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Dear Colleagues,

It is with great pleasure that I welcome you to the second issue of our peer-reviewed academic journal named, Journal of Dental Sciences and Education (JDSE). In this second issue, interesting research articles and reviews of new developments in the field of dentistry are included. One of our most important goals is to mediate appropriately the sharing of knowledge and experience among dental professionals, researchers and academicians. In this issue, we share with you five articles covering various topics in dentistry.

Our first article of the journal "Effect of additional polymerization process on color change in composite resins hold in different solutions" is an original article and the authors aimed to compare the amount of coloration of composite resins with different filler content by keeping them in various coloring solutions after standard and additional polymerization processes. The second article " Comparison of aesthetic perceptions created by the factors affecting smile design in different occupational groups" is an original article, and the authors concluded that profession and education do not always have the same effects on aesthetic perceptions. The third article '' Investigation of maximum torque values in manual tightening of dental implant healing screws" is an in vitro study evaluated to the change of the maximum torque values applied by the physicians according to the parameters of gender, dental experience and glove type used in the tightening processes applied manually by assistants and interns to the implant superstructure parts. The fourth article, " Gingival and periodontal diseases in children '' is a review about gingival and periodontal diseases in childhood. Finally, the fifth article '' Use of fiber-containing materials in restorative dentistry'' is another an review article.

I would like to thank the authors, reviewers, editorial team and publisher for their hard work and dedication in bringing this second issue to fruition. We look forward to providing you with the latest insights and developments in dentistry, and we welcome your feedback and suggestions.

Sincerely,

Assoc. Prof. Elif Pinar BAKIR, PhD
Editor-in-Chief

Journal of
Dental Sciences
and Education

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Volume: 1 Issue: 2 Year: 2023

ORIGINAL ARTICLES

REVIEW

Journal of Dental Sciences and Education

Original Article

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Investigation of maximum torque values in manual tightening of dental implant healing screws

Elif Yalçın, Eyyüp Altıntaş

Department of Prosthodontics, Faculty of Dentistry, Fırat University, Elazığ, Turkey

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Corresponding Author: Elif Yalçın, elifyalcin94@live.com

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ABSTRACT

Aims: This study aimed to investigate the change of the maximum torque values applied by the dentist according to the parameters of gender,dental experience and glove type used in the tightening processes applied manually by pre-graduated and post-graduated dentists to the implant superstructure parts.

Methods: 24 dentists (11 Male, 13 Female) participated in our study.Participants were instructed to tighten the implant healing screw (Straumann Dental Implant System, Waldenberg, Switzerland) placed on the digital torque measuring device(Cap torque tester series TT01; Mark10, Copiague, NY)by applying maximum force with a manual wrench.Powdered latex gloves,powder-free latex gloves and sterile surgical gloves were made available to the participants in order to imitate the mouth conditions as much as possible.Manual tightening was repeated three times in each group,with at least three minutes duration.Data were recorded digitally and statistical analysis was performed with IBS SPSS statistics 22 program.Independent sample t-test and one-way Anova analysis were used to evaluate differences between groups,followed by the post-hoc Tukey test.

Results: Maximum torque value for tightening with powdered latex gloves (20.01±5.55) N, powder free latex gloves (17.27± 4.34) N and surgical gloves (20.27±6.02) N was found.In addition, we did not find a statistically significant difference in terms of gender and dental experience,which are the other parameters we investigated.

Conclusion: Gender, experience and glove type do not statistically affect the maximum torque to be applied in implant superstructure applications.

Keywords: Manual torque, Dental experience, Latex glove

This study was presented as an oral presentation at the 26th Turkish Dental Association International Dentistry Congress September 8-11, 2022.

INTRODUCTION

Dental implant is an osseointegrated prosthetic appliance that supports removable or fixed, partial or full dentures placed in the maxilla and/or mandible in cases of partial tooth deficiency or total edentulism.[1] Torque force means the turning force applied to an object. It is used when placing the dental implant in the jaw. Dentists may prefer various methods when tightening implant superstructure parts. Torque with manual wrenches and torque with ratchets are among these methods. Torque with ratchet is known to cause less screw loosening problems than torque with manual wrenches.[2-4]

After the dental implant is osseointegrated, healing caps are used to shape the soft tissue. The connection of the healing caps and other superstructure parts to the root part of the implant should be done with optimum torque. Screwing and tightening with proper torque is a very important factor for implant survival. Undertightening causes problems such as screw loosening, over-tightening exceeds the yield strength of the screw and may cause permanent deformation, loss of mechanical properties, and screw fractures. Dentists should have an idea of the amount of force they exert when using manual wrenches to torque implant suprastructure parts. Implant manufacturers usually give the average torque force required for implant placement and abutment screw between 20-32 N/cm², but do not specify average force for parts such as impression posts and healing cap.[6] There are no known studies on the torquing of the dental implant healing cap. In this study, we aim to determine how well the implant manufacturers recommended torque values matched with dentists gender, application method and experience.

METHODS

This study does not contain any human or animal materials. It is an in vitro study under laboratory conditions. Therefore, it does not require an ethics committee approval. Institutional approval has been obtained. All procedures were carried out in accordance with the ethical rules and the principles.

Twenty-four dentists (11 male, 13 female) participated in our study. Participants consist of 12 post-graduated dentists and 12 pre-graduated dentists. The post-graduated dentists were selected from the departments of prosthetic dentistry, oral and maxillofacial surgery

and periodontology, which have the opportunity to work with implant superstructures. In our study, there are three groups which separate each other with glove type. There are three types of gloves, Group 1 which is used powdered latex gloves (Valeriai, Turkey), Group 2 is used powder free latex gloves (Valeria, Turkey) and Group 3 is used surgical sterile gloves (Beybi Gold Plus, Malesia).

A setup was prepared with an implant screw embedded in cold acrylic to manually torque the healing cap (**Figure 1**).

Participants were instructed to tighten the healing cap with manual hand wrenches with maximum torque on the implant screw (Straumann Dental Implant System, Waldenberg, Switzerland) placed on a digital torque measurement device (Cap torque tester series TT01; Mark10, Copiague, NY) (**Figure 2**). Since the measurements were made digitally, they were measured and recorded once in each group. Because of digital measurements were not subjective, the application was not repeated.

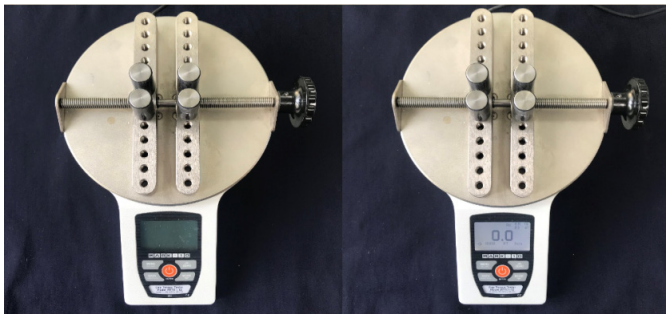

Figure 2. Digital torque measurement device (cap torque tester series TT01, Mark10, Copiague,NY)

Powdered latex, powder-free latex and surgical gloves were used by the participants (**Figure 3**).

Figure 3. There are three types of gloves.

Statistical Analysis

Maximum tightening was repeated three times in each group, with at least three minutes duration. Data were recorded digitally and statistical analysis was performed with IBS SPSS statistics 22 program. Independent sample t-test,one-way Anova analysis, post-hoc Tukey test were used to evaluate differences between groups with gender, glove type and experience parameters. In all analyses, $p<0.05$ was considered statistically significant.

