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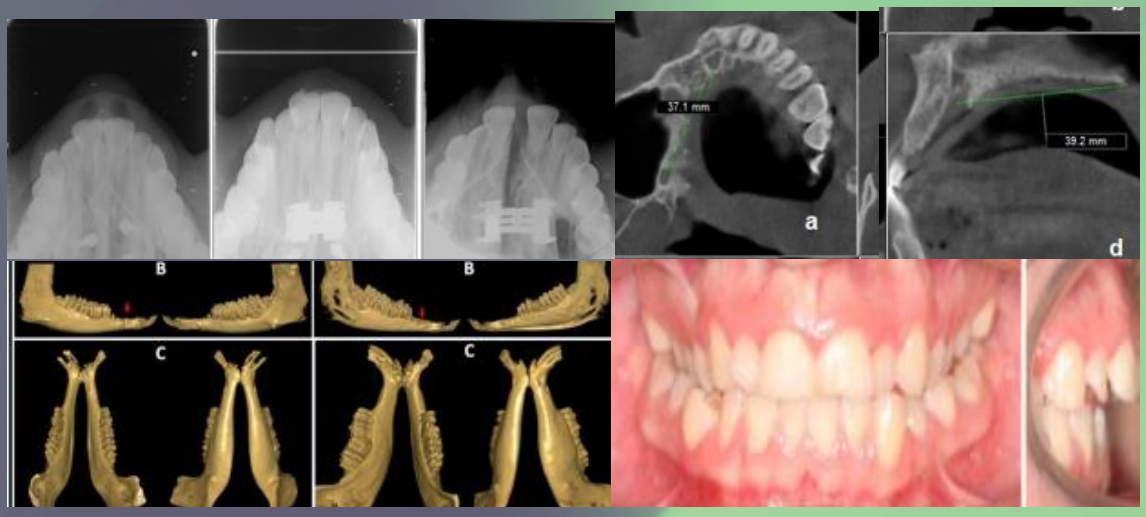

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Evaluation of Shear Bond Strength and Adhesive Remnant Index of New-Generation Adhesive-Coated Bracket Systems in Comparison With Traditional Systems

Yeni Nesil Adeziv Kaplı Braket Sistemleri ve Geleneksel Sistemlerin Bağlanma Dayanımı ve Artık Adeziv İndeksinin Değerlendirilmesi

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ABSTRACT

Objective: To evaluate the shear bond strength (SBS) and the adhesive remnant index (ARI) of different traditional orthodontic adhesive systems and newly developed pre-coated adhesive systems.
Methods: A total of 50 human maxillary premolars were bonded with Clarity advanced ceramic brackets using APC™ Flash-Free, APC™ PLUS, Transbond™ XT Light Cure, Opal® Bond™MV and, Blugloo™ adhesives. All samples underwent thermo-cycling. The SBS was determined using a testometric machine. A stereomicroscope was used to evaluate the adhesive remnant on debonded enamel surface. Differences among the adhesives were tested for statistical significance.
Results: Blugloo™ group had the highest SBS (22.69 ± 9.14 MPa). However, there was no significant difference in mean SBS among the groups ($P<.05$). The Flash-free adhesive group had a significantly lower ARI score than Opal® Bond™MV and, Blugloo™ groups ($P<.001$).
Conclusion: All experimental groups provided clinical bond strength higher than required. The flash-free adhesive group resulted in lower adhesive remnant, this saves time for the clinician.
Key words: Adhesive-coated bracket systems, shear bond strength, traditional brackets

ÖZ
Amaç: Farklı geleneksel ortodontik adeziv sistemlerin ve yeni geliştirilen önceden kaplanmış adeziv sistemlerin makaslama bağlanma dayanımını (SBS) ve artık adeziv indeksini (ARI) değerlendirmektir.
Yöntem: Toplam 50 insan üst küçük azı dişi, APC™ Flash-Free, APC™ PLUS, Transbond™ XT Light Cure, Opal® Bond™MV ve Blugloo™ adezivler kullanılarak Clarity advanced seramik braketlerle yapıştırıldı. Tüm örneklere termal-siklus uygulandı. SBS, bir testometrik makine kullanılarak belirlendi. Mine yüzeyindeki artık adezivi değerlendirmek için bir stereomikroskop kullanıldı. Yapıştırıcılar arasındaki farklılıklar istatistiksel anlamlılık açısından test edildi.
Bulgular: Blugloo™ grubu en yüksek SBS'ye (22,69 ± 9,14 MPa) sahipti. Ancak gruplar arasında ortalama SBS açısından anlamlı bir fark yoktu ($P<.05$). Flash-free adeziv grubu, Opal® Bond™MV ve Blugloo™ gruplarına göre anlamlı derecede daha düşük ARI skoruna sahipti ($P<.001$).
Sonuç: Tüm deney grupları, gerekenden daha yüksek klinik bağlanma dayanımı sağlamıştır. Flash-free adeziv grubu daha düşük adeziv artığına yol açmıştır, bu da klinisyene klinik kullanımda zaman kazandıracaktır.
Anahtar kelimeler: Adeziv-kaplı braket sistemleri, bağlanma dayanımı, geleneksel braketler

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INTRODUCTION

Despite the ever-increasing popularity of aligner therapy, fixed treatments with bands and brackets are still the most preferred technic in orthodontics. When classical brackets are used in the treatment, the composite is manually applied to the base of the bracket in a thin and homogeneous manner after that the bracket is placed on the facial surface of enamel at an appropriate position. Then the excess adhesive flowing from the margin of the bracket is removed (flash clean-up) and composite is polymerized. The flash clean-up provides protection against caries by reducing the area of dental plaque accumulation during the prolonged period of orthodontic treatment.[1,2]

Orthodontic bonding is time-consuming for clinicians, so it is important to simplify this procedure while optimizing bonding strength. Recently, 3M Unitek (Monrovia, California, USA) has launched the novel APC Flash-Free brackets to facilitate the bonding process.[3] The claimed advantages of these pre-coated brackets include the elimination of flash clean-up, fewer steps in the bonding process, and enhanced bond strength with less error.[3] Lee and Kanavakis[4] report that the bonding time was significantly lower in flash-free brackets compared to traditional bracket systems. In the same study, the bond strength was found to be significantly higher in APC Flash-free brackets compared to the Clarity Advanced bracket group, in which the composite is manually applied to the base of the bracket.

Ease of operation, bond strength, and accessibility are essential properties for orthodontic bonding systems in clinical practice. In the study by Reynolds, it was reported that the appropriate bond strength ranges from 5.6 MPA to 7.8 MPa. [5] Bishara reported that the major problem for safe debonding is excessive bond strength in ceramic brackets.[6] The debonding force applied to the ceramic bracket leads to the break-up of the bond between enamel and adhesive and cracks when enamel fails to resist sufficiently. Currently, many orthodontic bonding systems ensure sufficient bond strength. However, to the best of our knowledge, there is no study reporting a standardized comparison between recent pre-coated bracket systems, which shorten duration of bonding procedure, and traditional adhesive systems, which are widely used in orthodontic clinics.

In this in vitro study, it was aimed 1) to compare bond strength among adhesive materials from different brands and pre-coated brackets (Flash-free and APC-Plus); and 2) to compare the amount of adhesive remnant after debonding. The null hypothesis is that flash-free brackets will leave less adhesive remnant and have better bond strength compared to other adhesives.

METHODS

Specimen Preparation and Grouping

According to power analysis; with an effect size of 0.6190, an alpha level of 0.05, and a power of 0.90; it was assigned that a minimum of ten subjects in each group was required for five groups (version 3.1.9.3, G*Power; *HHU* Düsseldorf, Germany). Fifty newly extracted human maxillary premolars were collected and cleaned with a scaler to remove soft tissue and debris.[7] The criteria for selection were intact buccal enamel, no caries or cracks, no restorations and no prior orthodontic bonding. Until the test time the teeth were stored in 0.1% thymol solution for inhibition of bacterial growth at room temperature (maximum of two weeks).[4]

The specimens were randomly divided into five groups (APC Flash-free, APC Plus, Transbond XT, Opal, Blugloo), each containing ten teeth and five different adhesives were used for each (Table 1). 3M Clarity advanced brackets were used for all groups. Each tooth was individually embedded in a self-curing acrylic resin block exposing crown for bonding procedures.

Table 1. *Experimental groups and bonding materials used according to groups.*

Groups	n	Bracket	Primer	Adhesive
APC Flash-Free	10	Clarity™ Advanced	Transbond™ XT Primer	APC™ Flash-Free
APC Plus	10	Clarity™ Advanced	Transbond™ XT Primer	APC™ PLUS
Transbond XT	10	Clarity™ Advanced	Transbond™ XT Primer	Transbond™ XT Light Cure Adhesive
Opal	10	Clarity™ Advanced	Opal® Seal™	Opal® Bond™MV
Blugloo	10	Clarity™ Advanced	Ortho Solo™ Primer	Blugloo™

Methodology

Enamel preparation. All teeth were polished with a flour-free paste, then each rinsed with water and air-dried. A %37 phosphoric acid gel (3M™ Dental Products, USA) was applied 30 seconds to the buccal surface of the enamel. Then enamel surface rinsed with water for 20 seconds and dried with compressed air. The frosty white appearance was the criteria of a successful acid etching. After surface preparation a thin coat of primer was applied to enamel surface and air-thinned with gentle air. Transbond™ XT Primer was applied for APC Flash-free, APC Plus and, Transbond XT groups; Opal® Seal™ primer was applied for Opal Bond MV group and; Ortho Solo™ primer was applied for Blugloo group (Table 1). The primer was cured with light-emitting diode device (LED) for 10 seconds with a power of 1000 mW/cm^2.

Bonding procedure. Maxillary premolar Clarity™ Advanced ceramic brackets (3M Unitek) were bonded to all specimens by a single operator. The same bonding steps was applied to all non-pre-coated groups with different agents. A thin and homogeneous layer of adhesive was placed onto the brackets' base, and the brackets were placed in the ideal position of the buccal enamel. The brackets were then compressed 10 seconds with a force of 300 g by using a force gauge (P1025-00, Leone™, Italy) for standardization.[8] Excessive adhesive resin around the bracket was removed carefully with a dental probe. LED light was used 10 seconds from distal and mesial sides of each bracket for adhesive polymerization.

APC Flash-free and APC Plus groups has some differences in application of brackets. These precoated brackets, which requires no adhesive application onto the base or no removal of excess adhesive material, directly placed to the ideal position of buccal enamel surface, then compressed 10 seconds with a force of 300 g (P1025-00, Leone™, Italy). Adhesive material was light-cured with the same protocol of non-precoated groups.

Thermocycling was performed for simulating six months of oral thermal environment. All specimens underwent thermocycling (Julabo GmbH, FT 400, Seelbach, Germany) including 5000 cycles at 5 and 55 °C with a dwell time of 30 seconds.[9] Then, they were stored in distilled water at 37°C for 24 h,[7] and subsequently performed shear bond test on Testometric machine (Testometric M500 25kN, Rochdale, UK).

Shear Bond Strength

The specimens were fixed in the metal sample holder of lower part of the testing machine. Bracketed buccal surface of the teeth was positioned parallel to the moving upper part of the machine. The knife edged upper part of shearing device was placed perpendicularly

between bracket wing and base with motion direction parallel to vestibular surface of teeth and bracket base. The test was initiated with no force on bracket by shearing device which had slight contact with bracket. The crosshead velocity for this device was set as 1 mm/minute.

During test procedure, the increase in shearing force was monitored from screen of test device and maximum bonding strength (the strength at time of bracket debonding) was recorded (Newton, N). The maximum value of shearing force was divided by surface area of bracket body, indicating strength at unit area (MPa=N/mm^2).[7] In this study, Clarity Advanced ceramic brackets were used in all groups and surface area of this bracket body is 11.694 mm^2 according to the manufacturer (3M) (4).

Evaluation of Adhesive Remnant Index (ARI)

After bracket removal, the residual adhesive on the site of bonded enamel was evaluated using a stereomicroscope (Nikon SMZ800) under 10X magnification. Modified Adhesive Remnant Index (ARI) as described by Bishara and Trulove was used for scoring and was performed by the same examiner at two different times with one month interval.[10] This scale ratings from 1 to 5.

1, all adhesive remains on the enamel

2, more than 90% of the composite remained on the enamel

3, more than 10% but less than 90% of the composite remained on the enamel

4, less than 10% of composite remained on the enamel

5, no adhesive left on the enamel.

Statistical Analysis

Shapiro-Wilk test was used to assess normal distribution of quantitative parameters. One-way ANOVA test was used to compare data with normal distribution among groups while Kruskal-Wallis and All pair-wise multi-comparison tests were used to compare data with skewed distribution. Intra-observer agreement was assessed using Kappa coefficient. As reported by Landis and Koch,[11] the strength of agreement was rated as follows: 0.01-0.20, poor; 0.21-0.40, slight; 0.41-0.60, moderate; 0.61-0.80, substantial; and 0.81-1.00, almost perfect.

Descriptive statistics are presented as median, Q1 and Q3. All statistical analyses were performed using SPPS for Windows version 24.0 (SPSS, Chicago, IL, USA). p <0.05 was determined as significance level.

RESULTS

Table 2 presents shear bond strength after thermocycling procedure. The highest SBS value was recorded in Blugloo group (22.69±9.14 MPa) while lowest SBS value was observed in APC Flash-free group (17.51±6.03 MPa). However, no significant difference was found in mean SBS among study groups using different adhesives and primers (p=0.579).

Table 2. *Intra-group comparison of SBS (MPa) with one-way ANOVA test*

Groups	Mean ± SD	Min-Max	*p* value
APC Flash-Free	17.51 ± 6.03	10.2-27.5	0.579
APC Plus	20.50 ± 7.03	8.7-32.6	
Transbond XT	18.84 ± 8.15	9.3-29.6	
Opal	18.56 ± 6.81	9.4-28.3	
Blugloo	22.69 ± 9.14	11.8-38.8	

P value was obtained from one-way ANOVA test. SD; standart deviation

Table 3 presents Kappa values for intra-observer agreement of ARI scores obtained at two different time points. The intra-observer agreement was found to be substantial in APC Flash-free, APC Plus, Transbond XT and Opal groups while it was found to be almost perfect in Blugloo group. In all groups, intra-observer agreement was substantial of higher for ARI scores obtained in two different time points.

When mean modified ARI scores were compared after debonding, the amount of residual adhesive was significantly lower in APC Flash-Free group than those in Opal and Blugloo groups (P<.001). No statistically significant difference was observed between the other groups (Table 4).

Table 3. Kappa values for intra-observer agreement

Groups	Modified ARI	M	Q1	Q3	Kappa (CI 95%)
APC Flash-Free	ARI Score 1	1.00	1.00	2.00	0.610 (0.142 1)
	ARI Score 2	1.00	1.00	1.00	
APC Plus	ARI Score 1	4.00	4.00	4.00	0.792 (0.465 1)
	ARI Score 2	4.00	4.00	4.00	
Transbond XT	ARI Score 1	4.00	4.00	4.00	0.615 (0.300 1)
	ARI Score 2	4.00	4.00	4.00	
Opal	ARI Score 1	4.00	4.00	4.00	0.610 (0.140 1)
	ARI Score 2	4.00	4.00	4.00	
Blugloo	ARI Score 1	4.50	4.00	5.00	1 (1 1)
	ARI Score 2	4.50	4.00	5.00	

M; Median, CI; confidence interval, Q1 Quartile1(P25), Q3 Quartile3(P75)

Table 4. Comparison of mean ARI scores (M) among experimental groups

Groups	M	Q1	Q3	*p* value	Pairwise comparison
APC Flash-Free	1	1	1.5	<0.001	APC Flash-Free < Opal
APC Plus	4	4	4		APC Flash-Free < Blugloo
Transbond XT	4	4	4		
Opal	4	4	4		
Blugloo	4.5	4	5		

P value was obtained from Kruskal Wallis test. M, median; Q1, Quartile1 (P25); Q3, Quartile3 (P75)

DISCUSSION

The adequate enamel-bracket bonding strength is one of the prerequisites for success of orthodontic treatment. For this purpose, several adhesive materials have been produced by different companies. Recently, pre-coated brackets introduced by 3M provides sufficient bonding while shortening duration of bonding procedure.[3,4] However, higher cost of pre-coated brackets is a disadvantage.

In our study, Clarity advanced ceramic brackets were bonded to enamel using different adhesive systems (APC™ PLUS, Transbond™ XT Light Cure Adhesive, Opal® Bond™MV and Blugloo™) in experimental groups. The temperature alterations in intraoral environment were simulated using thermocycling, corresponding to 6 months; the SBS was assessed thereafter. The aging process simulating 6 months period between bonding and debonding procedures suggests that a realistic experimental environment was developed in our study.

The enamel preparation, type of adhesive used in bonding, debonding technique, time from bonding to debonding and storage conditions of samples are the factors that influences on bonding strength of brackets. In our study, bonding phases and debonding procedures were standardized across all groups; excluding factors which may impact SBS values.

In current study using different adhesives, the highest SBS value was recorded in Blugloo group (22.69±9.14 MPa) while the lowest SBS value was observed in APC Flash-free group (17.51±6.03 MPa). No significant difference was detected in SBS among groups. The Blugloo agent used in our study is an adhesive specially designed for ceramic bracket bonding. This may explain the highest bonding strength with this

adhesive. On the other hand, flash-free systems and traditional Transbond XT and Opal groups provided comparable strength values.

Gabriela MM *et al.* used similar bonding and debonding technique in their study and found that SBS was 21.77 MPa in APC Flash-free group (n=15), 27.11 MPa in APC Plus group (n=15), and 26.26 MPa in Transbond XT group.[12] Again, in a similar study, Ansari MY *et al.* found that SBS was 20.13 MPa in APC Flash-free group (n=10) and 27.26 MPa in Transbond XT group (n=10).[13] In our study, the SBS value was found to be lower than those in above-mentioned studies which employed similar techniques other than thermal-cycling. The difference in SBS values suggested thermocycling procedure reduces bonding strength.

In the study in which enamel prepared using self-etch primer, Lee and Kanavakis[4] found that SBS was 13.7 MPa in APC Flash-free group, 10.4 MPa in Transbond XT group and 10.8 MPa in APC Plus group. In that study, debonding test was performed using shear tension over wire attached to bracket wings. The SBS values were less than those observed in corresponding groups in our study. This difference may be due to different debonding method or self-etch primer use in the study by Lee and Kanavakis.

In the literature, there are studies reporting different bond strength values;[14-17] however, it will be meaningless to perform comparison with studies using different experimental design. In addition, in all adhesive types, we observed the bonding strength higher than optimal bracket bonding strength (5.9-7.8 MPa) as described by Reynolds.[5]

The modified ARI is a 5-points scale, which is commonly used to assess amount of adhesive residue over enamel. In this study, adhesive remnant scored twice (by one-month interval) by the same observer and intra-observer agreement was evaluated between two score using Kappa coefficient. The intra-observer agreement was found to be high in all experimental groups, which may be associated to experience of observer and eligibility of stereomicroscope for this assessment. The lower ARI scores indicate greater amount of residual adhesive on enamel surface that is thought to be concentration of debonding strength at bracket-adhesive interface while the higher scores indicate greater amount of residual adhesive over the base of bracket that is thought to be force concentration at adhesive-enamel interface.

In our study, lowest ARI score was found in APC Flash-Free group. It was lower than those in APC Plus and Transbond XT groups but did not reach statistical significance; however, it was significantly lower than those in Opalbond and Blugloo groups. After debonding, adhesive breakage occurring at bracket-adhesive interface decreases risk for enamel injury, although the removal of excess adhesive over enamel is time-consuming. In our study, the breakage more commonly occurred at bracket-adhesive interface in APC Flash-Free group which showed low ARI score while breakage occurred within adhesive resin in APC Plus, Transbond XT and Opal groups. In Blugloo group, the highest mean ARI score (4.5) showed that breakage occurred within resin in some teeth while at resin-enamel interface in others in this group. In addition, highest SBS value recorded in Blugloo group suggest that Blugloo adhesive can cause enamel cracks and fractures. However, there was no considerable number of enamel injury in any groups in our study.

In a study comparing adhesive remnant between precoated and uncoated brackets, Vicente and Bravoreported significantly lower residue over the enamel in APC Plus group.[18] On contrary, we observed the highest amount of residual adhesive in pre-coated APC Flash-free group. In another study comparing Flash-free and APC II adhesive coated appliance systems, Grrunheid *et al.* reported that the amount of residual adhesive over enamel was almost doubled in Flash-free group when compared to APC II system.[19] Similarly, Foersch *et al.*[20] compared APC Flash-Free and APC Plus systems and found that ARI score was 2.0 in APC Flash-Free group and 2.8 in APC Plus group. In both studies, lowest ARI score was reported in Flash-Free groups in agreement without study. These findings shows that flash-free systems are safe for enamel in bracket debonding; however, they prolong chair-time during debonding procedure.

In a recent study by Akl *et al*.,[21] no significant differences were found between conventional and APC Flash-Free brackets for shear bond strength. In the same study ARI score for APC Flash-Free brackets was higher with no significant difference between the conventional system and APC brackets.

In the present study, there was no significant difference in mean SBS values among groups but ARI score was significantly lower APC Flash-Free group. Thus, no significant correlation was detected between ARI score and SBS values of these five adhesives. These results show that the part of the null hypothesis of the study related to ARI is correct, but the part of the null hypothesis related to SBS cannot be confirmed.

CONCLUSION

In this in vitro study, following conclusions were drawn:

1. Highest SBS value was observed in Blugloo adhesive group.
2. All pre-coated and traditional adhesive systems used in this study had sufficient SBS for orthodontic treatment.
3. Traditional adhesives rather than pre-coated adhesive system ensure less adhesive remnant over the enamel surface in debonding; thus, they contribute shortening debonding time.
4. APC Flash-Free adhesive system is recommended to minimize enamel cracks which may occur debonding procedure in ceramic brackets.

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An Evaluation of The Effect of Passive Smoking on Caries and Periodontal Index in Preschool Children

Okul Öncesi Çocuklarda Pasif Sigara İçmenin Çürük ve Periodontal İndeks Üzerine Etkisinin Değerlendirilmesi

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ABSTRACT

Objective: To observe the changes that passive smoking causes in early childhood caries and periodontal tissues in preschool children.
Method: In our study, caries, periodontal, and plaque indexes were measured in preschool children aged 3-5 years and subjected to passive smoking. A 7-item questionnaire was administered to the parents.
Results: Periodontal and plaque indexes of children whose parents were smokers were higher than those of the children of non-smoking parents. In the evaluation made according to the education level of the parents, it was seen that the mean plaque index of the children of the fathers who were secondary school graduates was higher than that of parents with university degree. It was determined that the plaque index of children who did not use fluoride toothpaste and did not consume milk daily were higher than that of the other children. It was determined that the caries indexes of children who consumed sweet snacks during day were significantly higher than those who did not.
Conclusions: Passive smoking causes many changes in dental caries, periodontal health, and plaque status in preschool children. In order to protect the oral health of children in the risk group, preventive measures should be taken in the early period and routine dentist controls should be made.
Key words: Secondhand smoke, dental caries, periodontal status, dental plaque index

ÖZ

Amaç: Çalışmamız pasif içiliğin okul öncesi dönemdeki çocuklarda görülen erken çocukluk çağı çürüğü ve periodontal dokular üzerinde meydana getirdiği değişiklileri gözlemlemek amacıyla yapılmıştır.
Yöntem: Çalışmamızda pasif içicilik görülen okul öncesi dönemdeki 3-5 yaş aralığındaki çocuklarda çürük, periodontal ve plak indeksleri ölçülmüştür. Ebeveylerine ise 7 soruluk bir anket uygulanmıştır.
Bulgular: Çalışmamıza göre, ebeveynleri sigara içen çocukların içmeyenlere göre periodontal ve plak indekslerinin daha yüksek değerde olduğu görülmüştür. Ebeveylerin eğitim düzeyine göre yapılan değerlendirmede, babası ortaokul mezunu olan çocukların plak indeksi ortalamalarının, üniversite mezunu olanlara göre daha yüksek olduğu görülmüştür. Florlu diş macunu kullanmayan ve günlük süt tüketimi olmayan çocukların plak indekslerinin diğer çocuklara göre daha yüksek olduğu tespit edilmiştir. Gün içerisinde şekerli atıştırmalık tüketen çocukların, tüketmeyenlere göre çürük indekslerinin anlamlı derecede daha yüksek olduğu tespit edilmiştir.
Sonuç: Pasif içicilik okul öncesi dönemdeki çocuklarda diş çürüğü, periodontal sağlık ve plak durumu ile ilgili birçok değişikliğe neden olmaktadır. Risk grubundaki çocukların oral sağlığını korumak için erken dönemde koruyucu önlemlerin alınması ve rutin diş hekimi kontrollerini yaptırması gerekmektedir.
Anahtar Kelimeler: Pasif içicilik, diş çürüğü, periodontal durum, dental plak indeksi

INTRODUCTION

Passive smoking is defined as the inhalation of all harmful substances by non-smokers exposed to cigarette smoke.[1] Passive smoking can also cause adverse effects on oral health, apart from many systemic diseases such as cancer and cardiovascular diseases.[2-4]

Early childhood caries in the primary dentition in preschool children is a multifactorial, contagious, and chronic disease.[5] It is seen that passive smoking causes an increase in the frequency of caries due to an increase in the number of Streptococcus mutans in children and suppression of the immune system.[6] It was reported that the increase in the level of cotinine, which is the metabolite of nicotine, in the blood of children aged 4-11 years exposed to cigarette smoke increases the susceptibility to dental caries.[7]

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Cigarette smoke impairs revascularization in periodontal tissues, reduces the amount of oxygen going to the tissues, increases biofilm formation and causes periodontal disease by suppressing inflammatory responses. People who have never smoked but were exposed to secondhand smoke have a 1.6 times higher risk of developing periodontal disease than non-smokers.[8] An increase in melanin pigmentation in the gingiva was also detected in children with passive smoking.[9,10]

According to the hypothesis of our study, we hypothesized that caries, periodontal, and plaque indices would be higher in preschool children exposed to passive smoking due to the effect of smoking on the immune system compared to their healthy peers. Our study was carried out to observe the changes caused by passive smoking on early childhood caries and periodontal tissues in preschool children.

METHODS

Ethical approval was obtained for the study from the Non-Invasive Ethics Committee of Adıyaman University Faculty of Medicine (Decision Number: 2021/10-27, date: 14/12/2021).

The sample size of the study was determined as 160 (95% confidence interval, %5 margin of error).

Our study was carried out in cooperative pre-school children aged 3-5 years. Children with mood disorders, behavioral disorders, and hyperactivity, and who could not cooperate were excluded from the study.

Informed consent was obtained from the patient and their parents before the study. A questionnaire consisting of 7 items was administered to the parents of the patients. In the questionnaire, there are questions about the smoking status of the parents, their educational status, the tooth brushing habits of the parents and children, whether they use fluoride toothpaste, the child's consumption of sweet snacks during the day and how many times a day they consume, and the child's daily milk drinking status.

Intraoral examinations of the patients were performed by two pediatric dentists (XX, XX) in the dental unit under the reflector light. Caries the decayed, filled (df) indexes were measured with the help of sterile mirror and probe, and The community periodontal index of treatment needs (CPITN) indexes and plaque indexes were measured and recorded with the help of periodontal probe.

The data obtained as a result of the clinical examination were recorded. For the CPITN indexes, the number of quadrants with Code 2 and above, indicating the need for periodontal treatment, were calculated. The patients were divided into groups according to the questions in the questionnaire. The obtained index results were calculated separately for each group. The index data obtained in each group of patients were collected and divided by the number of patients in the group, and a mean of df, plaque and CPITN indexes was obtained for each group. The mean scores obtained were compared with the SPSS program.

Statistics

Statistical analyses were performed using IBM SPSS Statistics for indows, version 22 (IBM Corp., Armonk, NY, USA). Number, mean, standard deviation, and percentage calculations were used for descriptive statistics. One-way ANOVA analysis was used to compare the means. Significance was evaluated as $P < .05$.

RESULTS

A total of 198 pediatric patients participated in the study. Of these patients, 101 were male and 97 were female. The mean age of the patients was 4.6 ± 0.57 years.

It was found that the periodontal and plaque indexes of the children whose parents smoked significantly increased, and there was no significant difference between the caries indexes ($P > .05$) (Figure 1). It was observed that the number of cigarettes that parents smoked during the day did not make a significant difference on caries, periodontal, and plaque indexes.

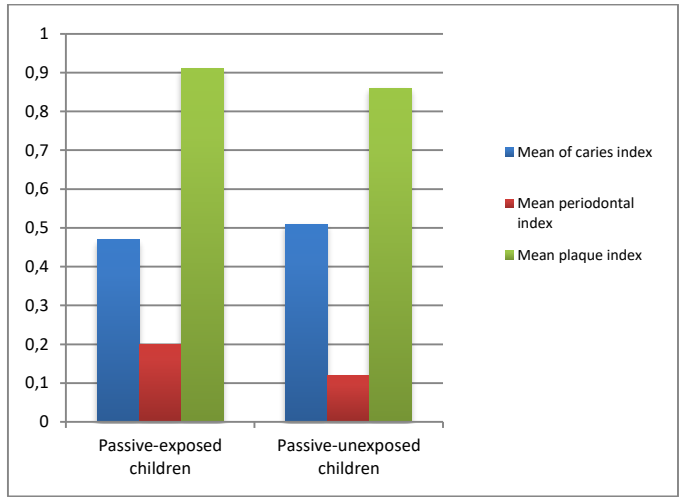

Figure 1. Comparison of children's index means according to parents' smoking status

There was no statistically significant difference between the caries, periodontal, and plaque indexes of the children according to the education level of the mother ($P > .05$)(Table 1). However, when the caries, periodontal, and plaque indexes of the children were evaluated according to the education level of the father, it was observed that the plaque index means of the children of secondary school graduates were statistically higher than those of university graduates ($P > .05$) (Table 1).

No significant difference was found between the caries and periodontal and plaque indexes of the children according to the number of daily brushing of the parents and whether they brushed their child's teeth or not ($P > .05$). In addition, the plaque indexes of the children who did not use fluoride toothpaste were significantly higher than those who used it (Table 1).

Although it was observed that the caries indexes of children who consumed sweet snacks during the day were significantly higher than those who did not, it was determined that the daily consumption frequency of sweet snacks did not make changes on caries, periodontal, and plaque indexes (Table 1).

The average plaque index of the children who drank milk 3 times during the day was statistically lower than the children who drank no milk per day. No statistically significant difference was found between the other groups ($P > .05$) (Table 1).

Table 1. Data from the study population.

Variable	Caries Index Mean	*P*	Periodontal Index Mean	*P*	Plaque Index Mean	*P*
	Indexes					
Number of cigarettes smoked by the parent per day						
None	0.45	.55	0.23		0.78	
>20				.25		.49
<20	0.39		0.18		0.94	
Mother's education level						
0-8 years (Middle School)	0.5		0.15		0.9	
8-12 years (High school)	0.5	.73	0.17	.64	0.92	.13
12 years or more (University)	0.45		0.18		0.82	
Father's education level						
0-8 years (Middle School)	0.53	.52	0.15	.49	0.93	.02*
8-12 years (High school)	0.47		0.21		0.90	
12 years or more (University)	0.46		0.14		0.85	
Parent's number of brushing teeth per day						
None	0.54	.65	0.17	.21	0.91	.875
1-2 times	0.48		0.16		0.88	
3-4 times	0.31		0.14		0.92	
Parents brushing their child's teeth per day						
Yes						
1-2 times	0.45	.46	0.19	.78	0.89	.213
3-4 times	0.57		0.25		0.87	
No	0.53		0.13		1	
Use of fluoride toothpaste						
Yes	0.54	.75	0.16	.36	0.93	.0*
No	0.46		0.16		0.87	
Daily consumption of sweet snacks						
Yes						
Once	0.48	.02*	0.18	.55	0.88	.51
Twice	0.5		0.15		0.93	
No	0.46		0.17		0.88	
Daily milk consumption						
Yes (Glass)						
1	0.48	.87	0.15	.56	0.87	.02*
2	0.49		0.13		0.90	
3	0.59		0.04		0.63	
No	0.49		0.19		0.91	

DISCUSSION

Children exposed to cigarette smoke experience similar effects as smokers on periodontal tissues. Cigarette smoke and its components reduce the amount of oxygen delivered to periodontal tissues by causing vasoconstriction and they delay wound healing, both of which pave the way for the formation of periodontal disease.[11] In our study, it was determined that periodontal and plaque indexes in children with passive smoking were higher than those in healthy children.

Many studies have shown that exposure to cigarette smoke is an important risk factor for early childhood caries, which is common in preschool children.[5,12,13] It has been observed that tooth mineralization is negatively affected and the susceptibility to dental caries increases in children with passive smoking.[14] There is a decrease in vitamin C levels in the blood of smokers and their children, and it is stated that this is associated with an increase in the number of *Streptococcus mutans.*[15,16] In our study, it was observed that there was no difference between the decayed, missing and filled teeth (DMFT) means of children with passive smoking and healthy children. It is thought that the data in our study originated from the selected population.

Studies have shown that there is a relationship between smoking status of parents and education level, diet, and oral hygiene habits.[17] It was observed that smoking habits and consumption of sugar-containing beverages between meals were higher in parents with low education levels, while tooth brushing habits were lower.[18] In our study, it was observed that there was no relationship between the education level of the mother and the caries, periodontal, and plaque indexes of the child, but as the education level of the father decreased, the plaque indexes of the child increased and oral hygiene habits decreased. In addition, in our study, it was observed that the plaque indexes of the children using fluoride toothpaste were lower than those of the other children. Hanioka et al. reported that there was no relationship between parents' smoking status and their child's tooth brushing with fluoride tooth paste and plaque level.[5]

Children's daily consumption of sweet snacks and tooth brushing habits were found to be associated with parents' smoking.[5] In our study, the fact that the mean caries index was higher in children with high daily sugar consumption indicates that sugar is an important risk factor for dental caries. The increase in cotinine level in children's saliva due to parental smoking results in an increase in the amount of *S. mutans*, thus an increase in the amount of caries.[19]

Milk and dairy products can change the microbial flora in the mouth due to their probiotic content.[20] The most frequently studied probiotics related to oral health are *lactobacilli*. These microorganisms help to protect periodontal tissue health by showing an inhibitory effect against biofilm members and reducing the concentrations of TNF-alpha, IL-1Bet, and IL-17 in the gingival groove fluid.[21,22] For this reason, it is thought that periodontal health will be better in children with increased consumption of milk and dairy products. Hanioka et al. reported that there was no relationship between passive smoking and daily milk consumption.[5] In our study, mean plaque index was lower in children with high daily milk consumption.

