sistmeleri yıllardır kullanılan oklüzal analiz metotlarına göre daha hassas ve kayıtları saklanabilen sonuçlar vermektedir.[35]

SONUÇ

İmplant üstü overdenture protezlerin ağız içi yüklenmeleri sonrasında oklüzal temasların dağılımının değişimi hakkında literatürde henüz yeterli bir çalışma bulunmamaktadır. Yapılan çalışmada total protezin implantlara bağlamadan sonraki oklüzal temaslarının dağılımı öncesinde düzenlenen haline çok yakın değerler vermiştir. Bu yüzden

oklüzal temaslarının tekrardan düzenlenmesine ihtiyaç duyulmamıştır. Ancak bu konuda daha kesin bir sonuca ulaşmak için yeni çalışmalara ihtiyaç duyulmaktadır.

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Tek Diş İmplant Üstü Sabit Protezlerde Dişeti Çıkış Profilinin Oluşturulması

Creation of Emergence Profile in Single Tooth Implant Retained Fixed Prosthesis

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ÖZ

Kısmi ve tam dişsiz vakalarda implant üstü protetik restorasyonlar günümüzde sıklıkla tercih edilen tedavi seçeneklerinden biridir. İmplant tedavisi sonrası daimi protez yapımına geçilmeden önce çeşitli yöntemlerle komşu dişlerle uyumlu yumuşak doku profilinin oluşturulması gerekmektedir. Bazı kaynaklar stabil ve uygun kontura sahip geçici protezin yerleştirilmesinden sonra oluşan yumuşak doku profilinin daimi restorasyona aktarılması gerektiğini ifade etmektedir. Bu olgu raporunda 36 ve 14 numarasını kaybeden 34 yaşında kadın ve 29 yaşında erkek hastaya okluzal vidalı geçici kron kullanılarak dişeti şekillendirmesi planlandı. Uygun dişeti çıkış profili sağlandıktan sonra kişisel ti-based abutment hazırlandı. Hastaya zirkonya seramik restorasyonlar uygulanarak estetik ve fonksiyonel kayıp geri kazandırıldı. Hastanın 1,3 ve 6 aylık kontrollerde herhangi bir komplikasyon görülmedi.
Anahtar kelimeler: Dişeti çıkış profili, implant, zirkonya

ABSTRACT

In partial and complete edentulous patients, prosthetic restorations over implants are often one of the preferred treatment options today. Before switching to permanent fixed prosthesis construction after implant treatment, it is necessary to create a soft tissue profile compatible with proximal teeth by various methods. Many case reports stated that the soft tissue profile formed after the placement of a temporary prosthesis with a stable and appropriate contour should be transferred to permanent restoration. In this case report, 34-year-old female patient and 29-year-old male patient who missing teeth 36 and 14 were planned to shape their gingiva using temporary crowns with occlusal screws. A personal ti-based abutment was prepared after the appropriate emergence profile was provided. Aesthetic and functional loss was restored by applying zirconia ceramic restorations to the patient. No complications were observed 1,3 and 6-month control appointments of the patients.
Keywords: Emergence profile, implant, zirconia

GİRİŞ

Günümüzde teknolojinin gelişmesi ve hastaların istekleri doğrultusunda implant üstü sabit protez tedavileri giderek yaygınlaşmıştır. İmplant üstü protezlerin amacı kaybedilen estetik ve fonksiyonu geri kazandırmaktır. [1]

İmplant üstü restorasyonların başarısında implantı çevreleyen yumuşak dokuların sağlığı ve stabilitesi önemli bir rol oynamaktadır .[2] İmplantlar, krestal kemik ve mukoza seviyesinde boyut ve şekil olarak doğal dişlerden farklılık gösterir. İyileşme başlıkları çıkarıldıktan sonra doku profilinin geometrisi daireseldir ve dişlerin etrafındaki dokular ile uyuşmazlık gösterir. Bu nedenle peri-implant yumuşak doku profilinin, komşu diş yapısı ile uyumlu bir doku profiline dönüştürülmesi gerekir. [3]