RESULTS

When we investigate the each group, we found that Maximum torque value for Group 1 (20.01±5.55) N, Group 2 (17.27± 4.34) N and Group 3 (20.27±6.02) N was found (**Table 1**).

The maximum force differences between genders, tightening with powdered latex gloves, the maximum torque value is (18.34±4.80) N for women and (21.98± 5.95) N for men; The maximum torque value when tightening with powder-free latex gloves is (15.90±4.27) N for women and (18.89±4.02) N for men. On the other hand, it was found (18.32±5.92) N in women and (22.49±5.60) N in men in tightening with surgical gloves (**Table 2**).

Table 2. Torque application values by gender

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Powdered gloves	Men	13	18.3462	4.80271	1.33203
	Women	11	21.9818	5.95043	1.79412
Powder-free gloves	Man	13	15.9077	4.27365	1.18530
	Women	11	18.8909	4.02006	1.21209
Surgical gloves	Men	13	18.3923	5.92361	1.64291
	Women	11	22.4909	5.60900	1.69118

For dental experience parameters, which have equal participants, for tightening with powdered latex gloves, the maximum torque value was (19.45±4.57) N for post-graduated and (20.57±6.54) N for pregraduated dentists; (17.25±2.54) N for post-graduated and (17.29±5.79) N for pre-graduated dentists with powder-free latex gloves; (19.55± 4.29) N post-graduated and (20.99±7.51) N and pre-graduated dentists with surgical gloves were found (**Table 3**).

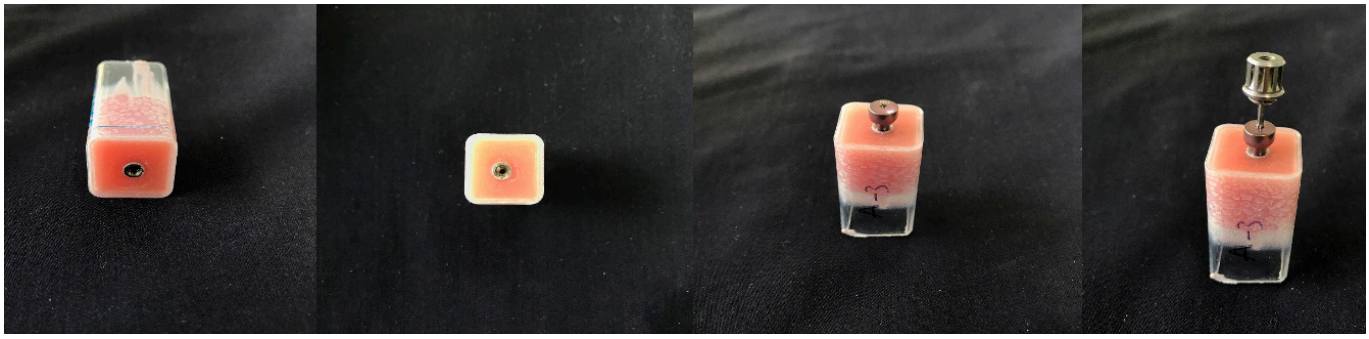

Figure 1. A setup was prepared with an implant screw embedded in cold acyrclic to manually torque the healing cap.

Table 1. Torque application values by glove type

	N	Mean	Std. Deviation	Std. Error	%95 Confidence Interval for Mean		Min.	Maks.
					Lower Bound	Upper Bound		
Powdered gloves	24	20.0125	5.55458	1.13382	17.6670	22.3580	9.90	31.70
Powder-free gloves	24	17.2750	4.34294	0.88650	15.4411	19.1089	8.30	24.70
Surgical gloves	24	20.2708	6.02808	1.23048	17.7254	22.8163	10.60	31.90
Total	72	19.1861	5.45337	0.64269	17.9046	20.4676	8.30	31.90

Table 3. Torque application values by experience

	Experience	N	Mean	Std. deviation	Std. error mean
Powdered gloves	Post-graduated dentists	12	19.4500	4.57612	1.32101
	Pre-graduated dentists	12	20.5750	6.54830	1.89033
Powder-free gloves	Post-graduated dentists	12	17.2583	2.54289	0.73407
	Pre-graduated dentists	12	17.2917	5.74194	1.65756
Surgical gloves	Post-graduated dentists	12	19.5500	4.29323	1.23935
	Pre-graduated dentists	12	20.9917	7.51090	2.16821

The difference between the maximum torque measurements in the studied parameters was not statistically significant (p>0.05).

Table 4. Post-graduated dentist manual torque values - women

	Powdered gloves	Powdered-free gloves	Surgical gloves
1	12	13.9	13.4
2	23	20.2	20.1
3	16.6	14.6	13.5
4	12.4	15	12.4
5	17.6	16.2	21.4
6	25.6	20.6	22.4
7	19.6	18.3	21.2

Table 5. Post-graduated dentist manual torque values - men

	Powdered gloves	Powder-free gloves	Surgical gloves
1	19	17.3	21.7
2	18.3	14.4	17.3
3	24.2	17	24.1
4	19.4	18.3	23.2
5	25.7	21.3	23.9

Table 6. Pre-graduated dentist manual torque values - women

	Powdered gloves	Powdered-free gloves	Surgical gloves
1	24.5	14.2	31.5
2	15	8.3	14.9
3	18.4	23.4	11.3
4	19.5	13.7	23.8
5	23	18.6	20.5
6	11.3	9.8	12.7

Table 7. Pre-graduated dentist manual torque values - men

	Powdered gloves	Powdered-free gloves	Surgical gloves
1	18.4	16.7	18.9
2	28	24	27
3	31.7	20.9	31.9
4	21.2	21.6	22
5	9.9	11.6	10.6
6	26	24.7	26.8

DISCUSSION

Studies on the torque of the dental implant are related to the implant loading and the torque of the abutment screw. There are no known studies on the torquing of the dental implant healing cap. The most common complication in implant-supported prosthetic restorations is loosening of the abutment screw.[6-8]

Previous studies have indicated that the lowest applied force abutment screw preload torque is important. They also showed that excessive torque can exceed the yield strength of the material.[6]

Both Goheen et al.[5] and Hill et al.[11] showed a variable range in torque force reached with manual wrenches among study participants. The study by Goheen et al. tested oral and maxillofacial surgeons and prosthetic dentists working with dental implant parts. The total maximum torque produced with the manual wrenches was 36.2 N/cm². Our study confirms that participants show different degrees of torque values in their applications. In addition; In our study, it was observed that the participants could not reach the maximum torque value of 32 N/cm², which is determined by the implant manufacturers, with manual wrenches.[9] Therefore, dentists should be careful about both the under-torque and over-torque of implant parts. Dental implant manufacturers need to be more precise about the torque values they recommend for all implant superstructure parts.[10]

The in vitro study of Neiburger et al.[12] showed that,likewise in our study, patient-specific intraoral factors such as salivation, mouth opening,lack of vision,and patient cooperation can negatively affect the dentist's manual dexterity. It can be assumed that these factors will have a negative impact on the dentist's ability to grip the manual hand wrench and on his ability to generate preload torque. It has been shown that even the gloves that we use in clinical practice greatly reduce the ability to hold hand tools and the tactile sense.[13]

In their study, Tomoki Nishiuchi et al.[14] had participants torque with and without gloves using manual wrenches. Our study differs from theirs in gender parameters. As a result of their study, it was seen that the torque value created by male participants when wearing gloves was higher. It was observed that the force applied by the female participants was relatively lower than the male participants. If we examine our study, no statistically significant difference was found between the maximum torque values applied by men and women, regardless of whether they were wearing gloves or not.