One of the limitations of our study is its cross-sectional design. Studies involving larger populations are needed to investigate the effect of passive smoking on caries, periodontal, and plaque indices in preschool children.

CONCLUSION

Passive smoking causes many changes in dental caries, periodontal health, and plaque status in preschool children. In order to protect the oral health of children in the risk group, preventive measures should be taken in the early period and routine dentist controls should be made.

Etik Komite Onayı: Bu çalışma için etik komite onayı Adıyaman Üniversitesi Tıp Fakültesi Girişimsel Olmayan Etik Kurul'dan (No: 2021/10-27, Tarih: 14/12/2021) onay alınmıştır.
Hasta Onamı: Tüm katılımcılara prosedürler ayrıntılı olarak anlatılmış ve yazılı onam alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir – K.N.T.; Tasarım–K.N.T., U.A.; Denetleme–K.N.T., U.A.; Kaynaklar-K.N.T.; Veri Toplanması ve/veya İşlenmesi–K.N.T., U.A.; Analiz ve/veya Yorum–K.N.T., U.A.; Literatür Taraması-K.N.T., Yazıyı yazan-K.N.T.; Eleştiriel İnceleme- K.N.T., U.A.
Çıkar Çatışması: Yazarlar, çıkar çatışması olmadığını beyan etmiştir.
Finansal Destek: Yazarlar bu çalışmanın herhangi bir finansal destek almadığını beyan etmişlerdir.

Ethics Committee Approval: Ethical approval was obtained for the study from the Non-Invasive Ethics Committee of Adıyaman University Faculty of Medicine (Decision Number: 2021/10-27, date: 14/12/2021).
Informed Consent:: All participants were provided with detailed explanations of the procedures and written informed consent was obtained.
Peer-review: Externally peer-reviewed
Author Contributions: Concept – K.N.T.; Design–K.N.T., U.A.; Supervision– K.N.T., U.A.; Resources–K.N.T.; Data Collection and/or Processing– K.N.T., U.A.; Analysis and/or Interpretation–K.N.T., U.A.; Literature Search–K.N.T; Writing Manuscript– K.N.T; Review– K.N.T., U.A.
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Evaluation of the Accuracy of Two Apex Locators for Determining the Working Length of Endodontically Retreated Curved Mesial Roots of Maxillary Molar Teeth: An Ex Vivo Study

Maksillar Molar Dişlerin Eğimli Mesial Kanallarının Kök Kanal Tedavisi Tekrarı Esnasında Çalışma Uzunluğu Belirlenmesinde İki Farklı Apeks Bulucunun Doğruluğunun Değerlendirilmesi: Ex Vivo Çalışma

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ABSTRACT

Objective: To evaluate the accuracy of PROPEX PİXİ (Dentsply Sirona, Ballaigues, Switzerland) and Apex ID (Sybron Endo, Orange, CA, USA) in determining the working lengths of curved mesial roots of upper molars during the retreatment procedure.

Method: Twenty curved mesial roots of upper molar teeth were selected. Canals were shaped with ProTaper Next instruments (Dentsply Sirona) up to X3. The canal lengths were determined with a stereomicroscope (Carl Zeiss GmbH, Oberkochen, Germany) at 2,5X magnification (DM) and then also detected electronically (EM1P and EM1A) with PROPEX PİXİ (Dentsply Sirona) and Apex ID (Sybron Endo) in an alginate model. Specimens were then obturated using a size X3 master gutta-percha cone and an epoxy resin-based root canal sealer. Seven days later, the coronal part of the filling was removed with a Gates Glidden drill size 3 and for the middle part Protaper Universal Retreatment File D2 used. Working lengths electronically were detected again by two different apex locaters (EM2P and EM2A). Data were analysed by using the Wilcoxon Signed Rank and Mann Whitney u test. The analyses were carried out with MedCalc Statistical Software.

Results: No significant difference was found between direct measurements (DM) and electronic measurements before and during retreatment for PROPEX PİXİ and Apex ID (P>.01). Also there was no significant difference between two apex locaters before and during retreatment (P>.01).

Conclusion: PROPEX PİXİ and Apex ID were considered accurate for the root canal length determination during retreatment procedure.

Keywords: Apex locator, curved molar, retreatment, working lenght

ÖZ

Amaç: Bu çalışmanın amacı kök kanal tedavisinin yenilenmesi işlemi sırasında üst azı dişlerinin eğimli mezial köklerinin çalışma uzunluklarının belirlenmesinde PROPEX PİXİ (Dentsply Sirona, Ballaigues, İsviçre) ve Apex ID'nin (Sybron Endo, Orange, CA, ABD) doğruluğunu değerlendirmektir.

Yöntem: 20 adet üst molar dişin eğimli mesial kökü seçildi. Kanallar ProTaper Next (Dentsply Sirona) ile X3'e kadar şekillendirildi. Kanal uzunlukları stereomikroskopla (Carl Zeiss GmbH, Oberkochen, Almanya) 2,5X büyütmede (DM) belirlendi ve ardından PROPEX PİXİ (Dentsply Sirona) ve Apex ID (Sybron Endo) ile elektronik olarak aljinat model kullanılarak (EM1P ve EM1A) tespit edildi. Daha sonra kanallar, X3 boyutunda bir ana güta-perka konisi ve bir epoksi reçine bazlı kök kanal patı kullanılarak dolduruldu. Yedi gün sonra dolgunun koronal kısmı #3 Gates Glidden frez ile orta kısmı ise Protaper Universal Retreatment eğesi (D2) kullanılarak çıkarıldı. Çalışma uzunlukları elektronik olarak iki farklı apeks bulucu (EM2P ve EM2A) tarafından yeniden tespit edildi. Veriler Wilcoxon Signed Rank ve Mann Whitney u testi kullanılarak analiz edildi. Analizler MedCalc İstatistik Yazılımı ile gerçekleştirildi.

Bulgular: PROPEX PİXİ ve Apex ID için kanal tekrarı öncesinde ve kanal tekrarı sırasında yapılan ölçümler ile stereomikroskopla yapılan ölçümler arasında anlamlı fark bulunmadı (P>.01). Ayrıca kanal tekrarı öncesinde ve sırasında iki apeks bulucu arasında anlamlı bir fark yoktur (P>.01).

Sonuç: PROPEX PİXİ ve Apex ID'nin kanal tekrarı işlemi sırasında kök kanal uzunluğunun belirlenmesinde doğru olduğu kabul edildi.

Anahtar Kelimeler: Apeks bulucu, kavisli azı dişi, geri çekilme, çalışma uzunluğu

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INTRODUCTION

Achieving a successful root canal treatment relies on an ideal chemomechanical cleaning, shaping and hermetic closure that dominates the entire canal anatomy. The basis for the success of these stages is the correct determination of the apical constriction and working length.[1] The apical constriction is most commonly determined with a radiographic technique using average distance value.[2] The disadvantages of using this technique are encountered in cases such as the presence of an apical lesion, root resorption etc.[3] In these cases, the apical constriction is not detectable with average values from the radiographic apex. Because radiography provides a 2D view of a 3D object, radiography also has other technical disadvantages.[4] In addition, the radiographic working length determination may be difficult in certain cases, for example, in maxillary molars, as it is closely related to anatomical marks .[5] Thus, in addition to the radiographic technique, the use of electronic apex locators (EALs) has become increasingly important in determining the working length.

Many studies have shown that, in primary root canal treatment cases, the presence of canal contents, such as debris, dentinal chips, pulp remnants and irrigating solution, can affect the accuracy of electronic apex locators. Because root canal preparation and root canal filling material affect root canal impedance, in the retreatment cases, components such as gutta- percha pieces, sealer remnants and gutta-percha solvent may also affect the measurements.[6-12] In addition, during removal of the gutta-percha, dramatic changes can occur in the area that apex locators are trying to identify.[13]

Molar teeths have a more complex structure anatomically compared to other teeth with their variable number of roots and canals, inclined roots and isthmus.[14,15] It has been reported that the error rate in determining the working length by radiography increases in direct proportion with the degree of curvature of the canal, and the working length of the curved canals varies during different preparation processses. Although EALs have a greater clinical importance in curved canals, most EAL studies have been performed using straight single-rooted teeth.[16]

The purpose of the present study was to evaluate the accuracy of Propex Pixi (Dentsply Sirona) and Apex ID (Sybron Endo), Orange in determining the working lengths of curved mesial roots of upper molars during root canal retreatment. To the best of our knowledge, no study has evaluated the accuracy of these EALs in determining working lengths during the retreatment procedure of curved maxillary molar canals. The null hypothesis tested was that there was no difference between Propex Pixi and Apex ID in working lengths determination during root canal retreatment.

METHODS

Preparation of Teeth

Twenty roots of maxillary molar teeth with mature apices extracted for periodontal and orthodontic reasons were selected. The angle of canal curvature was calculated by using Schneider's technique, and a 10° to 20° degree of curvature of mesiobuccal canals was selected.[17] The roots were viewed radiographically and examined with a stereomicroscope. Roots with calcifications, multiple canals and apical foramen, immature root tip or root canal treatment, and apical diameter greater than 15-K file were excluded from the study. The 20 teeth selected with these inclusion criteria were immersed in 4°C distilled water until use.

Endodontic access cavities were prepared using a fissure bur, and a stable reference point was created by smoothing the mesiobuccal cusps. A 10 K-file was advanced in the canal until it was just visible, the stopper was seated at the reference point and the file was removed from the canal. The working length was determined to be 0.5 mm shorter than the distance between the stopper and the tip of the file. The canals were prepared with ProTaper NEXT instruments (Dentsply Sirona,) up to X3 with 2 mL of 2.5% sodium hypochlorite (NaOCl) irrigation between each instrument.

Measurement Using the Direct Method (DM)

Once canal preparation was complete, the working lengths were determined with a microscope (Carl Zeiss GmbH, Oberkochen, Germany) at 2.5X magnification using the DM, the same way as before the preparation. The distance from the stopper to the file tip was measured with a digital ruler to the nearest 0.25 mm. These values were reduced by 0.5 mm and recorded as the direct measurement (DM).

Measurement Using the EAL (EM1A and EM1P)

An alginate model defined by Kaufman et al. was used.[18] The mesial canals of the teeth placed in the alginate model were irrigated with 2.5% NaOCl and dried with paper points. Apex ID (Sybron Endo) and Propex Pixi (Dentsply Sirona) were used in accordance with the manufacturers' instructions. For the Apex ID, a size 25 K-file (Dentsply Sirona) was advanced until the 'APEX' signal was seen on the LCD display and then withdrawn until a flashing bar showing '0.5' had been reached (the third green bar). For Propex Pixi, the file was advanced within the root canal until the 'OVER' bar appeared and was then withdrawn until the 0.0 mark signal appeared.

The stopper was seated at the reference point, and the file was removed from the canal. The distance between the tip of the file and the stopper was measured with a digital ruler and noted as EM1A (Apex ID) and EM1P (Propex Pixi).

Root Canal Filling

The canals were irrigated with 2 mL 5.25% of NaOCl, dried with paper points and then obturated with a single cone technique using a size X3 master gutta-percha cone (Dentsply Sirona) and an epoxy resin-based root canal sealer (AH Plus; Dentsply DeTrey, Germany). Endodontic cavities were filled with temporary filling material (Cavit; 3M ESPE Dental Products, USA). The roots were stored at 100% humidity to set the sealer.

Electronic Measurement after Removal of Root Filling (EM2A and EM2P)

After seven days, the coronal part of the filling material was removed using a Gates Glidden drill size 3 and than the Protaper Universal Retreatment File D2 was used for the middle part. The teeth were placed back into the alginate model. 0.1 mL of Eucalyptus oil was introduced into the root canal for 2 min the soften the gutta-percha at the apical third of the roots after using D2 .Number #20 and #15 K-files were advanced through the softened apical gutta until reaching the working length. After the root canal was negotiated a 25 K-file was inserted into the canal and the working length was achieved, electronic measurements were repeated as described prior to the root canal filling. Measurements were recorded as EM2A and EM2P.

Electronic measurements were performed to insure that the alginate was kept fresh. These measurements were made at 2-h intervals, and the alginate was refreshed each time. The signals that flashed continuously for 5 s were taken into consideration. Measurements were made by a single operator to maintain consistency. All measurements were repeated three times, and average values were taken.

Evaluation Criteria

Electronic measurements obtained before and after root filling (EM1A/P and EM2A/P) were compared with the direct measurement (DM), and EAL devices were compared with each other.

The differences were noted with a negative sign when the direct measurement was greater than the electronic measurements. Indicating that, in the electronic measurement, the file tip was inside the canal and did not reach the foramen. When the DM was less than the EM1A/P or EM2A/P, the difference was given as a positive sign, indicating the file tip had passed beyond the foramen. The means of differences between DM/EM1A,P and DM/EM2A,P were then calculated, and data was analysed by using the Wilcoxon signed-rank and Mann–Whitney *U* tests. Statistical significance was accepted at the alpha level of 5% ($P < .05$).

RESULTS

The differences between measurements detected by direct and electronic measurements before and after root canal filling are shown in Table 1 and Figure 1. It can be seen that the mean values of the differences between all electronic measurements and direct measurement are positive. In general, the electronic measurements were very close to the direct measurements, but they were found to be higher. According to these results, no statistically significant difference was found between direct measurements and electronic measurements before and after retreatment for Propex Pixi and Apex ID ($P>.01$). Also, there was no significant difference between the two apex locaters before and during retreatment ($P>.01$).

Table 1. Means, Standart Deviations, Minimum and Maximum of difference and ratio values of between electronic measurements before and after root canal filling and direct measurements

Measures	DM	EM1A	EM1P	EM2A	EM2P	EM1A-DM	EM1P-DM	EM2A-DM	EM2P-DM	Ratio EM1A/DM	Ratio EM1P/DM	Ratio EM2A/DM	Ratio EM2P/DM
Mean	18.2	18.3	18.4	18.4	18.6	0.1	0.2	0.2	0.4	1.0	1.0	1.0	1.0
SD	1.6	1.7	1.6	1.8	1.8	0.5	0.3	0.4	0.4	0.03	0,02	0.02	0.02
Minimum	16.2	16	16.2	15.9	16.2	-0.54	-0.09	-0.6	-0.19	0.97	0.99	0.97	0.99
Maksimum	21.6	21.1	21.7	22.1	22.1	1.8	1.4	1.1	1.4	1.1	1.1	1.1	1.1

DM,direct measurements; EM,electronic measurements; SD,standart deviation; 1,before root filling; 2,after root filling; A,apex ID; P, propex pixi

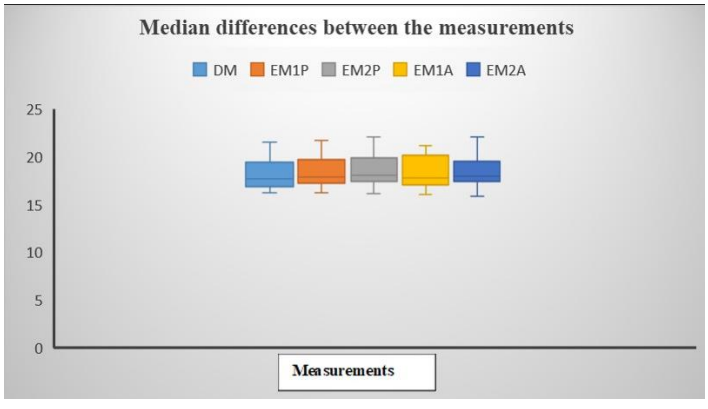

Figure 1. Mean differences between the all measurements, *Bold* lines Show median values.

DISCUSSION

Studies have shown that retreatment procedures affect the success of the EALs. Mancini et al. [11] showed that measurements obtained with Root ZX (J Morita Corp, Kyoto, Japan) during retreatments can lead clinicians to perform over instrumentation and overfilling. Cimilli et al. [19] determined significant differences and indicated that Dentaport ZX (J Morita Corp, Kyoto, Japan) cannot detect the minor foramen accurately in molars during the root canal retreatment procedure. To the best of our knowledge, there is no information about comparing the accuracy of Apex ID and Propex Pixi devices during retreatment procedures. Therefore, the present study contributes valuable insights as it evaluated the accuracy of these two devices in establishing the working lengths of curved mesial roots of maxillary molars during the root canal retreatment.

While most EAL studies have preferred straight canal anatomy, in our study, we preferred to use the curved mesial roots of upper molars where root filling removal can be more complex.[9,20.21]

In this study, the alginate model, frequently used in EAL studies and described by Kaufman et al. [18] was performed. Alginate is a conductive medium which imitates the human periodontium by means of wrapping tooth roots during measurements and providing electricity transmission.[22] The referenced canals length measurement (DM) was obtained just before the root canal filling because the shaping procedures can affect the channel length.[20]

The study showed that there was no significant differences between two apex locaters before and during root canal retreatment. The null hypothesis can be accepted. Yolagiden et al. .[23] stated that the ApexID showed acceptable measurements similar to Raypex 5 and 6 of the working length. Serna-Peña et al. [24] showed that no statistically significant differences were observed amongst the Apex ID, Propex Pixi and Root ZX. Also, de Vasconcelos et al. [12] showed that Apex ID measurements were not affected by foraminal obstruction. Ustun et al. [3] indicated that there were no significant measurement differences between the Raypex 6 and Propex Pixi. Saxena et al. [25] found that similar accuracy results were obtained amongst the iRoot, iPex II, and Propex Pixi apex locators. In our study, the analysis of the results of the electronic measurement performed before the canal filling was similar to those found in these studies. In their work on mesial curved canals of mandibular molar teeth, Piasecki et al. [14] showed that the Root ZX and Apex ID devices were equally accurate in determining the working length and stated that the 0.5-mm mark on both EALs were more acceptable than subtracting 0.5 mm from the 0.0-mark. In our study, we used the value of 0.5-mm mark as a reference in EM1A and EM2A measurements. Although, there is no retreatment study comparing Apex ID and Propex Pixi, there are few studies examining the measurements of Propex Pixi during root canal retreatment. Tufenkci and Kalaycı, examined the accuracy of Dentaport ZX, Propex Pixi and iPex II devices in root canal retreatment and found their accuracy at %83.3,-%83.4-%80 respectively, even if there was no statistical significance between them.[26] Similarly, our study gave safe results in the application of Propex pixi during root canal retreatment. Tejaswi et al.[27] reported that Dentaport Root ZX apex locator showed more accuracy in detecting the apical and middle root canal perforation when compared with the Propex pixi apex locator during root canal

treatment. This result is inconsistent with our study, this might be the due to presence of irrigating solutions or penetration of the conducting media into the root canal.

The most significant goal of this study was to identify the reliability of two untested devices in determining the working length in a canal with the most complex mixture of contents, such as debris, dentin chips, organic remnants, gutta-percha pieces, sealer and solvent. However, according to our analysis, no significant difference was found between DM and electronic measurements before and after retreatment with Propex Pixi and Apex ID or between EALs.

CONCLUSION

Within the limitations of this study, it can be concluded that the accuracy of Apex ID is similar to that of Propex Pixi when used with curved mesial roots in the retreatment process and that both devices can be safely used in endodontic treatment.

Etik Komite Onayı: Bu makale, insan veya hayvan katılımcılar ile yapılan herhangi bir araştırma içermemektedir.
Hasta Onamı: Hasta üzerinde çalışma yapılmadığından onam formu alınmamıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir – D.A.; Tasarım- D.A., M.B.G.; Denetim- D.A., M.B.G.; Kaynaklar – D.A, M.B.G.; Malzemeler – M.K.B., F.K.; Veri Toplama ve/veya İşleme – M.B.G.; Analiz ve/veya Yorum – M.K.B., F.K.; Literatür Taraması – M.K.B., F.K.; Yazma –D.A. .; Eleştirel İnceleme – D.A., M.K.B., F:K., M.B.G.
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Assessment of Bleaching Treatments with the Ohip-14 Survey

Beyazlatma Tedavilerinin Ohip-14 Anketi ile Değerlendirilmesi

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ABSTRACT

Objective: The aim of this study is to evaluate the effect of teeth bleaching on oral health and quality of life (OHIP-14) in adults who have undergone office bleaching treatment.
Methods: One hundred patients who applied to our clinic for bleaching treatment between 2016-2021 and underwent bleaching treatment with Opalescence Boost 40% PF were included in the study. Pre-treatment color determination is routinely done for each patient in the clinic. They were divided into four different groups as follow-up patients in 3rd month for Group 1, 6th month for Group 2, 1st year for Group 3, and 2nd year follow-up patients for Group 4 (n=25). Shade guide unit (ΔSGU) values were calculated for the patients using the Vita Classic color scale. In addition, the OHIP-14 questionnaire was applied to each patient to evaluate the effect of bleaching on oral health and quality of life. Wilcoxon and Kruskal-Wallis tests were performed at *P.*<05.
Results: In evaluating OHIP-14 quality of life among patients, there was no significant difference was noticed for all times (*P.*>05). In terms of color change, no significant difference compared to baseline levels with the measurements made at the 3rd, 6th months, and 1st and 2nd years (*P.*>05, κ=0.81).
Conclusion: After the bleaching treatment, the color remained stable for two years. However, a positive psychosocial effect and improved self-perception occurred in the patients.
Keywords: Bleaching treatment, OHIP-14, quality of life

ÖZ

Amaç: Bu çalışmanın amacı ofis tipi beyazlatma tedavisi görmüş erişkinlerde diş beyazlatmanın ağız sağlığı ve yaşam kalitesine (OHIP-14) etkisini değerlendirmektir.
Gereç ve Yöntem: Çalışmaya 2016-2021 yılları arasında beyazlatma tedavisi için kliniğimize başvuran ve Opalescence Boost %40 PF ile beyazlatma tedavisi uygulanan 100 hasta dahil edildi. Klinikte her hasta için tedavi öncesi renk tespiti rutin olarak yapılmaktadır. Grup 1'e 3. ay, Grup 2'ye 6. ay, Grup 3'e 1. yıl, Grup 4'e 2. yıl takip hastaları (n=25) olmak üzere 4 farklı gruba ayrıldı. Vita Classic renk skalası kullanılarak hastalar için renk tonu kılavuzu birimi (ΔSGU) değerleri hesaplandı. Ayrıca beyazlatma işleminin ağız sağlığı ve yaşam kalitesine etkisini değerlendirmek amacıyla her hastaya OHIP-14 anketi uygulandı. Wilcoxon ve Kruskal-Wallis testleri *P.*<05'te yapıldı.
Bulgular: Hastalar arasında OHIP-14 yaşam kalitesinin değerlendirilmesinde tüm zamanlar için anlamlı bir fark saptanmadı (*P.*>05). Renk değişimi açısından ise 3., 6. ay, 1. ve 2. yılda yapılan ölçümlerde başlangıç değerlerine göre anlamlı farklılık saptanmadı (*P.*>05, κ=0.81).
Sonuç: Beyazlatma tedavisi sonrasında renk iki yıl boyunca stabil kaldı. Ancak hastalarda olumlu bir psikososyal etki ve gelişmiş benlik algısı oluştu.
Anahtar Kelimeler: Beyazlatma tedavisi, OHIP-14, yaşam kalitesi

INTRODUCTION

The aesthetic appearance and color of the teeth constitute an important part of the harmony of the person's facial structure.[1] In recent years, aesthetic treatments and applications made to meet the patients' expectations have become very significant within dentistry. Studies conducted in the USA and the United Kingdom revealed that 20% to 35% of the population, especially the young population, noticed the stain on their teeth and were not satisfied with its color[2,3] and increasing demand for teeth bleaching treatments was reported.[4] Teeth bleaching treatment, which is one of the methods used in the treatment of discoloration in the teeth, is the preferred procedure because it is minimally invasive, fast and effective, and does not wear out the tissue as in fixed prostheses.[5,6]

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The discoloration seen in the teeth can be examined in two ways as the external and internal origin. Extrinsic discoloration from these discolorations can usually be caused by ingested food and drink, tobacco products, poor oral hygiene, or long-term use of some oral hygiene products.[7] External discolorations usually occur in the tooth surface's gingival margin and interproximal areas, where cleaning cannot be done with ease. In addition, internal discoloration may occur due to many different causes, such as before the eruption as in tetracycline use and discoloration and fluorosis, or after the eruption as in trauma, pulpal hemorrhage and improper root canal treatments.[8]

Bleaching is the name given to the lightening of the tooth color as a result of the oxidation of organic pigments in the dental tissue by the whitening gels applied to the discolored teeth.[9] Whitening systems can be performed at home (home bleaching), in the clinic under dentist control (in-office bleaching), or a combination of both.[5,10] A study has shown that bleaching treatment of vital teeth is effective, long-lasting, and safe.[11]

Oral Health-Related Quality of Life (OHRQoL), which was developed by modeling the questions about the "structure, function, competence, participation" revealed by the World Health Organization (WHO), about the positive and/or negative effects of oral health on general health, demonstrate their knowledge, skills and perceptions.[12,13] OHRQoL is used within studies in the field of oral health, for purposes such as evaluating the data obtained after clinical studies or clinical practice, and determining the appropriate treatment method. OHRQoL can be evaluated with many multifaceted scales that question symptoms and mental states. For this purpose, the Oral Health Impact Profile (OHIP) scale is generally used.

Developed in Australia and accepted by WHO, the OHIP scale is the most comprehensive and subjective tool used in the measurement and assessment of oral health.[14,15] The oral health model developed by Locker was taken as an example to define the dimensions covered by the questionnaire in the OHIP scale. The questions in the scale consist of 7 different areas such as functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap, and a total of 49 questions. The answers in the scale are a 5-point Likert scale with categories ranging between “very often” and “never” and it is applied to adult individuals.[16] This original scale with 49 questions was reduced to 14 questions by Slade and the Oral Health Impact Profile-14 (OHIP-14) was created.[17] The OHIP–14 scale was developed by Slade ve Spencer[18] to comprehensively measure the quality of life of oral and dental problems, injuries, and disabilities. As a result of the comparison of this newly obtained scale with the original form, it was reported that it was sufficient to measure oral and dental health-related quality of life and its validity reached 94%.[19] There are 7 dimensions in the OHIP-14 scale, as in the original scale, and two questions are asked for each dimension. Scoring can be done by giving 0 for never, 1 for hardly ever, 2 for occasionally, 3 for fairly often, and 4 for very often. At the end of the scale, the scores obtained according to the dimensions and the sum of the scale are summed. According to the scoring to be made according to the answers to be given in the OHIP-14 scale, the lowest score is 0, while the highest score is 56. The zero score to be obtained as a result of answering all of the questions as "never" indicates that the quality of life regarding oral and dental health is very good, nevertheless all questions are answered "very often", the score to be obtained is 56, indicating that the quality of life related to oral and dental health is very poor.[16] The OHIP-14 scale was adapted into Turkish by Mumcu ve ark.[20], and as a result of validity and reliability studies, it was stated that it is a valid and reliable scale for determining the quality of life related to oral and dental health.

Measurement and recording of tooth color in clinical conditions is determined by color measurement devices or using dental color scales, where the color is mostly visually standardized.[21] The classic Vita Lumin - Vacuum dental color scale (Vita Zahnfabrik) is a widely accepted color scale that has been used for many years to determine the color of restorative materials.[22] According to this scale, there are four different color series (A, B, C and D). The four different color series in this scale correspond to the primary colors brown, yellow, gray and red, respectively. While the color bars in each letter series correspond to the same primary color, the bars in the main color group are ordered according to increasing saturation (chroma) and decreasing brightness (value) expressed in numbers (A1, A2, A3, A3,5 etc).[23]

In this study, it was aimed to examine the color changes of patients who underwent long-term color follow-up after bleaching treatment and the effect of bleaching treatment on quality of life. Although there are many studies evaluating the quality of life after bleaching in the literature, there is no study in which the quality of life obtained from bleaching is followed over different times for different patients. The null hypothesis of the study is that the efficacy obtained from the bleaching treatment will not change at different times as the main outcome.

METHODS

Patients who had bleaching treatment and were followed up in our clinic between 2016-2021 were included in the study.

General exclusion criteria include pregnant or breastfeeding patients in our clinic, patients with moderate or severe fluorosis, severe tetracycline stains, orthodontic treatment, individuals with periodontal disease or orofacial tumors, patients with bruxism or tooth sensitivity, trauma or dental malformations. It was questioned that the patients do not have any systemic diseases, and bleaching treatment is not applied to the patients who use cigarettes, tobacco, etc., and/or do not have adequate oral hygiene.

General inclusion criteria included patients over 18 years of age, of both sexes, and without any systemic disease.

Necessary oral care procedures after the procedure are explained to each patient undergoing bleaching treatment, and it is reported that patients should comply with this in order for the color obtained to be permanent for a longer period of time. In our clinic, the conditions that require treatment and attention to our patients after bleaching is explained both orally and in writing.

Sample Size

Sample size calculation was considered at (1-β) 0.80 with 5% (α=0.05) significance level by using G*Power software. The minimum sample size in each group was found as 20. Assuming any discontinuing patient during follow-up, 5 drop-out subjects were added to each group.

Study Design

In our clinic, consent forms are routinely obtained from all patients before the bleaching treatment, and color determination is also performed during the anamnesis. The study included 100 participants performed to our clinic for bleaching treatment between 2016 and 2021 and were then reached (n=25). The design is demonstrated in Fig 1. The participant were divided into four different groups: Group 1, 3rd month follow-up patients; Group 2, 6th month follow-up patients; Group 3, 1st year follow-up patients; Group 4, 2nd year follow-up patients. The existing tooth color to be taken from the patients who were called for control was measured with Classic Vita (Classic Vita, Vita Zahnfabrik, Shade guide unit (ΔSGU)) and the Turkish version of the OHIP-14 questionnaire was applied to determine the effect on quality of life.

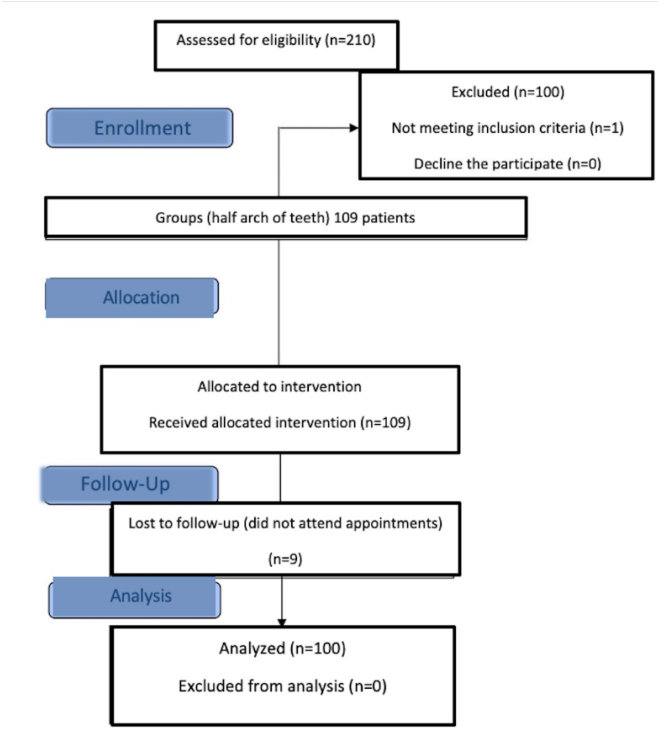

Figure 1. Flow diagram

Application of Bleaching Treatment

Before the bleaching treatment, each patient is measured using a color scale and recorded in the patient's file. Afterwards, the bleaching process is performed by dentists who are experts in their field (restorative dental treatment). In our clinic, Opalescence Boost 40% PF (Ultradent, South Jordan, UT, USA) as a bleaching agent is applied in accordance with the manufacturer's instructions, for a maximum of 2 x 20 minutes in a single session for each patient. Gingival barrier was applied continuously along the gingival margin, overlapping approximately 0.5mm onto the enamel to completely seal and cover exposed papilla. The whitening gel was applied evenly on the exposed enamel surface in a 0.5-1-mm thick layer with a spatula for 10 min. The gel was left on the surface undisturbed and then removed by using a damp cotton. Then, the teeth were rinsed under running water and dried with a gentle blast of air. This whitening procedure was repeated two times. The authors used the same method throughout the bleaching treatment.

Color Evaluation

Color measurements were evaluated on the vestibule surfaces of the maxillary central incisors of the individuals in each study group. The Vita color scale is ordered from left to right (16 different shades), from the lightest to the darkest. At least two consistent results from 3 different determinations made by each observer were recorded as the color value of the tooth measured for that observer. During the determination of the color, the patient was positioned to sit at the same eye level as the physician, and the Vita color scale was positioned at an arm's length from the observer's eye. While the lower and upper teeth were in full contact with each other, the incisor edge of the maxillary central tooth to be measured with the cutting edge of the tooth-shaped color sample on the scales was placed side by side, and the tooth color was determined within the first 5 seconds. The color evaluation was performed by two physicians and calibrated on 100 patients. Cohen's Kappa coefficient was used to make the clinical evaluation among the physicians. As a result of the examination, the Kappa coefficient for reliability was 0.72 for all variables and the Kappa coefficient for repeatability was 0.81.

OHIP-14 Questionnaire

The questions in the questionnaire were asked to the follow-up patients registered in the system who underwent bleaching treatment. It was recorded by scoring between 0 and 56 according to the answers given by the patients. Satisfaction effect was measured using the OHIP-14 questionnaire validated and reliability in Turkish version. The questionnaire was performed by researchers due to different groups at 3-month, 6-month, 1 year and 2 years after bleaching. Each statement was accompanied by a Likert-type scale, which generated a score ranging from 4 to 0 (very often = 4, fairly often = 3, occasionally = 2, hardly ever = 1, never = 0). It was recorded by scoring between 0 (minimum) and 56 (maximum) according to the answers given by the patients. The outcomes were considered the sum of the OHIP-14 and dimension scores, the internal consistency was evaluated using the Cronbach's Alpha test.