Güncel literatürlerde yumuşak doku profili oluşturma ile ilgili farklı teknikler mevcuttur. Birçok yazar stabil ve uygun kontura sahip geçici protezin yerleştirilmesinden sonra oluşan yumuşak doku profilinin daimi restorasyona aktarılmasını önermektedir. [4]

İmplant yerleştirildikten sonra geçici restorasyonla yapılan şekillendirmede yumuşak doku korunabilir, değiştirebilir ve desteklenebilir; böylece doğal bir dişeti çıkış profili sağlanır. Uygun bir dişeti çıkış profili implant üstü protezin hijyenini sağladığından peri- implant dokuların sağlığı için çok önemlidir. İnterdental papilladaki dişeti dokusu da geçici restorasyon ile uygun şekilde destekleniyorsa istenen şekle getirilebilir. [5]

Dişeti şekillendirmesindeki amaç; komşu diş yapısıyla uyum sağlayan bir mukoza/dişeti seviyesini yeniden oluşturulması, doğru bir dişeti çıkış profili oluşturmak, dişeti zenith noktasını tam olarak yeniden konumlandırmak, dengeli papilla yüksekliği/genişliği elde etmek, implant kronu ve komşu diş ile proksimal bir temas alanı oluşturmaktır.

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Başarılı estetik bir restorasyonu; ideal implant pozisyonu, uygun geçici restorasyonların kullanımı, dişeti konturunun şekillendirilmesi, restoratif platformun boyutu ve formu, abutment materyali, daimi restorasyon için kullanılacak materyal gibi birçok faktör etkilemektedir.[6]

Bu makalede aşırı madde kaybından dolayı dişini kaybetmiş iki hastanın, okluzal vidalı geçici protezlerle dişeti çıkış profilinin oluşturulması sonrası kişisel ti-base abutmentlar ve zirkonya seramik restorasyonlarla tedavisi sunulmaktadır.

OLGU SUNUMLARI

OLGU 1

Otuzdört yaşında kadın hasta diş eksikliği sebebiyle Afyon Karahisar Sağlık Bilimleri Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi kliniğine başvurdu.

Sistemik bir rahatsızlığı olmayan hasta radyolojik ve klinik olarak incelendi. Hastadan alınan anamnezde aşırı madde kaybı sebebiyle 36 numaralı dişini kaybettiği tespit edildi. Ek olarak hastada 26 numaralı dişin okluzal düzleme doğru yer değiştirmesinden dolayı okluzal mesafe kaybı mevcuttu. Hasta tedavi seçenekleri ile ilgili bilgilendirildi. Bilgilendirilmiş gönüllü onam formu alınarak implant destekli bir protez yapılmasına karar verildi.

Daha sonra cerrahi rehber plak kullanılarak kemik seviyesinde bir implant (Astra tech 4.2 C-13mm) ideal implant pozisyonu kurallarına göre yerleştirildi. Dört aylık iyileşmeden sonra ikinci bir cerrahi işlemle implantın üzeri açıldı ve ginival former yerleştirildi. (Resim 1,2).

Hastadan ölçü postu ile C tipi silikon ölçü maddesi (Zetaplus, Zhermack, İtalya) kullanılarak geçici kron yapımı için ölçü alındı. Geçici abutment hastanın ağzına yerleştirildi. Hazırlanan geçici kron referans alınan bir noktadan bond (Bond Force II, Tokuyama, Japonya) ve akışkan kompozit (Dynamic Flow,President Dental, Almanya) kullanılarak abutmente sabitlendi. Abutment vidası gevşetilerek geçici kron ve abutment hasta ağzından çıkarıldı.