In the study of Alikhasi et al.[15] it was requested participants to apply maximum force to the abutment screw by using different types of manual wrenches.As a result, it was concluded that the torque strength of male users was higher than that female participants. In our study, unlike to the study of Alikhasi et al.[15] the gender parameter does not affect the torque strength.

Goheen's study[5] examined at the ability of the abutment screw to generate preload torque; based on dental experience in dentistry. It was concluded that the force applied by the oral and maxillofacial surgeons who participated in the study was better than the general dentists,but we did not found any differences in dental experience parameters.

Parnia et al.[16] compared manual wrenches and abutment screw torque strengths of professors and general dentists using a digital torque measuring device. As a result, no statistically significant difference was found between the two groups in the maximum force. Dental experience data, which is one of the parameters examined in our study, also showed parallelism with the results of this study.[15]

Tahir Karaman et al.[17] torqued the abutment screw with manual wrenches using latex and nitrile gloves also investigated gender differences. As a result, it was found that the maximum torque force applied with powdered latex was higher than the nitrile glove. No significant difference was found in the gender parameter. The gender parameter, which is also one of the parameters investigated in our study, did not show a significant difference as in this study.

Altintas et al.[18] They applied manual torque to prefabricated posts using the digital torque measuring device (Cap torque tester series TT01; Mark10, Copiague, NY) like we used in our study.

CONCLUSION

In the manual torque of the healing cap, the maximum torque values were investigated according to different parameters. Gender, which is one of the parameters related to the torque of the dental implant healing cap, did not make a significant difference in the ability to torque the healing cap. Likewise, the type of glove used did not change the ability to generate torque. Dental experience, the last parameter we examined, also did not make a difference in torque. Further work is required for more accurate and reliable results.

ETHICAL DECLARATIONS

Ethics Committee Approval: This study does not contain any human or animal materials. It is an in vitro study under laboratory conditions. Therefore, it does not require an ethics committee approval.

Informed Consent: This study is in vitro study under laboratory conditions. Therefore, it does not require informed consent.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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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

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Comparison of aesthetic perceptions created by the factors affecting smile design in different occupational groups

Dilan Ayluçturhan Ayçiçek[1], Elif Pınar Bakır[2]

[1]Oral and Dental Health Center, Diyarbakır, Turkey
[2]Department of Restorative Dentistry, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey

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Corresponding Author: Dilan Ayluçtarhan Ayçiçek, dr.baycicek@gmail.com

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ABSTRACT

Aims: This study aimed to compare the effects of factors affecting smile design on aesthetic perceptions in different occupational groups.

Methods: For this study, a questionnaire form was prepared including 42 modified photographs obtained by incorporating different levels of changes in the factors affecting smile design such as gingival visibility, incisal embrasure, buccal corridor, incisor visibility, midline, smile line, vermilion height of the lips, golden ratio, and diastema within a photograph of a woman and a photograph of a man. Voluntary participants were asked to evaluate each photograph in terms of aesthetics and mark the most appealing options on VAS and Likert-type scales.

Results: Fine arts faculty graduates reactedto the differences in the images more positively than the other participants. Restorative dentistry specialists gave higher scores to the smile criteria most liked by all participants compared to other participants, while the criteria that were least liked by all participants received the lowest scores in this group. They gave answers in parallel with the values accepted as ideal. Male and female models were found to be more aestheticwhen golden ratio, incisal embrasures and the midline were not changed, the gingiva covered the central teeth by 1 mm, the lip vermilion height was increased by 2 mm, the line drawn from the incisors of the maxillary anterior was parallel to the lower lip's curvature, the visibility of the central incisorswas 3 mm, and no diastema.

Conclusion: We determined that profession and education do not always have the same effects on aesthetic perceptions. We suggest that the most appropriate results can be achieved in terms of diagnosis and treatment in aesthetic dentistry when the personal tastes of individuals are supported by data from the relevant literature.

Keywords: Aesthetic dentistry, smile, smile design

INTRODUCTION

Demands and expectations for aesthetic dentistry have changed in recent years as individuals have become more visible on social media, and the need for knowledge and experience in dentofacial aesthetics inspired by beautiful faces and smiles and smile aesthetics has increased.[1-5] In order for treatment results to be satisfactory, the criteria for smiles should be considered in more detail in the planning process.[6] In smile analysis, the amount of the visible teeth and gingiva in the smile, the smile arc, tooth ratios, gingival height and contour, the relationship between the tooth midline and the midline of the face, the relationship of the occlusal plane with the interpupillary and commissural line, and the shape and color of the teeth should all be evaluated.[7] In order to determine all of the criteria and factors affecting these outcomes, all details of the teeth should be investigated and carefully evaluated.[8] To ensure that treatmentsprovide ideal aesthetic results, some clinical guidelines should be taken into account. However, the fact that aesthetics is a subjective concept makes it necessary to question these reference parameters according to individual tastes and cultural differences.[9] In the literature, it is observed that different criteria such as the golden ratio, buccal corridor, smile arc, gingival visibility, incisal embrasure, visibility of incisors, vermilion height of the lips, midline, and diastema are considered in different combinations and the perceptions of different occupational groups have been evaluated.[10-14]

This study aimed to examine perceptions of changing aesthetic parameters among different occupational groups using a visual analogue scale (VAS) and a Likert-type scale to determine the ideal values of smile criteria for smile design. The hypothesis of the study was that there would be differences in aesthetic perceptions among occupational groups.

METHODS

Ethics committee approval for the study was obtained from the Ethics Committee of the Dicle University Faculty of Dentistry (Date: ..... , Decision No: .....). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. A total of 315 people, including fifth-year dentistry students, general dentists, restorative dentistry specialists, orthodontists, dental prosthesis laboratory technicians, graduates of the faculty of fine arts, and non-dentists, were divided into seven groups according to their professions. Photographs of a male and female model who signed consent forms were used as the reference photos. The reference photographswere created with right and left buccal corridor widths of 2%, upper central incisor visibilityof 4mm and gingival visibility of -1 mm for the upper central incisors (i.e., gingival margins of the upper central incisors covered by the upper lip line), overlapping facial midline and dental midline, and smile arc parallel to the lower lip curve. Nine smile components were modified using the Adobe Photoshop CC 2014 program within the original reference photos and 33 modified smile photos were created. The changed smile components included the golden ratio, buccal corridor, gingival visibility, lip vermilion height, smile arc, incisal embrasures, incisor visibility, dental midline, and diastema.

Figure 1. Reference photos for maleReference photos for female

The modified photos were created as follows:

- Golden ratio or less than or greater than 60% (**Figure 2**),
- Buccal corridor width 10%, 15%, 22%, 28% (**Figure 3**),
- Visibility of the gingival created via gradually increasing by 1 mm over the reference photographs (**Figure 4**),
- Height of the lip vermilioncreated via gradually increasing the intervals by 0.5 mm over the reference photographs (**Figure 5**),
- Smile arc created straight and reservedin the reference photographs (**Figure 6**),
- Incisal embrasure of ideal size, enlarged, equal, reducedand without embrasure based on the reference photographs (**Figure 7**),
- Central visibility created via gradually decreasing and increasing by 0.5 mm over the reference photographs (**Figure 8**),
- The midline created by gradually shifted to the left at 0.5 mm intervals over the reference photographs (**Figure 9**),
- The diastema created via gradually increased by 0.5 mm intervals over the reference photographs (**Figure 10**).

