e-ISSN: 2822-6755

Dicle Dental Journal

Volume: 25 Issue: 3 Year: 2024

The Official Journal of
Dicle University Faculty of Dentistry

https://dergipark.org.tr/tr/pub/dicledentj

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Dicle Dent J. 2024;25(3):69-72.

Determining the knowledge levels and opinions of high school students aged between 13-17 about fluoride in toothpastes

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Cite this article as: Akleyin E, Polat Y. Determining the knowledge levels and opinions of high school students aged between 13-17 about fluoride in toothpastes. *Dicle Dent J*. 2024;25(3):69-72.

Received: 20/07/2024 ◆ **Accepted**: 30/07/2024 ◆ **Published**: 19/09/2024

ABSTRACT

Aims: Fluorine, which has been proven to be effective in preventing dental caries, is applied systemically and topically as a public health method in children and adults. Toothpastes are the most common form of topical fluoridation. The aim of this study was to evaluate the level of knowledge of high school students aged 13-17 years about fluoridated toothpastes and the information sources from which they accessed this information.

Methods: A questionnaire prepared by us was administered to 750 volunteer high school students. In the questionnaire, demographic information, tooth brushing habits, knowledge and opinions about fluorine in toothpastes and the sources of this information were asked. In this study, percentage (%) and frequency (n) values were given as descriptive statistics.

Results: Of the 750 high school students who answered our questionnaire, 44% were female, 56% were male and the average age was 14.62 years. When the brushing habits of the students were analyzed; it was seen that 19% of them brush irregularly and 7% of them do not brush their teeth. About fluorine in toothpastes, 47% of the students had no information, 27% thought it prevented caries, 14% thought it was harmful, and 12% were undecided. When students were asked whether the toothpaste, they used to contain fluorine or not, 53% of them did not have any information, 37% of them had access to information from family and friends, 34% from dentists, 27% from social media, and 2% from school.

Conclusion: It was observed that high school students' tooth brushing habits were inadequate and their basic knowledge about fluoride applications was weak. Within the scope of community oral and dental health, it was thought that students should be informed about the caries preventive effect of fluoride at optimum intervals from accurate information sources such as dentists and schools.

Keywords: Fluorine, fluoridated toothpaste, high school students, toothpastes, tooth brushing habits

*This study was presented as an oral presentation at the 2nd International Congress on Health Research (ICOHER'22), held online from October 12-15, 2022.

INTRODUCTION

Oral and dental health is an important component of general health and plays a critical role in the protection of general health.[1] Dental caries, which affects 60-90% of children worldwide, is one of the most common chronic diseases in childhood.[2] In a study conducted on high school students in Turkiye, 44.86% of permanent first molars had caries and 7.92% were missing.[3] Öztürk and Sönmez[4] determined the rate of dental caries in the 15-year-old age group as 85.2%. Removal of microbial dental plaque is of great importance in the prevention of dental caries, especially in young individuals.[5] Plaque-inhibiting chemicals have been developed to support mechanical plaque control.[6]

Fluoride ion is one of these chemical substances and shows caries preventive effect by acting on the demineralization and remineralization balance of dental hard tissues. Fluoride, which has been proven to be caries preventive in teeth, is applied systemically and topically as a public health method in children and adults. Toothpastes are the most common form of topical fluoride application. The use of fluoridated toothpaste has been shown to reduce the increase in caries by approximately 25% compared to a toothpaste without fluorine. Excessive fluorine content in drinking water or ingestion of fluorine from toothpaste in young children without a swallowing reflex may cause fluorosis.[7-9] It has been

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reported that oral health of children is affected by individual, family and community levels.[10] Therefore, considering that determining the basic knowledge of young individuals, whose level of awareness is gradually increasing, about dental fluoride applications is important for public health, this study aimed to examine the level of knowledge of high school students aged 13-17 years about fluoridated toothpastes and the sources of this information.

METHODS

The questionnaire questions prepared by us were applied individually face-to-face to 750 volunteer students studying at Diyarbakır Competition Authority Republic Science High School. The necessary the Dicle University Faculty of Dentistry Ethics Committee obtained for the study (Date: 28.09.2022, Decision No: 2022-38). All procedures were carried out in accordance with ethical rules and the principles of the Declaration of Helsinki. In this study, a cross-sectional survey consisting of questions whose reliability and validity have been proven in similar studies in the literature was administered.[1,17] Our questionnaire consisted of demographic information questions and questions to determine the level of knowledge and opinions about fluorine in toothpastes. Individuals who participated in the questionnaire were asked questions about demographic information (age and gender), tooth brushing habits, knowledge and opinions about fluorine in toothpastes, and sources of access to this information.

Statistical Analysis

In this study, frequency (n) and percentage (%) values were given as descriptive statistics. SPSS 20 (IBM Corp., Armonk, NY, USA) package programme was used for statistical analyses.

RESULTS

Of the 750 high school students who participated in our survey, 44% were female and 56% were male. The ages of the participants ranged between 13 and 17, with a mean age of 14.62 years. When the tooth brushing habits of the students were analysed, it was found that 47% of them brushed their teeth twice a day (morning and evening), 27% brushed their teeth once a day regularly, 19% brushed irregularly and 7% never brushed their teeth (Table 1). It was determined that 47% of the students had no information about fluorine in toothpastes, 27% thought that fluorine prevented caries, 14% thought that fluorine was harmful and 12% were undecided (Table 2). When asked whether toothpastes contain fluorine or not, 53% of the students stated that they had no information on this subject, 35% stated that they used fluoridated toothpaste and 12% stated that they used fluorine-free toothpaste (Table 3). When the sources of information about the content and effects of toothpaste were evaluated, 37% obtained information from family and friends, 34% from dentists, 27% from social media and 2% from school (Table 4).

Table 1. Frequency of tooth brushing in students

Brushing frequency	Number	Percentage (%)
Twice a day (morning/evening)	353	47
Regular once a day	203	27
Irregular	143	19
No brushing	53	7

Table 2. Students' thoughts about fluoride

Thought about flor	Number	Percentage (%)
No information	353	47
He thinks it is harmful	105	14
I think it prevents caries	203	27
Undecided	90	12

Table 3. Thoughts on the content of the toothpaste used

Toothpaste content	Number	Percentage (%)
No information	393	53
Fluoride	263	35
Fluoride free	90	12

Table 4. Sources of information about toothpaste ingredients for students

Source of information	Number	Percentage (%)
Family and friend circle	278	37
Dentist	255	34
Social media	203	27
School	15	2

DISCUSSION

Today, toothpastes are the most accessible and widely used plaque preventive agents.[11] Fluoride is one of the most commonly added therapeutic agents to toothpastes, and the main effect of fluoride toothpastes is to prevent caries.[12]

In a study conducted with Iranian students aged 13-16 years, 79.7% of the participants reported brushing their teeth at least once a day, while 14.8% reported brushing their teeth twice a day.[13] Kocaoğlu et al.[14] conducted a study with 151 students aged 7-15 years and reported that 66.9% of the students did not have tooth brushing habits and 35.8% did not own a toothbrush. In a study conducted in a private school in Diyarbakır province, the caries rate of children in high school was found to be 37.8%. Brushing habits were found to be 54.3% twice a day and 34.4% once a day.[15] In our study, when the tooth brushing habits of the students were analysed, it was found that 47% brushed their teeth regularly twice a day (morning and evening), 27% brushed their teeth once a day, 19% brushed their teeth irregularly and 7% did not brush their teeth at all. In our study, tooth brushing habits, which are affected by socioeconomic status and many environmental factors, were thought to be inadequate similar to other studies.

Mechanical removal of dental plaque by tooth brushing with fluoridated toothpastes and other supportive methods is the

most widely recommended method worldwide for plaque control and prevention of dental caries.[16] When Iranian students aged 13-16 years were asked what is the importance of fluoride in toothpaste, 59.03% answered that it strengthens teeth.[13] In a study of 718 Romanian students with an average age of 14.54 years, 20.47% stated that fluoride in toothpaste can remineralize hard tooth tissue.[17] In a survey conducted on adults in Konya province, it was reported that 40% chose toothpaste unconsciously, 16% thought that fluoride-containing toothpastes were effective in preventing caries, and the opinion that fluoride-containing toothpastes were toxic/harmful increased with the increase in the educational status of the individual.[7] According to the results of the survey we applied to young individuals, it was determined that 53% chose toothpaste unconsciously, 27% thought that fluoride had a caries-preventive effect, and 14% thought that it was harmful. According to the results of the study, it was observed that the level of awareness about fluoride was insufficient in young individuals, similar to adults.

In a study conducted in Bangladesh, it was reported that 35% of the participants obtained information about fluoride from family and friends, 25% from dentists, 20% from school, 15% from social media and the internet, and 5% from textbooks and educational materials.[1] Ak et al.[7] and Ota et al.[18] reported that parents accessed information about fluoride more through social media and the internet. In our study, it was determined that young individuals obtained information about dental fluoride from family and environment, and the importance of educating parents on this issue was understood. Since our study was cross-sectional, participation was based on the availability and willingness of volunteers. Access to only one high school in the city limited our ability to reach a wider participant population.

CONCLUSION

This study revealed that students' knowledge and performance regarding the use of fluoride-containing toothpaste was inadequate and that they did not act consciously in their choice of toothpaste. Within the scope of oral and dental health of the society, it is thought that students should be told about the caries preventive effect of fluoride at optimum levels from reliable information sources such as dentists and schools.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee obtained for the study (Date: 28.09.2022, Decision No: 2022-38).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Original Article

Dicle Dent J. 2024;25(3):73-78.

Evaluation of error types seen in digital panoramic radiographs

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Cite this article as: Kaplan B, Katı E. Evaluation of error types seen in digital panoramic radiographs. *Dicle Dent J*. 2024;25(3):73-78.

Received: 20/07/2024 ◆ **Accepted**: 11/09/2024 ◆ **Published**: 19/09/2024

ABSTRACT

Aims: This study aimed to assess the prevalence of different types of errors in panoramic radiography and explore potential correlations between these errors, age, and gender.

Methods: A total of 2000 panoramic radiographs randomly selected from the patient archives of the Department of Oral, Dental, and Maxillofacial Radiology at Dicle University Faculty of Dentistry, taken in 2023 for various indications, were analyzed. Two experienced radiologists (BK and EK) reviewed the digital panoramic X-ray images. Interobserver agreement was assessed by having both observers re-evaluate 10% of the sample. Patients with developmental anomalies, history of trauma, orthognathic surgery, maxillofacial pathology (e.g., tumors/cysts), and those under 16 years old were excluded. Statistical analyses were conducted using SPSS 20.0 software (IBM Corp., Armonk, NY, USA), with a significance level set at α=5%. Cohen's kappa statistics were utilized to calculate intraobserver agreement.

Results: In the analysis of 2000 panoramic radiographs, it was found that 81.16% exhibited at least one error. The predominant error identified was the misplacement of the tongue against the palate, accounting for 34.75% of cases. A statistically significant association was observed between increasing patient age and higher error rates ($p<0.05$). However, no significant correlation was found between gender and error occurrence ($p>0.05$).

Conclusion: The prevalence of positioning errors in panoramic radiography is considerable. It underscores the importance of providing adequate training to healthcare professionals and technicians to mitigate the risk of misinterpretation and unnecessary exposure to radiation.

Keywords: Patient positioning, diagnostic errors, panoramic radiography

INTRODUCTION

Panoramic radiography is a simple and useful method that shows the maxillomandibular structures and adjacent structures on a single film.[1-4] The technique of panoramic radiography is a curvilinear variant of conventional tomography, which works on the principle of an image receiver with a reciprocally moving x-ray source located around a central point or plane in the image layer. The image layer is a three-dimensional "focal trough" in which the dentition and associated structures must be positioned. Images of structures outside the focal trough are observed as blurred, magnified and distorted.[5,6] Various studies have shown that a significant portion of panoramic radiographs are of non-diagnostic quality.[7-12]

The most important disadvantages of panoramic radiographs are low resolution, low detail, distortion, and unequal magnifications compared to the images obtained from intraoral radiographs, making measurements unreliable and evaluations inaccurate due to superpositions.[3] Low-quality radiographs may lead to misinterpretation and may cause incorrect diagnosis and treatment planning.[7,13-15] Therefore, when obtaining panoramic radiographs, the imaged structure should be of high quality and with minimal distortion.