Şekillendirme sürecinde ilk adım olarak fasiyal kritik kontur belirlendi. Bu olguda fasiyal yumuşak doku marjini ideal seviyeden daha koronalde olduğundan dolayı dişeti sınırını apikalde yeniden konumlandırmak için geçici restorasyonun kritik konturu, fasiyal/apikal yönde fazla şekillendirildi. Kritik kontur bölgesi dış bükey olarak şekillendirilirken kritik kontur altı bölge de iç bükey olarak hazırlandı. (Resim 3).

İki hafta sonra yapılan kontrollerde yumuşak dokunun durumuna göre geçici restorasyon modifiye edildi. Şekillendirmeye 35 numaralı dişin dişeti seviyesine ulaşılana kadar devam edilmesi planlanıyordu ancak hastanın isteği doğrultusunda bu aşamada bırakıldı (Resim 4,5). Daimi restorasyon için ölçü aşamasına geçildi. Dişeti çıkış profilini kaybetmemek için hastaya bireysel ölçü postu hazırlandı.

Bireysel ölçü postu hazırlanması şu sıralama ile uygulandı: Analoğa vidalanan geçici kron, vida deliği dışarıda kalacak şekilde C tipi silikon ölçü maddesi içine gömüldü. Sertleşme tamamlandıktan sonra light body ile ölçünün ikinci aşaması tamamlandı. Silikonun polimerizasyonunun ardından geçici restorasyon analogtan söküldü. Bu esnada analogun hareket etmemesi için analogun uç noktasından dikkatlice tutularak sabitlendi. Böylelikle yumuşak dokuda oluşturulan dişeti çıkış profilinin şekli ölçü maddesine aktarıldı. Ardından ölçü maddesinin içinde bulunan analoga ölçü postları bağlandı. Ölçü postu ve silikon arasında kalan boşluklar patern rezin ile kapatılarak ışık cihazı (Castellini T-Led , İtalya) ile 20 sn polimerize edildi. Polimerizasyonun ardından sökülen ölçü postları ağız içine yerleştirildi ve açık kaşık yöntemi ile A tipi silikon ölçü maddesi (Elite HD+, Zhermack, Italya) kullanılarak ölçü alındı. Model oluşturulduktan sonra kişiye özel ti-base abutment hazırlandı ve ağız içi provaları yapıldı. Prova esnasında bireysel abutment ile mukoza arasında boşluk kalmamasına, abutmentin mukozada belirgin bir staz oluşturmamasına, abutmentin basamağı ile mukozanın aynı seviyede olmasına dikkat edildi. Daha sonra zirkonya altyapılı tam seramik restorasyon üretildi ve ağız içi uyumuna bakıldı (Resim 6).

Kritik kontur altı bölgede epitel hücre adezyonunu arttırdığı için sadece mekanik cila yapıldı.[7] Restorasyon glaze işlemlerinden sonra rezin siman (Panavia SA, Kuraray, Japonya) ile simante edildi (Resim 7). Hastaya ağız hijyeni konusunda öneriler verildi ve düzenli kontrollere çağırıldı. Yapılan 1, 3 ve 6 aylık kontrollerinde herhangi bir biyolojik, fonksiyonel ve estetik sorunla karşılaşılmadı.

Resim 1.İmplantasyon sonrası panoramik röntgen görüntüsü

Resim 2.İmplantasyon sonrası 36 numaralı bölgenin görüntüsü

Resim 3. Hazırlanan geçici kron

Resim 4. Geçici restorasyon ile şekillenen yumuşak dokunun görüntüsü

Resim 5. Dişeti şekillendirmesi sonrası yumuşak doku görünümü

Resim 6. Ti-based abutment ağız içi provası

Resim 7. Simantasyon işleminden sonra restorasyonun ağız içi görünümü

OLGU 2

Yirmidokuz yaşında erkek hasta diş eksikliği rahatsızlığı sebebiyle Afyon Karahisar Sağlık Bilimleri Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi Anabilim Dalına başvurdu.

Sistemik bir rahatsızlığı olmayan hasta radyolojik ve klinik olarak incelendi. Hastadan alınan anamnezde aşırı madde kaybı sebebiyle 14 numaralı dişini kaybettiği tespit edildi.