Separate VAS and Likert-type scales were added to a questionnaire formfor each photograph. The VAS consisted of a ruler with labels ranging from 0 to 10 while the five-point Likert-type scale consisted of a linear sequence ranging from Very Ugly to Ugly, Undecided (Neutral), Beautiful, and Very Beautiful. Voluntary participants were asked to evaluate each photograph aesthetically and mark the most appealing options for them according to the VAS and Likert-type scales.

Figure 2. Male model, Golden ratio 60%, golden ratio greater than 60%, golden ratio less than 60%

Figure 3. Male model, buccal corridor 2%, buccal corridor 28%

Figure 4. Male model, gingival visibility -1 mm, gingival visibility 3 mm

Figure 5. Male model, height of the lip vermilion0, height of the lip vermilion 2 mm

Figure 6. Male model, smile arcparallel, smile arc straight, smile arc reverse

Figure 7. Male model, incisal embrasure ideal, enlarged, equal, reduced, absent

Figure 8. Male model, central visibility 3 mm, Central visibility 5 mm

Figure 9. Male model, midline not shifted, midline shifted 2.5 mm to the left

Figure 10. Male model, diastema not formed, diastema formed 2 mm

Statistical Analysis

The data obtained in this study were analyzed using the IBM spss 21 package program. Data were analyzed using Shapiro Wilk's, two-way ANOVA, Kruskal Wallis-H tests and post-hoc multiple comparison test.

RESULTS

Fine arts faculty graduates reacted to the differences in the images more positively than the other participants. Restorative dentistry specialists gave higher scores to the smile criteria most liked by all participants compared to other participants, while the criteria that were least liked by all participants received the lowest scores in this group. They gave answers in parallel with the values accepted as ideal.

Male and female models were found to be more aesthetic when the golden ratio, incisal embrasures and the midline were not changed, the gingiva covered the central teeth by 1 mm, the lip vermilion height was increased by 2 mm, the line drawn from the incisors of the maxillary anterior was parallel to the lower lip's curvature, the visibility of the central incisors was 3 mm, and no diastema.

In all professional groups, images with a golden ratio of less than 60%, a buccal corridor width of 28%, a central visibility of 5 mm, and a gingival visibility of 3 mm were the least liked.It was determined that the photographs in which the height of the lip vermilion was not changed, the smile arch was reversed, the incisal embrasures were absent or reduced-enlarged, the midline was shifted 2.5 mm to the left, and the diastema was formed were not liked by any professional group. There was strong agreement between the ratings on VAS and the Likert scale.

Table 1. Results related to the golden ratio, buccal corridor, and gingival visibility in the Likert scale for evaluating photographs of male models.

	Meslek													Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	p
Altın Oran %60	3,76	0,61	3,62	0,58	3,4	0,58	3,53	0,69	3,6	0,69	3,53	0,79	3,58	0,66	0,336
Altın Oran %60'dan Büyük	2,69	0,9	3,04	0,93	2,76	0,88	2,82	0,65	2,71	1,04	3,42	0,97	2,8	0,81	0,001*
Altın Oran %60'dan Küçük	2,73	0,84	2,51	0,82	2,69	0,79	2,29	0,82	2,51	1,01	3,29	0,89	2,64	0,98	0,001*
Bukkal Koridor %2	4,16	0,74	3,67	0,71	3,89	0,53	3,76	0,57	3,78	0,64	3,76	0,53	3,64	0,68	0,01*
Bukkal Koridor %15	2,38	0,61	2,38	0,61	2,36	0,48	2	0,64	2,27	0,84	2,6	0,78	2,42	0,69	0,01*
Bukkal Koridor %22	1,76	0,65	1,98	0,69	1,49	0,51	1,76	0,8	2,13	0,79	2,38	0,68	2,2	0,59	0,001*
Bukkal Koridor %10	3,62	0,58	3,4	0,62	3,62	0,49	3,36	0,57	3,62	0,78	3,62	0,71	3,56	0,81	0,143
Bukkal Koridor %28	1,47	0,5	1,6	0,62	1,38	0,49	1,64	0,71	1,91	0,7	1,91	0,7	1,91	0,7	0,001*
Diş eti görünürlüğü 1 mm	2,69	0,6	3,62	0,58	3,4	0,58	3,51	0,69	3,6	0,69	3,55	0,79	3,53	0,66	0,336
Diş eti görünürlüğü 3 mm	1,62	0,5	2,07	0,65	2,07	0,72	2,07	0,65	1,98	0,69	2,44	0,76	2,24	0,68	0,028*
Diş eti görünürlüğü 0	3,58	0,62	3,33	0,67	3,27	0,69	3,4	0,54	3,53	0,73	3,87	0,69	3,4	0,78	0,001*
Diş eti görünürlüğü 2 mm	2,07	0,49	3,04	0,93	2,76	0,88	2,82	0,65	2,69	1,04	3,42	0,97	2,8	0,81	0,001*
Diş eti görünürlüğü -1 mm	3,78	0,52	3,4	0,72	3,47	0,73	3,53	0,69	3,42	0,89	3,98	0,78	3,56	0,59	0,002*

Table 2. Results related to the height of the lip vermilion, the smile arch and incisal embrasures in the Likert scale for evaluating photographs of male models.

	Meslek													Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	p
Dudak V.Y 0,5 mm	3,16	0,67	3	0,77	2,71	0,59	2,73	0,81	3,16	0,77	3,31	0,7	2,96	0,93	0,001*
Dudak V.Y 1,5 mm	3,58	0,58	3,27	0,89	3,49	0,51	3,44	0,78	3,27	0,89	3,49	0,94	3,29	1,01	0,512
Dudak V.Y 0 Likert	2,91	0,79	2,82	0,81	2,44	0,59	2,47	0,81	2,62	0,81	3,16	0,98	2,82	0,81	0,001*
Dudak V.Y 1 mm	3,24	0,61	3,24	0,71	3,29	0,51	3,04	0,71	3,13	0,79	3,56	0,89	2,78	0,82	0,001*
Dudak V.Y 2 mm	3,76	0,61	3,51	0,73	3,76	0,43	3,69	0,63	3,27	0,94	3,5	1,01	3,33	0,93	0,009*
Gülümseme Arkı Düz	3,2	0,79	3,21	0,91	3,16	0,67	3,04	1,09	3,18	1,03	3,53	0,94	3,13	0,69	0,239
Gülümseme Arkı Ters	2,67	0,88	2,73	1,03	2,89	0,78	2,8	1,1	2,53	1,06	2,96	0,93	2,67	0,85	0,258
Gülümseme Arkı Paralel	3,49	0,79	3,22	0,93	3,56	0,62	2,73	1,03	3,47	0,89	3,82	0,75	3,42	0,87	0,001*
İnsizal Embraşür Eşit	2,67	0,56	3,16	0,74	3,44	0,89	2,91	0,97	2,8	0,89	3,27	0,65	3,02	1,06	0,001*
İnsizal Embraşür İdeal	3,98	0,5	3,6	0,62	3,8	0,5	3,69	0,67	3,49	0,97	3,82	0,81	3,47	0,81	0,014*
İnsizal Embraşür Azalmış	2,38	0,61	2,42	1,03	2,64	0,83	2,33	0,88	1,78	1	2,6	1,12	2,53	1,14	0,001*
İnsizal Embraşür Yok	2,36	0,61	2,67	0,95	2,33	0,6	2,4	0,84	2,07	1,1	2,53	1,31	2,11	1,15	0,036*
İnsizal Embraşür Artmış	2,67	0,52	2,89	0,71	2,69	0,56	2,71	0,79	2,78	0,9	3,02	0,97	2,84	0,9	0,578

Table 3. Results related to the central visibility, midline and diastemain the Likert scale for evaluating photographs of male models.