Errors that frequently occur in the production of panoramic radiographs are technical errors or errors that occur during patient positioning.[16] Some radiopaque and radiolucent images may occur as a result of errors occurring in panoramic radiographs. In addition to the shadows of some soft tissues and anatomical air spaces, foreign body images and ghost images may occur due to errors made during patient positioning and preparation in the examined areas.[17] The use

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of digital imaging leads to the elimination of processing errors, allowing the technician or dentist to focus on patient and technician errors to obtain more accurate and diagnostically acceptable images.[12,17] Dentists need to prevent unnecessary radiation exposure by knowing the errors and their causes.[18]

The aim of this study was to evaluate the distribution of the types of errors encountered in panoramic imaging by age and gender and to evaluate the image quality of panoramic radiographs. We believe that this information will increase the awareness of both physicians and technicians to improve image quality by revealing the common causes of errors.

METHODS

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee (Date: 31.01.2024, Decision No: 2024-03). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In this study, 2000 images randomly selected from the archive of patients who were examined in Dicle University Faculty of Dentistry, Department of Oral and Maxillofacial Radiology in 2023 and whose panoramic radiographs were taken for various reasons were evaluated. All the images obtained using Planmeca ProMax (Planmeca ProMax, Helsinki, Finland) and Midmark Vantage, (Midmark, Ohio, USA) digital panoramic X-ray machines in standard acquisition mode (66 kV, 6 mA, 16 s). All panoramic imaging was conducted by the same eight operators.

The images were examined by two expert radiologists, BK and EK, who had 9 and 12 years of experience, respectively. To determine inter-observer agreement, 10% of the study population was re-evaluated by both observers. Since the agreement between the observers was "very good agreement" for error number 9 and "almost perfect agreement" for the other error types, only one observer's (BK) assessment was used for further statistical evaluations.

Radiographs of patients with developmental anomalies, history of trauma, history of orthognathic surgery or pathology such as tumors/cysts in the maxillofacial region and patients under 16 years of age were not included in the study. Relevant data was supplied by the Metasoft program, which maintains the medical history and radiological information of patients at our clinic. The age and gender of the patients were recorded and the distribution of acquisition errors according to different age groups (16-18, 19-24, 25-34, 35-44, 45-54, 55-64, 65 and over) was analyzed. In line with previous studies, we evaluated the quality of panoramic films into three distinct categories (acceptable, unacceptable, and perfect) based on the number and type of errors.[7,17]

Perfect

There are no errors that affect the radiograph's diagnostic ability.

Acceptable

The radiograph has one or more errors that make it less diagnostic.

Unacceptable

The radiographs are undiagnosable due to errors.

Radiographs were evaluated according to the following 10 general error categories:

- Error 1. The patient tilts his head forward: "V" shaped smile line, incision of the symphysis on radiograph, distortion of the anterior teeth
- Error 2. The patient tilts his head back: Flattened occlusal plane, distortion of the mandible, superposition of the radiopaque image of the hard palate on the upper tooth roots
- Error 3. The patient shifts the head to one side: Reduction in the image on the side the head is turned and enlargement on the opposite side
- Error 4. Patient not standing upright: Superposition of the radiopaque shadow of the cervical vertebrae on the mandibular symphysis
- Error 5. Patient's tongue positioning error: Radiolucent area superimposed on the apex of the maxillary teeth due to palatoglossal airspace caused by the tongue dorsum not touching the palate
- Error 6. Patient movement: Blurred and erroneous image
- Error 7. Foreign bodies: Images that can obscure normal anatomy or pathology, causing both a radiopaque image and a ghost image contralaterally on the panoramic radiograph
- Error 8. Lack of image: Structures such as condyle, mandibular corpus, maxillary sinus not included in the image
- Error 9. The patient tilts the head to one side: The image will be tilted; one angle of the mandible is higher than the other, the condyles are not of equal height.
- Error 10. Lip positioning error: Radiolucent area in the anterior regions due to the patient not keeping the lip closed (Figure 1-9).

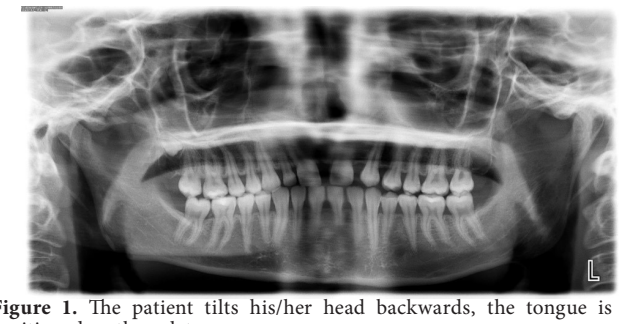

Figure 1. The patient tilts his/her head backwards, the tongue is not positioned on the palate

Figure 2. The patient is not standing upright, the tongue is not positioned correctly

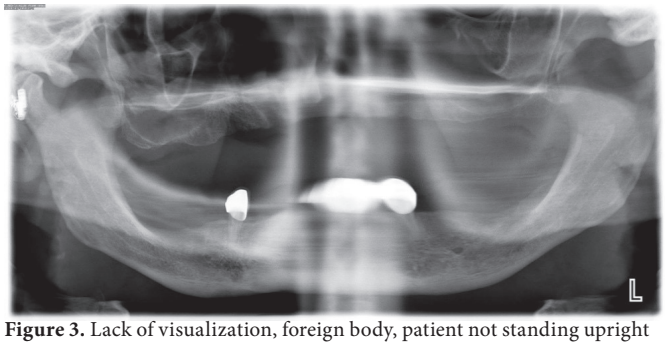

Figure 3. Lack of visualization, foreign body, patient not standing upright

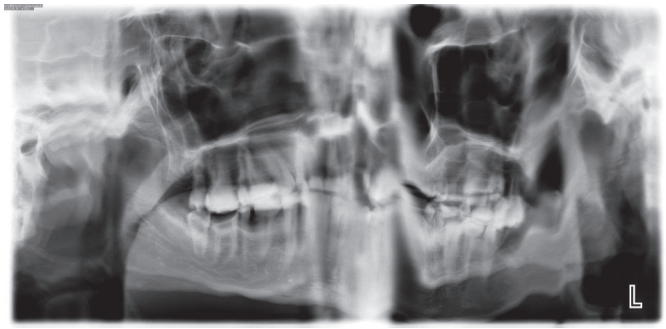

Figure 4. Patient movement

Figure 5. The patient shifts his head to the right side

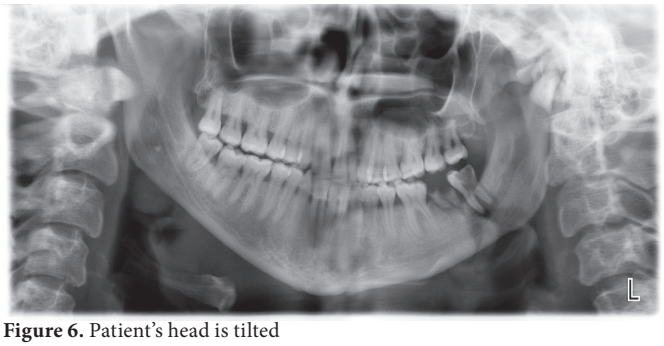

Figure 6. Patient's head is tilted

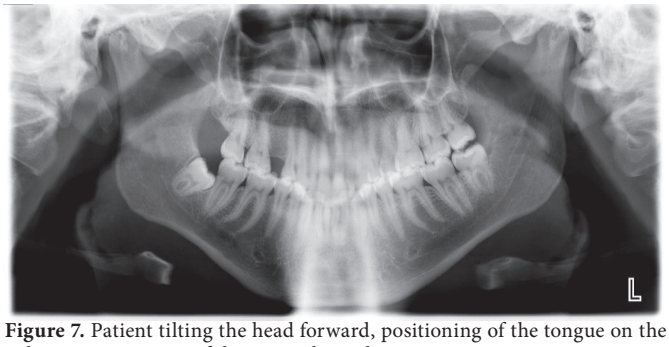

Figure 7. Patient tilting the head forward, positioning of the tongue on the palate, superposition of the cervical vertebrae

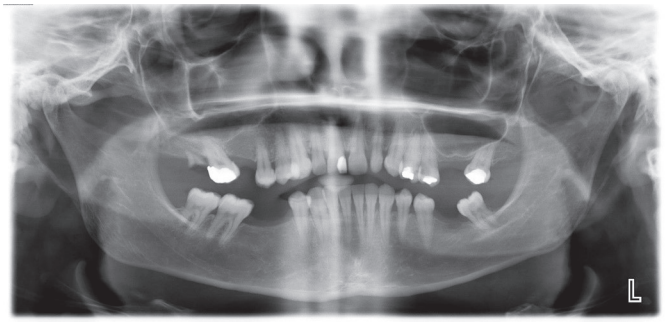

Figure 8. Lip positioning error

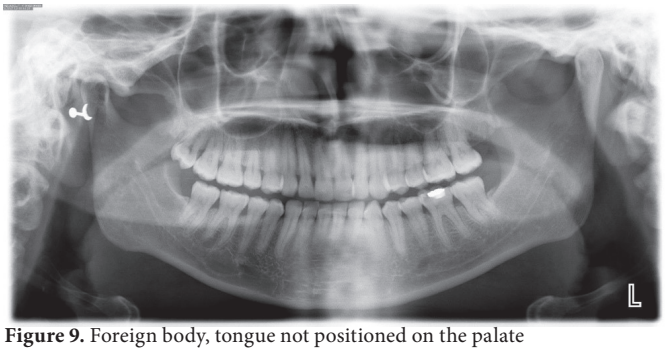

Figure 9. Foreign body, tongue not positioned on the palate

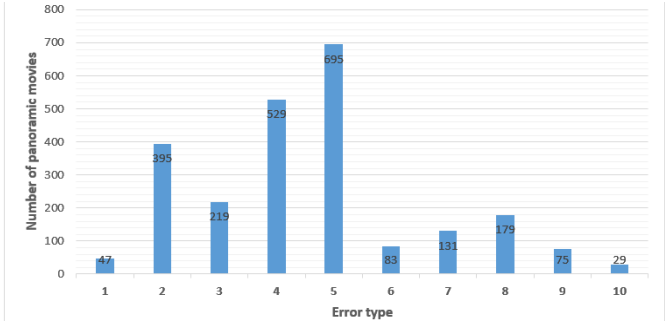

Figure 10. Visualization of the distribution of error types in the presence of errors

Statistical Analysis

Cohen's Kappa test was used to determine the inter-observer agreement. Chi-square test, Cochran-Q test and McNemar test for pairwise comparisons of error types were used to determine whether there were significant differences between error types. Pearson R values were used for correlation analysis. All analyses were performed using SPSS 20.0 software (IBM Corp., Armonk, NY, USA). The significance level was set at α=5%. Intraobserver agreement was calculated using Cohen's Kappa statistics.

RESULTS

A total of 2,000 panoramic X-rays, 881 of which belonged to male patients and 1,119 to female patients, were included in this study. The mean age of the women was 34.70 years, while the mean age of the men was 35.88 years. Kappa test results showed that there was no statistically significant difference in the observed values between the examiners in the scoring of error 1, error 2, error 3, error 4, error 5, error 6, error 7, error 8, error 9, error 10 (Cohen kappa value=1.000, 0.932, 0.834, 0.883, 0.951, 1.000, 0.957, 0.935, 0.793, 1.000).