Statistical analysis

The findings were analyzed using the IBM SPSS 22.0 package program (IBM SPSS Statistics 22, SPSS inc., an IBM Co., Armonk, New York). Significance was accepted as $p < 0.05$. During the evaluation of color change, Cohen's kappa coefficient was calculated among researchers. In addition, Wilcoxon and Kruskal-Wallis tests were performed to evaluate the between-group and within-group differences of non-parametric findings.

RESULTS

The sample consisted of 62 women (62%) and 38 men (38%) with average ages of 28.98 ± 6.1 years for men and 27.35 ± 5.12 years for women. There were no differences between the two groups in terms of the characteristics of the baseline color (*P.*>05). (Table 1)

Color Change Values

No statistically significant difference was found for color change according to the baseline values for the patients according to the measurements made at the 3rd, 6th months, and 1st and 2nd years (*P.*>05) (Table 3). The highest ΔSGU change value from baseline was observed in Group 4, which included the measurements made in the 2nd year (*p*=.09, 5.19± 3.74); the lowest ΔSGU value was found in Group 1, which included measurements followed for three months after bleaching (*P*=.80, 1.98± 2.1).

Table 1. Baseline demographics features of participants.

	n	%	Mean (± SD)	*P*
Male	38	38	28.98 ± 6.1	>.050
Female	62	62	27.35 ± 5.12	
Total	100	100	27.37 ± 5.93	

OHIP-14 Questionnaire Values

According to the evaluation made in terms of quality of life among the patients, no statistically significant difference was found between the groups for all times (OHIP-14, *P.*>05) (Table 2 and 4). When the OHIP-14 questionnaire was evaluated in terms of 7 different sections, including functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap, no significant difference was observed (*P.*>05).

Table 2. Mean ± standard deviation (SD) of 7 different domains and OHIP-14 total scores for groups

	Group 1 (3rd month (T_1))	Group 2 (6th month (T_2))	Group 3 (1st year (T_3))	Group 4 (2nd year(T_4))
Functional limitation	3.42 ± 0.75[a]	3.58 ± 0.70[a]	3.62 ± 0.86[a]	3.68 ± 0.77[a]
Physical pain	1.38 ± 1.25[a]	1.42 ± 1.17[a]	1.50 ±1.25[a]	1.62 ± 1.58[a]
Psychological discomfort	1.04 ± 0.97[a]	1.10 ± 0.95[a]	1.12 ± 1.01[a]	1.21 ± 1.02[a]
Physical disability	3.32 ± 0.76[a]	3.3 ± 0.84[a]	3.62 ± 0.51[a]	3.72 ± 0.62[a]
Psychological disability	2.42 ± 1.31[a]	2.56 ± 1.25[a]	2.67 ± 1.52[a]	2.74 ± 1.32[a]
Social disability	3.12 ± 0.82[a]	3.37 ± 0.49[a]	4.10 ± 0.46[a]	4.82 ± 0.32[a]
Handicap	2.52 ± 1.14[a]	2.55 ± 1.40[a]	2.55 ± 1.47[a]	2.59 ± 1.43[a]
OHIP – 14 TOTAL	16.5 ± 2.32[a]	19.0 ± 2.87[a]	20.0 ± 2.10[a]	21.4 ± 2.31[a]

Small letters in each line indicate the statistical difference between groups. It was considered statistically significant for *P.*<05.

Table 3. ΔSGU mean± standard deviation and p values for groups

	ΔSUG ± SD	*P*
Initial - Group 1 (3rd month)	1.98 ± 2.1	.8
Initial - Group 2 (6th month)	2.35 ± 3.12	.43
Initial - Group 3 (1st year)	3.37 ± 2.12	.34
Initial - Group 4 (2nd year)	**5.19 ± 3.74**	**.09**

* It was considered statistically significant for *P.*<05.

Table 4. OHIP-14 scale scores and p values between groups

	P
Group 1 (3rd month) - Group 2 (6th month)	.602
Group 1 (3rd month) - Group 3 (1st year)	.281
Group 1 (3rd month) - Group 4 (2nd year)	.065
Group 2 (6th month) - Group 3 (1st year)	.074
Group 2 (6th month) - Group 4 (2nd year)	.089
Group 3 (1st year) - Group 4 (2nd year)	.391

*It was considered statistically significant for *P.*<05.

As a result of the evaluation of all OHIP-14 scale total scores, no significant difference was found between the data obtained at the 3rd month (T_1), 6th month (T_2), 1st year (T_3), and 2nd year (T_4) (*P.*>05).

When we evaluate the questions within the classification;

1. No significant difference determined between all groups in questions about functional limitation (Q_1) (Q_1T_1- Q_1T_2, Q_1T_1-Q_1T_3, Q_1T_1-Q_1T_4, Q_1T_2- Q_1T_3, Q_1T_2-Q_1T_4, Q_1T_3-Q_1T_4; *P.*>05).
2. No significant difference determined between all groups in questions about physical pain (Q_2) (Q_2T_1- Q_2T_2, Q_2T_1-Q_2T_3, Q_2T_1-Q_2T_4, Q_2T_2- Q_2T_3, Q_2T_2-Q_2T_4, Q_2T_3-Q_2T_4; *P.*>05).
3. No significant difference determined between all groups in questions about psychological discomfort (Q_3) (Q_3T_1- Q_3T_2, Q_3T_1-Q_3T_3, Q_3T_1-Q_3T_4, Q_3T_2- Q_3T_3, Q_3T_2-Q_3T_4, Q_3T_3-Q_3T_4; *P.*>05).
4. No significant difference determined between all groups in questions about physical disability (Q_4) (Q_4T_1- Q_4T_2, Q_4T_1-Q_4T_3, Q_4T_1-Q_4T_4, Q_4T_2- Q_4T_3, Q_4T_2-Q_4T_4, Q_4T_3-Q_4T_4; *P.*>05).
5. No significant difference determined between all groups in questions about psychological disability (Q_5) (Q_5T_1- Q_5T_2, Q_5T_1-Q_5T_3, Q_5T_1-Q_5T_4, Q_5T_2- Q_5T_3, Q_5T_2-Q_5T_4, Q_5T_3-Q_5T_4; *P.*>05).
6. No significant difference determined between all groups in questions about social disability (Q_6) (Q_6T_1- Q_6T_2, Q_6T_1-Q_6T_3, Q_6T_1-Q_6T_4, Q_6T_2- Q_6T_3, Q_6T_2-Q_6T_4, Q_6T_3-Q_1T_4; *P.*>05).
7. No significant difference was found between all groups in questions about handicap (Q_7) (Q_7T_1- Q_7T_2, Q_7T_1-Q_7T_3, Q_7T_1-Q_7T_4, Q_7T_2-Q_7T_3, Q_7T_2-Q_7T_4, Q_7T_3-Q_7T_4; *P.*>05).

DISCUSSION

Due to the importance of aesthetics over the years, patients have started to apply to dentists for treating aesthetic problems. Teeth bleaching treatment, which is one of these aesthetic treatments, increases the frequency of patients who are disturbed by their tooth color to apply to dentists day by day. This study aimed to evaluate the results obtained from teeth bleaching treatment, an aesthetic intervention in dentistry, with the OHIP-14 questionnaire.

There are three different bleaching techniques today: office bleaching (professional application), home bleaching (individual application), and combining both methods.[5,10] Although these different techniques usually vary according to the patients' aesthetic expectations and treatment needs; both methods have advantages and disadvantages. The most significant disadvantage of at-home bleaching is that it requires a long time and cannot be easily controlled by the participants during treatments. In-office bleaching treatments, on the other hand, compared to at-home bleaching, it is more preferred because of faster results, no plaque use, ingestion of the bleaching agent due to its application in the clinic by the physician, and the risk of burning and irritation by leaking into the soft tissue.[24] In our study, the follow-ups of in-office type bleaching treatments, which are more frequently applied due to the reasons mentioned, were evaluated.

Depending on the many different bleaching agents and treatment techniques used, adequate aesthetics and patient satisfaction are provided after the bleaching application. It is known that the bleaching application of vital teeth has a long-term effect and is safe.[11] There are many methods and questionnaires used to evaluate patient satisfaction during dental practice.[25-27] OHIP-14, OHQoL-UK, PIDAQ scales can be given as examples. Teeth discoloration can affect social relationships between people and lead to a negative image.[4] Questionnaires were administered at 3, 6, 12, and 24 months post-bleaching to see the results of the bleaching process and the continuation of its effects. The aesthetic component measured by OHIP-14 probably did not lead to a significant difference in months measured for bleaching efficacy. OHIP-14 is an scale used to scored aesthetic perception.[28] A higher score indicates that the patient has a poor self-perception regarding cosmetic dentistry. The low OHIP-14 scores after teeth bleaching support the suggestion that self-perception in dental aesthetics may be strong. To experience any positive change after bleaching treatment, patients need to interact with their social environment.[29] In the current study, outcomes were determined after treatment. In addition, all dimensions in OHIP-14 measured two years after bleaching showed no significant change compared to measurements at 3 months, suggesting that the psychosocial outcomes achieved not only have a long-term effect at 3 months, but also have a long-term effect.

In OHRQoL studies performed after bleaching treatment, contradictory results were found.[30,31] In their study, Meireles et al.[31] investigated the effect of at-home vital bleaching treatment using bleaching agents containing carbamide peroxide (CP) and observed positive effects. However, it has been reported that patients have difficulties in maintaining oral hygiene. n another study, the effects of bleaching treatment were evaluated among university students and it was shown that bleaching positively affected OHRQoL in OHIP subscales.[30] In contrast to these studies, Bruhn et al.[32] reported that bleaching treatment in 30-year-old adults had no effect on OHIP subscales. Another study evaluating in-office bleaching treatments also observed the lack of effect of vital bleaching on quality of life.[33] A systematic review concluded that vital bleaching was not associated with improvements in overall OHRQoL. Bleaching may affect the quality of life positively or negatively in some areas.[34] The most well-known

problem with bleaching treatment is the small sample size, as discussed in different studies.[34,35] In our study, the OHIP-14 scale was preferred among these questionnaires to evaluate the quality of life in patients.

Color selection methods in dentistry are examined in two different categories, visual and instrumental.[36] Visual color selection, which is one of these methods, is one of the most frequently preferred methods by dentists because it is easy to access in the clinic.[37-40] However, the biggest disadvantage of this type of scales based on subjective evaluation, such as the Vita Classic, is that the subjective results measured with the SGU (shade guide unit) unit cannot fully overlap with the objective findings and remain inconsistent.[41] The difference in the measurement of two adjacent teeth by different observer groups in color determination and the resulting low reliability explains this situation. In our study, Vita Classic color scale, which is frequently preferred for color measurement after bleaching treatment, was used.

There is limited article on awareness of the aesthetic and psychosocial effect of teeth bleaching treatment applied to meet aesthetic expectations in the literature.[25,27,42] In the study of Bersezio et al.[25] using 35% hydrogen peroxide (HP) and 37% CP, intracoronal bleaching treatment was performed and the effect of whitening treatment on quality of life was evaluated. It was reported that both gels used in the study were effective in the bleaching treatment and the color remained stable in the 3rd month after the procedure. In addition, a statistically significant decrease was observed in the OHIP questionnaire scores at the 3rd month compared to the results obtained. Although this study and our OHIP-14 scale scores are not compatible, the findings obtained for color assessment are compatible. It has been estimated that the reason for obtaining different results regarding OHIP-14 scores may be related to the bleaching method.

In another study, Bersezio et al.[43] the effect of bleaching on the quality of life of patients who underwent bleaching with 6% HP was evaluated and followed for 2 years. In the study, it was observed that the total score of OHIP values decreased in the 24-month follow-up period. In our study, the scores decreased during the 2-year follow-up period but were not statistically significant. This situation was thought to be due to the good oral hygiene of the patients or the use of bleaching paste after the treatment.

According to study of Estay et al.[28], after the bleaching treatment with 37.5% and 6% HP, the color did not change for 1 and 6 months. In our study, 40% HP was used, and, in the results we obtained, a decrease in color values occurred in the 2-year follow-up, but it was not found statistically significant. In the OHIP questionnaire, at the end of 24 months, although a decrease was detected in all evaluation areas, such as functional, physiological, and social, compared to the initial measurements, a significant difference was noticed.

According to the results of our study, bleaching continued for 24 months, the effect on the quality of life was preserved in the second year, and the OHIP-14 questionnaire proved these results. OHIP-14 scale questions were not asked of the patients before bleaching. This finding shows that patients will experience positive psychological, social and functional effects as long as the teeth bleaching effect durability. Smiling, which plays an important role in facial aesthetics, undoubtedly contributes to the increase of self-esteem in individuals.[29] Appearance is one of the most important factors that determine and affect the self-esteem of individuals, their social communication with other people, their adaptation to the environment and their quality of life.[44] According to the results of the study, it has been shown that vital tooth bleaching treatment causes an increase in self-confidence in individuals and this increase continues over time. The null hypothesis was accepted because the rebound of color change was insignificant in assessments.

One of the limitations of our study is the preference of visual color scales instead of color-measuring devices that can give more objective results. Studies in the literature also support this view, and more studies are needed on this subject.

CONCLUSION

In present study, the bleaching obtained from the bleaching treatment can affect the positive effect on psychosocial and self-perception. Patients were generally satisfied with this treatment, despite the evaluation time differences between all groups.

Etik Komite Onayı: Çalışma, Gaziantep Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından 440/2019 (26.02.2020) onayı ile onaylandı.
Hasta Onamı: Takip değerlendirmesi için geri dönmeyi kabul eden olgulardan bilgilendirilmiş onam alındı.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir– Z.M.Ö.; Tasarım – Z.M.Ö.; Denetim – Z.M.Ö.; Kaynaklar - Z.M.Ö.; Malzemeler – D.G.S.; Veri Toplama ve/veya İşleme – D.G.S.; Analiz ve/veya Yorum – D.G.S.; Literatür Taraması – D.G.S.; Yazma – Z.M.Ö.; Eleştirel İnceleme – D.G.S.
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Youtube™ as an Information Source for Clinicians and Patients on Inlay-Onlay-Overlay Procedures

İnlay-Onlay-Overlay Restorasyonlar Hakkında Klinisyenler ve Hastalar İçin Bir Bilgi Kaynağı Olarak Youtube™

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ABSTRACT

Objective: The aim of this study was to evaluate the quality of YouTube™ videos on inlay, onlay, overlay restorations and to understand whether they were useful to patients and clinicians.
Method: In the present study, "inlay, onlay and overlay" were used as keyword and YouTube videos was analyzed. The first 159 videos were analyzed by two independent researchers, and 69 were subsequently included in the study. The characteristics of the videos, target audience and source of uploaded were evaluated. A 15-point scale was used to classify videos into low and high content. Each video was evaluated for content quality using the Video Information and Quality Index (VIQI) and Global Quality Scale (GQS).
Result: Most of the videos (44.9 %) had been uploaded by healthcare professionals, and followed by hospital/university (24.6 %). Definition of inlay-onlay-overlay was most mentioned topic. 63.8% of the videos was determined as low content and 36.2% high content. The VIQI and GQS scores of the high content group were significantly higher than low content group (*P* :.001; *P* <.05).
Conclusion: This study implies that YouTube™ is not a reliable source of information on inlay-onlay-overlay restorations. It is important that the contents of video sharing platforms are controllable by health professionals.
Keywords: GQS, Inlay, Onlay, Video content, VIQI, YouTube

ÖZ

Amaç: Bu çalışma, indirekt parsiyel restorasyonlarla ilgili bilgi sağlamak amacıyla başvurulan YouTube™ platformundaki videoların bilgi içeriği ve bilgi kalitesini değerlendirmeyi amaçlamıştır.
Yöntem: Bu kesitsel çalışmada, YouTube™ video paylaşım sitesine 'inlay-onlay-overlay' arama terimi girilerek tarama yapıldı. İlk 159 video iki bağımsız araştırmacı tarafından analiz edildi, hariç tutma kriterleri uygulandıktan sonra 69 video çalışmaya dahil edildi. Yüklenen videoların özellikleri, hedef kitlesi ve kaynağı değerlendirildi. Videoları düşük ve yüksek içeriğe göre sınıflandırmak için 15 puanlık bir ölçek kullanıldı. Her video, Küresel Kalite Skalası (GQS) ile Video Bilgileri ve Kalite İndeksi (VIQI) kullanılarak içerik kalitesi açısından değerlendirildi.
Bulgular: Videoların çoğunun (%44,9) sağlık çalışanları tarafından yüklendiği, bunu hastane/üniversite (%24,6) kuruluşlarının izlediği görüldü. Videoların %63,8'i düşük içerikli, %36,2'si yüksek içerikli olarak belirlendi. Yüksek içerikli grubun VIQI ve GQS puanları, düşük içerikli gruba göre anlamlı derecede yüksekti (*P* :.001; *P* <.05).
Sonuç: Bu çalışma, YouTube™'un inley-onlay-overlay restorasyonlar konusunda güvenilir bir bilgi kaynağı olmadığını göstermektedir. Video paylaşım platformlarının içeriklerinin alanında uzman hekimler ve akademisyenler tarafından kontrol edilebilir olması önemlidir.
Anahtar Kelimeler: GQS, Inlay, Onlay, Video içeriği, VIQI, YouTube

INTRODUCTION

Developments in adhesive technologies and the increase in conservative approaches have increased the indications for partial indirect restorations, especially based on the aesthetic dentistry approach.[1] Partial indirect restorations are classified as inlay (without covering the tubercles), onlay (covering at least one tubercle) and overlay (covering all tubercles).[2] Inlay-onlay-overlay restorations protect the remaining tooth structure.[2,3] Partial indirect restorations can be considered as a more conservative option than post-core and veneer crowns. In addition, they indicated in posterior teeth that have undergone root canal treatment and show excessive material loss.[4] Indirect inlays, onlays and overlays provide good proximal contact compared to direct resin composites and also eliminate the disadvantages caused by polymerization shrinkage.[5,6] In addition, ceramic inlay-onlay-overlay restorations have advantages such as longevity, durability and degree of translucency.[6] Nowadays, with the increasing interest in the conservative approach, the use of indirect restorations has become popular.[1] Inlay-onlay-overlay restorations are among the commonly used indirect treatment methods.

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With its increasing popularity since 2005, YouTube™ has become the third most visited site. YouTube™ has become a video encyclopedia containing important information on many medical topics, including inlay, onlay and overlay procedures. However, healthcare professionals (specialists, dentists), dental manufacturer or anyone who is a layperson can publish content on this platform.[7] This, a potential risk for patients and/or healthcare professionals depending on the timeliness, quality of the information in the video content.[8] The content and quality of YouTube™ videos on topics related to dental treatments have been evaluated in various studies.[7-10]

Acceleration of production with the introduction of CAD/CAM and 3D printers into our laboratories, increased interest in the conservative approach, aesthetic and mechanical developments in materials. In recent years, the increasing aesthetic demands of patients have led to an increased interest in porcelain inlay-onlay-overlay restorations.[11-14] When current literature is examined, studies evaluating the information content quality of videos about porcelain inlays, onlays and overlays are quite insufficient.

Information about various dental treatments can be obtained using the YouTube™ platform. However, the quality of these contents can affect people's thoughts and attitudes towards treatment. The presence of incorrect and incomplete information on this platform can damage the quality of treatment, effective use of time, and patient-physician relationship. Therefore, this study was aimed to evaluated the reliability and quality of videos on YouTube™ for patients and clinicians seeking information about inlay-onlay-overlay restorations.

METHOD

"Google Trends" is an online search engine that can be used to determine how frequently selected keywords have been queried over a certain period of time.[15] After a search for "Inlay-Onlay-Overlay" using this application on March 24, 2023, we found that the most commonly used terms were "inlay, onlay, overlay" (Google Trends, 2023). According to research, most YouTube™ users generally look only at the first three pages of their search results to find the information they are curious about, and often scan only the first 30 videos.[16,17] In previous studies on the subject in the literature, it was stated that approximately 95% of users watched the first 60-200 of the scanned videos.[16-20] In this study, the first 159 most viewed videos were selected and their Uniform Resource Loader (URL) addresses were recorded. 90 videos were excluded from the study for the reasons stated in Table 1. All evaluations were made on 69 videos and by two independent observers. The videos that caused disagreements among the researchers were rewatched and disagreements were resolved by consensus. Evaluation of the videos by two independent observers prevents subjectivity as much as possible, and the high correlation rate observed between the referees increases the reliability of the evaluation results.

Table 1. Exclusion criteria.

Exclusion criteria	n	%
No audio	48	53.3
Not in English	30	33.3
Duplicate	8	8.9
Not related to subject	4	4.4
Total	90	100

Video features such as the number of days since the video was uploaded, the country of origin, the duration of the video, the number of likes/dislikes it received, and viewers' comments were recorded.

The content evaluation of these videos was performed independently on the following subjects: (1) definition of inlay-onlay-overlay; (2) indications; (3) contraindications; (4) procedures involved; (5) advantages; (6) complications/disadvantages; (7) prognosis and Survival; (8) post-operative sensitivity; (9) abrasion resistance/fracture resistance; (10) stain resistance; (11) aesthetic satisfaction; (12) cost satisfaction; (13) plaque involvement; (14) chewing performance; and (15) application time. The presence of each content was scored as 1 point out of a total of 15 points. Videos considered as 9-15 points were identified as high content, and 0–8 points as low content.

The upload source of the videos was divided into five groups: healthcare professionals (dentist, specialist), hospitals/ universities/ dental clinics, commercial agencies (dental manufacturing or dental supply company), laypersons and others (tv channels, news agencies). The target audience was classified into three groups: professional, layperson and both.

The videos were evaluated with the VIQI, which uses a five-point Likert scale from 1 (poor) to 5 (high) to evaluate characteristics such as informativeness, accuracy, quality, and compatibility of the video title and content. In addition, the content quality of the videos was evaluated with the GQS, which consists of 5-points and takes into account video flow and ease of use. On this scale, 1-2 determined as low, 3 moderate and 4-5 high quality (Table 2). [21-23]

Table 2. Global quality scale

Poor quality, poor flow of the video, most information missing, not helpful for patients/specialist/dentist	1
Generally poor quality and poor flow, some information listed but many important topics but of limited use to patients/specialist/dentist	2
Moderate quality,suboptimal flow, some important is adequately discussed but others poorly discussed, somewhat useful for patients/ specialist/dentist	3
Good quality generally good flow, most relevant informations is covered, useful for patients/ specialist/dentist	4
Excellent quality and flow, very useful for patients/ specialist/dentist	5

Since the present study is an observational study as it involved the use of public access data only, there is no need for approval of the ethics committee.

Statistical analyses

IBM SPSS Statistics version 22.0 was used for statistical analysis in this study. The suitability of the parameters for normal distribution was evaluated with the Shapiro Wilks test and it was seen that the parameters did not show a normal distribution. In the study, descriptive statistical methods and Kruskal Wallis test (past hoc Dunn's test) for comparisons of quantitative data between more than two groups. Mann Whitney U Test were used for the comparison of quantitative data between two groups. Spearman's rho correlation analysis was used to examine the relationships between parameters. For the comparison of qualitative data, Chi-Square test, Fisher's Exact Chi-Square test, Fisher Freeman Halton Exact Test and Continuity Correction were used. Significance was evaluated at the P <.05 level. Significance was evaluated at the P <.05 level.

RESULTS

The USA scored highest for video uploads (40.6%, n = 28), with India ranking second (17.4%, n = 12). Eight videos were uploaded by users from Turkey

(11.6%), seven from Iranian (10.1%), three from United Kingdom (4.3%), two from both Japan and Spain (2.9%) and the remaining videos from Asia, China, England, France, Korea, South Africa and United Arab Emirates (each 1%, n = 1).

Descriptive statistics of the YouTube™ videos were provided in Table 3 and Table 4. Most videos (44.9%, n = 31) were uploaded by healthcare

professionals (Table 4). Mean duration of the YouTube™ videos on inlay-onlay-overlay was 9:84 min (varies: 0:22–98:00 min; median: 3:13). The mean number of views for these videos was 24203,57 (varies: 11–405302; median: 2027) with a mean interaction index of 31,83 views/d (varies: 0–1362,58 views/d) and a mean viewing rate of 1294,52 (varies: 1,8–11778,61). The overall mean of the number of "likes" was 190,19 (varies: 0–1,300), while the overall mean number of "dislikes" was 0,00. The upload of the video was 1466,78 days (varies: 70–4568). The mean total content score of the YouTube™ videos on inlay-onlay-overlay was 6.48, the mean GQS score was 2.81, and the mean VIQI total score was 13.88 (Table 3).

Fourty-four (63.8%) and twenty-five (36.2%) videos were included in the low-content and high-content groups, respectively.

Table 3. Descriptive Statistics of the YouTube™ Videos

Variables	Minimum	Maximum	Mean	Std. Dev.	Median
Video characteristics					
Number of views	11	405302	24203.57	59917.28	2027
Duration in minutes	22sec	98min	9:84	15:49	3:13
Days since upload	70	4568	1466.78	1124.21	1220
Number of comments	0	98	9.94	22.36	0
Number of likes	0	1300	190.19	346.00	24
Number of dislikes	0	0	0.00	0.00	0
Viewing rate	1,8	11778.61	1294.52	2384.17	246.5228
Interaction Index	0	1362.58	31.83	171.39	1.2402
Total Content Score	0	13	6.48	4.13	6
VIQI content assessment					
Flow of information	1	5	3.49	1.30	3
Information accuracy	2	5	3.99	1.02	4
Quality	1	5	2.71	1.57	2
Precision	1	5	3.74	1.30	4
VIQI total score	7	20	13.88	4.42	14
GQS	1	5	2.81	1.35	3

There was no statistically significant difference between the low and high content video groups in terms of the number of views, the day since upload, and the number of dislikes (P >.05). There was no statistically significant difference between the low and high content video groups in terms of viewing rate and interaction index (P >.05). Video durations of videos with high content were statistically significantly longer than lowcontent videos (P :.001; P <.05). The number of comments with high content was statistically significantly higher than videos with low content (P :.014; P <.05). The number of likes of high content group was statistically significantly higher than low content group (P :.035; P <.05). Flow and accuracy of information, content quality and total VIQI scores of high content videos were statistically significantly higher than low content videos (P :.001; P <.05). GQS scores of high content videos were statistically significantly higher than low content videos (P :.001; P<.05).

Table 4. Distrubition of Youtube™ videos source of upload, target audience, video contents

		n	%
Source of Upload	Healthcare professionals	31	44.9
	Hospital/university	17	24.6
	Commercial	6	8.7
	Layperson	1	1.4
	Other	14	20.3
Target audience	Professional	28	40.6
	Layperson	17	24.6
	Both	24	34.8
Total Content Score	Low content (0-6)	44	63.8
	High content (7-13)	25	36.2
Video Contents	Definition of Inlay-Onlay-Overlay	62	89.9
	Indications	48	69.6
	Contraindications	21	30.4
	Procedures involved	57	82.6
	Advantages	46	66.7
	Complications/Disadvantages	22	31.9
	Prognosis and Survival	32	46.4
	Post-operative sensitivity	7	10.1
	Abrasion resistance/Fracture resistance	22	31.9
	Stain resistant	9	13.0
	Aesthetic satisfaction	36	52.2
	Cost satisfaction	22	31.9
	Plaque involvement	12	17.4
	Chewing performance	18	26.1
	Application time	36	52.2

DISCUSSION

The aim of this study was to evaluate the accuracy and quality of video contents related to inlay-onlay-overlay on the YouTube™ video platform. With easy and free access to many videos, YouTube™ has become a powerful resource for learning about dentistry.[19] Partial indirect restorations have gained popularity and become the focus of attention of both patients and clinicians, due to their conservative approach and highly aesthetic results, along with the developments in adhesive systems.[24] For this reason, especially the patients' need for additional information and research curiosity about such treatments encourage individuals to seek information from their physicians as well as directs to internet use. Moreover, no study has been found that analyzes the content quality of the information presented in YouTube™ videos related to inlay-onlay-overlay restorations. Video shared information exchange has grown rapidly and has become an important source of information today.[25] Although it is undeniable that social media, including YouTube™, on patients, students and healthcare professionals who use social media for education and access to information, these tools also bring with them various risks such as lack of accurate information and uncontrolled dissemination[26]; For this

Table 5. Comparison of variables Low-Content and Moderate+High Content videos

	Low Content			High Content			
Variables	Min	Max	Mean±SD (median)	Min	Max	Mean±SD (median)	*P*
Video characteristics							
Number of views	11	405302	23571.8±70769.35 (1702)	22	121678	25315.48±34592.88 (8469)	.099
Duration in minutes	0.22	29	3.63±5.49 (1.3)	0.23	98	20.77±20.75 (15.5)	.001*
Days since upload	70	4383	1494.82±1169.1 (1209.5)	185	4568	1417.44±1062.12 (1220)	.930
Number of comments	0	59	4.55±11.53 (0)	0	98	19.44±32.1 (2)	.014*
Number of likes	0	1300	117.07±252.55 (17.5)	0	1300	318.88±444.81 (54)	.035*
Number of dislikes	0	0	0±0 (0)	0	0	0±0 (0)	1.000
Viewing rate	2.69	11778.61	1146.23±2520.09 (213.4)	1.8	7383.37	1555.51±2148.39 (364.3)	.074
Interaction Index	0	1362.58	48.97±213.59 (1.2)	0	4.79	1.68±1.51 (1.5)	.680
VIQI content assessment							
Flow of information	1	5	2.84±1.08 (3)	2	5	4.64±0.76 (5)	.001*
Information accuracy	2	5	3.55±0.93 (3)	2	5	4.76±0.66 (5)	.001*
Quality	1	5	2.14±1.3 (2)	1	5	3.72±1.51 (4)	.001*
Precision	1	5	3.14±1.13 (3)	1	5	4.8±0.82 (5)	.001*
VIQI total score	7	20	11.59±3.35 (11)	7	20	17.92±2.93 (19)	.001*
GQS	1	4	2±0.78 (2)	1	5	4.24±0.88 (4)	.001*

Mann Whitney U Test* P <.05

reason, in order to increase the content quality of YouTube™ videos, especially those related to the field of health, video sources must be checked and the information in the video content must be evaluated by health professionals in terms of currency, accuracy and quality.[16,27]

Additionally, quality of the information in the content of YouTube™ videos is questionable, as it is difficult to standardize the content of uploaded videos.[28] This study supports the results. There were many videos on inlay-onlay-overlay procedures, but the proportion of videos with high content (n = 25) was low; and most of the uploaded videos were low content videos (n= 44) (Table 6).

Table 6. Comparison of variables Low-Content and Moderate+High Content videos

		Low Content (n=44)	High content (n=25)	
		n (%)	n (%)	*P*
Source of Upload	Healthcare professionals	18 (40.9)	13 (52)	[1].743
	Hospital/university	10 (22.7)	7 (28)	
	Commercial	5 (11.4)	1 (4)	
	Layperson	1 (2.3)	0 (0)	
	Other	10 (22.7)	4 (16)	
Target audience	Professional	11 (25)	17 (68)	[2].001*
	Layperson	16 (36.4)	1 (4)	
	Both	17 (38.6)	7 (28)	
Video Contents	Definition of Inlay-Onlay-Overlay	37 (84.1)	25 (100)	[3].043*
	Indications	24 (54.5)	24 (96)	[4].001*
	Contraindications	2 (4.5)	19 (76)	[4].001*
	Procedures involved	33 (75)	24 (96)	[3].025*
	Advantages	22 (50)	24 (96)	[4].001*
	Complications/Disadvantages	4 (9.1)	18 (72)	[4].001*
	Prognosis and Survival	11 (25)	21 (84)	[4].001*
	Post-operative sensitivity	1 (2.3)	6 (24)	[3].008*
	Abrasion resistance/ Fracture resistance	3 (6.8)	19 (76)	[4].001*
	Stain resistant	0 (0)	9 (36)	[3].001*
	Aesthetic satisfaction	12 (27.3)	24 (96)	[4].001*
	Cost satisfaction	8 (18.2)	14 (56)	[4].003*
	Plaque involvement	2 (4.5)	10 (40)	[3].001*
	Chewing performance	5 (11.4)	13 (52)	[4].001*
	Application time	14 (31.8)	22 (88)	[4].001*

[1]Fisher Freeman Halton Exact Test [2]Ki-kare test [3]Fisher's Exact test [4]Continuity (yates)
*P <.05

In many studies evaluating YouTube™ content, it was found that the content quality was low, similar to this study. In their study on dental implants by Abukaraky et al.[9], it was shown that 114 videos mostly had poor content. In a study evaluating the content quality of YouTube™ videos uploaded by patients undergoing dental implant treatment, it was observed that the majority of the videos were incomplete and incorrect in information.[30] In the current study, no sharing of patient experience was found as a video source.

In a study conducted among medical doctors, it was observed that 85% of the participants encountered at least once a patient who came with information obtained from the internet, and 75% found it useful. They also believe that incorrect and incomplete information will harm the quality of the treatment they receive, the effective use of time, and the patient-physician relationship.[31] This research was found to be important in terms of showing the importance of the quality of information in the field of health on the social media.

Due to the increase in internet usage and ease of access and application, YouTube™ has become an open platform where anyone can upload videos. In this study, most of videos (44.9%, n= 31) on inlay-onlay-overlay were uploaded by healthcare professionals (specialist, dentists), however, there was no statistically significant difference between the low and high content video groups in terms of uploaded resources (P >.05). The rate of targeting professionals in high content videos (68%) was statistically significantly higher than low-content videos, which indicated that the majority of the uploaded high-content videos were directed toward healthcare professionals. According to a study that investigated the quality of information regarding burning mouth syndrome in YouTube™ videos, these videos reported that they had low video content and quality, were generally aimed at patients and the layperson, but not dentists and specialists.[32]

In a study evaluating YouTube™ as a source of information on digital dentistry, it was observed that 44.44% of the analyzed videos had medium content quality, while 37.03% had poor content quality. It was reported that the majority of the videos (38.88%) were uploaded by dentists, but although the reporter was a dentist in 75.90% of them, 57.40% of the videos had poor content, receiving 2 points on the GQS.[33]

Definition of inlay-onlay-overlay, procedures involved and advantages was most frequently mentioned subject in all the videos reviewed. The content quality of high content videos was statistically significantly higher than low-content videos (P <.05) (Table 6). In addition, low-content videos did not discuss stain resistant. This provides necessary information and guidance to both patients and healthcare professionals interested in partial indirect restorations.