	Meslek														Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler		
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	p
Keserlerin Görünürlüğü 3,5 mm	3,69	0,6	3,51	0,84	3,44	0,55	3,27	0,78	3,36	0,93	3,51	0,82	3,27	0,86	0,175
Keserlerin Görünürlüğü 4,5 mm	2,47	0,66	2,58	0,84	2,18	0,81	2,31	0,82	2,33	0,67	2,91	0,95	2,69	1,08	0,002*
Keserlerin Görünürlüğü 3 mm	3,78	0,6	3,67	0,71	3,69	0,56	3,38	0,75	3,56	0,89	3,67	0,93	3,38	0,86	0,085
Keserlerin Görünürlüğü 4 mm	2,84	0,64	2,96	0,93	2,47	0,92	2,69	1,02	3	0,48	3,09	1	2,82	0,98	0,015*
Keserlerin Görünürlüğü 5 mm	1,44	0,5	1,73	0,72	1,24	0,57	1,62	0,65	1,36	0,48	2,11	1,23	1,78	0,93	0,001*
Orta Hat 0	3,67	0,74	3,42	0,69	3,71	0,46	3,4	0,84	3,27	0,96	3,64	0,91	3,38	0,83	0,089
Orta Hat 2 mm Sola Kayma	2	1,09	2,38	0,68	2,22	0,6	2,16	0,82	2,29	1,1	2,78	1,18	2,2	0,5	0,012*
Orta Hat 0,5mm Sola Kayma	3,42	0,62	2,71	0,84	3,36	0,57	2,78	0,93	2,76	0,77	3,04	0,8	2,87	0,81	0,001*
Orta Hat 1,5 mm Sola Kayma	2,2	0,84	2,67	0,93	2,76	1	2,58	1,12	2,49	0,73	2,98	0,81	2,67	1,04	0,005*
Orta Hat 2,5 mm Sola Kayma	1,89	0,53	2,36	0,8	2,02	0,62	2	0,8	2,04	1,13	2,38	1,07	2,11	1,11	0,088
Orta Hat 1 mm Sola Kayma	2,89	0,61	2,89	0,78	3,07	0,69	2,84	1,04	2,76	0,98	3,16	1	2,89	0,91	0,38
Diastema 0,5mm	2,47	0,76	2,4	0,91	2,38	0,83	2,24	1,07	2,47	1,12	2,73	0,89	2,33	0,9	0,226
Diastema 1,5mm	1,6	0,69	1,62	0,65	1,49	0,55	1,49	0,63	1,38	0,65	1,73	0,65	1,64	0,8	0,132
Diastema Yok	3,91	0,67	3,31	0,73	3,64	0,65	3,44	0,69	3,44	1,01	3,76	0,68	3,2	0,84	0,001*
Diastema 1mm	1,96	0,52	1,91	0,7	1,69	0,6	1,69	0,63	1,98	0,78	2,09	0,73	2,02	0,78	0,039*
Diastema 2mm	1,27	0,45	1,33	0,48	1,29	0,51	1,16	0,37	1,24	0,53	1,44	0,69	1,38	0,61	0,332

Table 4. Results related to the golden ratio, buccal corridor, and gingival visibility in the VAS scale for evaluating photographs of female models

	Meslek														Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler		
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	p
Altın Oran %60	6,42	2,44	5,51	2,28	6,29	1,88	5	2,61	5,02	2,85	4,82	2,68	5,07	2,48	0,008*
Altın Oran %60'dan Büyük	4,07	2,43	4,11	2,29	4,73	2,6	3,84	2,55	3,62	2,66	4,80	3,05	3,6	2,61	0,003*
Altın Oran %60'dan Küçük	2,11	1,47	2,49	1,98	2,51	1,98	1,87	2,12	2,2	2,35	3,13	2,42	2,36	2,56	0,106
Bukkal Koridor %2	5,71	2,25	5,36	1,98	6,38	1,83	6,04	2,53	5,02	2,8	5,70	2,69	5,29	2,73	0,175
Bukkal Koridor %15	2,42	1,64	2,73	1,86	2,11	1,47	2,42	2,21	2,44	2,36	2,78	2,34	2,98	2,9	0,822
Bukkal Koridor %22	6,98	1,51	6,33	1,76	6,98	1,51	6,31	2,22	5,91	2,65	5,71	2,8	5,73	2,47	0,085
Bukkal Koridor %10	3,69	1,78	3,89	1,54	3,93	1,45	3,8	1,82	3,56	2,38	3,62	2,46	3,42	2,29	0,586
Bukkal Koridor %28	0,8	1,29	1,6	1,76	0,98	1,31	1,29	1,84	1,98	2,45	1,67	2,27	1,98	2,05	0,03*
Diş eti Görünürlüğü 0	6,51	1,71	5,22	2,37	6,07	2,04	4,89	2,87	5,02	2,78	4,71	2,7	5,33	2,83	0,012*
Diş eti Görünürlüğü -1 mm	6,67	2,15	4,87	2,61	6,6	1,88	5,22	2,54	5,87	2,73	5,82	2,74	5,8	2,63	0,007*
Diş eti Görünürlüğü 1 mm	2,8	1,58	2,96	2	2,64	1,84	2,8	1,96	3,31	2,39	3,67	2,14	3,84	2,32	0,078
Diş eti Görünürlüğü 3 mm	0,87	1,16	1,4	1,37	0,71	0,97	0,84	1,3	1,11	1,86	1,27	1,94	1,38	1,5	0,095
Diş eti Görünürlüğü 2 mm	2,27	1,79	2,04	1,62	1,71	1,24	2,04	1,93	1,8	2,06	2,56	1,84	2,84	2,15	0,031*

Table 5. Results related to the height of the lip vermilion, the smile arch and incisal embrasures in the VAS scale for evaluating photographs of female models.