In Table 1, there is a significant proportional difference between age categories (p<0.001). The error rate in the 45-54 and 65+ age groups was significantly higher than in the 19-24 and 25-34 age groups (p<0.05). There was no difference between the groups in terms of the error rate in panoramic films taken in the 16-18, 35-44 and 55-64 age groups (p>0.05).

Table 1. Distribution of the presence/absence of errors according to ages

	16-18 a, b, c, d	19-24 d, e	25-34 c, e	35-44 b, c, d, e	45-54 a, b	55-64 a, b, c, d, e	>65 a	Total
Error								
No	24 (17.9)	84 (21.2)	131 (20.5)	71 (20.6)	29 (11.4)	27 (16.4)	2 (3)	368 (18.4)
Yes	110 (82.1)	313 (78.8)	507 (79.5)	273 (79.4)	226 (88.6)	138 (83.6)	65 (97)	1632 (81.6)
Total	134 (100)	397 (100)	638 (100)	344 (100)	255 (100)	165 (100)	67 (100)	2000 (100)

*Pearson chi-square test, *There is no significant difference between age groups with the same letter

Table 2 shows the distribution of the acceptability of panoramic films according to the presence/absence of defects. There is a strong negative correlation between the presence of defects and acceptability (pearson r=-0.801). Accordingly, acceptability decreased significantly as the presence of defects increased (p<0.001).

Table 2. Distribution of acceptability by presence/absence of error

	Acceptability			
Eror	**Acceptable**	**Unacceptable**	**Flawless**	**Total**
No	0 (0)	0 (0)	368 (100)	368 (100)
Yes	900 (55.1)	732 (44.9)	0 (0)	1632 (100)
Total	900 (45.0)	732 (36.6)	368 (18.4)	2000 (100)

*Chi-square

Table 3 shows the acceptability of panoramic films according to gender. No correlation was found between gender and acceptability (p>0.05).

Table 3. Acceptability of panoramic films by gender

	Acceptability			
Gender	**Acceptable**		**Flawless**	**Total**
Woman	383 (43.5)	367 (41.7)	131 (14.9)	881 (100)
Male	517 (46.2)	365 (32.6)	237 (21.2)	1119 (100)
Total	900 (45.0)	732 (36.6)	368 (18.4)	2000 (100)

*Chi-square

Figure 10 and Table 4 show the distribution of the number of X-rays according to error types. There is a significant difference according to the distribution of error types (p<0.001). The number of panoramic X-rays with error 5 was the highest, followed by error 4, errors 2 and 3 (p<0.05).

Table 5 shows the distribution of acceptability according to the number of errors. The relationship between the number of errors and acceptability was analyzed and η=0.383 was obtained when acceptability was taken as the dependent variable. The increase in the number of errors has a great effect on acceptability.

Table 4. Distribution of faulty panoramic radiographs according to error types

Error type	n (%)
Error 1	47 (2.35)^{gh}
Error 2	395 (19.75)^{c}
Error 3	219 (10.95)^{d}
Error 4	530 (26.45)^{b}
Error 5	695 (34.75)^{a}
Error 6	83 (4.15)^{fh}
Error 7	132 (6.55)^{ef}
Error 8	179 (8.95)^{de}
Error 9	76 (3.75)^{fgh}
Error 10	29 (1.45)^{h}
Total	2000 (100)

Cochran Q a-h: There is no significant difference between values with the same letter (p>0.05)

Table 5. Distribution of acceptability by number of errors

	Acceptability		
Eror	**Acceptable**	**Unacceptable**	**Total**
One mistake	690 (69.1)	309 (30.9)	999 (100)
Two errors	203 (38.7)	321 (61.3)	524 (100)
Three and four errors	7 (6.4)	102 (93.6)	109 (100)
Total	900 (55.1)	732 (44.9)	1632 (100)

*Chi-square

DISCUSSION

In our study, we aimed to determine the prevalence of ten different errors in panoramic radiographs obtained in our faculty and to classify their image quality as "perfect", "acceptable" and "unacceptable".

Paying attention to some issues while taking radiographs ensures an accurate radiograph. These parameters include bilateral symmetry, occlusal plane with a slight upper concavity, localization of the two mandibular condyles at the same height, clear visualization of the tooth apices of the upper teeth, flat position of the cervical spine, correct adjustment of tube voltage, current and exposure time.[18] In order for the diagnostic quality of panoramic radiography to be adequate, attention should be paid to the correct preparation and positioning of the patient.[2,19] Errors in the radiographic image lead to a decrease in diagnostic benefits, in some cases to repeat imaging and thus to unnecessary radiation exposure of the patient.[20] In this study, only 18.4% of the panoramic radiographs evaluated were free of errors, while 81.16% had at least one error.

Upper jaw periapical tissues cannot be clearly observed due to the radiolucent band formed at the level of the apex of the maxillary teeth as a result of incomplete positioning of the tongue ridge on the palate.[8,21] Due to improper positioning of the cervical vertebrae, the radiopaque shadow of the vertebrae may appear superposed on the mandibular symphysis region. This shadow may prevent clear visualization of the mandibular and maxillary anterior region.[22] Hacıosmanoğlu et al.[10]

examined 186 panoramic images and found at least one error in 93.01%. In their study, the most common error was not positioning the tongue on the palate with 66.12% and the second most common error was the skier position error (27.95%). In our study, the first and second most common errors were not positioning the tongue on the palate (34.75%) and patient not standing upright (26.45%), respectively, similar to the study of Hacıosmanoğlu et al.[10] Although there is a significant difference in the number of images analyzed, the results obtained are consistent. Belgin et al.[8] reported at least one error in 81.6% of 500 panoramic radiographs and the most common error was not positioning the patient upright, while Dhillon et al.[17] reported at least one error in 89% of 1,782 radiographs and the most common error was not positioning the tongue on the palate. When compared in terms of error rates, it is seen that the results of the studies are compatible with our study. Kattimani et al.[1] included 500 panoramic images and found that 17.2% of the radiographs were error-free and 82.8% had at least one error. The most common of these errors (30.8%) were images obtained by turning the head to one side due to incorrect positioning of the midline. Bagherpour et al.[23] reported that 96.7% of 1815 permanent teeth panoramic radiographs and Akarslan et al.[24] reported that 62.39% of 460 panoramic radiographs contained positioning errors, and the most common error in both studies was not placing the tongue correctly on the palate. Costa et al.[25] reported a 68.7% error rate in radiographs, with the tongue not lying on the palate being the most prevalent error. Singh et al.,[26] in contrast to these studies, reported that the head tilting backwards (22.1%) was the most prevalent error in the panoramic radiographs they analyzed. The least common errors observed in our study were failure to close the lips, head tilt forward, head tilt to one side and patient movement. Kattimani,[1] Khator[11] and Dhillon[17] reported that the least common error was patient movement in their study. Belgin et al.[8] reported that the least common error was head rotation to the right side.

There are a limited number of studies in the literature examining the image quality of panoramic radiographs. Belgin et al.[8] found that 18.4% of the images they evaluated were perfect, 50.3% were diagnostically acceptable and 31.3% were unacceptable. Dhillon et al.[17] determined these values as 11%, 64.1% and 24.9%, respectively. In our study, 18.4% of the images in the study population were found to be perfect, 45% acceptable and 36.6% unacceptable. The results were considered to be compatible with our study. Mayil et al.[27] examined 150 panoramic radiographs in a study evaluating the image quality and imaging errors of panoramic radiographs and found that 3.3% of the images were diagnostically unacceptable, 78% were diagnostically acceptable and 18.7% had ideal conditions. When compared with our study, it is seen that the proportion of ideal images is similar, but there is a difference in the proportion of diagnostically acceptable and unacceptable images. This is thought to be due to the large difference in the number of images examined. Kumar et al.[7] reported 22.4% and Lingam et al.[12] reported 32.8% of the radiographs as excellent.

In this study, when we evaluated the acceptability of panoramic radiographs according to gender, no correlation was found between gender and acceptability. Belgin et al.[8] reported in a study that there was no significant difference between gender and the error rate seen in panoramic radiography.

In our study, the relationship between the number of errors and the diagnostic acceptability of panoramic films was examined; it was observed that the acceptability decreased significantly as the presence of errors increased ($p<0.001$). While the acceptability was 69.1% in the presence of a single error, this rate was 6.4% in panoramic images with three or more errors. In the literature review, no study evaluating the correlation between the increase in the number of errors and acceptability was found.

A significant proportional difference was found between age categories and error rate ($p<0.001$). The rate of obtaining error-free images decreased with increasing age. In their study, Marsha et al.[15] classified patients as children, adults, and the elderly. They discovered that the elderly had a higher prevalence of errors than adults (33.6%). In the study by Belgin et al.[8] evaluating the relationship between error types and age, it was reported that positioning errors that may be related to age, such as patient inability to stand upright and patient movement, were frequently seen in elderly patients. Positioning challenges may also arise, particularly in elderly patients with conditions like Parkinson's.[15] The reason for this was thought to be the inability of these patients to remain immobile during the radiography procedure and inadequate communication between the patient and the operator.

Limitations

In our investigation, there are certain limitations. The impact of technician experience could not be assessed due to the lack of information regarding which panoramic radiograph was taken by which technician. Since our hospital is one of the busiest in the region, we are of the opinion that operator density increases the error rate. Therefore, a multicenter study with a larger population would be more advantageous for assessing the prevalence of various types of errors in panoramic radiography.

CONCLUSION

Panoramic radiography offers a wide range of advantages, including a wide field of view and minimal radiation exposure. However, the frequency of errors in preparation and positioning of panoramic radiographs is high. Physicians and technicians should be familiar with the correct panoramic techniques and should make every effort to minimize the patient's radiation dose when taking diagnostic panoramic radiographs. We are of the opinion that operators should receive annual training to provide an explanation of the ideal patient positioning, common errors, and their causes and solutions during panoramic radiography. This will prevent the unnecessary exposure of patients to radiation and prevent the repetition of panoramic imaging. The increasing error rate with advancing age indicates that a special effort is needed for these patients. Better communication with patients and giving them time to position themselves can reduce the number of errors and allow for high-quality panoramic radiographs.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee (Date: 31.01.2024, Decision No: 2024-03).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Acknowledgments

We would like to extend our appreciation to Associate Professor Merve Yeniçeri Özata for her contributions to the statistical evaluation of the article.

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Original Article

Dicle Dent J. 2024;25(3):79-85.

Evaluation of the effect of different fiber reinforced composite resins on the flexural strength of Bulk Fill composite resin

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Cite this article as: Demir R, Ayna B. Evaluation of the effect of different fiber reinforced composite resins on the flexural strength of Bulk Fill composite resin. *Dicle Dent J*. 2024;25(3):79-85.

Received: 22/07/2024 • **Accepted**: 02/08/2024 • **Published**: 19/09/2024

ABSTRACT

Aims: The aim of this study was to evaluate the effect of reinforcing a Bulk Fill composite resin material with different fiber reinforced composite resins (FRCRs) on flexural strength.

Methods: For the flexural strength test, 60 specimens were prepared using 4x4x8 mm polymethyl methacrylate (PMMA) blocks in accordance with the standards and the specimens were divided into four study groups [Bulk Fill composite resin (group 1), Bulk Fill composite resin+glass fiber in braided structure (group 2), Bulk Fill composite resin+polyethylene fiber in leno woven structure (group 3), Bulk Fill composite resin+short glass fiber reinforced composite resin (group 4)]. The specimens were soaked in distilled water at 37°C for 24 hours and subjected to three-point bending test with Universal Test device. Data were statistically analyzed using Mann-Whitney U and Kruskal Wallis-H tests.

Results: The average bending resistance values were 654.72 Newton (N), 682.33 N, 643.87 N and 1003.91 N in groups 1, 2, 3 and 4, respectively. The effect of short glass fiber reinforced composite resin+Bulk Fill composite resin group on bending resistance was statistically significantly higher than all other groups ($p>0.05$). There was no statistically significant difference between the other groups in terms of flexural strength.