Hasta tedavi seçenekleri ile ilgili bilgilendirildi. Bilgilendirilmiş gönüllü onam formu alınarak implant destekli bir protez yapılmasına karar verildi.

Daha sonra cerrahi rehber plak kullanılarak ile kemik seviyesinde, dar çaplı (3.0 mm) bir implant (Astra Tech) ideal implant pozisyonu kuralları dahilinde yerleştirildi (Resim 8).

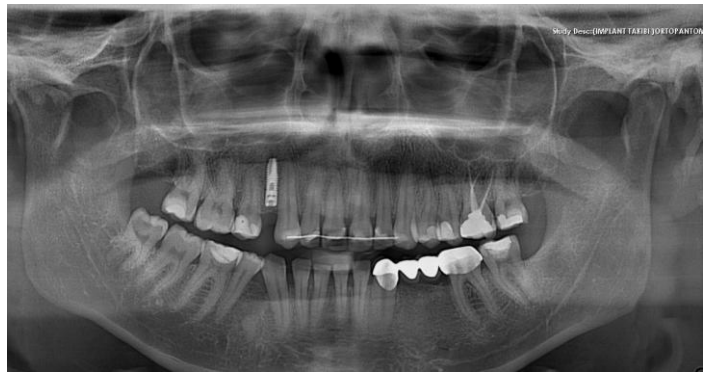
Hastadan ölçü postu yardımıyla C tipi silikon ile ölçü alınarak geçici kron hazırlandı. Bir önceki olguda anlatılan yöntemle geçici kron uygun dişeti çıkış profili sağlamak için uyumlandırıldı (Resim 9). Altı haftalık şekillendirmeden sonra ideal dişeti çıkış profili ve papil oluşumu sağlandı.

Daimi restorasyon için ölçü aşamasına geçildi. Hastaya kişisel ölçü postu hazırlandı.

Ölçü aşamasından sonra model elde edildi. Model üzerinde kişiye özel ti-base dayanak üretildi ve ağızda provaları yapıldı sonrasında zirkonya altyapılı tam seramik restorasyon üretildi ve ağız içi uyumuna bakıldı (Resim 10).

Glaze işlemlerinden sonra rezin siman (Panavia SA, Kuraray, Japonya) kullanılarak simante edildi (Resim 11).

Yapılan 1, 3 ve 6 aylık kontrol randevularında herhangi bir biyolojik, fonksiyonel ve estetik sorun görülmedi.



Resim 8.İmplantasyon sonrası panoramik röntgen görüntüsü

Resim 9. Hazırlanan geçici kron

Resim 10. Ti-based abutment ağız içi provası

Resim 11. Simantasyondan sonra restorasyonun ağız içi görünümü

TARTIŞMA

İmplant tedavilerinin estetik sonuçları, yetersiz protez yapımı nedeniyle implantların başarılı osseointegrasyonuna rağmen tehlikeye girebilir. İmplantın restorasyonunun başarısı, protezin ve biyolojik olarak yönlendirilmiş implantın yerleştirilmesine ve son derece estetik bir protez ve peri-implant yumuşak doku mimarisine bağlıdır.[8,9] Geçici restorasyon, optimum papiller profili oluşturmak için belirli bir mukoza hacmini yeniden yönlendirmek için kullanır. Şimdiye kadar literatürde sunulan en sık kullanılan teknik, yumuşak doku iyileşmesi aşamasında geçici kron üzerine kompozit rezin ekleyerek peri-implant dokuyu şekillendirmektir. İlk aşamada dokuyu doğru yönde sıkıştırmak önemlidir. Nekroz, anemi ve ağrıyı önlemek için basınç birkaç adımda uygulanır. Basınç, yumuşak dokuyu doğru pozisyona yönlendirmek için lateral olarak sıkıştırır. Ardından, dokunun oluşturulan alanı doldurmasına izin vermek için özellikle papiller bölgede yetersiz konturlama yoluyla geçici krona ilave edilen kompozit yeniden düzenlenerek yumuşak doku şekillendirmesi sağlanır. Bu, birkaç randevu üzerinden yapılabilir.[10]