Table 7. Correlations between Total Content Score, VIQI, GQS and YouTube demographics

		Total Content Score	VIQI	GQS
Total Content Score	r	1.000		
	P	.		
VIQI	r	**0.741**	1.000	
	P	**.001***	.	
GQS	r	**0.888**	**0.875**	1.000
	P	**.001***	**.001***	.
Number of views	r	0.075	**0.349**	0.230
	P	.540	**.003***	.058
Duration in minutes	r	**0.560**	**0.597**	**0.614**
	P	**.001***	**.001***	**.001***
Days since upload	r	-0.016	0.061	0.016
	P	.897	.617	.899
Number of comments	r	**0.336**	**0.469**	**0.372**
	P	**.005***	**.001***	**.002***
Number of likes	r	0.139	**0.399**	**0.295**
	P	.255	**.001***	**.014***
Viewing rate	r	0.070	**0.358**	0.227
	P	.569	**.003***	.061
Interaction Index	r	-0.040	-0.011	0.023
	P	.746	.926	.854

Spearman's Rho Correlations*P <.05

Table 8. Comparison of scores according to source of upload and target audience

		Total Score	VIQI	GQS
		Mean±SD (median) (Min-Max)	Mean±SD (median) (Min-Max)	Mean±SD (median) (Min-Max)
Source of Upload	Healthcare professionals	7.13±4.22 (8) (0-13)	15±4.31 (16) (7-20)	3.03±1.35 (3) (1-5)
	Hospital/ university	6.76±3.96 (7) (1-13)	13.35±5.07 (13) (7-20)	2.71±1.49 (2) (1-5)
	Commercial	5±4.29 (3.5) (2-13)	13.67±3.39 (13) (11-20)	2.67±1.37 (2.5) (1-5)
	Other	5.29±4.25 (4.5) (1-12)	12.5±3.98 (11) (8-20)	2.57±1.28 (2) (1-5)
	[1]*P*	.458	.329	.692
Target audience	Professional	8.18±4.58 (10) (1-13)	16.61±3.96 (18) (7-20)	3.5±1.45 (4) (1-5)
	Layperson	4.88±2.83 (6) (1-9)	10.24±2.88 (10) (7-17)	1.82±0.73 (2) (1-3)
	Both	5.63±3.75 (5) (0-13)	13.29±3.78 (13.5) (7-20)	2.71±1.12 (2.5) (1-5)
	[2]*P*	.021*	.001*	.001*

[1]Mann Whitney U Test [2]Kruskal Wallis Test
Source of Upload Layperson (n=1), is not included in the comparison.

The results of most studies conducted in the field of dentistry agree that YouTube™ videos are scientifically inaccurate and often contain incomplete and/or incorrect health-related information.[10,11,28,32-34] This result is similar to the present study. Contrary to the results of this study, studies where videos about dental practices on the YouTube™ video platform were evaluated, it was reported that the videos had high information content.[35-36]

A systematic review reported that YouTube™ contains misleading, mostly anecdotal information that conflicts with reference standards.[37] All VIQI and GQS evaluation criteria were scored higher in the high-content video group than in the low-content video group (Table 6). Contrary the results of this study, Lena et al.[10] reported that there was no difference in terms of total VIQI score between high and low content video groups. This study results were different from their study because there were many low-content videos (n = 44) in this study.

This study showed a strong positive correlation between total content score and VIQI (r = 0.741, *P* <.05), GQS (r = 0.888, *P* <.05) (Table 6). The results obtained from the study are similar to the results of the study by Aydin et al.[38], in which videos on the YouTube™ video platform about removable orthodontic appliances were evaluated. There was no statistically significant relationship between total content score and viewing rate, interaction index (*P* >.05). In this study, it was determined that videos with good quality information content received more likes and comments. In addition, there was a statistically significant positive correlation between VIQI and GQS, video duration, number of view, number of comments, number of likes (Table 7). There was no statistically significant relationship between VIQI and interaction index (*P* >.05). This study results are similar to those of Paksoy et al.[16] In their study, there was a positive correlation between VIQI and total content score and there was a positive relationship between total content score and the variables of duration in minutes, VIQI, number of comments, number of likes and number of dislikes. Contrary to the results of this study, there was a positive relationship with the interaction index. The results of many studies have shown that videos with good quality information content have a longer duration, higher viewing rate and GQS index.[39-43] Additionally, Ustdal et al.[44] reported a significant positive relationship between GQS score and quality information score.

This study had several limitations. There was no validated evaluation tool that rated video-based resources.[33] In addition, study results may vary depending on the search words used to find the YouTube™ video. In other words, different results may occur when different search terms are used. In this study, the search was made using only a single data to avoid confusion.

Search term, “inlay-onlay-overlay”; It is thought to be the search term that the average person would most likely use when searching on the topic. Secondly, YouTube™ is a dynamic platform and its content changes over time.

CONCLUSION

Although social media provides a great advantage in terms of reaching a large population, it can also easily cause false information to spread with the same method. Operational videos of inlay-onlay and overlay restorations method should be uploaded to YouTube™ after approval by experts. Considering that the YouTube™ platform plays an important role in patients' treatment preferences, it is thought that it will be useful for informing specialist physicians about treatment. It is very critical that dentists, public health institutions or academics provide unbiased and realistic information on this platform.

Etik Komite Onayı: Bu çalışma gözlemsel bir çalışma olduğundan ve yalnızca kamuya açık erişim verilerinin kullanılmasını içerdiğinden etik kurul onayına gerek yoktur.
Hasta Onamı: Mevcut çalışma yalnızca kamuya açık erişim verilerinin kullanılmasını içerdiğinden ve gözlemsel bir çalışma olduğundan bilgilendirilmiş gönüllü onam onayına gerek yoktur.
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How the Translucency and Color Stability of Single-Shade Universal Resin Composites Are Affected by Coffee?

Tek Renkli Universal Rezin Kompozitlerin Translüsensi ve Renk Stabilitesi Kahveden Nasıl Etkilenir?

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ABSTRACT

Objective: The aim of this study was to examine how staining with coffee affects single-shade universal resin composites and a multi shade universal resin composite in terms of translucency and color stability.
Method: Five different resin composites (Omnichroma, Vittra APS Unique, Zenchroma, Charisma Diamond One, and Neo Spectra ST) were used to create 50 samples (n=10). A spectrophotometer was used to record translucency parameter (TP_{00}) and color changes (ΔE_{00}) at baseline and after immersion in coffee for 24 h. Color differences were calculated according to CIEDE2000. Data analysis was performed using one-way ANOVA and the paired-samples t-test.
Results: After immersion of resin composite samples in coffee for 24 h the Vittra APS Unique group showed the highest ΔE_{00} value and the Neo Spectra ST group the lowest (P<.001). At baseline, low TP_{00} values were observed in Neo Spectra ST and Charisma Diamond One and high TP_{00} values in Omnichroma and Vittra APS Unique (P<.001). After being stained with coffee On day 1, low TP_{00} values were recorded in Neo Spectra ST and Charisma Diamond One, and high values TP_{00} in Omnichroma and Zenchroma (P<.001).
Conclusion: Short-term staining resulted in less color change in the multi shade universal resin composite than in the single-shade universal resin composites. ΔE_{00} and TP_{00} values varied between the single-shade universal resin composites
Keywords: Color Stability, Multi shade Universal Resin Composite, Single-Shade Universal Resin Composite, Translucency Parameter

ÖZET

Amaç: Bu çalışmanın amacı, kahve ile renklendirmenin tek renkli universal rezin kompozitlerin ve bir çok renkli universal rezin kompozitin translüsensi ve renk stabilitesini nasıl etkilediğini incelemektir.
Yöntem: 50 örnek oluşturmak için beş farklı rezin kompozit (Omnichroma, Vittra APS Unique, Zenchroma, Charisma Diamond One ve Neo Spectra ST) kullanıldı (n=10). Başlangıçta ve 24 saat boyunca kahveye batırıldıktan sonra translüsensi parametresi (TP_{00}) ve renk değişikliklerini (ΔE_{00}) kaydetmek için bir spektrofotometre kullanıldı. Renk farklılıkları CIEDE2000'e göre hesaplandı. Veri analizi, tek yönlü ANOVA ve eşleştirilmiş örnekler t-testi kullanılarak yapıldı.
Bulgular: Rezin kompozit numunelerin 24 saat boyunca kahveye batırılmasından sonra en yüksek ΔE_{00} değerini Vittra APS Unique grubu, en düşük ΔE_{00} değerini ise Neo Spectra ST grubu gösterdi (P<.001). Başlangıçta; Neo Spectra ST ve Charisma Diamond One'da düşük TP_{00} değerleri, Omnichroma ve Vittra APS Unique'de ise yüksek TP_{00} değerleri gözlendi (P<.001). Kahve ile boyama sonrası 1. Günde ; Neo Spectra ST ve Charisma Diamond One'da düşük TP_{00} değerleri, Omnichroma ve Zenchroma'da ise yüksek TP_{00} değerleri kaydedildi (P<.001).
Sonuç: Kısa süreli renklendirme; çok renkli universal rezin kompozitlerde, tek renkli universal rezin kompozitlere göre daha az renk değişikliğine neden oldu. ΔE_{00} ve TP_{00} değerleri, tek renkli universal rezin kompozitler arasında değişiklik gösterdi.
Anahtar Kelimeler: Renk Stabilitesi, Çok Renkli Universal Rezin Kompozit, Tek Renkli Universal Rezin Kompozit, Translüsensi Parametresi

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INTRODUCTION

It is the task of restorative dentistry to restore the natural appearance of teeth that have lost material due to caries or trauma.[1] Resin composites are preferred because they give natural and esthetic results. When restoring

teeth using multi shade resin composites, dentists typically use a color guide and employ their visual skills to select a shade that is compatible with the tooth .[2] With the introduction of nanotechnology to reduce the time spent at the chairside, the use of single-shade resin composites has risen. These composites can simulate all shades alone, in contrast to multi shade resin composites.[3] It is reported that composites are in better harmony with the color of dental tissues due to their "chameleon effect".[4] This effect is synonymous with the blending effect and in resin composite restorations is the potential for color shift from reflected light to match the color of the surrounding tooth structures. When the restoration is illuminated, the light is diffused on the surface of the filling particles and is scattered in many directions.[5]

The success of a restoration esthetically speaking depends on its optical appearance. The color and translucency of esthetic restorations are important optical properties. The restorative materials applied should be able to imitate both the color and translucency of the natural tooth structure and be resistant to discoloration in the long term, which may be caused by external factors.[6] Absorption of pigments in staining liquids such as coffee, wine, and cola causes coloring of the resin composite.[7]

Knowledge of the processes related to color change in resin composites will contribute to improvement of their esthetic properties. In addition, color selection and matching will be simplified with a small number of color options. The number of single-shade system resin composites with different properties is gradually increasing. The variety in the chemical contents of resin composites implies that their clinical performance is affected by numerous factors.[8] Various clinical behaviors can be shown by single-shade resin composites with specific color-matching mechanisms through their filler structures.[9] There are limited data on color stability and translucency variation in the increasing number of single-shade resin composites. In the present study, four single-shade resin composites were examined in terms of their color stability and translucency parameters. The aim of the study was to examine how the color stability and translucency of four single-shade universal resin composites and a multi shade universal resin composite were affected by staining with coffee. The null hypothesis was that staining with coffee will not create any difference in the color stability or translucency of the universal resin composite samples tested.

METHOD

Since disc-shaped composite samples were used in the study, informed consent and ethics committee approval were not applied. The study was performed in vitro to evaluate a multi shade resin composite and four commercially available single-shade resin composites from different manufacturers. Details of the resin composites are presented in Table 1.[10] The composites tested were placed in silicone molds (8 mm in diameter and 2 mm in depth) in one go with the help of hand tools. The overflowing composite material was removed by placing a piece of transparent tape on the resin composites and applying finger pressure via a 1-mm-thick glass coverslip. The samples were polymerized for 20 s at 1000 mW/cm² by touching the tip of a Woodpecker LED-E light device (Woodpecker Medical Instrument Co., Guilin, China) onto the glass coverslip. The polishing was performed by a single experienced operator as described by the manufacturer (under slight hand pressure, 20 s application per sample). For polishing, a Minitech 233 (Presi, Grenoble, France) was used under running water (170 rev/min, 15 s). Power analysis was performed using the software package G*Power 3.1.[11] Sample size was calculated with a Type I error is 5% and power of 80% and large effect size 0,6 it is necessary to include at least 8 samples in each group. Considering data losses, 50 disc-shaped samples were prepared, 10 samples in each group, with an increase of 20%. The samples were finished and polished, and then placed in a 10-well plate (1 sample per well). Afterward, following 24 hours of incubation in distilled water at 37 °C, the baseline color of all samples was determined using a spectrophotometer (SpectroShade, MHT Optic Research, Niederhasli, Switzerland). The averages of three measurements obtained from each sample were calculated to determine the L*, a*, and b* values. The device was calibrated before each measurement. Color on a white background and translucency on a black and white background were conducted under D65 standard illumination conditions. Samples were prepared by mixing 3.6 g of coffee granules (Nescafe Classic, Nestle, India) with 300 ml of boiled coffee powder at 37 °C and incubated for 24 hours in an incubator (NUVE EN 55, Esetron, Ankara, Turkey). The colors of the samples were measured again, and the values were recorded. The ΔE_{00} and TP_{00} values were calculated using the CIEDE2000 formula based on the L*, a*, and b* values on the baseline and day 1.[12,13] The formulas for ΔE_{00} and TP_{00} are given below.

$$TP_{00} = \left[\left(\frac{L'_B - L'_W}{k_L S_L}\right)^2 + \left(\frac{C'_B - C'_W}{k_C S_C}\right)^2 + \left(\frac{H'_B - H'_W}{k_H S_H}\right)^2 + R_T\left(\frac{C'_B - C'_W}{k_C S_C}\right)\left(\frac{H'_B - H'_W}{k_H S_H}\right)\right]^{\frac{1}{2}}$$

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

The preliminary analysis, skewness coefficients, and histogram graphs showed that the measurements were in accordance with the normal distribution. The data obtained were analyzed with SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY) using one-way ANOVA and the paired-samples t test. Significance was set at $P<.01$.

RESULTS

The perceptible threshold value of ΔE_{00} determined was 0.8, and $\Delta E_{00}>0.8$ indicated visually perceptible color change. The acceptable threshold value determined for ΔE_{00} was 1.8, and values of $\Delta E_{00}>1.8$ were regarded as clinically unacceptable color changes.[14] The mean and standard deviation of ΔE_{00} in the resin composite groups according to the CIEDE2000 color system after coloring solution are shown in Table 2. ΔE_{00} values were between 1.2 and 2.76 in the resin composite groups after soaking in coffee. The highest statistically significant ΔE_{00} was in the VU single-shade composite resin group ($P<.001$), while the lowest statistically significant ΔE_{00} was in the NS multi shade resin composite group ($P<.001$). ΔE_{00} in the other three single-shade composite resin groups (OC, ZC, DO) were similar to each other.

In a study by Salas et al.[15], the translucency perceptibility and acceptability thresholds of resin composites according to the CIEDE2000 formula were 50%:50% TPT (perceptibility) 0.62 and TAT (acceptability) 2.62. In the present study, based on these threshold values, the TP_{00} values (6.97-11.98) were in the clinically unacceptable range for the resin composite groups after soaking in coffee. The mean and standard deviation TP_{00} values and comparative results of the resin composite groups before and after staining with coffee according to the CIEDE2000 formula are shown in Table 3.

Baseline, mean TP_{00} values differed significantly (P<.001). Among the groups, NS and DO showed similarly low TP_{00} values, while OC and VU showed similarly high TP_{00} values. After 1 day immersing in coffee, mean TP_{00} values again differed significantly (P<.001). NS and DO showed similarly low TP_{00} values among the groups. OC and ZC showed similarly high TP_{00} values. In addition, the values for ZC and VU TP_{00} were similar.

After 1 day immersing in coffee, the TP_{00} values of the ZC resin composite group were significantly increased (P=.009), while the TP_{00} values of the NS and DO resin composite groups were significantly decreased (P<.001). The TP_{00} values of the OC and VU resin composite groups were not affected by coffee staining (P=.114 and P=.083, respectively).

DISCUSSION

The effects of coloring solution on the color stability and increase/decrease in TP_{00} values of a multi shade universal resin composite and four single-shade universal resin composites were evaluated. The hypothesis that staining brown would cause no difference in color stability and increase/decrease in TP_{00} in the resin composite samples tested was rejected. Single-shade universal resin composites are used clinically to make color selection quicker and to decrease costs by reducing the amount of waste and because of their good esthetics.[16] The color stability of resin composite restorations in the anterior region is especially important. Discoloration of these restorations is considered an esthetic failure but can often be corrected by re-restoration.[17] The quality of the restoration surface is one of the most important indicators of external discoloration. There is information in the literature that polishing the restoration surface removes the resin-rich oxygen inhibition layer and, as a result, provides a smoother, smoother, more cleanable surface, and these features of the surface play an important role in external discolorations.[18,19] The use of transparent tape enables a shiny surface to be obtained. Although it is known that the part just below the band does not polymerize at the same rate as the entire resin composite, and when this layer is removed with polishing application, a harder and more resistant to discoloration surface is obtained.[20] In our study, taking into account the imitation of clinical applications, all sample surfaces were applied using standard polishing discs. A finishing polishing process was applied. The degree of monomer conversion affects the chemical stability of the material. Unconverted double carbon linkages can make the material more susceptible to degradation reactions.[21] This may result in decreased color stability.[22] It has been reported that composite resins that have not been sufficiently polymerized undergo significant color change when exposed to chemical dyes and food dyes.[23]

It's reported that color analysis with a spectrophotometer is more accurate and reproducible than visual color assessment.[24] A clinical study found that SpectroShade exhibited better reproducibility than VITA Easyshade (VITA Zahnfabrik, Bad Sackingen, Germany).[25] In addition, SpectroShade (SpectroShade, MHT Optic Research, Niederhasli, Switzerland) allows defining the outline of the tooth on the image and displaying color parameters for the entire tooth surface or the gingival, middle and incisal thirds. For this reason, the use of

Table 1. Properties of composite resin materials used in the study

Material	Manufacturer	Lot Number	Type	Monomer	Filler Composition/Size	Filler w/V%	Code
Omnichroma	Tokuyama, Japan	158S3	Nanofilled	UDMA TEGDMA	Uniform sized supra-nano spherical filler (SiO2-ZrO2) /260 nm	79/68	OC
Zenchroma	President Dental, Germany	2022003395	Microhybrid	UDMA Bis-GMA TEMDMA	Glass powder, silicon dioxide inorganic filler / (0.005–3.0 µm)	75/53	ZC
Charisma Diamond One	Kulzer, Germany	K010021	Nanohybrid	UDMA TCD-DI HEA TEGDMA	Barium Aluminium Boro Fluor Silicate Glass / (5 nm–20 µm)	81/64	DO
Neo Spectra ST HV A2	Dentsply, North Carolina, USA	2111000985	Nanohybrid	Bis(4-methyl-phenyl)iodonium hexafluorophosphate	Spherical, pre-polymerized SphereTECfillers, Methacrilate-modified polysiloxane barium glass, and ytterbium flüoride/ (3 µm-7 µm)	79/61	NS
Vittra APS Unique	FGM, Brazil	230921	Nanohybrid	UDMA TEGDMA	Zirconia charge, silica/ (200 nm)	82/72	VU

Table 2. Comparison of color changes (ΔE_{00}) of composite resins (between baseline and day 1)

Groups	Mean ± SD
Omnichroma	2.25 ± 0.36[b]
Zenchroma	1.81 ± 0.33[b]
Charisma Diamond One	2.0 ± 0.67[b]
Neo Spectra ST	1.2 ± 0.17[c]
Vittra APS Unique	2.76 ± 0.84[a]
ANOVA test	F=11.6; p: <0.001

a, b, c: Different letters indicate statistical differences between groups.

Table 3. Comparison of translucency parameter (TP_{00}) baseline and day 1 interval for each composite resin.

	Baseline	Day 1	Paired t test	
	Mean ± SD	Mean ± SD	t	*P*
Omnichroma	11.57 ± 0.47[a]	11.98 ± 0.56[a]	-1.748	.114[ns]
Zenchroma	10.76 ± 0.47[b]	11.50 ± 0.63[ab]	-3.287	.009[**]
Charisma Diamond One	7.82 ± 0.67[c]	7.10 ± 0.39[c]	5.603	<.001[***]
Neo Spectra ST	7.49 ± 0.64[c]	6.97 ± 0.67[c]	6.082	<.001[***]
Vittra APS Unique	11.48 ± 0.37[a]	10.97± 0.95[b]	1.952	.083[ns]
ANOVA test	***F*** 141.3	137.3		
	P <.001	<.001		

Ns: not significant, **:P<.01; ***: P<.001
SD: standard deviation.
Different letters indicate statistical differences between the same columns(P<.001).

SpectroShade was preferred in this study. Its disadvantage compared to the clinical spectrophotometer Vita Easyshade is that it may not provide L*, a* and b* values. However, it can be used in studies as stated in the literature.[26]

CIELAB is calculated using the ΔE_{00} formula with the L*, a*, and b* color change values in the materials. In 2001, an updated formula, CIEDE2000, was introduced by the CIE.[27] Researchers have reported that the CIEDE2000 formula is more suitable for evaluating color differences[28] and has greater sensitivity than the CIELAB.[29] Therefore, in our study, color differences and TP_{00} values were calculated with the CIEDE2000 formula.

Tea, coffee, and wine are beverages commonly consumed daily and cause the most color change.[30] In this study, coffee, was used for short-term coloring. Ertaş et al.[31] reported that keeping samples in coffee for 24 h mimics approximately 1 month of coffee consumption. In the present study, the resin composites were subjected to short-term staining. They were kept in coffee for 24 h and so were exposed to the equivalent of 1 month of staining. The water absorption rate is related to the material's resin content and the bonding at the filler/resin interface. The resin expands and becomes plastic if water absorption is excessive. This causes microcracks in the resin composite that prepare the environment for stain penetration and color change.[32] In addition, resin composites with the main monomer content of Bis-GMA have been reported to show less water absorption than those containing TEGDMA and more water absorption than those containing UDMA and Bis-EMA.[33] Ertaş et al.[31] reported that greater change was seen in TEGDMA resin composites in their study about color change in nanohybrid and microhybrid resin composites caused by various drinks (water, cola, tea, instant coffee, and red wine). The monomer TEGDMA is usually found in the structure of monochrome resin composites. Reis et al.[34] stated that the structure of the material and the amount of organic matrix filler are important factors affecting color change in resin composites. It has been reported that the colors of composites with more filler particles are more stable because they absorb less water.[30] The smaller particle size found in resin composites, on the other hand, may explain their lower susceptibility to coloration. The presence of smaller filler particles is associated with lower susceptibility for surface smoothness and coloration compared to other resin composites with larger filler particles.[35] Ren et al.[36] reported that the porosity of zirconia/silica nanoparticles facilitate the penetration of fillers and dyestuffs. They emphasized that although the resin matrix structures are similar, differences in color stability are related to the differences in filler composition.[36] In our study, coloration equivalent to 1 month the resin composite showing the greatest color change was VU. Although the amount of filler particles in VU is high and the filler particles are small, the reason for its greater staining may have been the zirconia-silica nanoparticles it contains. More studies on the color change of VU are needed. In our study, it was the NS multi shade universal resin composite group that showed the least color change. This may have been because NS does not contain TEGDMA. Coloration equivalent to 1 month , NS showed clinically acceptable color change values (1.2 ± 0.17). Fidan et al.[37] reported that single-shade composite resins found a higher color change than the multi-shade composite resin. Within the limitations of our study, short-term staining of resin composites can be demonstrated. The color change in NS can be evaluated with long-term staining.

Translucency can be defined as a state between full opacity and full transparency, where the background appears as a result of the light transmitted through the material. Higher values for TP_{00} indicate greater translucency of the material. A completely opaque material has a zero TP_{00} value. In a previous study, a higher TP_{00} was said to indicate a higher blending effect.[38] Large filler particles (about 10 µm in diameter) transmit less light and appear opaquer.[39] When baseline TP_{00} values were compared in our study, OC and VU showed high TP_{00} values, while NS and DO showed low TP_{00} values. This may have been because OC and VU resin composites contain smaller filler particles compared to the other composites, and NS and DO resin composites contain larger filler particles. However, it is stated that the ratios of radiopaque substances (barium glass particles, etc.) added to resin composites affect their TP_{00} values.[40] The reason for the low TP_{00} values of NS and DO may be related to the barium particles they contain. After staining with coffee, OC and ZC showed high TP_{00} values and NS and DO showed low TP_{00} values. The content differences and coloration status of the materials after staining with coffee may have caused the changes in TP_{00} values. It has also been reported that aging affects the color stability and translucency of resin composite materials.[41] Differences between resin composites may be attributed to the chemical structure of the materials, the number of particles, or the diameter of the particles. Researchers have reported that Bis-GMA has greater translucence than UDMA and TEGDMA.[42] The reason given was that the refractive index of Bis-GMA was similar to that of silica filler. However, the ZC group in our study showed significantly higher TP_{00} values with OC only after staining with coffee, although it contained Bis-GMA. In addition, a significant increase was observed in the TP_{00} values of ZC after staining with coffee (P=.009). In a study conducted by Fidan et al.[41], the TP_{00} value of ZC has decreased after aging. This may have been related to the monomers and fillers contained in ZC. Translucency changes may occur in composites due to light curing or aging.[43] In a study examining the color and translucency change of single-shade composite after repeated heating cycles and coloring, it was reported that the TP_{00} value decreased significantly after one heating cycle.[44] Quek et al.[45] found that red wine and coffee significantly reduced the TP_{00} values of direct and indirect restorative material after 7 days. TP_{00} values in the NS and OC resin composite groups showed a significant decrease after staining with coffee. Weakening of the bond between resin and filler and then colorants leaching into the resin matrix might be responsible for this decrease.[42] The translucency of esthetic restorative materials was established by comparatively small additions of pigments and possibly all other chemical components in these materials, including initiating components and filler coupling agents as well as more macroscopic factors, like matrix and filler composition and filler content.[46] For success in complex clinical cases, the clinician must test the translucency, opalescence, chroma, and fluorescence of the material beforehand.[47] How each component affects changes in translucency should be studied further. This study evaluated many single-shade composite resins that have recently been introduced to the dental market. The color stability of the single-shade composite resin selected for clinical success in esthetic restorations may be important for the clinician. In addition, we thought that the color change and increase/decrease in translucency that occurs after short-term staining with coffee in single-shade composite resins may be useful in clinical studies planned in the future. Limitations of this study include short-term coloration, the use of only one multi shade composite resin, and it was in vitro study. To better interpret the color results of the materials, FTIR, Vickers, adsorption and solubility, and surface roughness tests should be performed and included in future studies. Laboratory experiments cannot fully simulate intraoral conditions. Future in vivo studies are needed.

CONCLUSION

Short-term staining with coffee resulted in less color change in the multi shade universal resin composite than in the single-shade universal resin composites. ΔE_{00} and TP_{00} values varied between the single-shade

universal resin composites. Since the physicochemical properties of the material and the patient's dietary habits as well as oral hygiene practices are important determinants of color changes in composite resins, we think that including this parameter in future studies will be beneficial in terms of the results obtained.

Etik Komite Onayı: Çalışmada disk şeklinde kompozit numuneler kullanıldığı için Etik Kurul Onayı alınmamıştır.
Hasta Onamı: Kompozit numuneler kullanıldığından hasta onam formu alınmamıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir– B.Ö., B.K.K.K., S.B.Ö., Ö.A.; Tasarım - B.Ö., B.K.K.K., S.B.Ö.; Denetim - B.Ö., B.K.K.K., S.B.Ö.,; Kaynaklar - B.Ö., B.K.K.K., S.B.Ö.,; Malzemeler - B.Ö., B.K.K.K., S.B.Ö.; Veri Toplanması ve/veya İşlemesi - B.Ö., B.K.K.K., S.B.Ö.; Analiz ve/veya Yorum - B.Ö., B.K.K.K., S.B.Ö.,Ö.A.; Literatür Taraması - B.Ö., B.K.K.K., S.B.Ö.,Ö.A.; Yazan - B.Ö., B.K.K.K., S.B.Ö.,Ö.A.; Eleştirel İnceleme - B.Ö., B.K.K.K., S.B.Ö.,Ö.A.
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Readability Analysis of Turkish Patient Informing Texts about Teeth Whitening on the Internet: Cross-Sectional Study

İnternet Ortamında Diş Beyazlatma ile İlgili Türkçe Hasta Bilgilendirme Metinlerinin Okunabilirlik Analizi: Kesitsel Çalışma

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ABSTRACT

Objective: Considering that the texts presented on the internet will be read by people of very different education levels, it is important to examine the readability of these texts. The aim of this study was to evaluate the readability analysis of Turkish patient information texts about teeth whitening on the internet.

Method: A Google search using the term "Teeth Whitening" revealed the top 100 websites. Turkish patient information texts on the 86 websites included in this study were evaluated according to the Atesman Readability Index. The information texts originated from dentists, specialist dentists, private health institutions, university hospitals, and newspapers. The Kolmogorov–Smirnov test and descriptive statistics were used for statistical evaluation. Statistical significance level was accepted as $P < .05$.

Results: Atesman Readability Index score was 59.08 ± 8.14. According to the findings obtained in the research, 0% of the websites examined were rated as very easy, 7% as easy, 86% as moderately difficult, 5.8% as difficult, and 1.2% as very difficult. When the readability levels of the texts were examined according to grade levels, the following was found: 43% were grades 11th–12th , 43% grades 9th–10th, 7% grades 7th–8th, and 5.8% grade associate degree.

Conclusion: The readability of Turkish texts on teeth whitening on the internet was found to be of medium difficulty. When creating texts for the internet about teeth whitening, it would be beneficial to make them easier to read by using readability programs before they are published.

Keywords: Access to information, dentists, internet, teeth whitening

ÖZ

Amaç: İnternette sunulan metinlerin çok farklı eğitim seviyesindeki kişiler tarafından okunacağı düşünüldüğünde bu metinlerin okunabilirliğinin incelenmesi önemlidir. Bu çalışmanın amacı, internet ortamında diş beyazlatma ile ilgili Türkçe hasta bilgilendirme metinlerinin okunabilirlik analizlerinin değerlendirilmesidir.

Yöntem: "Diş Beyazlatma" terimini kullanan bir Google araması, en iyi 100 web sitesini ortaya çıkardı. Bu çalışmaya dahil edilen 86 internet sitesinde yer alan hasta bilgilendirme metinleri Ateşman Okunabilirlik İndeksi'ne göre değerlendirildi. Bilgilendirme metinleri diş hekimleri, uzman diş hekimleri, özel sağlık kuruluşları, üniversite hastaneleri ve gazetelerden alındı. İstatistiksel değerlendirme için Kolmogorov-Smirnov testi ve tanımlayıcı istatistikler kullanıldı. İstatistiksel anlamlılık düzeyi $P < .05$ olarak kabul edildi.

Bulgular: Ateşman Okunabilirlik İndeks puanı 59.08±8.14 bulundu. Araştırmada elde edilen bulgulara göre; incelenen web sitelerinin %0'ı çok kolay, %7'si kolay, %86'sı orta derecede zor, %5,8'i zor ve %1,2'si çok zor düzeyde olduğu bulundu. Metinlerin okunabilirlik düzeyleri sınıf düzeylerine göre incelendiğinde; %43'ü 11-12. sınıflar, %43'ü 9-10. sınıflar, %7'si 7-8. sınıflar, %5,8'i ön lisans sınıf derecesinde olduğu bulundu.

Sonuç: İnternette diş beyazlatma ile ilgili Türkçe metinlerin okunabilirliği orta zorlukta bulunmuştur. İnternette diş beyazlatma ile ilgili metinler oluşturulurken yayınlanmadan önce okunabilirlik programları kullanılarak daha kolay okunabilir hale getirilmesi faydalı olacaktır.

Anahtar Kelimeler: Bilgiye erişim, diş hekimleri, internet, diş beyazlatma

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INTRODUCTION

Since the 1990s, the use of the internet as a resource used to both publish and obtain health advice or information has been growing.[1] As a result, it has become easier for internet users to access information on health and other matters.[2] The internet offers rich information on many subjects, and its omnipresence in daily life has resulted in it becoming a common source of information for many users. Thanks to the internet, the opportunity to access information has increased exponentially, and almost all the services that people need are covered in digital media.[3] While the rate of internet usage in Turkey was 82.6% in 2021 for individuals in the 16–74 age group, it was 85.0% in 2022, according to the Turkish Statistical Institute (TUIK).[4,5] It has been reported that doing research on the internet provides people with the opportunity to obtain more information, support communication with their physician, and enable them to make more informed decisions about their treatment.[6]

Advances in media technologies have reshaped today's patient–health relationship, and this has enabled the use of digital health technology by all types of patients and in all areas of health services.[3] However, the internet offers its readers both true and false (fake) information. In a previous study, the difficulties of accessing accurate and reliable information on the internet were mentioned.[7] There are no regulations regarding the sources that upload information on the internet, but there are also no mechanisms in place to check the accuracy or usefulness of the information.[8] However, although the reliability and accuracy of health-related information found on the internet is of primary importance, it is also essential that the information is readable and understandable for a wide range of users.