Conclusion: Within the limits of this in vitro study, it was concluded that short glass fiber reinforced composite resin increases the flexural strength of Bulk Fill composite resin as a base material.

Keywords: Excessive material loss, Bulk Fill composite resin, FRCR, fiber, three-point bending test

INTRODUCTION

Dental caries is one of the most common oral diseases in pediatric dentistry.[1] It is known that the most caries-prone tooth surfaces in permanent dentition are the pits and fissures of the first and second molars and the buccal and palatinal pits of the first molars, respectively.[2]

It is possible to maintain the function of permanent posterior group teeth with excessive loss of material for a long time with success in restorative treatment. It is important to restore function, phonation and aesthetics.[3] Composite resins, which started to be used in dental applications in the 1960s, are still frequently preferred in the treatment of teeth with excessive loss of material. Composite resins, which were used only in anterior teeth for many years, are also widely used in posterior teeth as a result of increased aesthetic expectations and developments in materials.[4]

In order to facilitate and accelerate the placement of composite resins in large layers in the posterior region, manufacturers have produced Bulk Fill composite resins that can be placed in single layers or thicker layers. The biggest advantage of Bulk Fill composite resins is that they can be placed as a single layer with a thickness of 4-6 mm, shortening the clinical working time and showing low polymerization shrinkage.[5,6] The lifetime of composite resin restorations is inversely proportional to the size of the restoration. In large restorations where the amount of remaining tissue in the tooth is insufficient, the resistance of the composite restoration to masticatory force decreases.

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However, failure of these restorations due to fracture is also frequently observed.[7,8]

Since the resistance of composite resins to compressive and bending forces is not sufficient, fiber reinforcement has been introduced to improve their physical properties. The properties of fibers such as flexibility, resistance to pressure, translucency, low specific gravity, resistance to corrosion and ability to bond with adhesive technique make them preferred for reinforcing composite resins and improving their mechanical properties. Fiber-reinforced composite resins (FRCRs) are formed as a result of the fiber structure and polymer matrix forming a whole. The stresses occurring in the matrix structure are transmitted to the fibers, thus preventing fracture development in the restoration or tooth. The mechanical properties of FRCR are affected by the type of fibers, the way they are saturated, their density, their arrangement, the content of the matrix structure or the bonding of the fibers to the matrix.[8,9]

FRCR consists of prefabricated and networked fibers of different structures and shapes added to the matrix.[10] The most preferred fibers today are glass and polyethylene fibers in woven mesh form, which are networked according to their types. Polyethylene fibers can be woven, leno woven, pigtail and unidirectional in structure. Ribbond® (Ribbond Inc, Seattle, WA, USA), on the other hand, is a polyethylene fiber material consisting of a multidirectional cross-locked loop-style leno weave.[11] Recently, a barium glass-filled short glass fiber reinforced composite resin has been introduced GC EverX Posterior® (GC, Tokyo, Japan). This material is a combination of a resin matrix with non-continuous electrical (E) glass fibers and inorganic fillers. This combination results in a semi-interpenetrating polymer network during polymerization, which gives the material good bonding and fracture toughness.[12,13]

The clinical success of a restorative material is directly related to its physical and mechanical properties. Determination of the mechanical and physical properties of the materials used and their stress and strain under functional forces is important for a successful restoration.[14] Mechanical tests are used to determine the mechanical properties of the material, which are defined as bending, compression, elasticity and hardness, which determine the clinical success of the material. ISO (International Organization for Standardization) standards have been accepted as the standard test technique to determine the physical and mechanical properties of the material. Among these tests, the three-point bending test is widely used in accordance with ISO 4049 standards and is one of the most preferred methods.[9]

The aim of this study was to evaluate the strengthening of a Bulk Fill composite resin with different FRCR by three-point flexural testing.

METHODS

The study was approved by the Dicle University Faculty of Dentistry Clinical Researches Ethics Committee (Date: 30.11.2022, Decision No: 2022-42). All procedures were carried out in accordaance with the ethical rules and the principles of the Declaration of Helsinki. All patients signed the free and informed consent form.

In order to investigate the strength of Bulk Fill composite resin reinforced with different FRCR by three-point bending test, blocks made of polymethyl methacrylate (PMMA) with 4 mm width, 4 mm depth and 8 mm length were prepared in accordance with ISO 4049 standards. The molds were designed and created with CAD/CAM in digital environment. A total of 60 specimens prepared from this mold, 15 specimens in each group, were divided into the following four study groups;

- **Group 1:** Bulk Fill composite resin
- **Group 2:** Bulk Fill composite resin+glass fiber in weave structure
- **Group 3:** Bulk Fill composite resin+polyethylene fiber in leno woven structure
- **Group 4:** Short glass fiber reinforced composite resin+Bulk Fill composite resin

The materials used in our study are given in Table 1. The following steps were applied to each test group:

Group 1: The mold was placed on a glass coverslip on a flat surface. Vaseline was first applied to the rectangular cavities on the PMMA mold with an applicator to prevent the composite resin from adhering to the material. Then, 4 mm Bulk Fill composite resin was placed into the cavities with the help of cement spatula and fulvar. The overflowing part of the Bulk Fill composite resin from the mold was removed with a spatula and the upper surface was flattened. In order to achieve an equal distance standard for each composite resin sample and to obtain the best polymerization depth, the tip of the light device was positioned in direct contact with the molds and at right angles. Bulk Fill composite resin specimens were polymerized for 20 seconds with the Woodpecker LED-F Light Device (Woodpecker, Foshan, China) in accordance with the company's recommendation, with light applied only on the top surface (Figure 1). After each sample model was polymerized, it was removed from the mold and placed in light-proof containers.

Group 2: A 2 mm Bulk Fill composite resin was placed on the substrate of the molds on the glass coverslip and no light was applied. The pre-saturated braided glass fiber was cut according to the prepared mold (7 mm in length) with scissors. The fiber was carefully placed on the Bulk Fill composite resin with the

Table 1. Materials used in the study

	Material	Feature	Producer company
1	Biolnfinity sirius dental composite	Bulk Fill composite resin	Avrupa Implant (Umg Uysal) Istanbul, Turkiye
2	Interlig	Glass fiber in braided structure	Angelus, Londrina, PR, Brazil
3	Ribbond	Polyethylene fiber in leno woven structure	Ribbond Inc., Seattle, WA, USA
4	EverX posterior	Short glass fiber reinforced composite resin	GC, Tokyo, Japan
5	Clearfil liner bond F	Binding agent	Kuraray, Okayama, Japan

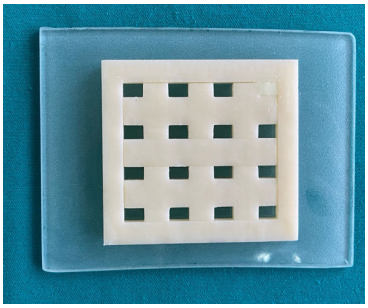

Figure 1. Image of Bulk Fill composite resin before polymerization

help of a press and polymerized for 20 seconds (Figure 2). Bulk Fill composite resin was placed into the remaining cavity with the help of a spatula and fulvar and polymerized for 20 seconds.

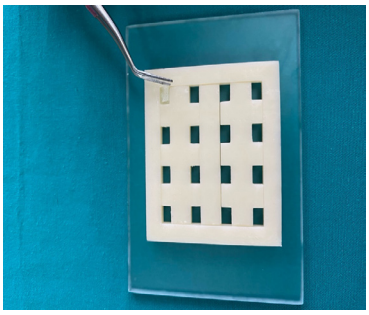

Figure 2. Placement of the cut braided glass fiber on the composite resin

Group 3: As in group 2, 2 mm Bulk Fill composite resin was placed on the bottom layer of the mold and no light was applied. Leno woven polyethylene fiber was cut with the help of special Ribbond scissors in 2x7 mm dimensions according to the prepared mold. The bond in the Kuraray Clearfil Liner Bond F dental bonding agent kit was used to pre-saturate the fiber material (Figure 3). After saturation with resin, the prepared fiber bulk fill was placed on the composite resin and polymerized with light for 40 seconds. After this process, the remaining upper part of the mold was placed on the bulk fill composite resin with the help of a spatula and fulvar and polymerized for 20 seconds.

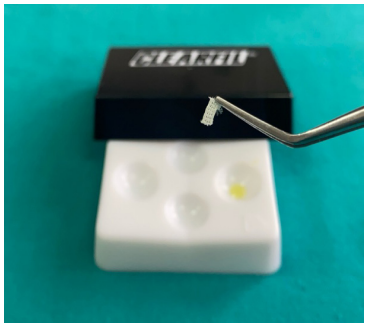

Figure 3. Fiber material and bond agent cut according to mold dimensions before saturation process

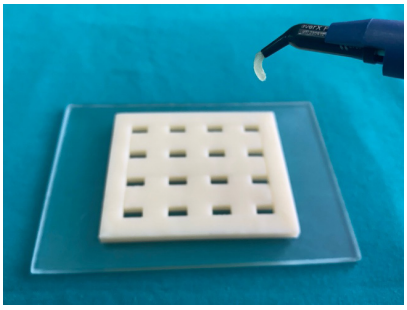

Figure 4. Short glass fiber reinforced composite resin placed in the substrate of the mold

Group 4: Short glass fiber reinforced composite resin was placed on the bottom layer of the molds on the glass coverslip as a 3 mm base material (Figure 4). It was polymerized with light for 20 seconds according to the manufacturer's recommendation. The remaining upper part of the mold was filled with Bulk Fill composite and polymerized with light for 20 seconds. After each sample model was polymerized, it was removed from the mold and placed in light-proof containers.

All specimens (60 specimens in total) were placed in distilled water at 37 0C for 24 hours and then subjected to three-point bending test. The three-point bending test was performed in the laboratory of the Department of Prosthodontics, Faculty of Dentistry, Van Yüzüncü Yıl University, Van Yüzüncü Yıl University, using a Universal Testing Machine (AG- 50 kNG, Shimadzu, Japan).

The crusher tip, which will perform the fracture, was connected to the upper part of the Universal Testing Machine moving downwards. In order to adjust this crushing tip to the exact midpoint of the samples, the exact midpoint of the samples was previously determined with a digital micrometer. The Universal Testing Machine was then operated at a speed of 1 mm/minute and force was applied to the samples. The device was stopped when a breakage occurred in the sample.

RESULTS

The conformity of the fracture values of the 4 groups used in our study with the three-point bending test to the statistical normal distribution was tested according to Shapiro Wilk's and/or Kolmogorov Smirnov methods. Mann-Whitney U and Kruskal Wallis-H tests were used for intergroup comparisons because the variables were not from normal distribution. In case of significant differences in Kruskal-Wallis-H test, post-hoc multiple comparison test was used to determine the groups with differences.

In the study in which the effect of fiber-reinforced composite resins on the flexural strength of Bulk Fill composite resin was comparatively examined, the average flexural strength values of groups 1, 2, 3 and 4 were determined as 654.72 N, 682.33 N,

Table 2. Results of the analysis related to the difference between group 1 and group 2 in terms of bending resistance

	Bending resistance						Mann-Whitney U test		
	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 1	15	654.72	613.4	275	1056	213.14	14.67	-0.518	0.604
Group 2	15	682.33	655.1	155.8	964	242.84	16.33		

Min: Minimum, Max: Maximum, SD: Standard deviation

643.87 N and 1003.91 N, respectively, as a result of three-point bending test. There is a statistically significant difference between the groups in terms of bending resistance ($p<0.05$).

The highest flexural strength value obtained was observed in the short glass fiber reinforced composite resin+Bulk Fill composite resin group, while the Bulk Fill composite resin+leno woven polyethylene fiber group was tested to have the lowest value. The effect of group 4 on bending resistance was statistically significantly better than all other groups (Tables 3, 4 and 5) ($p<0.05$). No statistically significant difference was found between the other groups in the study (Tables 2, 6 and 7) ($p>0.05$).