	Meslek														Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler		
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	p
Dudak V Y 0,5 mm	5,29	2,83	5,4	2,36	5,44	2,99	3,53	2,69	4,91	2,53	5,8	2,41	4,18	2,73	0,001*
Dudak V Y 1,5 mm	5,91	2,4	5,11	2,06	5,73	2,96	4,27	2,96	5,51	2,74	5,71	2,59	5,04	2,65	0,069
Dudak V Y 0	4,69	2,51	5,24	2,05	4,89	2,72	4,27	2,82	4,91	2,61	5,96	2,37	4,33	2,76	0,037*
Dudak V Y 1 mm	5,42	2,37	5,41	2,25	5,16	2,32	4,4	2,96	5,42	2,44	6,18	2,11	5,64	2,44	0,122
Dudak V Y 2 mm	6,2	2,38	5,44	2,38	4,58	2,79	4,51	2,78	5,93	2,52	6,11	2,79	6,04	2,44	0,001*
Gülümseme Arkı Düz	5,38	2,89	5,4	1,88	5,8	1,85	4,44	2,87	5,82	2,49	5,38	2,59	5,09	2,74	0,277
Gülümseme Arkı Ters	2,56	2,02	3,16	2,04	3,27	2,29	2,56	2,3	2,42	2,05	2,42	1,95	2,62	1,98	0,241
Gülümseme Arkı Paralel	6,96	1,73	5,41	2,06	5,82	2,26	6,33	2,08	6	2,62	6,27	2,47	4,71	2,77	0,001*
İnsizal Embrasür Artmış	4,13	2,33	4,47	2,33	5,11	2,14	3,82	2,36	3,13	2,28	3,4	2,15	2,8	2,25	0,001*
İnsizal Embrasür Eşit	5,02	2,48	5,2	2,06	5,47	2,26	3,98	2,96	4	2,58	5,2	2,55	3,93	2,2	0,002*
İnsizal Embrasür İdeal	6,96	2,28	6,2	1,74	6,91	1,56	5,84	2,63	6,24	2,37	6,91	1,53	6,16	2,26	0,102
İnsizal Embrasür Azalmış	3,73	2,38	3,89	2,52	4,07	2,26	3,53	2,69	3	2,35	3,64	2,59	3,78	2,44	0,354
İnsizal Embrasür Yok	3,93	2,29	4,87	2,02	5,18	2,45	3,93	2,52	3,73	2,32	4,31	2,63	3,69	2,28	0,014*

Table 6. Results related to the central visibility, midline and diastemain the VAS scale for evaluating photographs of female models.

	Meslek														Analiz Sonucu
	Restoratif Diş Tedavisi Uzmanı		Genel Diş Hekimi		Ortodonti Uzmanı		Diş Hekimliği 5. Sınıf Öğrencisi		Diş Protez Laboratuvar Teknisyeni		Güzel Sanatlar Fakültesi Mezunu		Diş Hekimi Olmayan Bireyler		
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	p
Keserlerin Görünürlüğü 3,5 mm	6,33	1,72	5,53	2,15	6,31	1,58	5,02	2,55	6,31	2,19	6,09	2,42	5,8	2,25	0,218
Keserlerin Görünürlüğü 4,5 mm	2,98	1,82	3,62	1,93	3,38	1,89	3,47	2,15	3,56	2,14	3,62	2,04	3,42	2,01	0,748
Keserlerin Görünürlüğü 3 mm	6,89	1,61	5,8	2,25	6,78	1,81	5,2	2,57	6,49	1,89	5,82	2,18	6,2	1,85	0,002*
Keserlerin Görünürlüğü 4 mm	4,38	1,79	5,29	2,14	4,64	1,63	4,58	2,68	5,02	2,32	5,07	2,07	5,09	2,11	0,358
Keserlerin Görünürlüğü 5 mm	1	1,43	1,96	2,06	1,93	1,56	1,71	2,01	1,42	1,23	1,8	2,16	2,06	1,97	0,083
Orta Hat 0	7,36	1,42	5,67	2,45	6,64	1,93	5,38	2,63	6,58	2,21	6,8	2,03	5,96	2,03	0,001*
Orta Hat 1 mm Sola Kayma	3,29	2	3,91	2,25	4,56	2,7	3,56	2,6	3,47	2,4	4,8	2,06	4,53	2,61	0,007*
Orta Hat 2 mm Sola Kayma	2,22	1,49	3,2	1,82	2,64	1,64	2,51	2,15	2,44	1,95	3,8	2,03	3,04	1,91	0,001*
Orta Hat 0,5 mm Sola Kayma	6,07	1,45	4,82	2,29	5,91	1,84	4,53	2,89	5,4	2,14	4,98	2,49	4,78	2,09	0,008*
Orta Hat 1,5 mm Sola Kayma	3,02	1,73	3,64	2,06	3,09	1,74	2,67	2,17	2,44	1,52	3,16	2,27	3,73	2,14	0,025*
Orta Hat 2,5 mm Sola Kayma	1,62	1,85	2,67	2,17	1,42	1,7	1,47	1,69	2,38	2,08	2,78	2,27	3,16	2,04	0,001*
Diastema 0,5 mm	5,58	2,45	4,38	2	5,53	1,47	4,13	2,84	4,29	1,98	5,02	2,32	4,02	2,23	0,001*
Diastema 1,5 mm	2,47	1,6	2,44	1,84	1,87	1,27	2,16	2,12	2,38	1,98	2,58	1,8	2,07	1,5	0,466
Diastema Yok	7,11	1,68	5,56	2,59	6,71	1,58	5,36	2,58	6,11	2,6	6,44	2,3	5,87	2,18	0,009*
Diastema 1 mm	1,62	0,98	1,4	1,37	1,2	0,99	1,29	1,95	1,27	1,4	1,44	1,36	1,27	1,4	0,254
Diastema 2 mm	0,38	0,98	0,87	1,16	0,71	0,97	0,67	1,41	0,49	0,87	0,93	1,01	0,82	1,64	0,046*

Table 7. Correlation results of the relationship between VAS and the Likert scale in female model photographs(The p value is 0.001 and the n value is 315).

	r value (p= 0.001 n=315)
Golden ratio 60%	0.890**
Golden ratio <60%	0.887**
Golden ratio >60%	0.814**
Buccal corridor 2%	0.865**
Buccal corridor 10%	0.857**
Buccal corridor 15%	0.868**
Buccal corridor 22%	0.872**
Buccal corridor 28%	0.905**
Gingival visibility -1 mm	0.904**
Gingival visibility 0	0.832**
Gingival visibility 1 mm	0.804**
Gingival visibility 2 mm	0.862**
Gingival visibility 3 mm	0.828**
Lip vermillion height 0	0.844**
Lip vermillion height 0.5 mm	0.873**
Lip vermillion height 1 mm	0.807**
Lip vermillion height 1.5 mm	0.861**
Lip vermillion height 2 mm	0.896**
Smile arc straight	0.841**
Smile arc reverse	0.833**
Smile arc parallel	0.841**
Incisal embrasure enlarged	0.831**
Incisal embrasure equal	0.840**
Incisal embrasure ideal	0.861**
Incisal embrasure reduced	0.865**
No incisal embrasure	0.856**
Central visibility 3 mm	0.848**
Central visibility 3.5 mm	0.845**
Central visibility 4 mm	0.815**
Central visibility 4.5 mm	0.862**
Central visibility 5 mm	0.870**
Midline 0	0.847**
Midline 0.5 mm	0.837**
Midline 1 mm	0.877**
Midline 1.5 mm	0.846**
Midline 2 mm	0.870**
Midline 2.5 mm	0.915**
No diastema	0.869**
Diastema 0.5 mm	0.833**
Diastema 1 mm	0.810**
Diastema 1.5 mm	0.884**
Diastema 2 mm	0.827**

DISCUSSION

Aesthetic perceptions have changed in recent years as individuals have become more visible on social media and the demand for smile design has increased. This, in turn,has increased the need for knowledge and experience in the field of smile aesthetics. In order to increase the success in diagnosis and treatment, criteria such as the golden ratio and buccal corridor, smile arc, gingival visibility, incisal embrasure, visibility of the incisors, vermilion height of the lips, midline, and diastema must be considered. However, it is also of critical importance to consider individual tastes and differences in cultural aesthetic perceptions with various scales to guide the process of treatment planning.

Since VAS and Likert-type scales are accurate, reliable, and reproducible methods for the subjective measurement of pain, they have been used in many studies evaluating the factors affecting smile design.[15-18] In the present study, it was aimed to use such scales to determine the consistency levels among participants' aesthetic preferences by evaluating the correlations between the scales.