Users who procure health information from the internet must have digital skills and be able to understand the information they read in order to improve their health.[9] The text should be easy for the user to read and fully comprehend.[10] Richards and Schmidt defined readability as the measure of how easily the text can be read and understood; they focused on the variables that determine readability, such as average sentence length, number of words contained in the sentences, and the complexity of the language used.[11] Various formulas are used in readability analysis, and many have been developed, including the Gunning Fog value, the Simple Measure of Gobbledygook (SMOG) measurement, Automatic Readability Index (ARI), and Flesch–Kincaid value.[12] The Atesman Readability Index was developed in accordance with the Turkish language structure.[13,14]

Today, with the increase in personal aesthetic concerns, the frequency of visiting a dentist with a tooth discoloration concern is increasing. A whitening treatment is a more conservative approach than other restorative treatments.[15] As teeth whitening treatments become more readily available, many patients request this cosmetic treatment. It is critical that patients are adequately informed before receiving these treatments, and the use of the internet may be a suitable option in raising public awareness, since texts containing sufficient, understandable information are accessible to the general public. Considering that most of the information on the internet is in a text format, it is important that the reader can easily read the text about teeth whitening. Considering that the texts presented on the internet will be read by people with different education levels, it is important to examine the readability of these texts. Therefore, the aim of this study was to evaluate the readability analysis of patient information texts about teeth whitening on the internet. The hypothesis of the study was that the readability analysis of Turkish patient information texts about teeth whitening on the internet was very easy.

METHOD

In the current study, informative articles about teeth whitening which are available to the public on easily accessible websites were evaluated. Therefore, ethics committee approval was not required. To identify written texts about teeth whitening, a single researcher searched the internet using the keyword "Teeth Whitening" with the Google (Google LLC, Mountain View, CA, USA) search engine in February 2023. The top 100 websites appearing in the search results were recorded. Except for languages other than Turkish, websites for commercial and advertising purposes, videos, academic articles, websites that can be accessed with registration and payment, social media, book content, websites for the education of dental professionals, websites describing patient experiences, and appointment sites held. In this study, websites concerning patient information and education about teeth whitening were included. According to author sources, the texts on 86 websites that met the inclusion criteria: dentist, specialist dentist, private health institution or private oral and dental health center, university hospital, and newspaper sources were evaluated. To determine the readability level, text contents were transferred to the free online readability calculation engine using the Atesman Readability formula.[13] The data obtained were then transferred to a Microsoft Excel (Microsoft Corporation, Redmond, WA, USA).

Flesch's Reading Ease classification was used as a basis for the development of the Atesman formula. The values ranged from 90–100 for students from grades 4th and below; from 80–89 for grades 5th–6th; from 70–79 for grades 7th–8th; from 60–69 for grades 9th–10th; from 50–59 for grades 11th–12th; from 40–49 for grades 13th–15th (associate degree); by undergraduate graduates; 29 and below that indicates that it is easily understood by postgraduate graduates.[12,13]

Statistical analysis

IBM SPSS Statistics V22.0 (IBM, Armonk, NY, USA) statistical package software was used for data analysis. Within the scope of the study, the normal distribution of the data was determined using the Kolmogorov–Smirnov test. The obtained results were presented as the mean, standard deviation, median, minimum, and maximum values. Readability Index value was classified according to the Atesman Readability Index classification.

RESULTS

When the included studies were examined with respect to the source of the texts, it was determined that 7% of the sources were dentists, 4.7% specialist dentists, 83.7% private health institutions, 2.3% the university hospitals, and 2.3% newspapers (Figure 1). None of the data showed normal distribution (Table 1). Linguistic statistics are shown in Table 2. The mean number of words was 760.67 ± 712.39. The average number of characters was 5,929.6 ± 5,607.06. The average number of difficult words was 743.7 ± 703.34. The average number of unique words was 426.13 ± 271.25. The average number of short words was 151.62 ± 144.16. The average number of characters without spaces is 5,146.55 ± 4,888.24. The average number of sentences was 69.39 ± 61.59. The average number of paragraphs was 31.10 ± 21.36. The average word length was 2.75 ± 0.1. The average sentence length was 11.21 ± 2.73. The mean Atesman Readability Index was 59.08 ± 8.14 (Table 2). The readability level of the examined websites is presented in Figure 2, based on the Atesman readability classification (Table 3) in line with the Atesman Readability Index values. According to the results in this study, 0% of the websites were very easy, 7% easy, 86% moderately difficult, 5.8% difficult, and 1.2% very difficult (Figure 2). When the readability levels of the texts were examined, 43% of the texts were at the grades

11th–12th readability level, 43% were at grades 9th–10th, 7% were at grades 7th–8th, 5.8% were at grades associate degree, and 1.2% were at grade degree (Table 4).

Table 1. Normality test results (Kolmogorov-Smirnov)

	Statistic	df	*P*
Number of word	0.221	86	.000
Number of characters	0.217	86	.000
Number of diffucult words	0.228	86	.000
Number of unique words	0.194	86	.000
Number of short word (<5 characters)	0.217	86	.000
Number of characters without spaces	0.219	86	.000
Number of sentences	0.227	86	.000
Number of paragraph	0.129	86	.001
Average word length	0.102	86	.027
Average sentence lenght	0.160	86	.000
Atesman readability index	0.103	86	.024

Table 2. Linguistic statistics of website texts

	n	Minimum	Maximum	Median	Mean	Std. Deviation
Number of word	86	128	5983	575.5	760.67	712.39
Number of characters	86	1,034	47,571	4,573.5	5,929.6	5,607.06
Number of diffucult words	86	128	5,919	562	743.7	703.34
Number of unique words	86	106	2207	366.5	426.13	271.25
Number of short word (<5 characters)	86	18	1180	113	151.62	144.16
Number of characters without spaces	86	903	41,583	3981	5,146.55	4,888.24
Number of sentences	86	11	511	56.5	69.39	61.59
Number of paragraph	86	4	117	26	31.1	22.36
Average word length	86	2.52	3.01	2.76	2.75	0.1
Average sentence lenght	86	7.8	29.9	11.05	11.21	2.73
Atesman Readability Index	86	9.9	72.4	59.95	59.08	8.14

Table 3. According to Atesman readability index range readability classification

	Atesman Readibility Index Range
Very easy	90-100
Easy	70-89
Medium diffucult	50-69
Diffucult	30-49
Very diffucult	1-29

Table 4. Readability at grade level

	f	%
Grade 7-8	6	7.0
Grade 9-10	37	43.0
Grade 11-12	37	43.0
Associate degree	5	5.8
Graduate degree	1	1.2

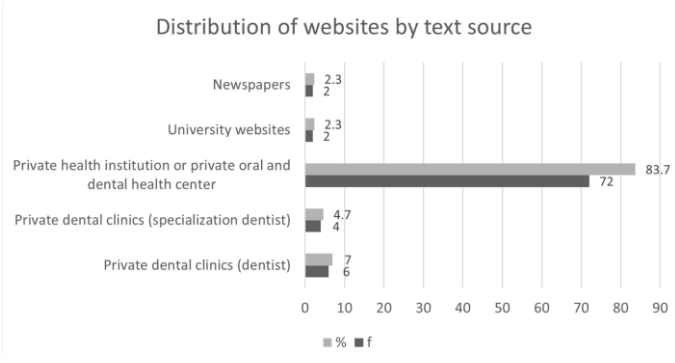

Figure 1. Distribution of websites by text source

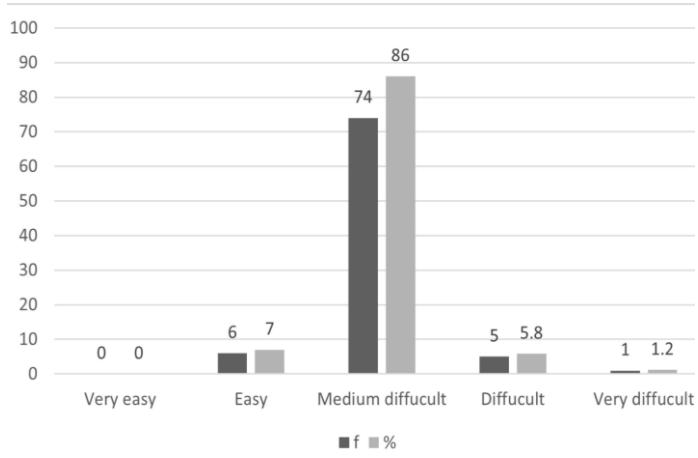

Figure 2. Readibility level of websites (according to Atesman index classification)

DISCUSSION

The tested hypothesis was rejected as it was found that he readability analysis of Turkish patient information texts about teeth whitening on the internet was not very easy.

Since restorative dental treatment is a specialty that aims to rehabilitate patients both aesthetically and functionally and includes very different treatment plans, it is natural for patients to want to research this subject because they have questions and expectations about their own treatment. The increase in information sharing via the internet and patients' ability to directly ask questions of their dentists allow patients to more effectively research teeth whitening treatments. In the study, it was determined that the websites that provide information about teeth whitening in Turkish should be of medium readability difficulty, and that people who want to get information from in these websites should have a level of education.

Conducting health-related research can have a positive effect on people's health-related behaviors.[16] However, it is also important that the information obtained by people doing research on health is comprehensible. Because information presented about teeth whitening contains scientific language, it may be difficult for people who have no knowledge of dentistry to understand it.

In determining the readability of a text, Flesch's Ease of Reading formula was used for texts in English, an analytical language, while the Atesman readability formula was developed for texts in Turkish.[13] Since only Turkish texts were evaluated in our study, the Atesman readability formula was used. When the Atesman readability formula values were examined, it was found that the average readability for the 86 websites was 59.08 ± 8.14. According to the readability index of this value was 11th–12th of the texts. It can be understood by individuals in the class of degree range. This finding is similar to those of previous studies in the field of dentistry in Turkey.[12,17] However, one study reported that the average education grade level in Turkey was 6.51.[18] Accordingly, it would be appropriate to prepare these websites, which are to provide information, in a way that could be understood by a grade 5th individual. The preparation of informative articles without considering the average education level of individuals living in Turkey negatively affects the readability level.[19] Informative articles sometimes consist of lengthy sentences and contain a large number of scientific terms, and these are factors that negatively affect readability level.

The patient may forget the information given to them after talking to the doctor,[20] and patients may want to do internet research to refresh their memory.[19] One study concluded that 75% of people who received health-related information verifying the credibility of the source of this information.[21] However, as the websites are difficult to read and cannot be understood by some patients, they may turn to photographs on the website. Individuals who try to evaluate photographs without properly understanding the text may have misconceptions about their own treatment.[19] Therefore, it is important to have general information texts that are accessible to people on the internet and are prepared using plain language that patients can understand.

Google was the only search engine used for our study, as it is the most commonly accessed search engine in Turkey. The use of other search engines in Turkey is quite low compared with Google usage.[22] In the present study, the majority of the text resources on the websites by private health institutions, followed by dentists and specialist dentists, respectively. In some of the private health institutions examined, the author of the text was not specified, but even in cases where the author was specified, credit was given to the source of the website in the evaluation. In other words, even if the author on the website of the private health institution was a dentist or a specialist dentist, the source of that site was considered a private health institution.

To the best of our knowledge, the present study is the first to examine the readability of Turkish texts on teeth whitening. However, as in all studies, there are some limitations. Since commercial websites were not included in the study, brand names were not included in the keywords. In addition, the findings are valid for a limited population as this study was conducted only on websites in Turkey using the Google search engine and with Turkish keywords. No research was done using other search engines. Factors such as type size, font, and text color of the analyzed texts were not included in the evaluation. In addition, the research was conducted within a specific time period. Considering that the internet environment is continuously evolving, new websites may have been prepared or updates may have been made to existing websites. In addition, it would be beneficial if future studies are conducted to evaluate the effect of reader characteristics on readability.

CONCLUSION

Our findings indicate that the readability of Turkish internet texts about teeth whitening is of medium difficulty. We found that the readability of the texts that were accessible via the internet and aimed to provide information to the patients was at various levels and ranged from easy to very difficult. Particular attention should be paid to ensure that the information is easy to read and can be understood by readers of different education levels. In addition, for readers who want to obtain further information, it will be useful to show the source of the information presented. This can be beneficial in terms of making the texts on the internet about teeth whitening easier to read by using readability programs before they are published.

Etik Komite Onayı: Çalışmada herkesin kolaylıkla erişebileceği internet sitelerinde kamuya açık olan diş beyazlatma ile ilgili bilgilendirici metinler değerlendirilmiştir. Bu nedenle etik kurul onayına gerek duyulmamıştır.
Hasta Onamı: Herkesin kolay erişilebileceği internet sitesinde kamuya açık olduğu için hasta onamına gerek duyulmamıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir– M.F.; Tasarım – M.F.; Denetim - M.F.; Kaynaklar – M.F.; Malzemeler – M.F.; Veri Toplanması ve/veya İşlemesi – M.F.; Analiz ve/veya Yorum - M.F.; Literatür Taraması - M.F.; Yazan – M.F.; Eleştirel İnceleme – M.F.
Çıkar Çatışması: Herhangi bir çıkar çatışması bulunmamaktadır.
Finansal Destek: Bu çalışma için herhangi bir finansman sağlanmamıştır.

Ethics Committee Approval: In the study, the informative text about teeth whitening that are available to the public on the websites that everyone can easily access were evaluated. Therefore, ethics committee approval was not required
Informed Consent: Patient consent is not required as it is publicly available on the website where everyone can easily access it.
Peer-review: Externally peer-reviewed
Author Contributions: Concept – M.F.; Design – M.F.; Audit – M.F.; Sources – M.F.; Materials – M.F.; Data Collection and/or Processing – M.F.; Analysis and/or Interpretation - M.F.; Literature Review – M.F.; Writing – M.F.; Critical Review – M.F.
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Knowledge and Attitude of Dentistry, Medicine and Pharmacy Students Related to HIV/AIDS

Diş Hekimliği, Tıp ve Eczacılık Öğrencilerinin HIV/AIDS Konusunda Bilgi ve Tutumlarının Değerlendirilmesi

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ABSTRACT

Objective: HIV is one of the main infectious diseases threatening world health for a long time. It is critical that today's healthcare students have the right knowledge and perspectives on HIV/AIDS, as they are the first line of defense against such a threat locally and globally. This cross-sectional study was carried out to evaluate the knowledge and attitudes of healthcare students toward HIV/AIDS.

Method: In this study, a 4-part questionnaire consisting of 50 questions was administered to 450 healthcare students. Participants' sociodemographic status, general knowledge of HIV/AIDS, their attitude to patients, and their knowledge related to oral manifestations of it were evaluated.

Results: With the participation of 100 students from each of the faculties of dentistry, medicine, and pharmacy, a response rate of 66.7% was achieved. The mean knowledge of HIV/AIDS score percentage was 44.2% in dentistry, 43.3% in medicine, and 44.6% in pharmacy. It was determined that they had a positive attitude towards HIV/AIDS patients, and their mean attitude percentage was 78.6% in dentistry, 75.9% in medicine, and 76.2% in pharmacy. When it comes to the oral manifestations of HIV/AIDS, as expected, dentistry students were found to have higher scores on the most common oral manifestations. Still, it was observed that students of all three faculties were not aware of most lesions.

Conclusion: Although students' knowledge levels were lower than expected, it was determined that most students displayed a professional attitude towards HIV/AIDS. The results obtained from this study revealed that dentistry, medicine, and pharmacy students need more detailed relevant education**.**

Keywords: HIV/AIDS, attitude, knowledge, dentistry students, medicine, pharmacy

ÖZ

Amaç: HIV, uzun süredir dünya sağlığını tehdit eden başlıca bulaşıcı hastalıklardan biridir. Yerel ve küresel olarak böyle bir tehdide karşı ilk savunma hattı olduklarından, sağlık alanında eğitim görmekte olan öğrencilerin HIV/AIDS konusunda doğru bilgi ve bakış açısına sahip olmaları çok önemlidir. Bu kesitsel araştırma, diş hekimliği, tıp ve eczacılık öğrencilerinin HIV/AIDS'e yönelik bilgi ve tutumlarını değerlendirmek amacıyla yapılmıştır.

Yöntem: Bu çalışmada, 450 öğrenciye 4 bölüm ve 50 sorudan oluşan bir anket uygulanmıştır. Katılımcıların sosyodemografik durumları, HIV/AIDS ile ilgili bilgileri, hastalara karşı tutumları ve oral bulgular ile ilgili bilgileri değerlendirildi.

Bulgular: Diş hekimliği, tıp ve eczacılık fakültelerinin her birinden 100'er öğrencinin katılımıyla %66.7'lik bir yanıt oranı elde edildi. Ortalama HIV/AIDS bilgi yüzdeleri diş hekimliğinde %44.2, tıpta %43.3 ve eczacılıkta %44.6 olarak bulundu. Genel olarak öğrencilerin HIV/AIDS hastalarına yönelik olumlu tutum sergiledikleri tespit edildi ve ortalama tutum yüzdelerinin diş hekimliğinde %78.6, tıpta %75.9 ve eczacılıkta %76.2 olduğu belirlendi. HIV/AIDS'in oral bulgularında diş hekimliği öğrencilerinin daha yüksek puanlara sahip olduğu tespit edilmiş olsa da her üç fakültede de öğrencilerin çoğu lezyonun farkında olmadığı görüldü.

Sonuç: Öğrencilerin bilgi düzeyleri beklenenden düşük olmasına rağmen öğrencilerin çoğunun HIV/AIDS'e karşı profesyonel bir tutum sergiledikleri belirlendi. Bu çalışmadan elde edilen sonuçlar diş hekimliği, tıp ve eczacılık öğrencilerinin konu ile ilgili daha detaylı eğitime ihtiyaç duyduklarını ortaya koymuştur.

Anahtar Kelimeler: HIV/AIDS, bilgi, tutum, diş hekimliği öğrencileri, tıp, eczacılık

INTRODUCTION

The Human Immunodeficiency Virus (HIV) is the etiological agent of Acquired Immunodeficiency Syndrome (AIDS), an infectious disease that leads to opportunistic infections with the ineffectiveness of the immune system.[1] The virus is transmitted through blood, semen, vaginal fluids, breast milk, or through an HIV-positive mother during pregnancy or delivery.[2] Although there is no cure for HIV today, current antiretroviral treatments allow infected people to live healthier and longer.[3]

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With the rapid spread of HIV infection worldwide in the 1980s, its spread was inevitable in Turkey, mainly due to its location in the middle of Eastern Europe and Central Asia. Afterward, the first cases in Turkey were reported in 1985, HIV was included in the list of notifiable diseases, and infection notification was started by following the confidentiality rules. According to the 2022 data from the Public Health Agency of Turkey, 34453 people have been living with HIV since the first case was seen in 1985, and 2177 people are in the AIDS stage.[4] According to the data of the World Health Organization, 38.4 million people living with HIV worldwide, and 1.5 million people acquiring HIV in 2021.[5] While the rates of new diagnoses are decreasing in the world, an increase is observed in Turkey.

HIV has a catastrophic effect on the immune system. HIV hides in specific white blood cells called CD4 cells and replicates, leading to an active infection.[1] HIV/AIDS patients experience various distressing symptoms associated with the disease, including oral lesions.[6] The appearance of oral manifestations of HIV/AIDS, such as candidiasis and hairy leukoplakia, is associated with decreased CD4 cell count and high plasma viral load and can also indicate HIV infection progression.[7]

Healthcare workers are occupationally at high risk of HIV/AIDS infection, as HIV is a contagious disease that can be transmitted through blood and contaminated splash.[8] Since healthcare students will be the first line to encounter such patients, they shoulder a great responsibility to spread awareness to the population, explaining all the basic knowledge about HIV/AIDS, discovering the cases at early stages, and maximizing the potential for disease prevention. Despite that, the willingness to treat HIV-infected patients has a positive relationship with the amount of knowledge related to disease and stages, awareness of intraoral symptoms, and transmission routes, so increasing the knowledge of the healthcare staff will be the cornerstone of a healthy, more aware, and capable society.[9]

To our knowledge, no published studies are comparing Turkish university students' knowledge and attitudes toward HIV/AIDS patients across the fields of dentistry, medicine, and pharmacy. Additionally, a few previously published studies assessed the knowledge and attitudes of healthcare students concerning HIV/AIDS.[10-11] For this reason, this cross-sectional study aimed to evaluate dentistry, medicine, and pharmacy students' knowledge and attitudes toward HIV/AIDS. At the same time, it is aimed to determine whether students need more education on HIV/AIDS.

METHOD

This cross-sectional study was conducted at Altinbas University in Istanbul, Turkey. This study was approved by the Ethics Committee of Altinbas University (19.04.2019, numbered 2019/6). Dentistry, medicine, and pharmacy students were included. Considering that courses on healthcare-acquired infections are offered in all faculties starting from the second year, students in the third year and above were included. All students were informed about the study, and that participation was voluntary. A written voluntary informed consent form was obtained from the students who wanted to participate in the study. Due to the language of faculties education being in English, an English questionnaire was used for the assessment, which is a modification of the ones used in different countries to evaluate the knowledge and attitudes of dental students.[12-14] To assess the survey's comprehensibility, pilot testing was carried out with a group of students from all three faculties. The survey is administered to a sample of participants on two separate occasions. They were asked to complete the questionnaire and provide feedback on any questions or instructions that they found confusing or unclear. All the participants ensured that the questions were clear and easy to understand. A reliability test (Cronbach's Alpha=0.896) and for validity two-tailed Pearson Correlation test (r=0.43) were performed. The pilot sample was not included in the study population. For sample size calculation, with a margin of error of 0.03, confidence level of 0.95, and an assumed general knowledge range of 75% to 80% regarding HIV,[13-14] it was determined that a minimum sample size of 285 participants would be required.

Data Collection

A self-administered, structured questionnaire consisting of four parts containing 50 questions was applied in the present study. Part I targeted the participants' sociodemographic characteristics, including age, gender, ethnicity, and grade.

Part II consisted of 18 closed-ended questions about knowledge of HIV/AIDS, with answering options of yes/no/don't know and a scoring of 2 for the correct answers and 0 for no/don't know responses were allocated. If the participant answered all the questions correctly, they would get maximum points for part II (100% correct answers 2× 18 = 36). If the participant answered none correctly, they would get a 0 score. A higher score indicates a higher level of knowledge. Scores of less than 25%, 25-50%, 50-75%, and more than 75% were considered weak, moderate, good, and excellent, respectively.

Part III contained 17 questions assisting the attitudes toward patients with HIV/AIDS. The answers include strongly agree/agree/ neutral/ disagree/strongly disagree. The participants were instructed to check one answer in each question and a scoring of 5,4,3,2,1, using the Likert scale as a template. If the participants' results were close to or scored 85, that would indicate a positive attitude toward HIV/AIDS patients. Nevertheless, if the participants' results were close to or scored 17 out of 85, that would indicate negative attitudes toward HIV/AIDS patients. Scores higher than 75% were considered as a positive attitude, between 50-75%, and less than 50% were considered as non-professional.

Part IV consisted of 15 questions about the oral manifestations of HIV/AIDS with yes/no/don't know answers and a scoring of 1 for the correct answers and 0 for the incorrect answers.

Statistical Analysis

Data analysis was conducted using SPSS 23.0 software (SPSS, Chicago, IL, USA). Descriptive and analytical tests were utilized in the statistical management of the data. The Kruskal-Wallis test was applied to assess whether there was a difference between the groups for each question. Mann-Whitney U analysis was performed to emphasize the differences between the groups. A p-value of $< .05$ was considered statistically significant.

RESULTS

A total of 450 students, 150 of whom were enrolled in the faculties of dentistry, medicine, and pharmacy were included in the study. Due to missing answers and abandoning the test, 150 participants were excluded. A valid response rate of 66.7% (300 questionnaires) was collected across the different groups, with 100 participants in each faculty. The age and gender data of the participants are shown in Table 1.

Table 1. Demographic characteristics among students across three faculties (n=300)

	Age (years)	Gender (n)
Dentistry	19~33	M=40 F=60
Pharmacy	19~33	M=26 F=74
Medicine	19~33	M=29 F=71

M: male, F: female

The total mean knowledge percentages regarding HIV/AIDS for dentistry, medicine, and pharmacy students were 44.2%, 43.3%, and 44.7%, respectively. Table 2 illustrates the percentages of correct answers related to HIV/AIDS knowledge. Across the three groups (dentistry, medicine, and pharmacy), participants displayed a high correct response rate to the statement 'HIV/AIDS can contaminate healthcare workers,' with rates of 82%, 81%, and 71%, respectively. Furthermore, dentistry, medicine, and pharmacy participants all agreed that 'needle stick injury can transmit HIV,' with a notably high correct response rate of 83%, 80%, and 81%, respectively. When examining the students' knowledge, a significant difference was found in only three questions among the three groups. In response to the statement "HIV/AIDS patients can be diagnosed with oral manifestations," dentistry students showed a significantly higher correct answer rate compared to pharmacy and medical students ($P < .05$). However, there was no significant difference between pharmacy and medical students. Regarding the statement "The specificity of HIV tests is 100%," medical students had a significantly higher correct answer rate than dental and pharmacy students ($P < .05$). No significant difference was observed between dentistry and pharmacy students for this statement. A difference in response to the statement "Healthcare workers can act as intermediaries for the transmission of HIV" was observed only between pharmacy and dental students, with dental students exhibiting a significantly higher correct answer rate ($P < .05$) (Table 2).

The total mean attitudes towards the patient with HIV/AIDS percentage, including dentistry, medicine, and pharmacy, were 78.6%, 75.9%, and 76.2%, respectively. A higher percentage means a positive attitude toward HIV/AIDS patients. Table 3 shows the percentage of students' attitudes toward patients with HIV/AIDS. While there is no difference between dental and medical students regarding the statement "All patients should be considered potentially infectious," dentistry students exhibit a significantly more positive approach to this question compared to pharmacy students ($P < .05$). The most positive approach to the statement "If I know that my friend has HIV, I end the friendship" is reported by dentistry students ($P < .05$). Although there is no significant difference between their response and that of pharmacy students, it is significantly higher than that of medical students ($P < .05$). Similarly, regarding the statement "HIV/AIDS patients can live with others in the same place," dentistry students display the most positive approach ($P < .05$). While there is no significant difference between their response and that of medical students, it is significantly higher than that of pharmacy students. No significant differences were detected between the groups in terms of other expressions ($P < .05$).

The total mean of oral manifestation of HIV/AIDS, including dentistry, medicine, and pharmacy, was 38.7%, 38.9%, and 25.1%, respectively (Table 4). Despite significant distributions of "yes", "no" and "don't know" answers being noticed between faculties, most of the students were not aware that the lesions questioned were related to HIV/AIDS.

Table 2. Correct response rates of students about Knowledge statements towards HIV/AIDS

	Question/Answers	Dentistry (d) %	Pharmacy (p) %	Medicine (m) %	*P**	*P*⁺⁺ Difference
1	HIV/AIDS patients can contaminate healthcare workers.	82	71	81	.117	
2	HIV/AIDS patients can be diagnosed with oral manifestations.	58	29	34	.000	p-d m-d
3	ELISA is a screening test for HIV infection.	65	51	54	.110	
4	The specificity of the HIV tests is 100.	12	15	37	.000	m-d p-m
5	Western blot is a definite test for HIV/AIDS diagnosis.	30	26	28	.821	>0.05
6	Healthcare workers can act as an intermediary for the transmission of HIV.	63	45	52	.037	p-d
7	Saliva can be a vehicle for the transmission of AIDS.	59	48	56	.273	>.05
8	All sterilization methods have cidal effects against HIV.	28	26	32	.635	>.05
9	Needle stick injury can transmit HIV.	83	81	80	.858	>.05
10	The negative HIV tests surely indicate that the persons are free of viruses.	46	38	48	.322	>.05
11	Hepatitis B is more communicable than HIV/AIDS.	14	15	15	.974	>.05
12	Infection control methods for Hepatitis B provide adequate protection against HIV transmission.	36	30	24	.181	>.05
13	Medical staff are more prone for cross-contamination.	66	60	59	.546	>.05
14	There is a lot of HIV in the saliva of HIV/AIDS patients.	54	38	44	.072	>.05
15	HIV can be transmitted through aerosols.	16	11	21	.157	>.05
16	There are special clinics for treatment of HIV/AIDS patients in Turkey.	21	26	25	.682	>.05
17	Now, AIDS is the most important health problem in the world.	33	43	45	.181	>.05
18	CPR for patients with AIDS can transmit HIV infection.	39	41	44	.771	>.05

**Kruskal Wallis, ⁺⁺Mann-Whitney U Test*

Table 3. Correct response rates of students regarding attitudes toward patients with HIV/AIDS

	Question/Answers	Dentistry (d) %	Pharmacy (p) %	Medicine (m) %	*P**	*P*⁺⁺ Difference
1	Treatment of HIV/AIDS patients means wasting national resources.	79	78	77	.611	>0.05
2	All patients should be considered potentially infectious.	76	68	73	.021	p-d
3	If I know that my friend has HIV, I end the friendship.	83	77	74	.039	m-d
4	Supporting HIV/AIDS patients improves community health.	81	79	79	.660	>.05
5	Healthcare workers with HIV/AIDS should not be allowed to treat patients.	65	66	60	.150	>.05
6	HIV/AIDS patients should be treated at a separate ward.	53	53	49	.467	>.05
7	A blood test should be taken for diagnosis of HIV in all patients.	46	43	46	.411	>.05
8	I am morally responsible to treat HIV/AIDS patients.	74	73	73	.931	>.05
9	HIV/AIDS patients can live with others in the same place.	78	70	72	.012	p-d
10	I am not obligated to treat HIV/AIDS patients.	64	68	63	.269	>.05
11	HIV/AIDS patients can lead a normal life.	75	73	73	.595	>.05
12	I can safely treat HIV/AIDS patients.	66	66	64	.717	>.05
13	I will treat HIV/AIDS patients.	73	71	74	.370	>.05
14	My knowledge about infection control is enough to treat HIV/AIDS patients.	61	55	58	.208	>.05
15	I worry about being infected with HIV by my patients.	51	55	51	.529	>.05
16	I will do CPR if HIV/AIDS patients need it.	73	69	73	.380	>.05
17	It is my right to know if my patients are infected by HIV.	37	40	39	.796	>.05

**Kruskal Wallis, ⁺⁺Mann-Whitney U Test*

Table 4 Percentage of Correct Answers to Oral Manifestation of HIV/AIDS

	Question/Answers	Dentistry(d)%	Pharmacy(p)%	Medicine(m)%	*P**	P ++ Difference
1	Oral candidiasis	74	51	67	.002	p-m p-d
2	Kaposi's sarcoma	46	16	37	.000	p-m p-d
3	ANUG	21	12	27	.029	p-m
4	Major aphthous	27	17	30	.083	>.05
5	Crohn's disease	29	22	30	.383	>.05
6	Cytomegalovirus	21	15	30	.036	p-m
7	Hairy leukoplakia	49	19	28	.000	p-d m-d
8	Severe periodontitis	47	26	44	.004	p-m p-d
9	Xerostomia	31	15	27	.023	p-d
10	Salivary gland infection	47	38	48	.294	>.05
11	Gingivitis	46	26	43	.007	p-m p-d
12	Herpes zoster	50	36	52	.047	p-m
13	Herpes simplex	47	34	50	.037	p-m
14	Condyloma	13	16	23	.160	>.05
15	Papilloma	32	33	48	.033	d-m p-m

** Kruskal Wallis, ++Mann-Whitney U Test*

DISCUSSION

Considering the HIV/AIDS epidemic affecting the world and the subsequent role as a first-line defense of healthcare students in clinical practices and treatments, it is undeniable that they need sufficient knowledge about the subject. Their knowledge will also enable them to develop confidence in managing HIV-infected individuals. Since healthcare professionals get their knowledge and attitude from their education system, revealing students' knowledge and perceptions of HIV/AIDS is essential in evaluating the adequacy of HIV/AIDS education in the dentistry, medicine, and pharmacy curricula. This study aims to assess dentistry, medicine, and pharmacy students' knowledge and attitudes toward HIV/AIDS and also analyze the needs of healthcare students regarding the curriculum for HIV/AIDS education.

The mean knowledge about HIV/AIDS among dentistry, medicine, and pharmacy students was 44.2%, 43.3%, and 44.7%, respectively. However, it is lower compared to the excellent level of knowledge reported by Iranian (82.1%) and Indian (78.8%) students.[12,15] A similar result was found in another study assessing students' knowledge from medicine, dental, and medical technology vocational training schools.[16] The researchers recommend that regular interactive workshops and seminars should be conducted along with HIV/AIDS education sessions and focused lectures.[16]

According to WHO, up to date, approximately 38 million people worldwide are living with HIV.[5] According to the data of the Ministry of Health, while the number of HIV-positive people was 2689 in 2016, the number of HIV-positive people in 2022 became 2971.[4] There has been an increase in the disease trend over the years. This increase in cases is concerning and addresses the need for massive public education to increase awareness regarding the disease. Compared to the literature, the lack of knowledge can be attributed to the low incidence of HIV/AIDS cases in Turkey and, therefore, the rare probability of students encountering infected patients.

The results of our study showed that about half of the students have the wrong information that HIV can be transmitted through saliva. According to studies directed by the Communicable Disease Center, there is no evidence of HIV transmission by saliva.[17] HIV cannot multiply outside of a human host and does not last very long outside of the body.[18] Almost all the students misunderstood that HIV is more communicable than Hepatitis B. WHO stated that the Hepatitis B virus could be spread by direct contact with infected blood or body fluids; however, it is 50 to 100 times more contagious than HIV.[19] A study carried out in Nigeria showed that if the level of knowledge about HIV/AIDS among the students and the public was improved, a change in their sexual behavior and increased knowledge in their families was observed.[20]

In line with the statement that 'HIV/AIDS patients can be diagnosed with oral manifestations', dentistry students scored higher than medicine and pharmacy students due to their lessons and the nature of their work field of encountering patients complaining about oral lesions and treating a specific part of the body. On the contrary, medicine students scored higher than the other groups regarding the statement that 'The specificity of the HIV tests is 100', also due to their encounters and experience. Considering these results regarding HIV/AIDS, adopting a multidisciplinary education approach can provide a better understanding of the disease in all aspects.

The finding of our study revealed that students did not have sufficient knowledge about HIV/AIDS; despite this, they exhibited a professional attitude toward the disease. So, it is notable that the dentistry, medicine, and pharmacy students scored higher in the attitude section than the other sections (78.6%, 75.9%, and 76.2%, respectively). Even if they have low scores on knowledge questions, they are willing to take the risk and treat infected people with HIV. In another study by Oberoi et al., the willingness to treat HIV-positive patients among dental students was 67.0%, and 74.20% were confident of treating a patient with HIV/AIDS. [21] This shows a better result when compared to a study published by Li et al., 93.7% of students expressed a negative attitude toward patients with HIV/AIDS. [22] In another survey conducted in Kuwait, although almost 58% of the respondents demonstrated a high level of knowledge, the majority of the participants (63.6%) showed a negative attitude.[23]

Healthcare professionals are among the most vulnerable groups when it comes to viral transmissions. Existing literature underscores the fact that healthcare professionals who are anxious about the possibility of infecting themselves often suffer from psychological consequences. It should be taken into consideration that this situation may affect the attitude of healthcare professionals to patients, and in future studies, it would be useful to assess healthcare workers' quality of life as well as their level of fear and anxiety regarding viral transmission in workplaces and the potential for cross-contamination among family members. Addressing these issues may require the implementation of necessary measures or initiatives aimed at improving the well-being of healthcare professionals in all healthcare settings.