DISCUSSION

It is possible for permanent posterior teeth that have suffered excessive loss of material due to caries or anomalies to maintain their functions for a long time with success in restorative treatment.[4] Since tissue loss is high in large restorations, the resistance of the remaining tooth tissue and the durability of the composite material used against occlusal forces are also reduced and thus fractures are seen in the restorations in the long term. For this reason, composite resins have been continuously developed. In order to reduce the failures of composite resins, it is recommended to use FRCR with these restorations, considering that it increases the support of the restorations and dental tissues they support.[15]

Table 3. Analysis results for the difference between group 1 and group 4 in terms of bending resistance

	Bending resistance						Mann-Whitney U test	
	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 1	15	654.72	613.4	275	1056	213.14	10.33	-3.215	0.001
Group 4	15	1003.91	943	616.6	1800	297.4	20.67		

Min: Minimum, Max: Maximum, SD: Standard deviation

Table 4. Analysis results for the difference between group 2 and group 4 in terms of bending resistance

	Bending resistance						Mann-Whitney U test	
	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 2	15	682.33	655.1	155.8	964	242.84	11.07	-2.758	0.006
Group 4	15	1003.91	943	616.6	1800	297.4	19.93		

Min: Minimum, Max: Maximum, SD: Standard deviation

Table 5. Analysis results for the difference between group 3 and group 4 in terms of bending resistance

	Bending resistance						Mann-Whitney U test	
	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 3	15	643.87	582.5	290	1091	193.39	9.73	-3.588	0.001
Group 4	15	1003.91	943	616.6	1800	297.4	21.27		

Min: Minimum, Max: Maximum, SD: Standard deviation

Table 6. Analysis results for the difference between group 1 and group 3 in terms of bending resistance

	Bending resistance						Mann-Whitney U test	
	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 1	15	654.72	613.4	275	1056	213.14	15.67	-0.104	0.917
Group 3	15	643.87	582.5	290	1091	193.39	15.33		

Min: Minimum, Max: Maximum, SD: Standard deviation

Table 7. Analysis results for the difference between group 2 and group 3 in terms of bending resistance

	n	Mean	Median	Min	Max	SD	Mean rank	z	p
Group 2	15	682.33	655.1	155.8	964	242.84	16.67	-0.726	0.468
Group 3	15	643.87	582.5	290	1091	193.39	14.33		

Min: Minimum, Max: Maximum, SD: Standard deviation

Since the restorative material is exposed to masticatory forces in clinical use, high flexural strength of the material is a desirable feature.[9] Flexural strength test is one of the tests that most closely mimics the forces to which restorative materials in the mouth are exposed. It allows determination of the material's resistance to fracture. It also provides an idea about whether the materials will be successful under pressure.[16,17]

It has been determined that there is a positive correlation between the high ratio of inorganic filler in the matrix structure of the restorative material used and the mechanical properties of the material. Therefore, the restorative material to be used in clinical studies should have high filler content and thus high flexural strength.[18,19] One of the methods to increase flexural resistance is fiber reinforcement of composite resins. It is claimed that appropriately placed and designed fibers increase the flexural resistance of the composite resin to which they are added.[20-22] Fibers improve the physical properties of the material by acting as fracture stoppers. The most preferred fiber types for this purpose are networked polyethylene and glass fibers.[23]

Braided glass fibers are pre-saturated fibers. Being pre-wetted eliminates the steps to be applied by the clinician. In addition, it is claimed that they have high bending resistance due to their higher fiber content compared to non-presaturated fibers.[9] Glass fibers are claimed to have high tensile strength and increase the flexural and impact resistance of composite resins.[24]

Leno woven polyethylene fibers are pre-saturated fibers and must be cut with special scissors and saturated in resin before use. These fibers can easily take shape during use and thus adapt to the cavity walls. Due to the gas-plasma treatment they are exposed to during their production, they easily absorb water, reducing the surface tension of the fiber and providing a good chemical adhesion with composite resins.[25]

Newly developed short-fiber reinforced composite resins, recommended for use in high-stress areas, contain silanated e-glass fibers optimized in size and length to provide maximum strengthening effect. These composite resins have many advantages in the restoration of teeth with excessive material loss. Their elastic modulus is similar to dentin, their tensile strength is high, they are cost-effective and suitable for single-session treatment. When short fiber reinforced composite resins are used as a substructure under conventional composite resins, the durability of the restoration is significantly increased and when the restoration is loaded to the fracture point, the fracture path changes and repairable fractures occur.[26]

In our study, the effect of short glass fiber reinforced composite resin on the flexural strength of Bulk Fill composite resin was statistically significantly better than all other groups. Garoushi et al.[27] compared the fracture and bending resistance of short glass fiber reinforced composite resin and different Bulk Fill composite resins in large posterior restorations and found that short glass fiber reinforced composite resin showed higher fracture and bending resistance. In an in vitro study by Garlapati et al.[28] comparing the fracture resistance of hybrid composite resin, leno woven polyethylene fiber+conventional composite resin and short glass fiber reinforced composite resin+conventional composite resin in endodontically treated teeth, it was shown that short glass fiber reinforced composite resin increased fracture resistance at a high rate. In addition, it was stated that the short fiber in the composite resin can be supported by filler particles and composite layers, thus preventing the progression of cracks. In the study of Rajaraman et al.[29] in which they compared the fracture resistance of short glass fiber reinforced composite resin with Class I cavity and intact teeth with a universal tester, it was found that the average fracture resistance of short glass fiber reinforced composite resin was close to that of intact teeth, but not statistically significant. They attributed the higher fracture resistance observed in intact teeth to the absence of material loss. In a 2.5-year clinical follow-up study by Tanner et al.[30] in which they treated 36 posterior teeth with short glass fiber reinforced composite resin, it was observed that short glass fiber reinforced composite resins had high fracture resistance properties. After follow-up, the survival rate of the restorations was 97.2% and the success rate (not requiring repair) was 89.9%.

The results obtained in our study are similar to the previous studies. It is thought that higher bending resistance values are obtained by micromechanical interlocking of the protruding short fibers in the short glass fiber reinforced composite resin with the composite.

In a study, Vallittu[31] investigated the flexural strength of acrylic resin reinforced with unidirectional and braided glass fibers. According to the results of this study, unidirectional glass fibers have higher bending resistance, but braided glass fibers increase the resistance at fracture in all polymer materials and this is clinically important. In an in vitro study by Candan et al.[9] in which the effect of using different substrate materials on the flexural resistance of nanofilament composite resin was evaluated, it was reported that only the nanofilament composite resin control group had the lowest flexural resistance, and the highest flexural resistance value was reported in the sample group in which glass fiber was used in mesh structure together with flowable composite resin. In the same study, it was reported that the use of flowable composite resins in the substrate of restorations increases the bending resistance of the restorations, reduces the harmful effects of occlusal forces and eliminates irregularities at the base of the cavity. Although there was no statistically significant difference between the group that placed braided glass fiber on fluid composite resin and covered with nanofil composite resin and the group that placed braided glass fiber directly on the mold base without using fluid composite resin and covered with nanofil composite, the bending resistance was found to be higher. Studies have been conducted on the placement of the fiber in which part of the specimens to be tested in bending tests. Chung et al.[32] examined the effect of adding glass fiber to the autopolymerizable acrylic base material used for the construction of temporary fixed prostheses on bending resistance and placed the unidirectional fiber in four different ways in a 9 mm high mold. According to the results of the study, the highest bending resistance value was observed in the lower 1/3 of the mold, while the lowest value was observed

in the upper and middle parts of the mold. Kanie et al.[33] examined the effect of the position of the braided glass fiber placed in acrylic resin on bending resistance and reported that the highest bending resistance was found when the fiber was placed in the lower part of the mold where the tensile stresses were the highest. Similarly, Lassila and Vallittu,[34] in their study where they placed the fiber between the composite layers, found that the highest bending resistance was found in the samples placed at the bottom of the composite.

In our study, it was observed that the braided glass fiber increased the flexural strength of Bulk Fill composite resin, although not statistically significant. We think that this may be related to the fact that we placed the braided glass fiber in the middle layer instead of the substrate in our study and used Bulk Fill composite resin instead of flowable composite resin as the base material.

In our study, the effect of leno woven polyethylene fiber on the flexural strength of Bulk Fill composite resin was found to be lower than that of Bulk Fill composite resin and braided glass fiber, although not statistically significant. Pereira et al.[35] compared the flexural strength of non-fiber reinforced hybrid, microfill and hybrid+microfill composite resin combinations and hybrid composite reinforced with polyethylene fiber in leno woven structure. According to the results of this study, they found that reinforcement with polyethylene fiber in leno woven structure showed higher bending resistance than microfill, hybrid+microfill composite resin combination and lower bending resistance than hybrid composite resins, but this difference was not statistically significant. Bae et al.[36] applied three-point bending test to their composite resin samples prepared by adding leno woven polyethylene fiber, polyaramide and three different glass fibers. As a result of the test, they found that all samples with fiber addition significantly increased the flexural strength compared to the group containing only composite resin. However, they found that the bending resistance of polyaramide and glass fibers was significantly higher than that of leno woven polyethylene fibers. Türkeş et al.,[15] in their in vitro study in which they examined the resistance of the restoration against compressive forces when leno woven polyethylene fiber material was placed in composite resin in different configurations with a universal test device, found that there was no statistically significant difference between the resistance values of the group in which only composite resin was used compared to the group in which polyethylene fiber was applied with fluid composite resin on the base. Tezvergil et al.,[37] Belli et al.[38] and Lassila et al.[39] used leno woven polyethylene fiber with flowable composite resin in their studies similar to this study. In composite resin restorations, it was reported that placing a leno-woven polyethylene fiber with a thin layer of flowable composite resin in the cavity positively affected the adhesion between the fiber and the composite resin and reduced the effect of shrinkage by acting as a buffer against the stresses occurring under occlusal forces and stresses occurring during polymerization of the flowable composite resin. They also reported that the use of fibers together with the flowable composite resin in cavities with a large surface area allows the flowable composite resin to penetrate better between the fibers of the fiber, creating a stable and high bonding resistance. In our study, unlike other studies, the leno woven polyethylene fiber was placed directly into the Bulk Fill composite resin instead of being placed into the fluid composite resin which is a base material. This may be related to the fact that Bulk Fill composite resin does not penetrate between the fibers of the fiber as well as the flowable composite resin, resulting in adhesive failure. At the same time, the in vitro nature of our study, the fact that the leno-woven polyethylene fiber was not pre-saturated, the time interval and ambient conditions expected during saturation, the volumetric size formed in the cavity after saturation, and the placement of the fiber mesh in the middle of the Bulk Fill composite resin layers may have caused the low bending resistance values.

CONCLUSION

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

- The highest flexural strength value was found in the short glass fiber reinforced composite resin+Bulk Fill composite resin group.
- There was no statistically significant difference between the glass fiber in braided structure, Bulk Fill composite resin and polyethylene fiber in leno woven structure groups.
- It may be more meaningful to use FRCR with flowable composite resin as a base material to increase the flexural strength of Bulk Fill composite resins.
- Since our study was conducted under in vitro conditions, the intraoral environment cannot be mimicked exactly. In addition, restorative materials are not only subjected to forces in the vertical direction in the mouth but are also subjected to forces in many directions.
- This study should be supported by the results of different in vitro and clinical studies.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Dicle University Faculty of Dentistry Clinical Researches Ethics Committee (Date: 30.11.2022, Decision No: 2022-42).

Informed Consent

In this study, no biological material was used, no personal data are available. Therefore, informed consent is not required.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Acknowledgment

I would like to thank Dicle University Scientific Research Projects Committee (Preoject number: 23.006) for supporting this thesis.

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Original Article

Dicle Dent J. 2024;25(3):86-91.