Tarnow ve ark,[11] daimi protez yapılmadan önce yumuşak dokuda değişiklik yapılması gerektiğini belirtmiştir. Estetik bir sonuca ulaşmanın önemli aşamalarından biri, detaylı bir ölçü transferi yapmak olduğu bildirilmiştir. Standart olan iyileşme başlıkları ve ölçü postlarının yuvarlak bir şekli olduğundan doğal dişleri taklit edemediklerinden dolayı bireysel ölçü postlarıyla implant etrafındaki mukozanın desteklenebileceği belirtilmiştir.[12,13] Bu şekilde doku kollapsı gibi sorunlarla karşılaşılmayacağı ve şekillendirilen yumuşak dokunun stabilitesini devam ettirebileceği belirtilmektedir.[1]

Okluzal vidalı geçici restorasyonlar dişeti şekillendirilmesinde simante geçici restorasyonlara göre daha sık tercih edilmektedir. Çünkü okluzal vidalı restorasyonlar siman içermediğinden kron-abutment bağlantısında pürüzsüz bir yüzey sağlayarak doku iyileşmesini kolaylaştırmaktadır.[14-16]

İmplantüstü protezlerde başarılı bir estetik restorasyonu sağlamak için kullanılacak implant abutment materyali de oldukça önemlidir. Titanyum; yüksek gerilme dayanıklılığı, korozyona direnci, biyolojik uyumu nedeniyle günümüzde en çok kullanılan abutment materyalidir.[17] İmplantın yüzeysel yerleştiği, ince dişeti biyotipi olduğu vakalarda titanyum abutmentın yumuşak dokuda oluşturduğu mavimsi-gri yansıma estetiği olumsuz etkileyebilir. Bu nedenle, zirkonya abutmentların kullanımıyla daha estetik sonuçlar elde edilebilmektedir. Bununla birlikte titanyum abutmentların kırılma dayanımının zirkonya abutmentlardan yüksek olduğu bildirilmiştir.[18,19] Titanyum abutmentların mekanik, zirkonyum abutmentların estetik avantajlarına sahip olan, bireysel olarak hazırlanarak uygun dişeti çıkış profilinin sağlanabildiği ti-based zirkonya abutmentlar, implantüstü protezler için en güncel ve en ideal seçenektir.[20]

Bu olguda ideal bir dişeti görünümü oluşturabilmek için final restorasyon yapımına geçilmeden önce okluzal vidali geçici restorasyon kullanımıyla başarılı bir dişeti çıkış profili oluşturulmuştur. Hazırlanan geçici restorasyonun dişeti şekillendirmesi süresince sorunsuz bir şekilde kullanıldığı görülmüştür İki olguda da geçici restorasyonla yapılan dişeti şekillendirmesi yönteminin başarılı sonuçlar verdiği görülmüştür.

Hasta Onamı: Bilgilendirilmiş gönüllü onam formu alınarak implant destekli bir protez yapılmasına karar verildi
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir –K.K., E.K., S.M.Ü.; Tasarım – K.K., E.K., S.M.Ü.; Denetleme – K.K., E.K., S.M.Ü.; Kaynaklar – K.K., E.K., S.M.Ü.; Veri Toplanması ve/veya İşlemesi –K.K., E.K., S.M.Ü.; Analiz ve/veya Yorum –K.K., E.K., S.M.Ü.; Literatür Taraması – K.K., E.K., S.M.Ü.; Makaleyi Yazan – K.K., E.K., S.M.Ü.; Eleştirel İnceleme – E.K.,K.K.,S.M.Ü.
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Informed Consent: It was decided to make an implant-supported prosthesis by obtaining informed consent form**.**
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