Most dentistry, pharmacy, and medicine students incorrectly identified the oral lesions associated with HIV/AIDS, such as Kaposi's sarcoma, hairy leukoplakia, and salivary gland infection. This shows a similar result with the Egyptian students,[24] Kaposi's sarcoma (37%), Hairy leukoplakia (42.1%), and Salivary gland infection (21.4%). Unlike Indian students, they showed higher scores for Kaposi's sarcoma (71%), Hairy leukoplakia (79.4%), and Salivary gland infection (60.9%).[12] This can be explained similarly to the fact that dentistry students responded more accurately to the statement 'HIV/AIDS patients can be diagnosed with oral symptoms' than medical and pharmacy students due to the courses they are enrolled in and their respective fields of study. However, being aware of these crucial intraoral findings can facilitate early disease detection and help minimize the spread of the virus. Therefore, education on this subject is highly essential.

The primary aim of this study was to assess the general knowledge about HIV/AIDS among healthcare students through a questionnaire. Survey responses can be provided anonymously, potentially encouraging more honest and candid answers, especially on sensitive topics like HIV/AIDS. This study was conducted at a single center. While the collected data were suitable for achieving the study's objectives, it's important to acknowledge that the results may not be fully representative of all healthcare students in Turkey. To gain a more comprehensive understanding of HIV knowledge levels among healthcare students in Turkey, conducting a multicenter study with a larger participant pool would be advantageous. Additionally, future research should focus on refining the questionnaire by including more specific questions that target not only students but also patients with HIV/AIDS. Incorporating these aspects into future studies would contribute to a more thorough analysis of HIV/AIDS awareness and its various dimensions.

CONCLUSION

In the limitations of this study, it was found that the students included had deficiencies in their knowledge about HIV/AIDS. It is crucial for healthcare students, as future healthcare providers, to possess sufficient knowledge about HIV/AIDS. Since healthcare professionals derive their knowledge and attitudes from their education system, assessing students' knowledge and perceptions of HIV/AIDS is essential to evaluate the adequacy of HIV/AIDS education in the dentistry, medicine, and pharmacy curricula and the lack of knowledge of faculties on this subject should be included. This is significant because their knowledge will also empower them to develop confidence in managing individuals with HIV infections. Despite knowledge deficiencies, most students in this study exhibited a positive attitude. Given these results concerning HIV/AIDS, adopting a multidisciplinary educational approach can lead to a more comprehensive understanding of the disease, greater awareness of attitudes towards HIV-infected individuals, and the prevention of new infections.

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Morphological Evaluation of Incisive Foramen According to Age, Gender and Edentulous Status

İnsiziv Foramenin Yaş, Cinsiyet ve Dişsizlik Durumuna Göre Morfolojik Değerlendirilmesi

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ABSTRACT

Objective: Evaluation of the change in incisive foramen (IF) diameter and localization according to age, gender, edentulous status and other anatomical landmarks by cone beam computed tomography (CBCT).
Method: 162 patients (81 females, 81 males, mean age 41.1+_15.2) were included in the study. IF diameter, distance between IF and the greater palatine foramen (GPF) and distance between IF and the most posterior of the median palatine bone (PNS: posterior nasal spine**)** were measured. The measurement values of the patients were compared with the Independent t-test according to gender and dental status. The relationship between age and measurements was examined with the Pearson correlation test.
Results: The mean IF diameter of the patients was 3.78±0.95 mm. The mean IF diameter (*P*<.001), the distance between the right GPF and the IF (*P*=.023) and the distance between the IF and the PNS (*P*=.039) of the dentate patients were found to be significantly lower than the edentulous patients.
Conclusion: The IF diameter and the IF - GPF distance were found to be lower in dentulous patients than in edentulous patients. It was determined that the IF diameter and the IF-GPF distance increased with age.
Keywords: Incisive foramen, greater palatine foramen, CBCT

ÖZ

Amaç: İnsiziv foramen (İF) çap ve lokalizasyonunun yaş, cinsiyet, dişsizlik durumu ve diğer anatomik landmarklara göre değişiminin konik ışınlı bilgisayarlı tomografi (KIBT) ile değerlendirilmesidir.
Yöntem: Çalışmaya 162 hasta (81 kadın, 81 erkek, yaş ort. 41.1±15.2) dahil edildi. İF çapı, İF ile palatinum majus mesafesi ve İF ile palatinanın posterioru arasındaki mesafe ölçüldü. Cinsiyet ve diş durumuna göre hastaların ölçüm değerleri Independent t-test ile karşılaştırıldı. Yaş ile ölçümler arasındaki ilişki Pearson korelasyon test ile incelendi.
Bulgular: Hastaların ortalama İF çapı 3.78±0.95 mm idi. Dişli hastaların ortalama İF çapı (*P*<.001), sağ palatinum majus ile İF mesafesi (*P*=.023) ve palatinanın en posterioru ile İF mesafesi (*P*=.039) dişsiz hastalara göre anlamlı düzeyde düşük saptandı.
Sonuç: Dişli hastalarda İF çapı ve İF ile palatinum majus mesafesi dişsiz hastalara göre daha düşük bulundu. İF çapının ve İF - palatinum majus mesafesinin yaşla birlikte arttığı belirlendi.
Anahtar Kelimeler: İnsiziv foramen, palatinum majus, KIBT

INTRODUCTION

The incisive foramen (IF), where the nasopalatine canal terminates and opens into the oral cavity, is located on the intermaxillary suture and posterior to the maxillary anterior teeth.[1] Nasopalatine duct contains the nasopalatine nerve, the terminal branch of the nasopalatine artery, fibrous connective tissue, sebaceous and minor salivary glands.[2] Therefore, both the IF and the nasopalatine canal are important landmarks in surgical procedures involving the maxillary anterior region or closely related to the maxillary anterior region.[1,3,4] The morphology of the alveolar bone in the maxillary anterior region has gained more importance due to implant surgery applications that have become widespread in recent years.[1,4] As the maxillary alveolar crest undergoes morphological changes according to age, gender, and edentulous state, shape and localization changes can also be observed in the IF.

The aim of this study is to evaluate the change of the IF diameter and localization according to age, gender, edentulous status, and other anatomical landmarks by cone beam computed tomography (CBCT).

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METHOD

Ethics committee approval was received from Alanya Alaaddin Keykubat University Clinical Research Ethics Committee for this study (05/10/2022:09-04). Using the retrospective data, the individuals included in the study were informed that their personal information would be kept confidential, and signed consent was obtained from the patients.

Maxillary cone beam tomography (CBCT) images taken from patients >18 years of age who applied to Alanya Alaaddin Keykubat University Faculty of Dentistry for various reasons were analyzed retrospectively. If there are artifact, history of implant surgery or pathologies such as infection, cyst, in the relevant region in the examined CBCT images, or if the imaging in the relevant region is of low quality (the presence of metal artifact due to prosthetic restorations) was not included in the study. Age and gender information of the patients were recorded. In addition, the patients were divided into two groups according to their edentulous status. If both maxillary central teeth were present in the mouth, the patient was considered dentulous. If at least one of the maxillary central teeth was not present in the mouth, the patient was considered edentulous.

Measurements were made by one observer (YYS). The widest length of the foramen in CBCT axial sections was used to measure the IF diameter. Since the IF and right-left GPF are located in different axial sections, the spatial measurement feature in the CBCT software was used to measure the distance between them. CBCT sagittal sections were used to measure the distance between the IF and the PNS (Figure 1).

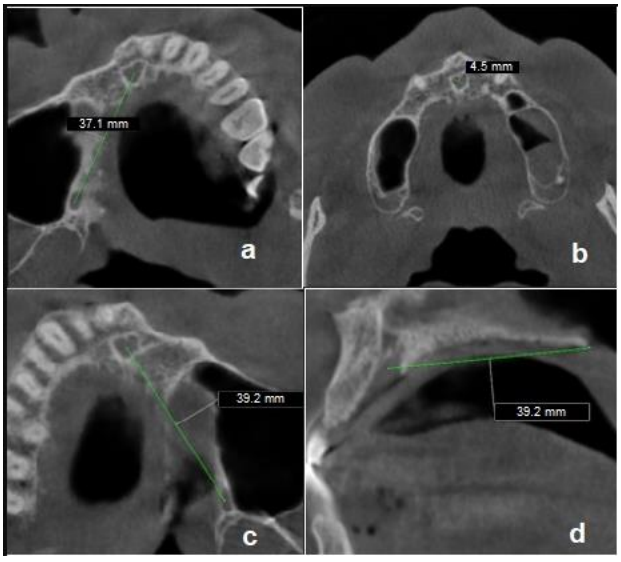

Figure 1. Measurement of the IF - GPF distance in CBCT axial section (a,c). Measurement of the IF diameter (b). Measurement of the distance between the IF and the PNS (d).

Statistical analysis

SPSS 23.0 (IBM SPSS, Inc., Armonk, NY, USA) program was used for statistical analysis. The conformity of the data to the assumption of normal distribution was checked with the Shapiro Wilk test. Data obtained according to gender and edentulous status were analyzed by Independent t-test. The relationship between age and IF measurements were evaluated with the Pearson correlation test. Statistically, *P*<.05 was considered significant.

RESULTS

162 patients (81 males, 81 females) were included in the study. The mean age of all patients was 41.1± 15.2. 127 patients (78.4%) were in the dentulous patient group. The mean IF diameter of the patients was measured as 3.78±0.95 mm. The distance between the right and left GPF and the IF was 38.8±2.35 and 38.97±2.54 mm, respectively. The distance between the IF and the PNS was determined as 40.6±3.03 mm (Table 1).

While the mean IF distance to the right and left GPF in males was 39.56±2.03 and 39.86±2.36 mm, and in females it was 38.05±2.41 and 38.08±2.41 mm, respectively. The distance on both sides was statistically higher in males than in females (*P*<.001). Although the mean IF diameter was higher in males than in females, no statistically significant difference was found (*P*=.078). Although the mean distance between the IF and the PNS was higher in males than in females, no statistically significant difference was found (*P*=.402) (Table 2).

The mean IF diameter of the dentulous patients (*P*<.001), the distance between the right GPF and the IF (*P*=.023) and the distance between the IF and the PNS (*P*=.039) were found to be significantly lower than the edentulous patients. The mean distance between the left GPF and the IF was lower in the dentulous patients, and it was not found statistically significant (*P*=.075) (Table 3).

A weak positive correlation was observed between age and the IF diameter (r=0.315; *P*<.001) and the right GPF and the IF distance (r=0.262; *P*=.001). A very weak positive correlation was found between age and the left GPF - IF distance (r=0.161; *P*=.041) and the IF - PNS distance (r=0.162; *P*=.039) (Table 4).

The changes in measured distances with age in the subgroups (female/male, dentulous/edentulous) are shown graphically (Figure 2). In this graph, it is observed that the IF - GPF distance and the IF - PNS distance increased slightly for each group on trend line. The mean values and the minimum-maximum values of the distances measured in the subgroups are presented in Table 5.

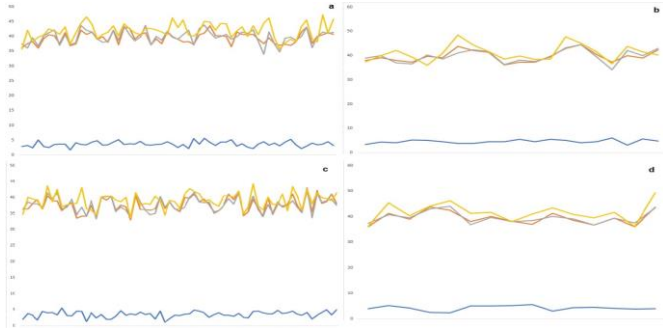

Figure 2. Changes with age in IF diameter (blue), the IF - right GPF distance (orange), the IF - left GPF distance (gray) and the IF - PNS distance (yellow) in the dentulous males (a), the edentulous males (b), the dentulous females (c) and the edentulous females (d)

Table 1. Patient characteristics

		All patients (n=162)
Age (years), mean±S.D.		41.1±15.2
Gender, n(%)	Male	81 (50)
	Female	81 (50)
Edentulous status, n(%)	Dentulous	127(78.4)
	Edentulous	35(21.6)
Measurements (mm), mean±S.D.	IF diameter	3.78±0.95
	IF - right GPF	38.8±2.35
	IF - left GPF	38.97±2.54
	IF - PNS	40.6±3.03

Table 2. Measurements according to gender

Measurements (mm), mean±S.D.	Males (n=81)	Females (n=81)	*P*
IF diameter	3.91±0.92	3.65±0.95	.078
IF - right GPF	39.56±2.03	38.05±2.41	**<.001**
IF - left GPF	39.86±2.36	38.08±2.41	**<.001**
IF- PNS	40.8±3.01	40.4±3.06	.402

Independent t-test

Table 3. Measurements according to edentulous status

Measurements (mm), mean±S.D	Dentulous (n=127)	Edentulous (n=35)	*P*
IF diameter	3.61±0.9	4.4±0.87	**<.001**
IF - right GPF	38.58±2.28	39.6±2.45	**.023**
IF - left GPF	38.79±2.53	39.65±2.49	.075
IF- PNS	40.35±3.05	41.54±2.8	**.039**

Independent t-test

Table 4. Correlation between age and measurements

Measurements	r	*P*
IF diameter	0.315	**<.001**
IF - right GPF	0.262	**.001**
IF - left GPF	0.161	**.041**
IF - PNS	0.162	**.039**

*Pearson **correlation** test*

Table 5. Measurements according to edentulous status with gender

Measurements (mm), mean (min-max)	Dentulous males (n=61)	Dentulous females (n=66)	Edentulous males (n=20)	Edentulous females (n=15)
IF diameter	3.70 (2.2-5.6)	3.53 (2.2-5.5)	4.56 (3.4-6)	4.17 (2.3-5.5)
IF - right GPF	39.50 (36-43.1)	37.67 (33-42.2)	39.73 (36.1-44.5)	39.42 (36-43.8)
IF - left GPF	39.91 (33.9-43.8)	37.72 (33.6-41.6)	39.69 (34.1-44.5)	39.58 (36.7-44)
IF- PNS	39.24 (35.7-47.2)	39.04 (33.5-44.2)	41.78 (36.6-48.5)	41.66 (36.2-49.2)

DISCUSSION

The IF - GPF distance and the IF- PNS distance were found to be significantly higher in males. Although the IF diameter was numerically higher in males than in females, no statistically significant difference was found. A statistically significant increase was observed in all measure- ments with age. While numerical measurements increased in the edentulous status, all values except the left IF - GPF distance were statistically significantly higher than in the dentulous status.

In a study where the IF morphological analysis was performed with CBCT in South Korea, edentulous status was determined by grouping patients with central incisors and patients without at least one central incisor, as in present study.[5] In the previous study, the IF diameter was measured lower in the patients with central incisors than in the edentulous patients, but no statistically significant difference was found. In present study, the IF diameter of the patients in the dentulous group was lower and there was a statistically significant difference. Again, in the previous study, it was determined that IF diameter tended to increase with age, but the change was not significant and males had the higher IF diameter than females.[5] In present study, a positive correlation was found between age and the IF diameter. Although the IF diameter of males was higher than that of females, no statistically significant difference was found. Although the statistical results are similar, the variables between the numerical distributions of the two studies can be explained by ethnic differences.

In another study in 2019, it was determined that the IF diameter increased with age in both the mesio-distal and anterior-posterior directions.[6] In present study, since a criterion was applied to measure the largest distance detected for the IF diameter measurement, no comment could be made about the changes in the directions. However, high similarity results were obtained with this study in the literature both in terms of the findings of the IF diameter change with age and in terms of the fact that the IF diameter of males was higher than that of females without significant difference.[6] However, in a study in Brazil, it was determined that IF measurements of males were statistically significantly higher than females in many parameters, including diameter width in the mesio-distal direction.[7]

In studies conducted in Africa[9] and in India,[10] the mean IF diameter was found to be 3.56 mm and 3.62 mm, respectively. Although the diameter was larger in males than in females in both studies, no statistically significant difference was found between genders. In the study of Panda et al,[10] it was stated that the IF diameter did not show a significant correlation with age and gender. It has been stated in the literature that the numerical variability in study findings may be due to ethnic differences. In addition, the fact that these authors only included patients with both anterior incisors in their study and did not examine the change in edentulous patients may have affected their results.

In their study, Bornstein et al[3] found that the IF diameter in males was higher than in females, but there was no significant difference between genders. The authors,[3] who found a decrease in the IF diameter with age, stated that these findings were contradictory with the study of Mardinger et al.[11] The findings of the present study were consistent with the results of Mardinger et al.[11] Bornstein et al[3] attributed the difference in their findings with other study[11] to the edentulous criteria in patient selection and the difference in the mean age of the patients included in the study.

In a study in China in which the localization of the foramina in the jaws and their distance from each other were measured, the distance between the IF and the GPF was measured as 43.17±2.55 mm.[8] In present study, the mean IF - GPF distance was found to be lower (Table 1). While the mean age of the patients included in present study was 41.1, the mean age of the patients included in the previous study[8] was 46.8. Although it was determined that the distance between IF - GPF increased with age in present study, no information is given about the correlation between IF - GPF distance and age in the previous study.[8] Therefore, the difference between the two studies in terms of the IF - GPF distance may be due to age distribution and/or ethnicity of the patients. In addition, the positive correlation between age and the IF - GPF distance in our study suggests that the IF may tend to shift anteriorly and the GPF shift postero-laterally when considered in the spatial plane.

In another study conducted in Italy,[12] the IF-GPF distance was found to be 40.4 mm and 38.8 mm in males and females, respectively. These results are quite compatible with present study. While interpreting the study results, Gibelli et al[12] emphasized that the distance of the GPF to anatomical landmarks depends on gender.

In a study including a meta-analysis which conducted in Poland, the GPF-IF distance was found to be significantly higher in males than in females.[13] When the meta-analysis data are evaluated, the results obtained in present study are compatible with the measurement ranges determined in the studies in the literature (33.2-41.1 mm). It has been stated that the GPF can be localized more easily in edentulous patients and that the distance between the GPF and the borders of the palatal bone may be related to the difference in growth levels and growth direction.[13] In the present study, only the presence of maxillary anterior teeth was used as a criterion when determining edentulous status. However, edentulism in the maxillary posterior teeth may also affect the IF -GPF distance. In the present study, considering the difficulty of interpretation that may be caused by the diversity of criteria, classification was made only on the basis of anterior teeth, and this can be considered a limitation of the study.

In another similar study conducted with CBCT in Lebanon, the mean distance between the GPF and the anterior nasal spine (ANS) in males and females was found to be 47.3 and 49.3 mm, respectively.[14] Although it is consistent with the result of a significant difference between genders, the numerical values obtained are higher than the present study, which may be related to the ANS being positioned anatomically more anterior than the IF in the axial section.

Since the present study was a cross-sectional study, it was not possible to reveal the effect of bone structure or age-related changes in the same individual at different times. For this reason, it would be more appropriate to conduct a longitudinal study to observe the changes of the foramen more clearly with respect to each other and to the spatial plane. Since the measurements were made by only one observer (YYS) in present study, the possibility of subjectivity increases. In similar studies planned to be done, choosing more than one observer, and repeating the same measurements to each observer with a certain time interval can be suggested as a preferable method to increase the reliability of the data. In addition, when the subgroups are evaluated according to gender and edentulism, the reason why the change with age cannot be revealed more clearly may be related to the decrease in the number of samples and narrowing of the age range when the groups are separated. For this reason, the number of patients included in the study can be increased and the relationship between gender - foramen diameter and the IF - GPF distance can be evaluated in more detail by performing it in larger populations.

CONCLUSION

The IF diameter and the IF - GPF distance were found to be lower in the dentulous patients than in the edentulous patients. It was determined that the IF diameter and the IF - GPF distance increased with age. The size and location of the anatomical foramen may differ across ethnic groups with age and gender. It may be useful to evaluate the morphological features of anatomical formations in dentists' intervention areas, such as IF and GPF, with studies with larger participation and different demographic information. Dentists should consider patients' data such as age, gender and edentulous status in surgical procedures involving maxillary anatomical landmarks such as IF or GPF.

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Hasta Onamı: Retrospektif veriler kullanılarak çalışmaya dahil edilen bireylere kişisel bilgilerinin gizli tutulacağı konusunda bilgi verildi ve hastalardan imzalı onam alındı.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir–Y.Y.S., S.Ş., T.Ç.; Tasarım - Y.Y.S., S.Ş., T.Ç.; Denetim - Y.Y.S., S.Ş., T.Ç.; Kaynaklar - Y.Y.S., S.Ş., T.Ç.; Malzemeler - Y.Y.S., S.Ş., T.Ç.; Veri Toplanması ve/veya İşlemesi - Y.Y.S., S.Ş., T.Ç.; Analiz ve/veya Yorum - Y.Y.S., S.S., T.C.; Literatür Taraması Y.Y.S., S.Ş., T.Ç.; Yazan - Y.Y.S., S.Ş., T.Ç.; Eleştirel İnceleme - Y.Y.S., S.Ş., T.Ç.
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Peer-review: Externally peer-reviewed
Author Contributions: Concept – Y.Y.S., S.S., T.C.; Design - Y.Y.S., S.S., T.C.; Audit - Y.Y.S., S.S., T.C.; Sources - Y.Y.S., S.S., T.C.; Materials - Y.Y.S., S.S., T.C.; Data Collection and/or Processing Y.Y.S., S.S., T.C.; Analysis and/or Interpretation - Y.Y.S., S.S., T.C.; Literature Review - Y.Y.S., S.S., T.C.; Writing - Y.Y.S., S.S., T.C.; Critical Review - Y.Y.S., S.S., T.C.
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The Role of Graphene and Biodentine™ on Proliferation and Odontoblastic Differentiation of Dental Pulp Stem Cells

Grafen ve Biodentine™'in Dental Pulpa Kök Hücrelerinin Proliferasyonu ve Odontoblastik Farklılaşması Üzerindeki Rolü

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ABSTRACT

Objective: The need for new biomaterials with biocompatibility, mechanical, and antimicrobial properties continues in regenerative endodontic clinical applications in dentistry. Biodentine™ is successfully used in vital pulp therapies and has regenerative effects. Additionally, graphene, which possesses good physicochemical, mechanical, and biological properties, promotes cellular biomineralization and osteogenic differentiation in dentistry, along with its neuroregenerative effect. This study aims to investigate the effects of graphene and Biodentine™ on cell proliferation, oxidative stress, and odontogenic differentiation in human dental pulp stem cells (hDPSCs).

Methods: Cryopreserved hDPSCs purchased from American Type Culture Collection (ATCC) were used in our study (Cat No: PT-5025). hDPSCs were seeded into the E-plate wells and subsequently four different doses of graphene (12.5, 25, 50 and 100 µg/ml) and Biodentine™ (2, 4, 8 and 16 µg/ml) were added. Results of MTT, total antioxidant capacity (TAC), total oxidant status (TOS) and alkaline phosphatase (ALP) tests were obtained at the end of the 24th hr. 96 hr-real time cell index data were collected with xCELLigence® system. Resulting data were compared using *one-way* analysis of variance (*ANOVA*).

Results: 12.5 µg/ml graphene and 2 µg/ml Biodentine™ were found to be the subgroups with the highest levels of cell proliferation and the lowest oxidative stress. Antioxidative effect was determined in all Biodentine™ doses but only in 12.5 µg/ml graphene. Odontogenic differentiation was observed in all doses of graphene and Biodentine™.

Conclusion: 12.5 µg/ml graphene and 2 µg/ml Biodentine™ were observed to have positive impacts on the proliferation, oxidative stress and odontogenic differentiations of hDPSCs.

Keywords: Cell proliferation, Graphene, Oxidative stress, Odontogenic differentiation, Tricalcium silicate

ÖZ

Amaç: Diş hekimliğinin rejeneratif endodontik klinik uygulamalarında biyouyumluluk, mekanik ve antimikrobiyal özelliklerine sahip yeni biyomateryal ihtiyacı devam etmektedir. Biodentine™ vital pulpa tedavilerinde başarıyla kullanılmakta ve rejeneratif etkisi bulunmaktadır. Ayrıca, iyi fizikokimyasal, mekanik, biyolojik özelliklere sahip grafenin diş hekimliğinde hücresel biyomineralizasyonu ve osteojenik farklılaşmayı sağlayan, nörorejeneratif etkisi bulunmaktadır. Bu çalışmada grafen ve Biodentine™ 'in insan dental pulpa kök hücreleri (hDPSC) üzerindeki hücre proliferasyonu, oksidatif stres ve odontojenik farklılaşma etkilerinin incelenmesi amaçlanmıştır.

Metot: Çalışmamızda Amerikan Tipi Kültür Koleksiyonu (ATCC) insan DPSC'si (Cat No: PT-5025) kullanılmıştır. DPSC'ler E-platelere ekildikten sonra dörder farklı dozda grafen (12.5, 25, 50 ve 100 µg/ml) ve Biodentine™ (2, 4, 8 ve 16 µg/ml) eklenmiştir. Deney gruplarının 24 saat sonunda MTT, total antioksidan seviye (TAS), total oksidan seviye (TOS) ve alkalen fosfataz (ALP) analiz sonuçları elde edilmiştir. Ayrıca 96 saatlik gerçek zamanlı hücre indeks verileri xCELLigence® cihazı kullanılarak elde edilmiştir. Verilerin karşılaştırılmasında tek yönlü varyans analizi kullanılmıştır.

Bulgular: Çalışmada proliferasyonu en yüksek ve oksidatif stres düzeyi en düşük gruplar grafen 12.5 µg/ml ve Biodentine™ 2 µg/ml olarak belirlenmiştir. Antioksidan etki grafenin sadece 12.5 µg/ml grubunda Biodentine™' in ise bütün dozlarında tespit edilmiştir. Grafen ve Biodentine™' in bütün dozları için odontojenik farklılaşma gözlenmiştir.

Sonuç: İnsan DPSC'si üzerinde grafen 12.5 µg/ml ve Biodentine ™ 2 µg/ml gruplarının hücre proliferasyonu, oksidatif stres ve odontojenik farklılaşma bakımından olumlu etkileri bulunmuştur.

Anahtar kelimeler: Hücre proliferasyonu, Grafen, Odontojenik farklılaşma, Oksidatif stres, Trikalsiyum silikat

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INTRODUCTION

In dentistry, vital pulp therapy (VPT) performed to maintain the pulp vitality is an important treatment approach preserving the teeth for longer periods of time.[1] VPTs aim to preserve the vitality of dentin-pulp-complex, which contains a pulpal tissue of mesenchymal origin and involves the specialized cells known as odontoblasts. The materials used in VPTs need to be non-cytotoxic and bioactive to preserve the vitality of the dentin-pulp complex and stimulate odontogenic differentiations. Although several new materials with different ingredients have been recently introduced into dental clinical applications, there is still an ongoing need for novel biomaterials with superior biocompatibility, mechanical and antimicrobial properties.[2,3]

Vast majority of the materials used in dentistry induce oxidative stress by producing free radicals. Excessive generation of reactive oxygen species greater than the antioxidant capacity of the cells for many reasons, cause damage to cellular macromolecules, such as lipids, proteins and DNA and lead to cell injury.[4] Impact of overwhelming production of cellular oxidative stress on both recovery time and cell viability necessitates the assessment of different dental materials' effects on cells.[5]

In addition to cell viability and proliferation, odontogenic cell differentiation is essential for pulp vitality. And alkaline phosphatase (ALP), secreted by the osteoblasts during bone formation is a marker of odontogenic differentiation regarding the hard tissue mineralization process.[6]

Biodentine™, used in the VPTs stimulating odontogenic differentiation is a tricalcium silicate (Ca_3SiO_5) based commercially available inorganic restorative cement also known as "bioactive dentin". Biodentine™ was reported to have better physical and biological properties than other tricalcium silicate cements, such as mineral trioxide aggregate (MTA) and BioAgregate™.[7,8] Although not widely used in clinical applications, MTA has been reported to have some drawbacks, including discoloration, prolonged setting time and worse dentinal tubule penetration. When compared to MTA, Biodentine™ has superior physical and biological properties concerning easier handling, shorter setting time, higher compressive strength and faster dentin bridge formation. The mechanism of these superior features can be explained by Biodentine's™ different particle size and induction of odontoblastic differentiation following to its application and thus initiation of a mineralization appeared similar to osteodentin. The therapeutic mechanism of Biodentine™ is that after application of this material, mineralization induces and occurs in the form of osteodentin, which makes dentin.[9,10]

Among the mostly researched nanocarbon materials in the recent years, graphene, is remarkable for being the thinnest, strongest, and the hardest material tested so far due to the flexible covalent bonds between its carbon atoms.[11,12] It is used for improving the physical, mechanical and biological properties of the biomaterials. Graphene has several types of applications in biomedicine, such as biosensors, and nano-carrier systems for gene and drug delivery, cell imaging, and phototherapy equipment due to not only its ease of handling but also its antimicrobial, antiviral, antitumoral effects.[13]

There is an increasing number of researches assessing the biological properties of graphene, which gradually find applications in the field of biomedicine, including dentistry. The aim of the present study is to evaluate the impacts of graphene and Biodentine™ on human dental pulp stem cells (hDPSCs) regarding cell proliferation, oxidative stress and odontogenic differentiation. In this study, graphene was compared with Biodentine™, which is a bioceramic based material, as it is a successful material in endodontic treatments.[14] Our research hypothesizes that Graphene and Biodentine™ do not have an effect on cell proliferation, oxidative stress, and odontogenic differentiation in hDPSCs.

METHOD

Ethical approval

Ethics committee approval was obtained from the Ataturk University, Faculty of Medicine Clinical Research Ethics Committee (dated as 30 September 2021 and Approval #64).

Cell Culturing

hDPSCs used in the present study (Pioteticsᵀᴹ #PT-5025, Lonza Bioscience, MD, USA) was procured from American Type Culture Collection (ATCC). Cryopreserved hDPSCs in the ampules were immediately thawed, centrifuged at 1200 rpm for 5 min. (Beckman Coulter, Allegra X-30-R Centrifuge) and the supernatant discarded. Pelleted cells were resuspended in a fresh medium containing 10% FBS (Fetal Bovine Solution, Gibco, USA), 1% antibiotic (Penicillin, Streptomycin, Amphotericin B (Thermo Fisher, Germany), 89% DPSC medium (DPSC Basal Medium; catalog #PT-3927 Lonza, USA), 1% L-glutamine and then transferred to a 25cm^2 flask. hDPSCs were subcultured in a humidified incubator (Esco CelCulture® CO_2 Incubator, England) at 37°C and under a 5% CO_2 atmosphere. It was determined with an inverted microscope (Inverted Fluorescent Microscope, Leica, Germany) whether the wells completely filled the bottom of the prepared well plate. The sample preparation phase began when the cells reached a density of 80% (Figure 1).

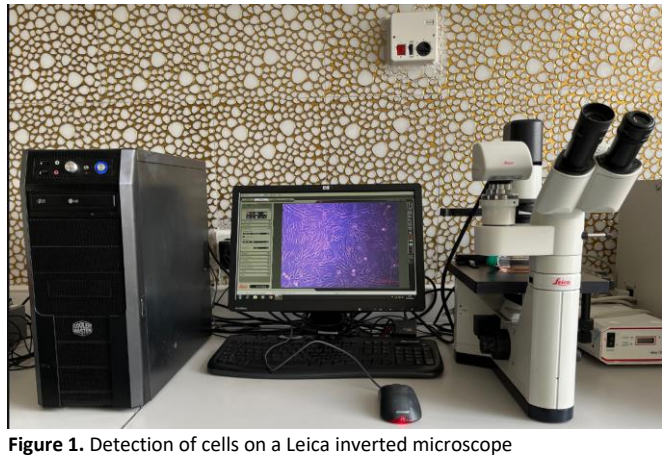

Figure 1. Detection of cells on a Leica inverted microscope

Study Groups

Solid form graphene and Biodentine™ (Septodont, Saint-Maurdes-Fosses, France) were tested in our study. The present study consisted of a negative control group consisting of only hDPSCs, a positive control group composed of hDPSCs+dimethyl sulfoxide (DMSO- C2H6OS) and two study groups, in which Biodentine™ was administrated in the doses of 2, 4, 8, and 16 µg/ml and graphene in the doses of 12.5, 25, 50, and 100 µg/ml. The sample size in each group (n=10) was determined using power analysis (effect size f = 1.4, $1 - \beta = 0.80$, $\alpha = 0.05$). Tests were repeated 10 times for each dose and different doses of both agents were analyzed with MTT (thiazolyl blue tetrazolium bromide), xCELLigence®, total antioxidant capacity (TAC), total oxidant status (TOS) and alkaline phosphatase (ALP).