Examination of stresses created by zygomatic and dental implants applied in combined form and implants placed with the "All-on-Four" technique in bilateral atrophic maxilla by finite element analysis

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Cite this article as: Özler M, Gülsün B. Examination of stresses created by zygomatic and dental implants applied in combined form and implants placed with the "All-on-Four" technique in bilateral atrophic maxilla by finite element analysis. *Dicle Dent J.* 2024;25(3):86-91.

Received: 24/08/2024 ◆ **Accepted**: 15/09/2024 ◆ **Published**: 19/09/2024

ABSTRACT

Aims: In severely atrophic posterior maxillae, there is usually not enough bone to place conventional dental implants. Dental implants and zygomatic implants placed with the "All-on-Four" technique have frequently been preferred in recent years because they eliminate the need for grafting, shorten the treatment time, and reduce the morbidity rate. The aim of our study was to select the most accurate surgical planning according to the stress values resulting from the forces applied to the combined zygomatic and dental implants and dental implants placed with the "All-on-Four" technique in the models we created.

Methods: In the present study, 2 group models were established. In group 1 model, one dental implant was placed in the canine and second premolar tooth regions with the "All-on-Four" technique. In the group 2 model, one dental implant was placed in the canine tooth region and one zygomatic implant was placed in the 1st molar region. In the prosthetic superstructure, a force of 150 N was applied vertically from the region of teeth 4-5-6 and 100 N was applied obliquely at an angle of 30°.

Results: In the present study, when the von Mises stress values on the implants were analyzed, it was found that the highest stress occurred in group 2 under vertical forces and in group 1 under oblique forces.

Conclusion: Based on these results, it is concluded that the most ideal planning in the rehabilitation of bilateral atrophic maxilla is group 1 with dental implants placed with the "All-on-Four" technique under vertical forces and group 2 with zygoma and dental implants under oblique forces.

Keywords: Atrophic maxilla, zygomatic implant, "All-on-Four" technique

INTRODUCTION

Dental implants enable the restoration of lost teeth without the need to prepare neighboring teeth, as well as providing fixed restoration in partial or complete edentulous patients. Studies on dental implantology first started in the 1960s.[1] Osteointegrated implants were introduced by Brånemark in 1965.[2] The aim of dental implants is to restore the function and aesthetics lost after tooth extraction.[3]

In patients with severe atrophy in the maxillary posterior region, insufficient bone quantity, poor bone quality and the presence of a severely pneumatized maxillary sinus limit standard dental implant applications.[4] The conventional surgical approach in patients with extreme atrophy of the maxilla is augmentation with autogenous block or cannellous grafts obtained from the intraoral/extraoral area or open sinus lifting. Interpositional application of corticocancellous iliac graft after Le fort I osteotomy is another technique. However, these techniques have disadvantages such as being more complicated, the inability to use the patient's temporary prosthesis during the healing period of the graft, prolonged treatment time due to grafting, the risk of morbidity at the recipient site, the high probability of infection especially in sinus lifting procedures and increased treatment costs.[5,6]

Due to some disadvantages of Le Fort I and iliac surgery for the reconstruction of atrophic posterior maxilla, researchers have developed other methods. It was in the 1990s that the zygoma was considered as an anchorage source for the application of implants in the prosthetic treatment of maxilla cases with excessive atrophy.[7] Aparicio et al.[8] first studied the

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possibility of applying dental implants to the zygoma. In 1993, it was decided that the zygoma could be used as a support for stabilization of implants.

The "All-on-Four" technique (Nobel Biocare AB, Goteborg, Sweden) was first introduced in 2003 in cases of mandibular complete edentulism and later in cases of maxillary complete edentulism.[9] In the maxillary "All-on-four" technique; maxillary sinus augmentation and sinus lifting applications are not necessary.[9,10]

Finite element analysis (FEA) is a method of analyzing the stresses and deformation of a complex geometric structure by converting it into a network structure in a computer environment. The structure is divided into finite elements connected to each other by nodes. The type, arrangement and number of these elements affect the result of the analysis.[11] The stress and displacement at each node can be calculated.[12] Weinstein et al.[13] were the first researchers to use FEA in implantology in 1976.

In the present study, the FEA method was used to investigate the amount and distribution of von Mises stress on the implants as a result of the application of vertical and oblique forces on the implants applied with zygomatic and dental implants and implants applied with the "All-on-Four" technique in bilateral atrophic maxillae.

METHODS

This study is not a clinical study, drug trial study, or a retrospective or prospective study. It is just an analysis study done on a computer. Therefore, no ethical committee decision is needed in such studies.

In the present study, a tomography scan of a total edentulous adult patient was taken to create a geometric model of the maxilla (Figure 1). The maxilla was scanned by Cone Beam Tomography (ILUMA, Orthocad, CBCT (cone beam computed tomography), 3M Imtec, Oklahoma, USA). In the scan, 601 slices were obtained with a 40-second scan at 120 kvp, 3.8 mA. The volumetric data was then reconstructed with a slice thickness of 0.2 mm. The reconstructed sections were exported in DICOM 3.0 format. The exported sections were imported into 3D-Doctor (Able Software Corp., MA, USA) software (Figure 2).

Figure 1. Tomography image of a completely edentulous adult patient

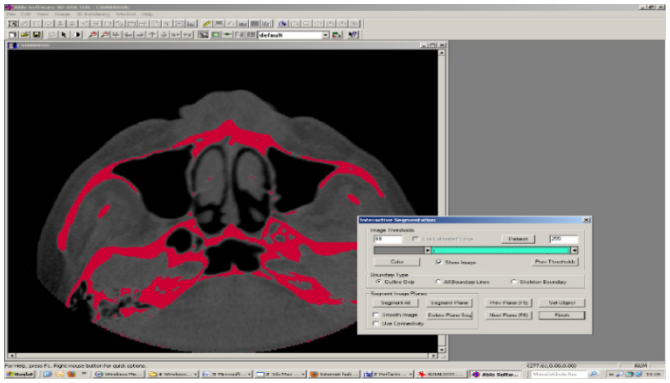

Figure 2. Transferring tomography images to 3D-doctor software

Bone tissues on the sections were separated with the "interactive segmentation" technique in 3D-Doctor software. The decomposed sections were converted into a 3D model with the "ComplexRender" technique. The modeling process of the upper jaw bone was completed by turning the 3D model into a smooth surface consisting of elements with low memory consumption and proper proportions with the simplification methods in 3D-doctor software. The 3D model was exported from 3D-Doctor software in .stl format. After the parsing process, the 3D model was obtained with the "3D ComplexRender" method and the bone tissue was modeled in this way (Figure 3).

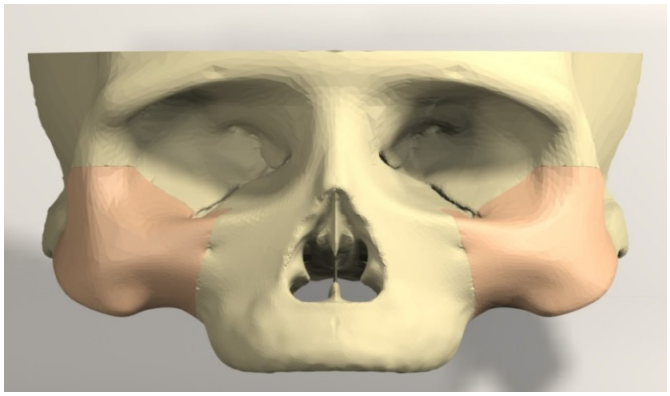

Figure 3. Bone model of the maxilla and zygoma

In the present study, 2 group models were established. In the group 1 model, one dental implant (Nobel Biocare AB, Goteborg, Sweden) was placed in the canine and second premolar tooth regions with the "All-on-Four" technique. The anterior implant with a diameter of 3.75 mm and a length of 11.5 mm was placed in the canine tooth region at a right angle, and the posterior implant with a diameter of 3.75 mm and a length of 13 mm was placed in the 2nd premolar tooth region at a 30º angle (Figure 4). In the group 2 model, one dental implant (Nobel Biocare AB, Goteborg, Sweden) with a diameter of 3.75 mm and a length of 11.5 mm was applied to the canine tooth area on the right and left sides at right angles, and one zygomatic implant (Nobel Biocare AB, Goteborg, Sweden) with a diameter of 4 mm and a length of 35 mm was applied to the 1st molar area at an angle of 45º using the extrasinus method (Figure 5). In the prosthetic superstructure, a force of 150 N was applied vertically in the region of teeth 4-5-6 and 100 N was applied obliquely at an angle of 30º (Figures 6, 7).

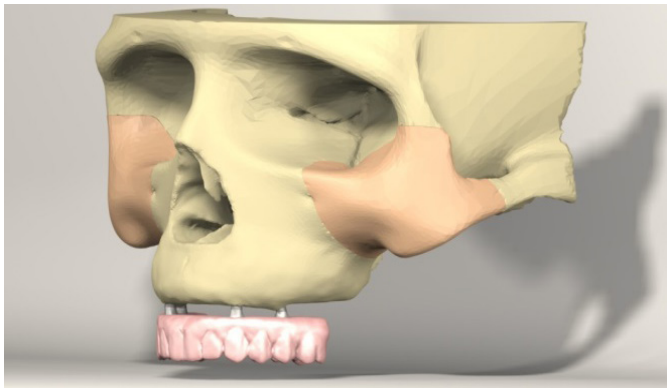

Figure 4. In the first group, the model with prosthetic superstructure and dental implant applied with the "All-on-Four" technique

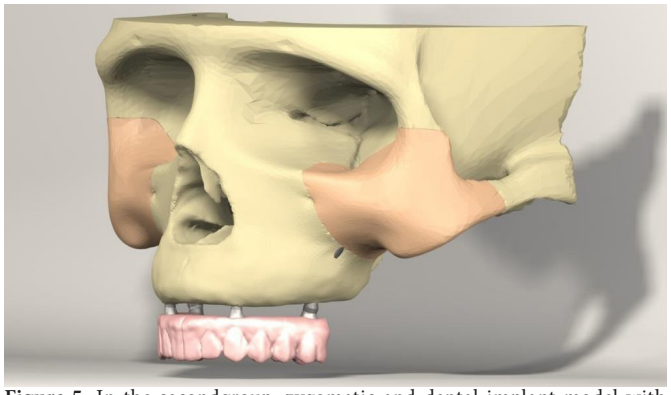

Figure 5. In the secondgroup, zygomatic and dental implant model with prosthetic superstructure

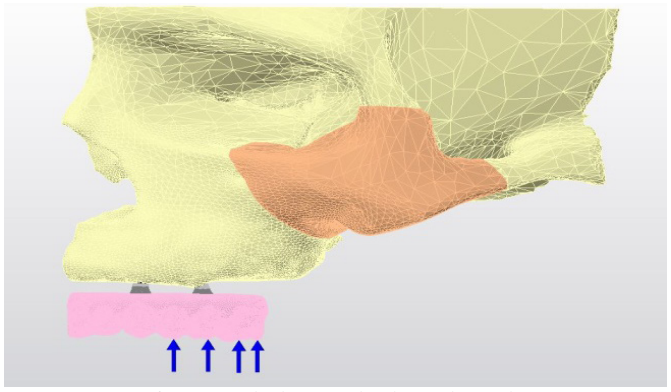

Figure 6. Force of 150 N applied perpendicular to the teeth

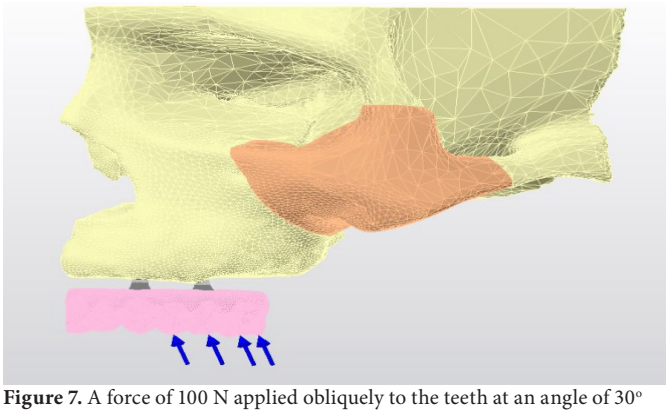

Figure 7. A force of 100 N applied obliquely to the teeth at an angle of 30°

The stresses on the implants were measured in megapascals (MPa) (N/mm^2). In the analysis, regions with high stress are shown in red and regions with low stress are shown in blue.