The importance of smile aesthetics in recent years has necessitated the need for physicians to pay more attention to generally accepted criteria in diagnosis and treatment planning. Sadrhaghighi et al.[19] evaluated effects on smile aesthetics by changing the golden ratio of the lateral incisors in their study. The difference in our study compared to the study of Sadrhaghighi et al.[19] lies in the evaluation of the effects on smile aesthetics of changing the golden ratio of the central incisor teeth along with the lateral incisors. In a study by Amuasi et al.[20] in which the presence of the golden ratio was investigated in terms of the width of the upper anterior teeth, it was suggested that the value obtained was different from the accepted golden ratio value and the golden ratio rule should definitely not be applied in restoring the anterior teeth of patients. Contrary to that study, we concluded that the golden ratio is a criterion that should be evaluated while designing a smile.

Oshagh et al.[21] created different sizes of buccal corridor width as 2% (wide), 10% (medium-wide), 15% (medium), 22% (medium-narrow) and 28% (narrow) and evaluated their effect on smile aesthetics.Participants preferred wider buccal corridors for the male model and narrower buccal corridors for the female model. The 28% buccal corridor width for both genders was not liked by our participants. In our study, photographs containing buccal corridors of five different sizes were created, and, in line with the findings of Oshagh et al.[21] we concluded that wider buccal corridors for the male model and narrower buccal corridors for the female model were more appreciated by our participants. When the buccal corridor width was 28% for both the male and female models, it was deemed less aesthetically pleasing.

Roden-Johnson et al.[22] and Ritter et al.[23] evaluated the effects of buccal corridors on smile aesthetics and concluded that buccal corridors had no effects on aesthetics. Contrary to those studies, we concluded that buccal corridors have an effect on aesthetics.

In a study conducted by Sybaite et al.[24] the effect of different amounts of gingival visibility (-6, -3, 0, 3, 6 mm) on smile aesthetics was investigated.Gingival visibility of 0 mm was aesthetically pleasing for all participants, while gingival visibility of 6 mm was not liked by any occupational groups. In a study by Maniyar et al.[25] gingival visibility was changed as -3, -1, 0, 1, 3.5 mm, and 0 mm gingival visibility was accepted as more aesthetic by all participants.In our study, five photographs were created with different levels of gingival visibility, including 0 mm, 1 mm, 2 mm, 3 mm, and -1 mm (i.e., the gingival margins of the upper central incisors being covered by the upper lip line). As a result, gingival visibility of -1 mm was evaluated as being most aesthetic by all participants for both the male and female models, followed by gingival visibility of 0 mm. Gingival visibility of 3 mm for the male and female models was not appreciated by any participants.

In a study by Ioi et al.[26] the upper and lower vermilion heights were varied by increasing or decreasing the vermilion height from -3 mm to 3 mm with 1-mm increments with reference to the average vermilion height. In our study, both the upper and lower vermilion heights were gradually increased in line with previous studies.[17] Rahmati Kamel et al.[27] evaluated the vermilion height of the upper lip on a main photo and three photos with variations of ±2 mm, and

they suggested that lips have a significant effect on smile aesthetics. In their study, the photo with the upper lip's vermilion height reduced by 2 mm was considered as the most aesthetic smile among all groups, while the photo with the upper lip's vermilion height increased by 2 mm was not liked by the participants. In our study, the photograph in which the upper lip's vermilion height was increased by 2 mm for the male and female models was evaluated as being more aesthetic by all participants, while the photographs in which the vermilion height was not changed were not liked by any occupational groups.

In a study by Shabbir et al.[28] in which the effects of smile arcs (parallel, straight, or exaggerated) and buccal corridors on smile aesthetics were evaluated, it was reported that most participants preferred the parallel smile arc as the ideal. Gaikwad et al.[29] also evaluated the effects of smile arcs on smile aesthetics. Smile arcswere modified to be flat or exaggerated. In their study, the "ideal" smile arc, in which the lower lip touches and parallels the incisal edges of the upper incisors, was the arc most admired by all groups. Consistent with that study, parallel, straight, and reverse smile arcs were created in our study and the most popular arc was found to be the parallel smile arc.

Foulger et al.[30] created five photographs reflecting ideal, equal, diminished, absent, and increased incisal embrasures, and the ideal or equal incisal embrasures were evaluated as being more aesthetic. The absence of incisal embrasures was not appreciated by the participants. In our study, similar to that previous study, five photographs of ideal, equal, decreased, absent, and increased incisal embrasure were used. Our findings are compatible with those of Foulger et al. in terms of ideal and equal incisal embrasures being more aesthetic, respectively. In our study, the absence of incisal embrasures and their increased or decreased appearance were evaluated asartificial appearances, and those photographs were liked less by all participants compared to the ideal and equal ones.

Jain et al.[31] evaluated the effect of modifying photographs according to the midline criterion for smile aesthetics using a Likert-type scale. Participating dentists stated that a midline shift did not affect the aesthetics and that shifting was acceptable. Contrary to that study, our findings showed that the midline criterion had an effect on smile aesthetics.

Ousehal et al.[32] evaluated the effect of upper midline deviation on perceptions of smile aesthetics using a VAS. A reference photograph was digitally modified with deviations of 1 mm toward the left side of the patient. Dentists gave significantly lower scores in response to all increased deviations in the maxillary midline compared to non-dentists.

In the study conducted by Talic et al.[33] dentists gave lower scores to midline deviations greater than 1 mm compared to non-dentists. It was concluded that dentists were more sensitive to midline deviations.

As a result of our study, among participants from all occupational groupsaccording to both scales, the reference photographs in which the midline was not changed for the male and female models were selected as the most aesthetic photographs. For the male model, the photographs in which the midline was shifted to the left by 1 mm, 1.5 mm, and 2 mmreceived the lowest scores from restorative dentistry specialists compared to other participants. For the female model, photographs in which the midline was shifted 1 mm and 2 mm to the left received the lowest scores from restorative dentistry specialists. Thus, our findings are similar to those of Talic et al.[33] and Ousehal et al.[32] and we concluded that specialist dentists were more critical of midline deviations than other participants.

Caramello et al.[34] evaluated the effects on smile aesthetics of modifying photographs by increasing the vertical dimensions of the maxillary incisors at intervals of 0.5 mm (0 mm, 0.5 mm, 1 mm, 1.5 mm, 2 mm, and 2.5 mm) using a VAS. In line with the approach of Caramello et al., the visibility of the maxillary incisors was gradually changed at intervals of 0.5 mm in our study.

Ousehal et al.[32] evaluated the effect of crown length on perceptions of smile aesthetics using a VAS. The crown length of the central incisors was shortened to 3 mm at increments of0.5 mm to shorten the crown length from the apex of the gingival margin according to the baseline reference. Dentists were more critical while evaluating crown length differences than non-dentists.

As a result of our study, the photographs in which the visibility of the incisors was 5 mm for the male and female models were not liked by any occupational groups. In accordance with the study of Ousehal et al.[32] we found that specialist dentists were more critical while evaluating the visibility of the incisors compared to other participants. We also observed that as the amount of visibility of the incisors increased, the appreciation of the participants decreased, and it was concluded that the vertical amount of visible maxillary incisors significantly affected perceptions of dentofacial aesthetics.