MTT Assay

hDSPCs were transferred to 48 well flat bottom- plates at a density of apx. 0.25 x 10^4 cell/cm^2 and subcultured, then incubated until reaching a cell density of 80%. Positive control group consisted of DMSO-treated cells whereas negative control group composed of untreated cells. Impacts of graphene and Biodentine™ doses on the viability of hDPSCs were assessed by MTT test. At the end of a 24 hr incubation period, cell media were dispensed into Eppendorf Tubes® (Eppendorf Limited, UK) for bioanalysis. In order to volume-up the wells to 100 µL, a 10 µL of MTT solution (5mg/ml) was added to each plate well and incubated at 37 °C. 100 µL DMSO was added to dissolve formazan crystals after removing the medium in the wells and absorbance was measured at wavelength of 570 nm using a microplate (ELISA) reader (Multiskan™ GO Microplate Spectrophotometer, Thermo Fisher Scientific Finland).[15]

Biochemical Analyses

TAC and TOS levels were measured by using Rel Assay Diagnostics® TAC and TOS assay kits (Rel Assay Diagnostics, Gaziantep, Türkiye) in the cell medium for 24 hr. ALP levels were assessed with ready-to-use ELISA test kits (Sunlog Biotech Co, China).[16,17]

xCELLigence® Analysis

50 µl of agar was added to E-plate wells, in which 10^4 hDPSCs were seeded and incubated at room temperature for 30 min. Then the E-plate was inserted in the cradle of real time analyzer (xCELLigence RTCA, ACEA Biosciences Inc.-Agilent, California, USA) and real time logarithmic proliferation of the cells was monitored at the scheduled temporal resolutions. Media in the wells were removed following to a 24 hr of incubation time and 100 µl agar solution with the different doses of the agents was added to each well, only medium and medium+DMSO were added into the control wells. Tests had been continued for 72 hr after the addition of the agents and meanwhile, cell index (CI) values were measured. In order to monitor the short-term cellular responses to the agents tested, CI values were measured in every 2 min during the post-addendum first hour then every 30 min for following-up the long-term responses.[18]

Statistical Analysis

GraphPad Prism 8.0a for Mac OS X (GraphPad Software, Inc., La Jolia California, USA) was use for assessing the study data at a 0.05 level of significance. One-way analysis of variance (One Way ANOVA) was used to evaluate the results of MTT, TAC, TOS, LDH and ALP assays. Fisher Least Significant Difference (LSD) test was used for determining the differences between groups' means.

RESULTS

MTT Assay

Cytotoxic effects of graphene and Biodentine™, administrated in different doses on hDPSCs were determined with MTT assay. Dose-depended changes were observed in cell viability whereas a statistically significant difference was found between negative control and DMSO groups (*P*<.05) (Figure 2).

The highest cell viability was seen in 12.5 µg/ml graphene and 2 µg/ml Biodentine™ subgroups. No significant difference was observed between the cell proliferation rates in these subgroups. Higher cell viability was observed in 25 µg/ml graphene, and 4 and 8 µg/ml Biodentine™ groups compared to DMSO group (*p*=0.59).

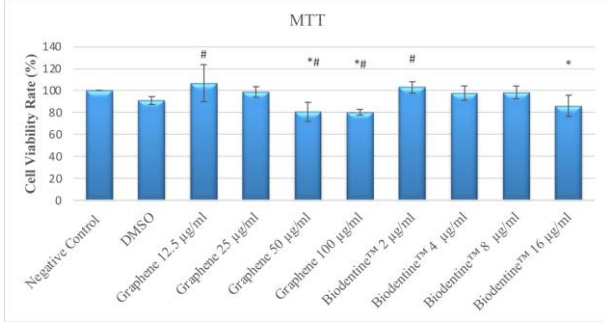

Figure 2. 24 hr-MTT assay results of control, graphene and Biodentine™ groups
** P<.05 significant difference in comparison with the control group # P<.05 significant difference in comparison with DMSO group*

xCELLigence® Analysis

For determining the influence of different Biodentine™ doses on of hDPSC proliferation, each dose was monitored in 3 wells in xCELLigence® system (RTCA) for 72 hr. Following to the 2 µg/ml, 4 µg/ml and 8 µg/ml Biodentine™ administration at the 24th hour, hDPSC viability was observed to increase at the end of the 72nd hour whereas cell viability significantly decreased in the 16 µg/ml Biodentine™ subgroup (Figure 3).

After dosages of 12.5 µg/ml and 25 µg/ml graphene were added into the media, an increase was observed in hDPSC viability. The highest CI value was detected in the 12.5 µg/ml graphene subgroup (Figure 4).

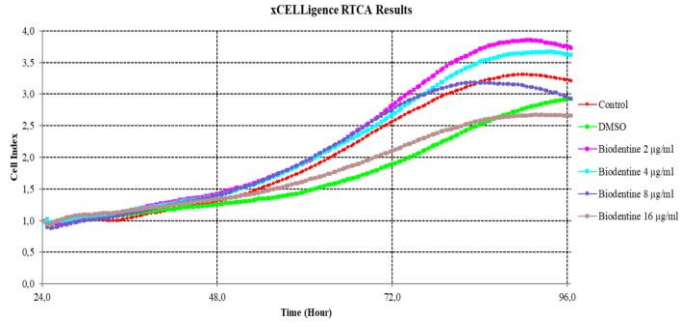

Figure 3. Distribution of Biodentine™ subgroups' hourly cell index values compared to DMSO group

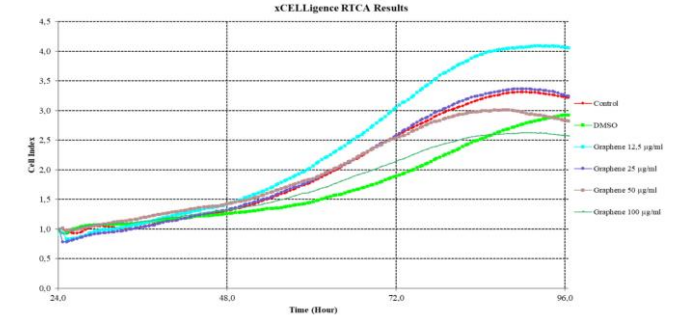

Figure 4. Distribution of graphene subgroups' hourly cell index values compared to DMSO group

TAC and TOS Assays

TAC and TOS assay kits were used to measure hDPSC oxidant and antioxidant levels 24 hr after administrating different doses of graphene and Biodentine™. Among all graphene subgroups, higher levels of antioxidant than DMSO (positive control) group seen only in 12.5 µg/ml dosage and presence of greater antioxidant capacity in all doses of Biodentine™ than both control groups were found to be statistically significant (*P*<.05) (Figure 5).

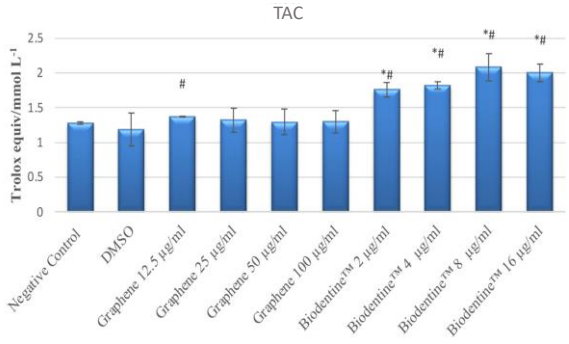

Figure 5. 24 hr-TAC assay results of control, graphene and Biodentine™ groups
** P<.05 significant difference in comparison with the control group # P<.05 significant difference in comparison with DMSO group*

12.5 µg/ml graphene and 2 µg/ml Biodentine™ subgroups had lower oxidant levels than DMSO group (*P*<.05) (Figure 6). Moreover, no statistically significant difference was observed between the median oxidant levels of these groups (*P*=0.34). 100 µg/ml graphene and 16 µg/ml Biodentine™ groups were observed to have greater oxidant levels than DMSO group (*P<.05*).

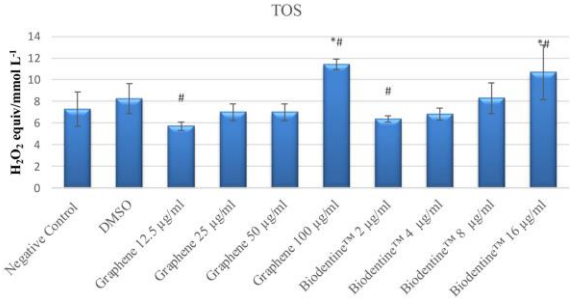

Figure 6. 24 hr-TOS assay results of control, graphene and Biodentine™ groups
** P<.05 significant difference in comparison with the control group # P<.05 significant difference in comparison with DMSO group*

ALP Assay

Effects of different Biodentine™ and graphene doses on the odontogenic differentiation of hDPSCs were detected using ALP activity assay. Significantly higher levels of ALP enzymes were seen in all study groups than DMSO group (*P*<.05) (Figure 7). ALP levels were observed to decrease in the doses more than 4 µg/ml Biodentine™ and 12.5 µg/ml graphene. The groups of Biodentine™ 4 µg/ml and graphene 12.5 µg/ml exhibit the highest ALP enzyme activities, and there is no statistically significant difference between the means of these groups (*P*=0.16).

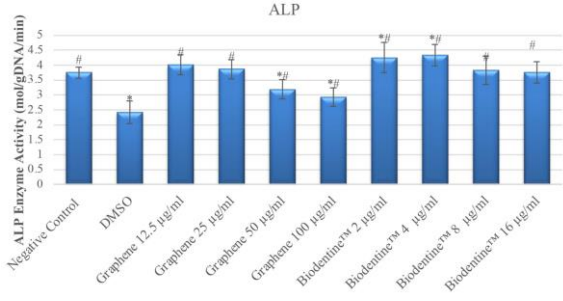

Figure 7. ALP enzymatic activity values of study and control groups
** P<.05 significant difference in comparison with the control group # P<.05 significant difference in comparison with DMSO group*

DISCUSSION

This study explored the proliferative, oxidative and odontogenic effects of graphene on hDSPCs. Biodentine™, a bioceramic-based material was used in the control group because it was accepted as the golden standard in post-endodontic restorations. The doses of 12.5 µg/ml for graphene and 2 µg/ml for Biodentine™ exhibited the lowest cytotoxicity based on the MTT and xCELLigence® tests, lower oxidative stress according to the TAC and TOS tests, and the highest odontogenic differentiation based on the ALP test. Therefore, the hypothesis stating that graphene and Biodentine™ have no effect on cell proliferation, oxidative stress, and odontogenic differentiation in human DPSCs is rejected.

Many studies have been conducted for investigating the cytotoxic and proliferative effects of Biodentine™ on DPSCs when used in VPTs.[19-21] Biodentine™ was reported to be bio-compatible since it was not cytotoxic and genotoxic for hDPSCs.[22,23] However, some researches performed in different cell lines remarked that Biodentine™ doses up to 2 µg/ml was bio-safe and its elevated doses led to a decrease in cell proliferation.[19,24] In this study, cell viability level in 2 µg/ml Biodentine™ administrated subgroup was found to be higher than the control groups. A lower viability was observed in 4 µg/ml Biodentine™ subgroup than the negative control group while a greater cell viability was determined when compared to DMSO group. Levels of cell viability in the subgroups treated with 8 and 16 µg/ml Biodentine™ were lower than the control groups. The cell viability of the subgroup treated with 25 µg/ml graphene was found to be higher compared to DMSO group and equivalent to negative control group. There were lower levels of cell viability in 50 and 100 µg/ml graphene-administrated subgroups than the control groups. The greatest cell viability was determined in 12.5 µg/ml graphene subgroup. Both findings of MTT assay matching with the literature and outcomes of xCELLigence® analysis confirmed our results.[19,24] In the 12.5 µg/ml graphene-administrated subgroup, cell viability was observed to be statistically different from all other groups during the 96 hr-RTCA.

Oxidative stress is regarded as an underlying factor for toxicity and ranked among the determinants in cytotoxicity tests. Subsequent to a change in the oxidant/antioxidant balance in favor of antioxidant system, TAC values measuring the oxidative stress increase whereas there is a decrease in the TOS values. However, some agents increase TAC levels although they do not have antioxidant capability. Similarly, Aksu et al.[25] also reported that at the 72nd hr post-administration, Biodentine™ was observed to demonstrate a strong defensive action on hDPSCs as a result of elevated TAC levels with a decline in TOS levels.

In our study, we also found that different doses of Biodentine™ had increased the TAC levels inversely proportional to TOS. Although 12.5 µg/ml graphene subgroup had higher levels of TAC than DMSO group, other graphene doses exhibited no antioxidant effect. Being independent of antioxidant effect, lower TOS levels in the graphene subgroups than the control groups were deemed compatible with the elevated cell viability. In their study assessing the biocompatibility of resin-based dental composites+graphene in in-vivo mandibular bone defect, Dreaneca et al.[26] remarked that following graphene administration TOS levels in the control and study groups were found to be lower than the sham-surgery group with no change in TAC levels. A study assessing the cytotoxicity of graphene-based nanomaterials on human dental follicle stem cells by Olteanu et al.[27] revealed that graphene oxide caused a decrease in superoxide dismutase (SOD) activity, used for measuring the antioxidant balance.

Several in-vitro and in-vivo studies revealed that Biodentine™ had a positive impact on pulp healing when the odontoblastic layer was partially injured.[8,28] In addition to other teccniques, ALP test is also used for assesing odontogenic and osteogenic differentiations.[29,30] ALP is relatively an early diferantiation marker that increases during the proliferation and matrix syntheses stage.[6] ALP activity was also evaluated in the present study since ALP was accepted as the primary marker of osteogenic/odontogenic differentiation.[29,30] 24hr-results of our study also showed higher levels of ALP in all Biodentine™ and graphene doses than DMSO group. Therefore, induction of ALP expression clearly demonstrate the significant role of graphene and Biodentine™ in accelerating osteogenesis/odontogenesis of hDPSC.

Numerous researches indicated that ALP inducted odontogenetic differentiation in DPSCs.[31,32] Jang et al.[33] determined that graphene oxide coated zirconia applications promoted the osteoblastic proliferation and differentiation. And Xie et al.[34] observed that graphene provoked osteogenic rather than odontogenic differentiation. Different from these researchers, we determined that like Biodentine™, all doses of graphene had also stimulated ALP enzymatic activity, which was used as a marker of hDPSC odontogenic differentiation.

However, our study reached consistent results with the other researches in the literature, inability to examine the effects of Biodentine™ +graphene combinations on hDPSCs constituted its limitation.

CONCLUSION

In the present study, at the end of the 24th hr, the strongest proliferative effect was observed in the subgroups of 12.5 µg/ml graphene and 2 µg/ml Biodentine™ whereas 100 µg/ml graphene and 16 µg/ml Biodentine™ exhibited the weakest cell viability. All administrated doses of graphene and Biodentine™ induced odontogenic differentiation. Graphene, which is biocompatible with hDPSCs may be added to endodontic agents or cements for improving their biological and mechanical properties. Nevertheless, comprehensive long-term studies are needed to achieve these goals.

Etik Komite Onayı: Atatürk Üniversitesi Tıp Fakültesi Klinik Araştırmalar Etik Kurulu'nun 30.09.2021 tarihli 6. toplantısında 64 karar numarası ile etik kurul onayı alındı.
Hakem Değerlendirmesi: Dış bağımsız.
Veri Kullanılabilirliği Beyanı: Bu çalışmanın bulgularını destekleyen veriler, makul talep üzerine ilgili yazardan temin edilebilir**.**
Yazar Katkıları: Fikir- P.Ç., S.Ş.D.; Tasarım - P.Ç.,S.Ş.D.; Denetim - P.Ç.,S.Ş.D.; Kaynaklar- P.Ç.,S.Ş.D.,F.Ş.,U.O.; Malzemeler - P.Ç.,U.O.; Veri Toplanması ve/veya İşlemesi - P.Ç.,F.Ş.,U.O.; Analiz ve/veya Yorum - P.Ç.,S.Ş.D.,U.O.; Literatür Taraması - P.Ç.; Yazan - P.Ç.,S.Ş.D.,F.Ş.; Eleştirel İnceleme - P.Ç.,S.Ş.D.
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Finansal Destek: Bu çalışma TÜBİTAK (Türkiye Bilimsel ve Teknolojik Araştırma Kurumu) tarafından desteklenmiştir (Proje No: 218S666).
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Author Contributions: Concept – P.C.,S.S.D.; Design - P.C.,S.S.D.; Audit - P.C.,S.S.D.,F.S.,U.O.; Sources - P.C., S.S.D.; Materials - P.C.,U.O.; Data Collection and/or Processing P.C.,F.S.,U.O.; Analysis and/or Interpretation - P.C., S.S.D.,U.O.; Literature Review - P.C.; Writing - P.C.,S.S.D.,F.S.; Critical Review - P.C.,S.S.D.
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Ultrasonography for Diagnosis of Technical Implant Errors: A Pilot Study in Sheep Model

Teknik İmplant Hatalarının Tanısında Ultrasonografi: Koyun Modelinde Pilot Çalışma

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ABSTRACT

Objective: The aim of this study was to investigate technical implant errors with CBCT and ultrasonography and to evaluate the success of USG in demonstrating these errors.
Method: Two freshly cut sheep heads were obtained. A radiological examination was performed with both CBCT and USG before and after the dental implant placement. 10 implants (2 right, 3 left) were placed to represent a represent normal placement implant and 4 different complications: crestal bone defect, cortical bone perforation, mental foramen perforation, mandibular canal perforation.
Results: The implants placed in the normal position without complications could not be visualized by USG in both sheep heads. Perforation areas of implants in the cortical bone were visualized by USG in both samples. The mental foramen could be visualized preoperatively with USG, and the perforations caused by the implants in the mental foramen could also be visualized with USG. In addition, positive findings were obtained by USG in a crestal bone defect. Mandibular canal perforation could not be visualized by USG in both heads.
Conclusion: USG is a useful imaging method that can be used to quickly detect technical errors such as cortical perforation, mental foramen perforation, crestal bone loss, and placement outside the bone that occur during implant surgery.
Keywords: Cone-beam computed tomography, ultrasonography, dental implant

ÖZ

Amaç : Bu çalışmanın amacı CBCT ve ultrasonografi ile teknik implant hatalarını tespit etmek ve USG'nin bu hataları göstermedeki başarısını değerlendirmektir.
Yöntemler : İki adet taze kesilmiş koyun kafası elde edildi. Dental implant yerleştirme öncesi ve sonrasında hem CBCT hem de USG ile radyolojik inceleme yapıldı. Koyun kafalarının her birinde 2'şer dental implant sağda 3'er dental implant solda olmak üzere toplam 10 adet dental implant krestal kemik defekti, kortikal kemik perforasyonu, mental foramen perforasyonu, mandibular kanal perforasyonu olmak üzere 4 farklı komplikasyonu gösterebilmek amacıyla flepsiz teknikle yerleştirildi.
Bulgular : Normal pozisyonda komplikasyonsuz yerleştirilen implantlar her iki koyun kafasında da USG ile görüntülenemedi. Her iki örnekte de implantların kortikal kemikteki perforasyon alanları USG ile görüntülendi. USG ile ameliyat öncesinde mental foramen görüntülenebildiği gibi, implantların mental foramende neden olduğu perforasyonlar da USG ile görüntülenebildi. Ayrıca krestal kemik defektinde USG ile pozitif bulgular elde edildi. Her iki kafada da USG ile mandibular kanal perforasyonu görüntülenemedi.
Sonuç : USG, implant cerrahisi sırasında oluşan kortikal perforasyon, mental foramen perforasyonu, krestal kemik kaybı, kemik dışına yerleşim gibi teknik hataların hızlı bir şekilde tespit edilmesinde kullanılabilecek faydalı bir görüntüleme yöntemidir.
Anahtar kelimeler: Konik ışınlı bilgisayarlı tomografi, ultrasonografi, dental implant

INTRODUCTION

Dental implants are an increasingly common treatment option used in the treatment of tooth deficiencies. There is an increase in the number and type of complications due to the increase in the number of applications, despite the high success rates of dental implants. While the term implant success describes an implant that is healthy and completely functional in the bone: Implant survival is described as the implant being in place.[1] Osseointegration is a straight structural and physiological connection between the bone and the functioning implant surface.[2–4] The condition of the marginal bone around the implant is directly effective in determining the success of the implant.[5] Resorption of more than half of the bone around the implant indicates failure of the implant.[2,6] Therefore, implant success is directly dependent on crestal bone resorption and is one of the most important determining factors for the post-operative success of implants.[3]

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It is as effective as cortical bone resorption in terms of the success of the implant, as well as the technical errors made during the surgical application and planning. Technical errors include insufficient distance between the implants and neighboring structures, drilling of cortical bones, and drilling into anatomical points, and these might lead to complications like bone defects, unsuccessful osseointegration, bleeding, neurosensory disorders and extra operations and increase the likelihood of early or late implant failure.[7]

Cone-beam computed tomography (CBCT) is one of the most common imaging methods used to identify the connection between dentals implant and bones determine anatomical structures and their variations accurately, and display them in 3D.[8] CBCT is frequently used for determining places of implants.[9] Also, it has an advantage, when compared in terms of radiation dose. For example, the total radiation dose in two-dimensional radiographs such as full-mouth series intraoral, lateral cephalometric, and panoramic radiographs is between 43.2 and 200.6 µSv; this dose is between 995 and 1160 µSv for CT and 30 and 68 µSv for CBCT.[10]

Although CBCT scanning causes low-dose radiation release, it is not a useful option for appreciating peri-implant structures due to continued radiation exposure on recurring scans on the same patient, a lack of detection of very thin bone layers, as well as beam hardening and scattering artifacts.[11–13]

Ultrasonography (USG), which was originally developed for the evaluation of soft tissues, is an imaging method with a portable device on which metals such as dental restorations and implants do not produ- ce artifacts. It is a noninvasive, cheap, painless, real-time, and radiation-free device. Although the structures behind the bone or completely within the bone cannot be visualized with USG, it has the ability to mea- sure the gingiva thickness in the oral cavity and show bone perforations. Additionally, the location, shape, and size of anatomical structures like the mental foramen can be easily determined by USG.[14–18]

Although it has been shown in previous studies that peri-implantitis can be evaluated using USG, no study has been found to evaluate technical errors (perforation of cortical plates, penetration of the mandibular canal and mental foremen, etc.) during implant placement. Our aim in this study was to investigate technical implant errors with CBCT and USG, and to evaluate the success of USG in demonstrating these complications.

METHOD

Study Design

Three freshly cut sheep heads were obtained from the national slaughterhouse for the study; however, two sheep mandibles were used because a fracture was detected in one of the sheep heads. A radiolo- gical examination was performed with both CBCT and USG before and after the implant placement. Implant planning was done using preopera- tive CBCT images, and the implants were placed in the diastema area, which was from the first incisor tooth to the first premolar in the sheep mandible.

Surgical Procedure

The surgical operations were all performed by YÖK, who has at least 10 years of experience in dental implant surgery using *Nucleoss T6 implant system* (Izmir, Turkey). Following the outline described in the manual for the implant system at specified sites, 10 implants (2 right, 3 left) were placed to represent normal placement (at the bone level and without the perforation of lingual or buccal bone, mandibular canal, or mental foramen) and 4 different complications crestal bone defect, cortical bone perforation, mental foramen perforation, and mandibular canal perforation (Fig 1).

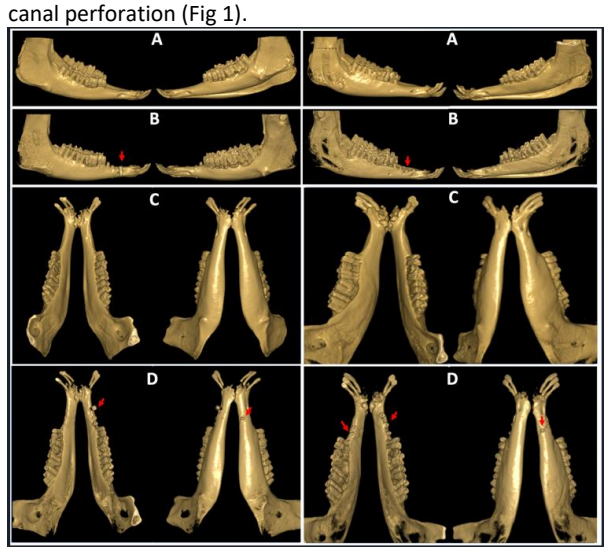

Figure 1(A-D): Preop and postop 3D CBCT images. A: Preop right and left images. B: Postop right and left images. Placed implants and complications can be seen. C: Preop occlusal and inferior view. D: Postop occlusal and inferior view. Crestal bone defect and cortical bone perforation can be seen.

Imaging procedures

CBCT scanning

CBCT procedures were performed with the same parameters before and after surgery. The images were taken with a *Newtom VGi evo* (Cefla, Imola, Italy, 110 kV, 15.3 mAs, slice thickness: 0.3, field of view: 240 × 190 mm). A secondary reconstruction with an axial thickness of 0.5 mm was performed parallel to the bases of the mandibles of sheep to be examined, followed by the primary reconstruction. Study reconstruction was obtained from both sheep heads with the same parameters. The mandibular canal was marked on the 0.1 mm thick panoramic sections for the right and left half-jaws. Then, the implant sites were examined in cross-sections with 0.5 mm intervals. The *QR-NNT version 11.5* (Quantitative Radiology) software program was used for analyses.

Ultrasound scanning

USG examinations were performed by a researcher (FC) with at least 10 years of experience in maxillofacial ultrasound. USG was applied using an *Aplio-300 device* (Toshiba Corporation, Tokyo, Japan), an 18 MHz hockey stick transducer. First, the probe was covered with gel and a sheath. During examinations, places where implants were placed were monitored on the horizontal and vertical planes by transoral approach. The visibility of normal placement implants and complications such as crestal bone defects, cortical bone perforation, mental foramen perforation, and mandibular canal perforation were evaluated by USG

RESULTS

In this study, the visibility of common complications in implant applications with CBCT and USG was evaluated. In two freshly cut sheep heads, 10 implants were placed, with 5 implants in each head.

CBCT was accepted as the gold standard in the evaluation of implant complications. The placement of all 10 implants in the bone, their positions, cortical bone perforations, and their relations with anatomical structures like the mandibular canal and mental foramen were clearly observed in both sheep heads with CBCT. The placement of the implants is generally seen in (Figure 2) in 0.5 mm axial sections and 1mm cross-sectional sections.

In the USG examination, similar findings were obtained in both sheep heads. The findings seen by USG in both sheep heads are summarized in Table 1. According to this, the implants placed in the normal position without complications could not be visualized by USG in both sheep heads. In the USG examination of alveolar bone, only the cortical surface of alveolar bone was seen as a hyperechoic line (Fig. 3A); the implant in the bone could not be seen in the USG, and it could only be visualized in the occlusal plane (Fig. 3B). Perforation areas of implants in the cortical bone were visualized by USG in both samples (Fig. 4). The mental foramen could be visualized preoperatively with USG, and the perforations caused by the implants in the mental foramen could also be visualized with USG (Fig. 5). In addition, positive findings were obtained by USG in a crestal bone defect (Fig. 6). Mandibular canal perforation could not be visualized by USG in both heads.

Table 1. Ultrasonographic visibility of implant complications and normal placement in both sheep heads.

Implant Placement Status	Ultrasound visibility	
	Sheep head 1	Sheep head 2
Normal placement	Invisible	Invisible
Cortical bone perforation	Visible	Visible
Mental foramen perforation	Visible	Visible
Mandibular canal perforation	Invisible	Invisible
Crestal bone defect	Visible	Visible

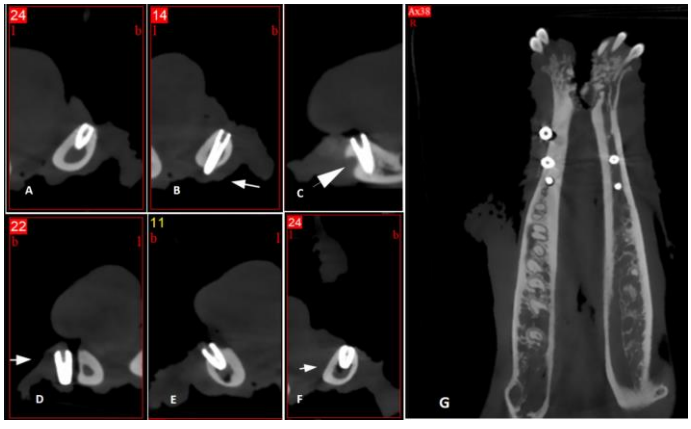

Figure 2 (A-G): Cross-sectional and axial CBCT images of implants. A: Normal placement, B: Cortical perforation, C: Mental foramen perforation, D: Advanced crestal bone loss, E: Crestal bone loss, F: Mandibular canal perforation, G: 0,5 mm axial view.

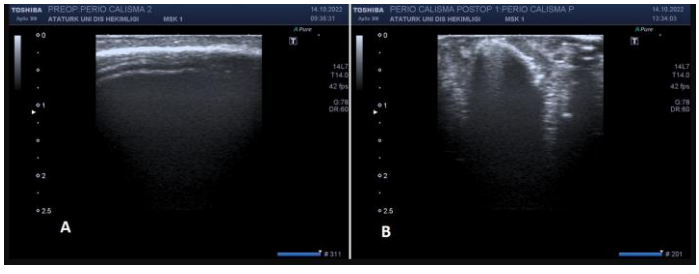

Figure 3(A-B): USG view of the normally placed intraosseous implant site. A: The implant in the bone is not visible, only the cortical surface of the alveolar bone was seen as a hyperechoic line. B: The upper edge of the implant is observed from the occlusal surface as hyperechoic on USG, comet tail artefact visible behind the metallic implant

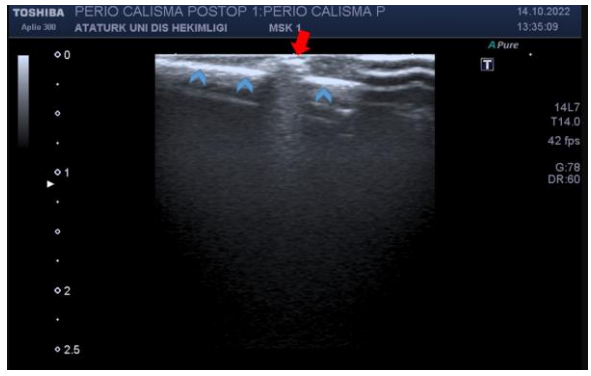

Figure 4: USG image of the implant causing the cortical perforation, blue arrowheads indicate mandibular cortical surface, red arrow indicates the tip of the implant at the perforation site. Reverberation artifact is observed behind the bone surface, and comet tail artifact is observed behind the implant.

Figure 5 (A-B): USG image of the mental foramen before and after the implant. A: The mental foramen opening is observed as an interruption on the hyperechoic cortical bone surface, B: The implant that has perforated the mental foramen is observed in the foramen (blue arrow).

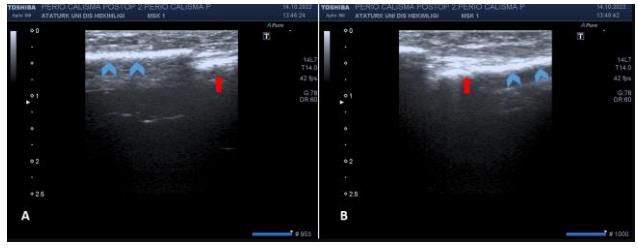

Figure 6 (A-B): Dislocated implants, blue arrowheads indicate mandibular cortical surface, red arrow indicates the tip of the implant. A: Advanced crestal bone loss. Placement outside the bone, B: Crestal bone loss

DISCUSSION

USG is becoming an increasingly popular method in the evaluation of implant success due to its ease of application, lack causing radiation exposure, and cost-effectiveness. In this study, the radiological evaluation of 6 different implant conditions artificially created in sheep mandible bones was compared with CBCT and USG.

Periodontal USG can be used in the evaluation of periodontal structures as a reliable, harmless, non-invasive and inexpensive method.[19] In recent studies, it has been seen that periodontal USG allows not only to evaluate the gingival thickness, also to examine many structures that cannot be evaluated by clinical examination.[20,21] Ultrasonic devices with small, high-frequency (40 MHz) transducers are used in periodontal USG. With this method, free gingival thickness, gingival sulcus depth, distance between gingival margin and alveolar bone crest, clinical and anatomical crown heights can be measured.[22] In addition, in-vitro studies have reported that it can be used in the evaluation of bone level and soft tissue thickness in implantology.[23,24]

In a study examining peri-implantitis by Bertram and Emshoff,[25] a probe with 12.5 MHz is used and in a study in which the height of alveolar bone around the teeth was compared with CBCT which was conducted on human cadavers by Chan et al.[26] a 14 MHz probe was used. In a study conducted by the same investigators and examining the peri-implant tissues of human cadavers, an ultrasound probe prototype with 25 MHz was used and the tissues around the implant were visualized.[27] In a clinical study conducted by Tattan et al.[28] the height and width of soft tissue level of crestal bone have been determined with a 24 MHz ultrasound probe. In our study, an ultrasound probe with 18 MHz was used and crestal bone loss around the implant, implant perforations that disturb mental foramen and cortical bone unity were detected. The use of higher-frequency probes increases image resolution, resulting in a clearer and more accurate topography of facial bones. With Ultra high ultrasound, a new USG technique developed recently, areas 1 cm from the surface can be examined with 30 µm resolution using frequencies up to 70 MHz.[29]

Probe sizes should also be smaller in order to obtain intraoral images more easily. Although it is easy to obtain images from buccal surfaces introrally with periodontal USG, the procedure becomes difficult due to the probe's reach on lingual surfaces. It is impossible to obtain images from proximal surfaces with current technology.[20] Although we used sheep's heads in our study, considering the use of the probe in the human mouth, we took the image by keeping the cattle head in the rest position. Although we encountered some difficulties in imaging the perforation in the submandibular region, depending on the probe size and shape, we were able to obtain an image.

An uninterrupted, complete cortical bone structure is seen as a single line on USG, and structures inside the bone cannot be detected with USG. Situations in which the cortical bone gets thinner or perforation of the cortical bone emerges can be visualized by USG.[19] Similarly, irregularities on the bone surface, such as the foramen, can be visualized. In our previous study, the foramen mentale could be detected accurately by USG.[30] Similarly, in our study, implants that were completely embedded in the bone (the appropriately placed implant and the implant with mandibular canal perforation by being inside the bone) could not be detected by USG; foramen mentale and foramen mentale with the implant placed as perforated and lingual and crestal bone perforations could be detected using USG.