RESULTS

According to the results of the vertical forces, the maximum von Mises stress values in the neck regions of the implants of the groups were measured as 136.521 MPa in the first group (All-on-Four group) (Figure 8) and 179.016 MPa in the second group (zygoma and dental implant group), respectively (Figure 9).

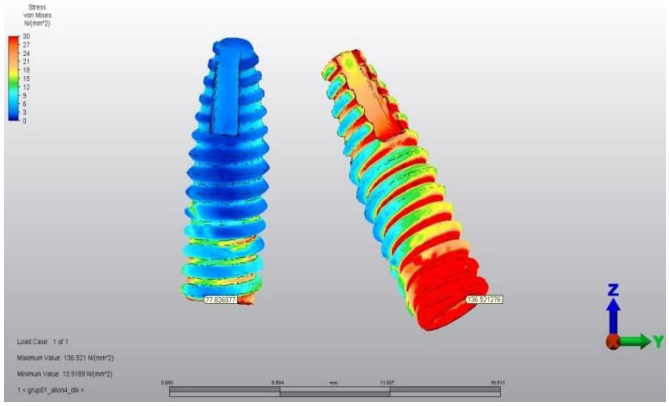

Figure 8. Maximum von Mises stress value of dental implants under vertical forces in group 1

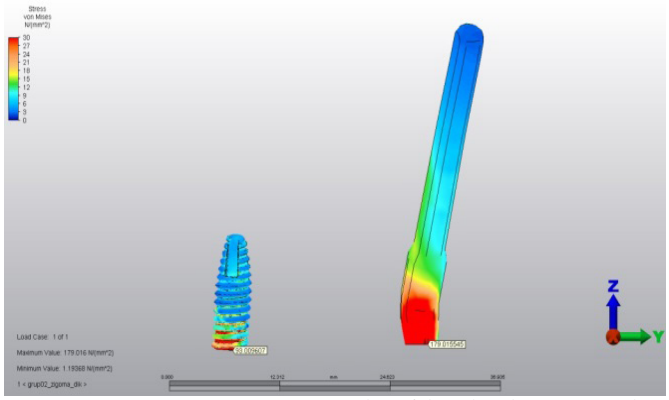

Figure 9. Maximum von Mises stress value of dental and zygoma implant under vertical forces in group 2

According to the results of the oblique forces, the maximum von Mises stress values in the neck regions of the implants of the groups were measured as 127.551 MPa in the first group (All-on-Four group) (Figure 10) and 103.223 MPa in the second group (zygoma and dental implant group), respectively (Figure 11).

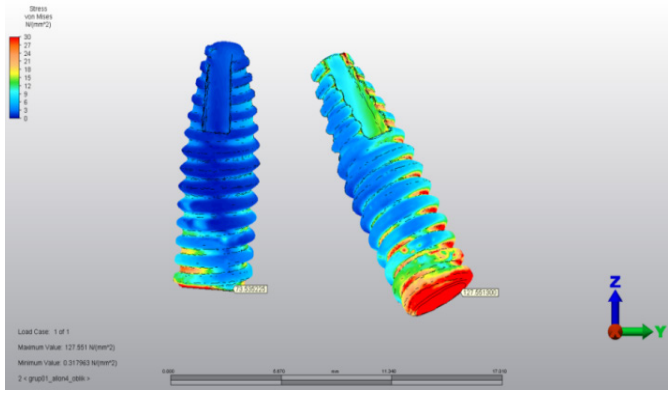

Figure 10. Maximum von Mises stress value in dental implants under oblique forces in group 1

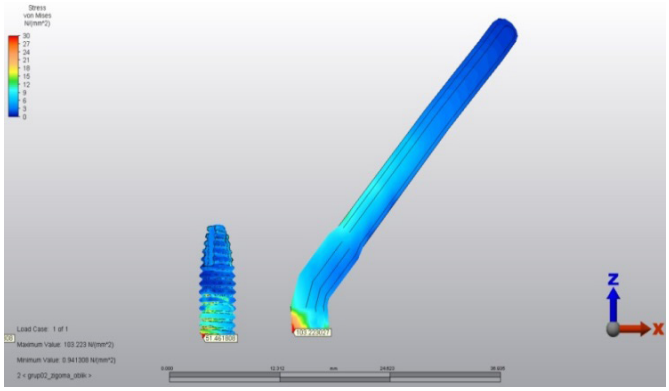

Figure 11. Maximum von Mises stress value in zygoma and dental implants under oblique forces in group 2

In the present study in which different systems were compared, the maximum von misses stress in the neck region of the implants in each group was evaluated in order to make a comparison between the systems. According to the results of our study, when the maximum von Mises stress values of the implants in each group were compared, it was seen that the least stress was observed in group 1 against vertical forces and in group 2 against oblique forces.

In group 1, the von Mises stress value in the anterior dental implant was 77.82 MPa and 136.52 MPa in the posterior dental implant against vertical forces. In group 2, the von mises stress value of the dental implant was 93 MPa and the stress value of the zygomatic implant was 179.01 MPa. In group 1, the von Mises stress value in the anterior dental implant was 73.535225 MPa and in the posterior dental implant was 127.551300 MPa against oblique forces. In group 2, the von Mises stress value of the dental implant was 51.461808 MPa and the stress value of the zygomatic implant was 103.223027 MPa.

When these results were evaluated; it was observed that the stresses accumulated in the neck regions of the implants increased with the increase in masticatory forces as we move posteriorly in both groups. When interpreted according to the stress values of the implants, it was seen that the most ideal planning was group 1 with "All-on-Four" under vertical forces and group 2 with zygoma and dental implants under oblique forces.

DISCUSSION

Implant applications have become widespread in the elderly population due to the increase in life expectancy, socioeconomic status, and aesthetic and functional expectations. The maxilla atrophies with advancing age and tooth loss, and the amount of bone to which traditional dental implants can be applied is not sufficient, especially if the amount of bone decreases with sinus pneumatization in the posterior field.[14]

Although it is possible to rehabilitate the maxilla with additional surgical procedures or modified implant applications and provide function to the patients, it is not preferred due to the degree of morbidity during and after additional surgical applications and the long duration of treatment, and recently, inclined, short, pterygoid and zygomatic implants have been applied.[15]

In 2003, Malò et al.[10] proposed the "All-on-Four" technique (All-on-4; NobelBiocare AG, Gothenburg, Sweden) for the prosthetic rehabilitation of mandibular edentulous jaws, which allows immediate loading with the application of 4 implants. The advantages of this technique are that it avoids the disadvantage of minimal bone height or sinus proximity in implant placement by placing two vertical implants anteriorly and two angled implants posteriorly and limiting the distal cantilever length. In 2005, this technique was introduced in the maxilla and requires sufficient alveolar bone height to allow the placement of 4 implants in the premaxillary area in highly resorbed maxillary alveolar crests. This planning has important advantages such as decreasing the treatment time, low patient morbidity and making the patient's quality of life more comfortable.[16,17] Studies have reported very high survival rates in the 3-year short and 5-year medium term. In a 5-year retrospective study of maxillary total edentulous cases, the "All-on-Four" treatment concept was reported to be a very suitable alternative treatment option.[18]

In the early loading protocol, the survival rates of the implants are 94.7-100% in the maxilla in the 1-3-year follow-up and 98.51-100% in the mandible in the 1-2-year follow-up, and 90.43-100% in the maxilla and 90-100% in the mandible in the 1-10 year follow-up has benn reported. In treatment based on the 'All-on-Four' concept, the survival rate of implants has been reported as 94.7% in the maxilla at the implant level, with a follow-up period of 5-13 years, and 93% in the mandible with a follow-up period of 10-18 years.[19,20] In the last review, the 13-year survival rates of implants in the maxilla were reported to be 93.9-100%, and the 18- year survival rates in the mandible were 91.7-100%.[21]

Kim et al.[22] investigated the effect of two posterior implant angles on stress distribution using photoelastic stress analysis according to the "All-on-Four" treatment method. Similar to other studies, they reported that the maximum stresses in the distal crestal bone of the posterior implant applied at an angle of 30° were on average 17% less than those of the vertically applied implants.

Bevilacqua et al.[23] reported more proportional load distribution with angled posterior implants. When the posterior implant placed at a 30° angle was compared with vertically applied implant-supported fixed prostheses with a longer cantilever, they reported that the angled implant reduced the amount of stress by 52% in compact bone and 47.6% in cancellous bone. In the present study, we placed the posterior dental implant at a 30° angle based on the advantages of a 30° angle reported in the literature.

Based on the maxillary "All-on-Four" dental implant technique, it is emphasized that the anterior implants should be applied perpendicularly, and the implant length should be at least 10 mm and the length of the posterior sloping implants should be at least 11.5 mm.[16] In the present study, anterior implants with a diameter of 3.75 mm and a length of 11.5 mm were applied parallel and perpendicular to each other, and posterior implants with a diameter of 3.75 mm and a length of 13 mm were applied at a 30° angle.

In 2010, Davo et al.[15] reported in their prospective study that zygomatic implants would be a successful alternative application technique for procedures that do not require additional surgery.

In their finite element stress analysis study, Wen et al.[24] used zygomatic and standard dental implants in different numbers and in different localizations in models in which traditional (brånemark), extracineus and extramaxillary methods were applied. In these techniques, they reported that the model in which the extracineus method was applied was biomechanically superior to the others and the stresses on the zygomatic implant were the least. They also reported that occlusal loads were met by the zygomatic bone and transmitted in the direction of the zygomatic arch. When the results were analyzed, they reported that von Mises stress values were highest in the neck and coronal region of the implant.

In their study, Migliorança et al.[25] reported success rates of 97.5%, 95.9% and 95.2% for ZI, traditional dental implants and superstructure, respectively, in the 8-year follow-up of 40 zygomatic implants and 74 traditional dental implants loaded immediately with the extracinus method in 21 patients (13 women and 8 men) with an average age of 55 years in atrophic maxilla. They reported that zygomatic implant with extracinus application is a successful technique.

In line with the results of these studies, the extracinus method is preferred because it is more comfortable to apply than other techniques, postoperative results are more successful, prosthetic superstructure rehabilitation is more satisfactory and the stresses accumulated in the zygomatic implants are less. Considering the advantages of the extracinus method mentioned in the literature, zygomatic implants were applied with the extracinus method in the present study.

In 2019, Çetindağ et al.[26] applied a force of 150 N vertically and 50 N obliquely to the region of teeth 2-4-6-7 in another finite element analysis study on zygomatic implants and reported that both the increase in the number of zygomatic implants and the increase in the number of dental implants significantly reduced the stress values.

Although there are many advantages of using the finite element analysis method in determining approximate and predictive results, many randomized clinical studies on this subject need to be conducted to obtain reliable and definitive results. Di Pietro N, and Callea C suggested that further studies are needed to simulate all treatment alternatives for atrophic jaws to include the dynamic forces reproducing chewing, take into account the anisotropic and regenerative properties of native bone, or simply test other implant designs and prosthetic attachments as in previous studies.[27,28]

In the 2 different models we planned in the present study, 150 N force was applied vertically, and 100 N force was applied obliquely at an angle of 30 degrees to the buccal tubercles of teeth 4-5-6 in the prosthetic superstructure in order to mimic the average values of posterior masticatory forces in parallel with the forces applied in the literatures.

CONCLUSION

According to the results of our three-dimensional SESA study in which we evaluated the stress effect of different treatment options and implant designs on the implants to be applied in extremely atrophic maxilla; it was observed that the maximum von Mises stress value was higher in the neck regions of all implants and the stress increased as we move from anterior to posterior in both groups. The maximum von Mises stress values seen in the implants under vertical forces were highest in group 2 with zygomatic and dental implants and lowest in group 1 with "All-on-Four". Under oblique forces, the highest von Mises stress values were observed in group 1 with "All-on-Four" and the lowest in group 2 with zygomatic and dental implants.

The use of dental implants and zygomatic implants applied with the "All-on-Four" technique in the atrophic maxilla eliminates the need for grafts and reduces patient morbidity, duration of procedures and costs. The 3D models used in the present study were obtained from a tomography image of a toothless patient. The mechanical properties of the tissues and prosthetic materials used were determined and limited as described in publications. However, it is foreseen that anatomical changes and changes in the materials used may change the format of this study and the findings. Therefore, the results of our study may differ in different implant systems. For this reason, in the future, studies on different implant systems can be performed and the biomechanical properties of these systems can be compared.

ETHICAL DECLARATIONS

Ethics Committee Approval

It is just an analysis study done on a computer. Therefore, no ethical committee decision is needed in such studies.

Informed Consent

It is just an analysis study done on a computer. Written consent form is not required.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Acknowledgment

This study was supported by Dicle University Scientific Research Projects Coordinatorship with project number DİŞ.20.009. We thank for their support.

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Review

Dicle Dent J. 2024;25(3):92-95.

Oil pulling in dentistry

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Cite this article as: Yollar ET. Oil pulling in dentistry. *Dicle Dent J.* 2024;25(3):92-95.

Received: 11/06/2024 • **Accepted**: 11/09/2024 • **Published**: 19/09/2024

ABSTRACT

All patients may not be able to correctly carry out mechanical teeth brushing methods in varied circumstances since they need for dexterity and specific motivation. On the other hand, since over-the-counter mouthwashes have various side effects, more natural counterparts are being researched. Oil pulling is an application that has been applied in India for 3000-5000 years and is good for various systemic diseases. This method, which is applied with different oils, provides various benefits to the teeth and surrounding tissues. The aim of this review is to provide an overview of the research on the oils used in oil pulling and their benefits.

Keywords: Oil, pulling, oral hygiene

INTRODUCTION

The most efficient way to stop plaque buildup and dental cavities is through mechanical plaque removal with brushing and flossing. For many patients, however, maintaining an adequate level of plaque control is challenging since it calls for particular drive and skill. Contrarily, using mouthwash improves oral health protection because of its chemical attributes that fight plaque and bacteria.[1,2]

In instances where it is difficult or impossible to maintain adequate oral hygiene, studies are looking into chemical antimicrobial treatments as an option to prevent plaque buildup.[2-4]

Old traditions are often used when looking for alternative agents. Oil pulling is a mouthwashing technique that has its roots in Ayurveda, an ancient holistic medical system that has been practiced in India for 3,000–5,000 years. It has gained popularity recently as an alternative medicine due to its many health advantages.[5] Common organic oils include coconut oil, sesame oil, and sunflower oil.[6]

In this review, it is aimed to provide an overview of the studies on how the traditional method of oil pulling is applied, the benefits and limitations of the process, by scanning the current articles in the literature about the oil pulling process.

PROCEDURE OF OIL PULLING

A spoonful of oil is used to rinse the mouth for around 20 minutes in the early morning before breakfast and on an empty stomach. A teaspoon of oil is used for kids older than five years old. The oil is "pulled" and stirred around the entire mouth in order for it to go between every tooth.If everything is carried out properly, the thick oil will turn milky white and grow thinner at the conclusion of this process. After spitting it out, the mouth is completely washed with warm, clean water or salt, and the teeth are then thoroughly cleansed with the fingers or by brushing them as usual.[7]

On an empty stomach, oil pulling should preferably be practiced every morning before brushing. It is important to avoid swallowing the oil.[8-10] The ideal position for oil pulling is a seated position with the chin up. To hasten the healing process, apply it three times a day on an empty stomach before meals.[11]

MECHANISM OF OIL PULLING

Oil pulling has an unclear mechanism of effect. One hypothesis is that oil is alkaline hydrolyzed, which results in the "creation of soap" process known as saponification.[12] Another hypothesis is that the oil's viscosity inhibits bacterial adherence and plaque formation.[13] The third hypothesis holds that the antioxidants in the oil prevent lipid peroxidation, aid

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in the eradication of germs, and enhance the effects of vitamin E in the oral cavity.[14]

Uses and Benefits of Oils

Oil pulling produces antioxidants that damage and kill the cell wall of microorganisms.[15] These oils will pull the lipid layer of the bacterial cell membranes, causing them to stick or be pulled into the oil. During oil extraction, the oil emulsifies and the surface area of the oil increases.[8] The first five minutes of oil extraction are spent emulsifying the oil.[16] By coating the teeth and gingiva, this oil prevents plaque production and bacterial coaggregation.[8] Thus, the oral cavity is cleared of the plaque-forming germs that cause tooth cavities, gingivitis, periodontitis, and foul breath. Gums become pink, healthy and the problem of bleeding gums is resolved. Oil pulling also helps relieve symptoms of mouth/throat and chapped lips.[17] Also teeth are whiter; breath is freshened; oral cavity muscles and jaws become stronger.[7,11] Oil pulling prevents the formation of dental caries, gingivitis, oral candidiasis and periodontitis, helps reduce toothache, corrects moving teeth and provides strong oral hygiene.[7,11] Regular oil pulling is thought to renew the senses, stimulate the body, and refresh the intellect. Additionally helpful are sore throat, dry skin, vision impairment, taste loss, and appetite loss.[18]

Moreover, oil pulling is predicted to improve cells, tissues, and organs of the body and extend human life.[7] Within two weeks of utilizing the proper oil pulling technique, oral hygiene has improved. Plaque and gingival indices were lowered as a result of utilizing sunflower oil for oil pulling for 45 days.[8]

Although refined oil can also be used to "extract" bacteria, viruses, and protozoa from the oral cavity, organic oils like sunflower, sesame, and coconut oil are advantageous, especially when cold-pressed. Oil pulling is best done using cold pressed oils because they are free of trans fats as compared to commercial oils made from potent oil-based solvents.[19] Sesame oil has long been known to be the preferred oil for use in oil pulling applications.[17] It has also been reported to use olive oil, milk, gooseberry, and mango extracts for oil pulling.[20] It has been discovered that sesame oil and sunflower oil can lessen plaque-induced gingivitis.[8] Chlorosesamon, found in sesame root (Sesamum indicum), has antifungal properties.[9] Moreover, sesame oil's polyunsaturated fatty acids lessen oral cavity free radical damage.[19]

OIL PULLING LIMITATION

There are no clinical guidelines for oil pulling because it is one of the alternative oral hygiene practices that has not been sufficiently studied. However, its use is not recommended for children under 5 years of age as there is a risk of swallowing. In addition, if there is an allergy to the active ingredients, its use is not recommended. Kuroyama et al.[21] reported rare cases of lipoid pneumonia as a result of repeated oil pulling practice. Reported cases have been associated with involuntary aspiration of small amounts of fat, which can be easily excreted through the feces and should not pose any risk to general health.[22,23]

Literature on this Subject

In a study by Siripaiboonpong et al.,[24] 36 volunteers with gingivitis were divided into 2 groups and instructed to apply coconut oil and palm oil extraction for 28 days in addition to their oral hygiene regimen. This was done to compare the microbiological effects of the two products. The individuals switched their oil type and repeated the experiment after a 21-day washout period. In the beginning, after the first oil-drawing period, after washing, and after the second oil-drawing period, plate samples were taken for microbial culture. Controlling plaque bacteria with coconut oil extraction did not outperform palm oil extraction. Palm oil has been demonstrated to decrease the baseline amount of *Mutans streptococci* when used as an additional oral hygiene measure. This finding, however, does not conclusively demonstrate whether the risk of dental caries is decreased. Oil pulling is recommended as an extra oral hygiene technique because it has a minimal risk of side effects compared to conventional treatments. During the course of the trial, none of the participants reported experiencing any side effects.[24]

In their study to evaluate the efficacy of probiotic mouthwash, sesame oil therapy, and chlorhexidine-based mouthwash on plaque accumulation and gingivitis in school children aged 10 to 12 years, Kandaswamy et al.[25] used modified gingival index (GI) scores as well as full-fledged oral prophylaxis. They were told to use the recommended mouthwashes once a day, and their parents watched over them as they did so. The kids underwent the same clinical evaluations on days 15 and 30. For both the GI and PI scores, within-group comparisons were statistically significant in all three groups ($p \leq 0.001$). Only the chlorhexidine group's difference in GI scores between days 15 and 30 was statistically significant ($p=0.024$). Comparisons between the three groups within each intergroup did not demonstrate statistical significance.

In a study by Griessl et al.[26] comparing whether the overall microbial load of the oral cavity was reduced in oil pulling and saline withdrawal conditions, oil pulling resulted in a higher saliva production and the oil/saliva emulsion appeared to contain more bacteria than saline-extracted samples. They came to the conclusion that oil pulling can momentarily lessen the total amount of microbes in the mouth and that the microbiota found in oil pulling samples is representative of the oral microbiome.

According to Peng et al.'s[27] meta-analysis, oil pulling may potentially reduce the number of salivary bacterial colonies, but it had no discernible impact on plaque index results or gingival index score.

The plaque index and bleeding index were initially assessed and assessed after 30 days in the pilot study by Ripari et al.,[28] which sought to determine the efficacy of coconut oil extraction as an adjuvant in reducing plaque formation and in the treatment of plaque-induced gingivitis. Twenty patients with gingivitis were included in the sample. The collected data were found to be important and promising in reducing plaque formation and gingivitis.

Oil pulling has become popular as a home whitening treatment due to its low cost and harmlessness. Oil pulling does not have complex procedures and the fact that natural oils are readily available in the market contributes to its popularity. In addition, the possibility of allergic reactions and bad taste sensations to oils is very low. However, the disadvantages of this method are that the treatment result does not appear immediately and requires longer patient compliance to achieve expectations. Coconut oil has become popular for oil pulling due to its pleasant taste and various benefits. Coconut oil can be used safely because it does not contain acids and other corrosives.[29]

In a study by Rajab et al.,[30] 60 female patients were divided into two main groups and used "coconut oil swish" and "crest 3D white," with the aim of evaluating the whitening effectiveness, tooth sensitivity, and soft tissue irritation of coconut oil extraction as a home bleaching method, in comparison to over-the-counter whitening mouthwash. Color measurement at week 1 and week 2 was done three times using the VITA Easyshade® Advance device. "tooth sensitivity and soft tissue irritation" pain assessment was performed using the "Wong-Baker FACES" Pain Rating Scale. Whitening mouthwash containing 1.5% hydrogen peroxide reported stronger color change after one or two weeks of usage, even though the elimination of coconut oil demonstrates a whitening efficacy after two weeks of use. When compared to mouthwashes that contain 1.5% hydrogen peroxide for teeth whitening, they discovered that using coconut oil regularly resulted in decreased tooth sensitivity and/or soft tissue irritation.

Ludwar et al.,[31] in their study to determine the subjective effectiveness of oil pulling on drug-induced xerostomia in terms of symptom relief, quality of life, taste, mucosal moisture, and oral parameters, showed that participants with drug-induced xerostomia had xerostomia burden, symptom relief and symptom relief with weekly use as a result of sunflower oil withdrawal. At baseline and at the conclusion of the follow-up, oral examinations (gingivitis index, plaque index, completely stimulated and unstimulated salivation rates) were looked at. Oil pulling alleviated the overall xerostomia burden. There was no difference in symptom relief between oil and water in the comparison.

CONCLUSION

Oil pulling has been the subject of various studies as a method that has been around for many years. Although the studies had various results, they generally had an effect on bacterial colonies in saliva. In the light of the studies carried out, more comprehensive studies should be planned and the benefits of oil pulling should be supported.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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