CBCT is frequently used to evaluate alveolar bone dimensions, and its accuracy has been achieved in thinner cadaver studies conducted, but it may be insufficient to detect bone thicknesses under 1mm due to the resolution limits.[31] The average anterior bone thickness of the maxillary teeth was between 0.5 and 0.7 mm, and the anterior wall thickness was less than 1 mm in approximately 90% of the teeth.[32] In a study in which 12 healthy implants were included and which was conducted by Veltri et al.[33] it was observed that the implant facial bone extended from the implant neck to the apical 3.8 mm, and the implant surface was not completely covered with bone in all of the implants. Another study that included 89 implants with peri-implantitis showed that 34% of the measured implant sites had uneven bone loss with greater resorption in the facial bone region.[34] In our study, all implants could be visualized with CBCT, but bone thickness under 1 mm could not be measured in the vestibule region. This situation supports previous studies, and the implant that is not at the bone level with artificial bone loss and the implant that has alveolar bone resorption in the vestibular region can be detected by USG. Bone measurement was not performed for this purpose in this study. As already mentioned, positive results may not be obtained in CBCT post-operative implant evaluations, especially in bone measurements, due to the artifacts. However, nowadays, with the development of various software programs and algorithms that minimize these metal-related disadvantages in CBCT, these disadvantages have begun to be overcome. Here comes the limitation of our work. Clinical studies using more samples and incldings measurements are needed in the future. However, with our findings, we can say that USG clearly shows complications such as cortical perforation, mental foramen perforation, crestal bone loss, and placement outside the bone. Our study may be a pioneer for future studies in this respect.

Especially in the diagnosis of peri-implantitis, 2D imaging methods such as panoramic radiography are frequently used, but even if bone losses in the interproximal regions are determined with these methods, bone losses in the vestibule and lingual region may not be detected due to the superposition of the implant. A similar problem is also valid for vestibule and lingual bone perforations caused by technical errors during surgery, revealing the necessity of applying CBCT imaging to detect these conditions. Although CBCT is a suitable bone evaluation method for implant planning, artifacts occur due to the metal of the implant, which creates problems in the evaluation of peri-implant tissues. Contrary to this, no such artifact is observed in USG, and no radiation exposure occurs. In addition, as in CBCT with USG, there is no need for a special room during image acquisition, and it is possible to quickly identify various implant complications and intervene in these complications by instantly taking images with USG after implant placement during the surgery. In this way, many complications can be addressed immediately without the need for a second operation.

The major limitation of the study was the small sample size. Another was that the anatomy of the sheep's head was not the same as the human head, even though it has similar features as a mammal.

CONCLUSION

In conclusion, USG is a useful imaging method that does not contain ionizing radiation and can be used to quickly detect technical errors such as cortical perforation, mental foramen perforation, crestal bone loss, and placement outside the bone that occur during implant surgery.

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İmplant Üstü Sabit Protezlerde Dişeti Çıkış Profilinin Oluşturulması

Creating an Emergence Profil in Implant Retained Fixed Restorations

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ÖZ

İmplant üstü restorasyonlarda ideal bir estetik ve fonksiyon elde edilmesi için kronun implant çevresindeki yumuşak dokuyla olan uyumu oldukça önemlidir. Uygun dişeti çıkış profili, geçici protez vasıtasıyla peri-implant mukozanın şekillendirilmesiyle oluşturulmaktadır. Başarılı bir şekillendirilme yapabilmek için yumuşak ve sert dokuların miktarı önemli rol oynamaktadır. Bu sayede komşu diş yapısıyla uyum sağlayan yumuşak dokunun yeniden oluşturulması, doğru bir dişeti çıkış profili oluşturmak, dişeti zenith noktasını tam olarak yeniden konumlandırmak, dengeli papilla yüksekliği elde etmek, implant restorasyonu ve komşu diş ile proksimal bir temas alanı oluşturulur. Bu derlemede implant üstü restorasyonlarda dişeti çıkış profili oluşturmanın önemi ve kullanılan çeşitli yöntemler anlatılmaktır.
Anahtar kelimeler: Dişeti çıkış profili, implant, estetik.

ABSTRACT

To achieve an ideal aesthetic and function in implant restorations, the harmony of the crown with the soft tissue around the implant is very important. The appropriate emergence profile is formed by shaping the peri-implant mucosa through a temporary prosthesis. The amount of soft and hard tissues plays an important role in successful shaping. In this way, the restoration of soft tissue that harmonizes with the adjacent tooth structure creates an accurate emergence profile, precisely repositioning the gingiva zenith point, achieving balanced papilla height, implant restoration, and a proximal contact area with the adjacent tooth. This review explains the importance of creating an emergence profile in implant restorations and the various methods used.
Keywords: Emergence profile, implant, aesthetics

GİRİŞ

Dental implantlar, kısmi ve tam diş eksikliği olan hastaların tedavisinde sıklıkla kullanılmaktadır[1]. Başarılı bir implant tedavisi yalnızca implantın osseointegre olabilmesini değil, aynı zamanda implant üstü protezin uzun vadeli stabilitesinin sağlanması, iyi bir estetik ve fonksiyonel sonuç vermesi, temizlenebilir olmasına bağlıdır.[1,2]

İmplant yerleşiminden sonra başarılı bir estetik 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.[3]

Estetik bölgede implantların kemik seviyesinde yerleştirilmesi; kron marjinin yeri, zenith pozisyonu, dişeti çıkış profili ve yumuşak doku şekillendirilmesi için oldukça önemlidir. 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.[4] Bu nedenle başarılı bir estetik sağlayabilmek için implant çevresindeki yumuşak dokunun, komşu diş yapısı ile uyumlu bir doku profiline dönüştürülmesi gerekir.[5]

Peri-implant mukozası; yumuşak dokunun kontrollü ve sürekli kompresyondan sonra modifiye edilebilir hale gelmesi prensibine dayanan bir şekillendirme süreci ile değiştirilebilir. Özellikle kalın dişeti biyotipi olan hastalarda, bu doku normal scallop, parabolik diş eti konturlarını yeniden oluşturmak için manipüle edilebilir[6]. Yumuşak doku şekillendirmesi üzerine güncel literatürlerde farklı yaklaşımlar önerilmiştir.[7–9] Birçok yazar stabil ve uygun kontura sahip geçici protezin oluşturduğu yumuşak doku profilinin daimi restorasyona aktarılmasını önermektedir.[6]

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 bölgede bulunan dişeti dokusu da geçici restorasyon ile uygun şekilde destekleniyorsa istenen şekle getirilebilir.[10]

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Geçici protez ile oluşturulan yumuşak doku şekillendirilmesinde okluzal vidalı geçici restorasyonlar tercih edilmektedir. Siman içermemesinden dolayı kron-abutment bağlantısında daha pürüzsüz bir yüzey sunarak doku iyileşmesini kolaylaştırır.[11–13]

Geçici restorasyonlar yumuşak dokuyu yönlendirmesi dışında hastaların estetik ve fonksiyonu ekonomik ve hızlı bir şekilde geri kazandırır, final restorasyon için tanısal bir şablon görevi görür.[14]

İmmediat ve Gecikmeli İmplant Geçici Restorasyonu

İmmediat ve gecikmeli yüklemelerde, son ölçüden önce yumuşak dokunun şekillenmesi ve stabilizasyonu için; geçici kuronların 3 ila 12 aylık kullanımı savunulmuştur. Bu süre, yumuşak doku kalitesine ve ihtiyaç duyulan şekillenme derecesine göre değişebilir.[15,16] Geçici restorasyonun son haline ulaşmak için birtakım düzenlemeler gerekli olabileceğinden, kompozit gibi modifiye edilmesi kolay bir restoratif materyal önerilir. Bu benzerliklerin yanı sıra, immediat ve gecikmeli yüklemeler için farklı stratejiler önerilmektedir.[17]

İmmediat İmplantasyon ve İmmediat Geçici Restorasyon

İmmediat implantasyon ile aynı zamanda geçici bir restorasyonun yerleştirilmesi, dişeti dokusu yüksekliğinin ve profilinin korunmasına yardımcı olabilmektedir.[18] Cerrahi yöntemlerdeki gelişmeler ve implant makro geometrisindeki ilerlemeler, implantın immediate yerleştirilmesi ve işlevi için gerekli primer stabiliteye ulaşılmasını kolaylaştırmaktadır. Böylece implantın immediate yerleştirilmesi giderek daha popüler hale gelmektedir.[19-22]

Mevcut mantık, geçici restorasyonun bukkal ve interproksimal yumuşak dokuları destekleyerek, dişetinde oluşacak çökmeyi önleyeceği fikrine dayanmaktadır.[23-25] Alternatif bir teknik, geçici bir restorasyonun yerleştirilmesiyle bağlantılı olarak özel bir geçici abutmentin kullanılmasını içermektedir.[26]

İyileşme esnasında immediat implantasyonda geçici restorasyonların amaçları şunlardır:

- Mevcut yumuşak doku profilini korumak:İmmmediat implant yerleştirilmesi esnasında immediat restorasyon yapılabilmesi mevcut yumuşak doku yeterli olduğunda veya ufak düzensizlikler gösterdiğinde uygulanabilir. Daha büyük kusurlar mevcutsa immediat olarak yerleştirilen bir implant rejeneratif tekniklerle beraber düşünülebilir. Fakat bu durumda immediat implant destekli restorasyonun uygulanması riskli olup başarısız sonuçlara yol açabilir
- Yumuşak ve sert doku kompresyonundan kaçınma: İmplant yerleşimini planlarken alveolar sokete bukkal ve interproksimal kompresyon kuvvetleri uygulanmamalı, mukoza restorasyon tarafından sıkıştırılmamalıdır. Ayrıca, geçici restorasyonda istenmeyen kompresyonla bağlantılı olarak; peri-implant yumuşak dokuların iskemisine yol açabilen ekstraksiyon, greftleme prosedürü ve implant yerleştirme ile ilişkili inflamatuar süreç dikkate alınmalıdır.
- Rejeneratif işlem için alan bırakma: Restorasyonun yüzeyi ile suprakrestal gingiva arasında oluşturulan boşluk, stabil bir kan pıhtısı oluşumuna müsaade etmelidir. Maturasyondan sonra yumuşak doku ve kemik gelişimi meydana gelir. Stabil bir pıhtılaşma elde edememe veya rejeneratif boşluğu koruyamama, yumuşak doku çökmesine ve yetersiz hacime sebep olabilir.

İstenilen yumuşak doku profilini oluşturmak için, immediat restorasyonun transgingival bölgesi şu kurallara göre hazırlanmalıdır:

-Mevcut dişeti marjinini ve papilla yüksekliğini destekleyen kritik bir kontur oluşturulmalıdır. Orijinal dişeti çizgisi palatal ve interproksimal olarak korunurken, iyileşme sürecinden sonra gingival marjının hafif koronale kaymasını desteklemek için geçici restorasyonun kritik konturu fasiyal yüzden 0,5 ila 1 mm arasında kısaltılabilir.

-Pıhtı ve greft materyalinin alveolar kemiği stabil hale getirmesi ve yeniden yapılandırması için alan sağlamak üzere subkritik kontur içbükey olarak şekillendirilmelidir.

-Pürüzsüz olarak hazırlanan bir yüzey, yumuşak bir geçiş sağlayarak iyileşme esnasındaki kontaminasyon riskini azaltır. Geçici restorasyonun yeterli boyutlarda olması, optimal bir sonuç elde etmek için önemlidir. Peri-implant bağ dokusu için ihtiyaç duyulan alan ile pürüzsüz bir subkritik kontur oluşturma arasındaki dengeyi sağlamak genellikle kolay değildir; protez tasarımının potansiyel konfigürasyonu üzerindeki etkileri nedeniyle implantın buccal ve lingual pozisyonu, derinliği ve platform yüksekliği dikkatli bir şekilde değerlendirilmelidir.

Pratik bir bakış açısıyla geçici restorasyon; hastanın kendi anatomik kronunu kompozit rezin ile modifiye edip, akışkan rezin aracılığıyla vidalı geçici abutmente bağlayarak imal edilebilir. Çekilecek dişin konik ışınlı bilgisayarlı tomografi profiliyle eşleşen bir rezin kron veya CAD/CAM ile üretilmiş polimetilmetakrilat kron da yararlı alternatifler olabilir.[17]

Sert ve Yumuşak Doku Maturasyonundan Sonra Yapılan Geçici Restorasyon

Osseointegrasyon ve yumuşak doku iyileşmesinin ardından, implantı çevreleyen yumuşak doku değerlendirilir. Yaygın olarak dört senaryo ile karşılaşılır:

- Koronale doğru aşırı artmış bir yumuşak doku kret profili,
- Doğal dişlere yakın İdeal bir yumuşak doku kret profili,
- 1,5 ila 2 mm'den daha az horizontal kayba sahip yetersiz bir yumuşak doku kret profili,
- Daha belirgin kontur tutarsızlığı olan yetersiz bir yumuşak doku kret profili

Geçici restorasyon yardımıyla yapılan yumuşak doku şekillendirmesi ilk iki durumda optimal bir restorasyona izin verebilir.

Günümüzde yumuşak doku şekillendirilmesinde kulanılan "dinamik bası tekniği"dişetine baskı uygulayarak sıkıştırılmasına dayanan bir yöntemdir.[27,28] Bu teknikte mesial ve distal bölgelerde hafifçe fazla konturlanmış okluzal vidalı geçici restorasyon yerleştirilir ve mukozayı oluşturmak için basınç uygulanır. Şekil ve kontur özelleştirilerek peri-implant çevresi iyileştirilir ve dişeti çıkış profili oluşturulur. Komşu diş ile implant kronu arasında interproksimal bir temas alanının varlığı önemlidir. Yerleştirilmede mukoza üzerine uygulanan basınca ilk reaksiyon iskemik tiptedir ve peri-implant yumuşak dokunun beyazlatılmasına neden olur ki bu sadece orta derecede olmalıdır ve 15 dakika içinde kaybolmalıdır. Bu reaksiyonu kontrol etmek için komşu dişlerin mesiodistal genişliğinin yarısına kadar sınırlamak esastır. Doku hasarını ve nihayetinde nekrozu önlemek için randevu esnasında bu iskemik reaksiyon ortadan kalkıncaya kadar beklenmesi tavsiye edilir, bu da spesifik bölgede periferal kan perfüzyonunun yeniden sağlandığını gösterir.

Şekillendirme sürecinde ilk adım olarak fasiyal kritik kontur belirlenmelidir. Fasiyal yumuşak doku marjininin ideal seviyesinden daha koronalde olduğu durumlarda; dişeti sınırını apikalde yeniden konumlandırmak için geçici restorasyonun kritik konturu, fasiyal / apikal yönde fazla şekillendirilebilir.

İdeal bir kret varlığında gingival marjinin yüksekliğini değiştirilmesi gerekmediğinden, kritik kontur doğal dişle uyumlu bir şekilde oluşturulabilir. Yumuşak doku marjinin yumuşak dokudan daha apikalde bulunduğu yetersiz bir yumuşak doku kreti olması durumunda, dişeti sınırının koronale doğru yer değiştirmesine izin verebileceğinden, geçici restorasyonun fasiyal kritik konturu daha az şekillendirilebilir.

Benzer şekilde, bir bağ dokusu greftiyle beraber geçici restorasyonu yerleştirerek; yetersiz dişeti sınırı telafi edilmeye çalışıldığında, fasiyaldeki kritik konturun azaltılması, baskı olmadan yumuşak dokuya yer sağlama açısından önemli olacaktır. Palatinal ve interproksimal kritik

konturlar, yumuşak doku yetersiz olmadığı zaman doğal dişi taklit etmelidir. Papillada yükseklik kaybının telafi edilmesi gerektiğinde, papillanın koronale yer değiştirmesini sağlamak için kritik konturda ilave bir artış yapılabilir. Bu sayede doğal olarak oluşan temas noktaları ve daha kare bir diş şekli yerine daha uzun interproksimal temaslar oluşturulabilir. Yumuşak doku kret profilinin aşırı arttığı veya ideal olduğu durumlarda fasiyal subkritik kontur düz yada içbükey olacaktır. Böylece gereksiz yumuşak doku baskısı önlenmiş olur. Öte yandan, küçük/ orta dereceli kret içbükeyliğinin üçüncü senaryosunda, yumuşak doku yetersizliğinin protetik yönden telafi edilmesinin sadece subkritik konturun fasiyal dışbükeyliğini arttırmakla sınırlı olduğu göz önüne alınabilir. Bu telafi, daha uygun final estetik için implant üstü restorasyonda şekil değişikliği yapmadan yumuşak doku profilini geliştirebilir. Dışbükeyliği daha fazla olan bir subkritik profil, diş eti sınırından apikale kadar yumuşak dokuların desteklenmesine yardımcı olur ve fasiyal dişeti etrafındaki gölgeleme etkilerini azaltabilir. Papilla yüksekliği kaybedildiği zaman, interproksimal olarak subkritik kontur da değiştirilebilir. Bu yöntem, geçici restorasyonun bitişik interproksimal alveolar kemiğe değmesini önlemek için 2 ila 3 mm interdental boşluğun varlığında düşünülebilir. Subkritik konturun dışbükeyliğini artırmak, interdental papillayı sıkıştırabilir ve yüksekliğini 0,5 ila 1,0 mm artırabilir.[17]

Hedefler; 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.[4]

Dişeti şekillendirilmesinde kullanılan geçici restorasyonların yapımıyla alakalı farklı seçenekler bunulmaktadır. Bichacho ve Landsberg, marjinal yumuşak doku seviyesi ve fasial zenith noktasına odaklanarak implantların çevresindeki yumuşak dokuyu yeniden şekillendirmek için kişiye özel hazırlanan bir geçici restorasyon kullanan servikal şekillendirme yönteminin kullanılmasını tavsiye etmiştir.[29] Rompen ve arkadaşları, dişeti çekilmesini azaltmak için içbükey bir transmukozal profilin kullanılmasını savunmuştur.[30]

Su ve arkadaşları, implant çevresindeki gingival dokuların abutment/ kron kontur modifikasyonlarına tepkisine dayanarak transgingival alanda kritik ve subkritik konturlar olmak üzere iki farklı bölge tanımlamıştır. Subkritik kontur implant çevresindeki mukoza desteğini ve diş eti rengini etkilerken, kritik kontur dişetinin seviyesini ve apikaldeki konumunu etkiler. Kritik konturun koronale yada apikale yer değiştirmesi, subkritik konturun uzunluğunu etkileyeceğinden iki bölge birbirine bağlıdır.[31]

Subkritik ve kritik kontur kavramlarının faydasına rağmen, geçici restorasyonla dişeti şekillendirmesinin nasıl yapılacağına dair ayrıntılı literatür azdır. İmmediat yüklemelerde geçici restorasyon yumuşak doku mimarisini desteklemeyi amaçlamaktadır. Gecikmeli yüklemelerde ise amaç genellikle yumuşak dokulara baskı uygulamak ve diş eti çıkış profilinin optimize edilebilmesi için yeniden şekillenmesine rehberlik etmektir. Üç boyutlu implant pozisyonuna, yumuşak dokuların klinik boyutlarına ve yerleştirme zamanına bağlı olarak geçici restorasyonlar farklı şekiller gerektirebilir.[17]

SONUÇ

İmplant uygulamaları hekim ve hastalar tarafından sıklıkla tercih edilmeye başlanan tedavilerden biri olmuştur. Diş çekimi sonrası önemli miktarda yumuşak ve sert doku rezorpsiyonu nedeniyle, hastanın estetik beklentilerini karşılayan ideal bir anterior implant estetiği elde etmek zor olmaktadır.

Literatürde implantlar ile doğal dişler arasında farklı anatomik yapılar olduğunu göstermektedir. Bu nedenle estetik açıdan başarılı bir implant restorasyonu elde etmek daha fazla klinik ve teknik bir bakış açısı gerektirmektedir.[32]

Günümüzde geçici restorasyonun kullanımı, klinik uygulamada doğal görünümlü implant destekli bir restorasyon oluşturmanın kabul edilmiş bir yöntemidir.

Başarısız bir restorasyon yapımı nedeniyle dental implantların başarılı bir şekilde osseointegrasyonuna rağmen implant restorasyonlarının estetik sonuçlarından ödün verilmektedir. Bir implant restorasyonu, biyolojik olarak yönlendirilmiş bir implant cerrahisine, estetik bir proteze ve çevreleyen peri-implant yumuşak doku mimarisine bağlamaktadır.

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Skeletal Transversal Expansion Using Modified RME Appliance in Adult Patient

Yetişkin Hastada Modifiye RME Apareyi Kullanılarak İskeletsel Transversal Genişletme

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ABSTRACT

In this study, rapid maxillary expansion without corticotomy with the use of a miniscrew-supported appliance in an adult patient is presented. As a result of the clinical examination of an 18-year-old Caucasian female patient, she had a bilateral posterior crossbite. The upper midline was coincident with the facial midline, whereas there was a deviation to the right in the lower midline. Angle's Class II molar relationship on the right and Angle's Class I on the left were observed. Arch-length deficiency values were -2 mm in the upper and -3 mm in the lower. Overjet was 7.5 mm and overbite was 0 mm. It was determined by the hand-wrist radiograph that the patient's growth was ceased. It was planned to expand maxilla non-surgically prior to any other orthodontic interventions. After 55 quarter-turns of activation the appliance was left in mouth passively for 3 months. Her fixed treatment is continuing. With RME SNB angle did not change and SNA angle increased by approximately 1 degree. 1-SN decreased by approximately 6 and IMPA by 1 degrees. Inclinations of the upper first molar teeth were not significantly changed as confirmed by postero-anterior radiograph. Overjet increased from 7.5 to 9 mm while the amount of overbite remained as 0 mm. It was determined by the model analysis that the increase in intermolar was 6.18 mm and intercanine widths was 5.21 mm. There was no significant change in lower teeth in model measurements. It is seen that the presented appliance can achieve sutural expansion without any corticotomy in adult patients.

Key Words: Modified RME, Appliance, Adult patient, Corticotomy, MARPE

ÖZ

Bu çalışmada, yetişkin bir hastada mini vida destekli aparey kullanımı ile kortikotomi olmaksızın hızlı maksiller ekspansiyon sunulmuştur. On sekiz yaşındaki kafkas kadın hastanın klinik muayenesinde bilateral posterior çapraz kapanışa sahip olduğu görüldü. Üst orta hat yüz orta hattı ile aynı hizada iken alt orta hatta sağa doğru bir sapma mevcuttu. Sağda Angle Sınıf II, solda Angle Sınıf I molar ilişki gözlendi. Üst çenede -2 mm ve alt çenede -3 mm yer ihtiyacı olduğu tespit edildi. Overjet 7,5 mm ve overbite 0 mm idi. El-bilek radyografisi ile hastanın büyümesinin sona erdiği tespit edildi. Diğer ortodontik müdahalelerden önce cerrahi olmayan bir şekilde maksilla genişletilmesi planlandı. 55 çeyrek tur aktivasyondan sonra aparey 3 ay pasif olarak ağızda bırakıldı. Hastanın sabit tedavisi devam etmektedir. RME ile SNB açısı değişmedi ve SNA açısı yaklaşık 1 derece arttı. 1-SN yaklaşık 6, IMPA ise 1 derece azaldı. Üst birinci molar dişlerin eğimleri, postero-anterior radyografiyle doğrulandığı gibi önemli ölçüde değişmedi. Overjet 7,5 mm'den 9 mm'ye çıkarken overbite miktarı 0 mm'de kaldı. Molarlar arası artışın 6,18 mm, kaninler arası genişliklerin ise 5,21 mm olduğu model analizi ile belirlendi. Model ölçülerinde alt dişlerde anlamlı bir değişiklik görülmedi. Sunulan apareyin yetişkin hastalarda herhangi bir kortikotomi gerekmeden sütür genişlemesini sağlayabildiği görülmektedir.

Anahtar Kelimeler: Modifiye RME, Cihaz, Erişkin hasta, Kortikotomi, MARPE

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INTRODUCTION

One of the most common orthodontic problems is maxillary transversal constriction.[1] This constriction has both skeletal and dental manifestations. It has been reported in scientific studies that maxillary constriction may be caused by several reasons and it has been treated by different methods such as slow expansion, rapid expansion, semi-rapid expansion, surgically assisted rapid expansion (SARME) and surgical expansion, which are applied according to individual case needs.[2]

Tooth-borne (Hyrax) and tooth- tissue –borne (Haas) appliances and their modifications have been widely used for maxillary expansion. During expansion, different screw activation protocols have been suggested in the literature and discussions on this issue have been continuing.[3,4]

Studies[5-8] have reported that conventional rapid maxillary expansion (RME) may be hazardous especially to the supporting teeth. Researc- hers[9] recommend corticotomy in order to overcome the resistance of bony structures in adult patients. However, this can cause extra costs and traumatic procedures for the patient. In an attempt to avoid surgery and reduce or eliminate complications, skeletal anchorage units have recently started to be used for maxillary expansion by orthodontists and a few appliances have already been presented.[10] However, some of these are also supported by teeth additionally and the other choices require some special expansion screws and attachments. This case report presents a simple, cost-effective and totally bone-tissue supported maxillary expansion appliance in an adult patient.

CASE PRESENTATION

The patient (18-year-old, Caucasian, female) was referred to our faculty due to maxillary constriction. As a result of her clinical examination, the presence of mouth breathing and nail biting habits were detected. Clinical observations showed that she had a symmetrical facial structure and a convex profile. The upper midline was coincident with the facial midline, whereas the lower midline was deviated to the right relative to the face. Angle's Class II molar relationship on the right and Angle's Class I on the left were observed. The patient had bilateral posterior crossbite as seen from the initial diagnostic records (Figure 1). Arch-length deficiency values were -2 mm in the upper and -3 mm in the lower. Overjet was 7.5 mm, and overbite was 0 mm. With the help of the hand-wrist radiograph it was detected that the patient had reached skeletal maturity. Lateral and postero-anterior cephalometric films were analyzed with Dolphin Imaging 11.8 Premium Software program (Dolphin Imaging, Chatsworth, CA, U.S.A.). Diagnostic radiographs are shown in Figure 2. Digital intraoral models and their analyzes were done by using 3Shape Trios 3 Cart (3Shape, Copenhagen, Denmark). The pre and post models and expansion measurements are shown in Figure 3.

Treatment goals set for the patient after clinical examination and analyzes were: first correction of the transversal constriction in the upper jaw, second bringing the teeth to their ideal positions and then optimizing the relationship between jaws. As treatment alternatives: since it was estimated that the amount of maxillary lateral deficiency was beyond the limits of dental expansion and considering the maturation of the patient, rapid maxillary expansion with surgical assistance was planned. However, the patient and her parents were quite concerned about the surgery and asked for a more conservative choice. Therefore it was decided to attempt maxillary expansion with a bone borne appliance[11] and avoid any potential hazardous effects on maxillary premolar and molar teeth. After the treatment method was explained to the patient, informed consent was obtained and the treatment phase was started.

Figure 1. Initial Diagnostic Records.

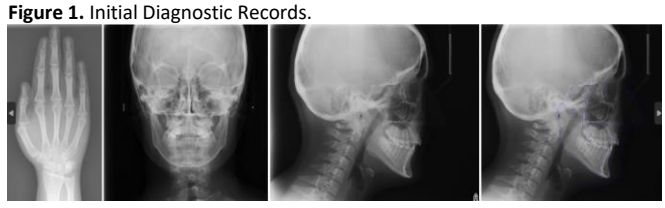
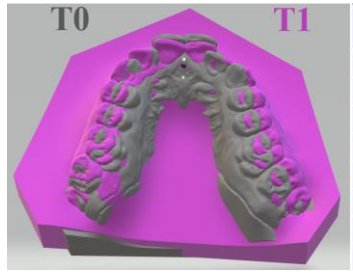


Figure 2. Pre-treatment radiographs.



Model analysis transversal change	Before Treatment	After RME	Difference
UR3 – UL3 (mm)	30.82	36.03	5.21
UR4 – UL4 (mm)	35.54	42.75	7.21
UR5 – UL5 (mm)	39.87	46.43	6.56
UR6 – UL6 (mm)	45.34	51.52	6.18
LR3 – LL3 (mm)	25.88	25.50	-0.33
LR4 – LL4 (mm)	32.76	32.71	-0.05
LR5 – LL5 (mm)	41.25	41.64	-0.39
LR6 – LL6 (mm)	47.36	47.76	-0.4

Figure 3. The pre and post models superimposition and expansion measurements.

Treatment Progress

1. Appliance preparation and application: Four mini screws (Lomas, 2x7 mm, Mondeal, Mühlheim, Germany) were applied to the palatal bone under local anesthesia between the patient's upper first and second premolars and between the upper second premolar and the first molar bilaterally with an angle of 90 degrees to the bone surface. The position of the screws relative to the teeth roots was evaluated by occlusal radiography (Figure 5). Then, a plaster model was obtained and a RME screw (Leone, catalog no: A0620-11, Florence, Italy) was placed on the model and integrated with the mini screws by acrylic resin. (Orthocryl, Dentaurum, Ispringen, Germany). After trimming and polishing, acrylic-coated expansion screw was attached to the miniscrews in the mouth with a sufficient amount of light cure composite resin bond (3M Unitek Transbond LR, Minnesota, USA). The appliance in situ is shown in Figure 4.
2. Activation of the appliance: The patient and her parents were instructed to activate the appliance one quarter-turn in the morning and the other in the evening. The patient was seen on the day of the 12th activation. Although the signs of sutural opening were observed on the occlusal radiograph (Figure 5.). A complete separation between the maxillary bones was not evident. As the

patient was almost an adult, she was told to activate the screw once daily after this control appointment to avoid any complications and the patient was called for control ten days later. In the second control, it was observed that there was a diastema between the central teeth of the patient. Occlusal radiography taken at that visit confirmed complete separation of the maxillary halves.

3. Completion of the activation protocol and consolidation: The RME screw was fixed after 55 turns and the appliance was left in mouth passively for 3 months. At the end of the consolidation period, clinical and radiological records were repeated (Figure 6-8.). Since the aforementioned RME appliance does not interfere with fixed appliances, it can also be left in the mouth as a retention appliance against late relapse. The patient's treatment continues in our clinic with fixed appliances.

Figure 4. RME appliance applied to the patient's mouth.

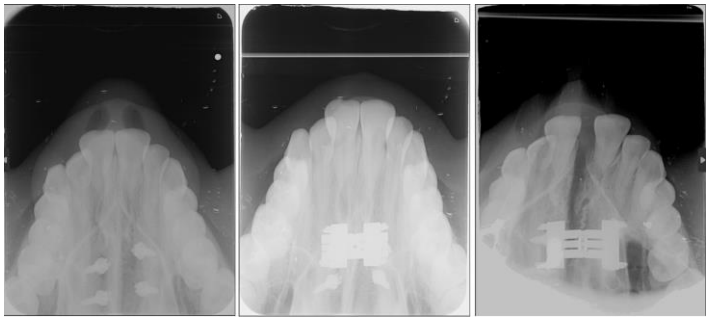


Figure 5. Occlusal radiography recordings taken from the patient.

Figure 6. Intraoral photographs at the end of consolidation.

Figure 7. Cephalometric radiographs at the end of consolidation

Cephalometric Analysis	Before Treatment	After RME
SNA (°)	69.5	70.3
SNB (°)	65.7	65.6
ANB (°)	3.8	4.7
SN - GoGn (°)	45.3	47.1
Mandibular Body Length (Go-Gn)(mm)	73.5	73.6
U1 - SN (°)	95.8	90.1
U1 - NA (°)	26.3	19.9
U1 - NA (mm)	2.9	2.9
L1 - NB (°)	13.9	13.6
L1 - NB (mm)	1.3	1.3
IMPA (L1-MP) (°)	80.0	79.3
Interincisal Angle (U1-L1) (°)	136.8	141.4
Pog - NB (mm)	5.8	5.8
Upper Lip to E-Plane (mm)	-10.3	-5.4
Lower Lip to E-Plane (mm)	-7.4	-6.1
UR6 - Midplane (°)	31.2	30.9
UL6 - Midplane (°)	19.9	20.6
AZ - ZA (mm)	129.6	129.7
JR - JL (mm)	62.4	64.7
UR6 - UL6 (mm)	45.5	51.9

Figure 8. Cephalometric analysis

DISCUSSION

RME is frequently used in the treatment of transversal maxillary deficiency. Although it has been suggested that the ideal age for this treatment is between 8 and 15 years old, many researchers recommends early intervention.[12] However, an increasing number of young adults and adults appear in the current orthodontic patient population. In order to avoid hazardous effects on supporting teeth, corticotomy is usually recommended to assist the expansion process in adult patients.[9] However, in our case an attempt was made to expand maxilla by a minicsrew-supported custom-made appliance without any surgical intervention or any tooth support. This partially tissue and mostly bone borne appliance was quite successful to separate median sutura and treat bilateral posterior cross bite in an adult patient. The appliance presented here technically resembles Transpalatal Distractor of Mommaerts, but it is less traumatic and easier to apply. This type of

appliance may also be the choice in younger patients with oligodontia and/or periodontally-compromised teeth. As it has nothing to do with teeth, presented appliance allows application of aligners or labial or lingual attachments, and beginning fixed orthodontic treatment during retention period. On the other hand, it does not interfere with effective mouth cleaning during the treatment process. Since any kind of jack screws can be integrated into the appliance and due to the simplicity in its design, production cost is reduced. Also the appliance can easily be produced with CAD-CAM systems eliminating laboratory stages.

Alveolar tipping[7,13], tipping and extrusion of maxillary posterior teeth[7,13], clockwise rotation and opening of the mandible[3,4,14], asymmetric expansion[8], dehiscence[5] and root resorption[15] have been mentioned among the side effects of tooth-borne and tooth-tissue-borne RME appliances. However, any type of detrimental effects on teeth seems unlikely with our bone-supported appliance. Furthermore, unlike tooth supported expanders, there was almost no molar tipping with the present appliance as measured on postero-anterior radiograph (Figure 8.). This effect may have resulted from the superior position of the screw which is closer to the median suture and rotation center of maxillary halves than tooth-borne appliances. As stated in previous studies[10] bone-supported appliances are more stable than dental-supported appliances and cause less dental side effects.

The form of sutural opening and skeletal effects of the presented appliance are comparable and similar to that of tooth-borne rapid maxillary expansion appliances (Figure 3,8).[4,7] On the other hand, additional cost of four titanium mini screws and mild gingival irritation under the acrylic part may be noted as the handicaps of the appliance. However, presented maxillary expander is promising overall and especially may be an alternative to SARME in adult patients.

CONCLUSION

In this case report, maxillary expansion was achieved by using a modified RME appliance that was designed to be supported by mini screws without corticotomy in an adult patient. The data (obtained) have shown that the appliance could effectively provide sutural expansion in adult patients without the aid of corticotomy. In addition, it can be an alternative to classical (conventional) RME appliances as it can be applied independently of the teeth.

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