In the study conducted by Chaves et al.[35] a video image was created using photographs modified by 0.5, 1, and 1.5 mm. As a result, it was determined that the presence of maxillary midline diastema significantly affected perceptions of dentofacial aesthetics. Images without diastema orwith midline diastema of 0.5 mm were liked, while images with diastema of 1 mm or more were not liked.

Taki et al.[36] evaluated the effects of modifying photographs according to smile criteria such as midline diastema, gingival visibility, smile arc, buccal corridor, central incisor length, and lateral incisor width. Four modified diastema photographs of 0.5, 1, 1.5, and 2 mm were created, with 0 mm as the baseline. All three groups of participants aesthetically preferred the control image without midline diastema, followed by midline diastema of 0.5 mm. In our study, similar diastema modifications were used and we obtained similar results as participants preferred no diastema or midline diastema of 0.5 mm. As a result of our study, based on evaluations of photographs of both the male and female models, it was determined that the presence of diastema was the least aesthetically acceptable criterion compared to all other smile criteria and that dentofacial aesthetic criteriasignificantly affect people's perceptions.

CONCLUSION

According to the results of our study, there was strong agreement between the VAS and Likert-type scale evaluations. Furthermore, when all occupational groups were compared, it was found that restorative dentistry specialists were more sensitive in terms of noticing the modifications applied to the photographs, while graduates of faculties of fine arts assessed the these changes more positively than the other participants.

As well as the expectations and wishes of patients who apply to dentistry practitioners for smile design, the practitioners' command of generally accepted criteria such as the golden ratio and their experience with these applications are also important for successful smile aesthetics. We found that profession and education are not always equally effective on aesthetic understandings. Therefore, we conclude that the most appropriate results will be reached in terms of diagnosis and treatment in aesthetic dentistry when the personal tastes of individuals are supported by knowledge gained from the relevant literature.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Dicle University Faculty of Dentistry. Ethics Committee (Date: ……., Decision No: ……).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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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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Effect of additional polymerization process on color change in composite resins hold in different solutions

Bahattin Yaşın[1], Şeyhmus Bakır[2]

[1]Bahattin Yaşın Clinic, Mazidağı, Mardin, Turkey
[2]Department of Restorative Dentistry, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey

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Corresponding Author: Şeyhmus Bakır, seyhmusbakir@gmail.com

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ABSTRACT

Aims: In this study, it was aimed to compare the amount of coloration of composite resins with different filler content by keeping them in various coloring solutions after standard and additional polymerization processes.

Methods: Three types of composite resins with different contents were used in our study: Filtek™ Z250 (3M ESPE), G-aenial Anterior (GC) and Neo Spectra™ ST HV (Dentsply Sirona). A total of 240 composite resin samples were prepared, 10 (n:10) for each group, using molds with a depth of 2 mm and a diameter of 8 mm. The polymerization of the samples was carried out for 20 seconds using a LED curing device (Woodpecker Led-G, China). After finishing and polishing was done with Super-Snap (Shofu, JAPAN) finishing discs, additional polymerization was performed on half of the samples. Then, all samples were kept in distilled water for 24 hours at 37°C in an oven (Microtest MST 55, Ostim Ankara). The first color measurement of the samples extracted from distilled water was made with a spectrophotometer device [VITA Easyshade V (Vita Zahnfabrik, Bad Sackingen, Germany)]. After the first measurement, the samples placed in 100-mesh plastic containers were placed on bags of tea (Lipton, Rize, Turkey), filtered coffee (Nescafe Classic, Nestle, Turkey), mouthwash containing chlorhexidine (Kloroben mouthwash, Drogsan, Ankara, Turkey) and red wine (Buzbağ). Classic, Öküzgözü-Boğazkere, 2021 Elazığ, Turkey) was added. One week later, the samples were removed from the vacuum furnace, washed in distilled water, and the second measurements were made.

Results: A statistically significant difference was found between the coloration values caused by the solution groups ($p<0.05$). It was observed that the solution causing the most color change was wine, followed by coffee and tea, respectively. Although there was no statistically significant difference between the coloration values caused by the composite groups ($p>0.05$), it was determined that the composite resin material with the lowest color change was the microhybrid-based Filtek™ Z250. Although there was no statistically significant difference between the coloration values caused by standard and additional polymerization ($p>0.05$), it was determined that the additional polymerization process affected the color change amount of the materials positively.

Conclusion: According to the findings of this study; Among the coloring solutions used, it was observed that the solution causing the most coloration in composite resins was red wine, followed by coffee, tea and mouthwash containing chlorhexidine, respectively. However, it was concluded that the addition polymerization process reduces the coloration of the composite resins.

Keywords: Coloring solutions, additive polymerization, color stability

INTRODUCTION

With the increase in aesthetic awareness in today's society, patients have started to demand treatments that are longer lasting and meet the aesthetic needs of physicians. In order to meet these demands, composite resins have started to be used more in dentistry practice. It is thought that these materials can be better recognized and better treatments can be made by conducting studies on the properties and causes of failure of composite resins. Clinical success in aesthetic restorations; It depends on many factors, such as filler and resin matrix structure, polish ability and color compatibility of the material used. At the same time, color stability should be very good for composite resins made. Otherwise, after a certain period, discoloration occurs in the restorations and the need for renewal occurs. In this sense, the areas where patients complain the most are the aesthetic restorations made to the anterior teeth.[1]

Water absorption, surface hardness and roughness of the composite resins, polymerization method, finishing and polishing processes are the factors affecting the color stability. At the same time, the patient's hygiene and consumption habits also affect color stability.[2]

When the color stability studies on composite resins were examined, it was seen that coloring solutions such as tea, coffee, cola, fruit juice and red wine were used and they caused different levels of coloration. It is very important that dental materials used in the mouth maintain their color stability after exposure to liquids with coloring properties.[3]

The aim of our study; The aim of this study is to evaluate the coloration levels of composite resins with different contents kept in coloring solutions after standard and additional polymerization processes.

METHODS

This study does not contain any human or animal materials. It is an in vitro study under laboratory conditions. Therefore, it does not require an ethics committee approval. Institutional approval has been obtained. All procedures were carried out in accordance with the ethical rules and the principles.

This work; It was planned to evaluate the effect of the addition polymerization process on the color stability of three different composite resins with different filler content. In our study, one micro hybrid-based Filtek™ Z250 composite resin (3M ESPE), one nano hybrid-based G-aenial Anterior (GC) composite resin and one nano ceramic-based Neo Spectra™ ST HV (Dentsply Sirona) composite resin material were preferred to be used.

As a result of the power analysis of our study; The number of samples for each group was determined as 10 (n=10), with a 95% confidence interval and 5% sensitivity. A total of 240 test materials were prepared, 80 for each composite resin, by a single researcher at the Dicle University Faculty of Dentistry Restorative Dentistry Clinic. The materials were condensed by placing them in plastic molds with a depth of 2mm and a diameter of 8mm with the help of a mouth spatula. Then, it was compressed between the transparent tape and two glass plates and polymerized for 20 seconds with the help of an LED light device (Woodpecker Led-G, China) in accordance with the recommendations of the manufacturers.

Before the polymerization process, the power of the light device was checked by means of a radiometer (Hilux, Benlioğlu Dental AŞ, Ankara, Turkey). 80 samples prepared from each test material were divided into 4 groups of twenty (n=20). For the finishing and polishing of the materials used in the study; Super-Snap (Shofu, JAPAN) finishing disc sets were used. Polishing and finishing processes were performed on the upper surfaces of the materials close to the light device during the polymerization, in accordance with the instructions of the manufacturers. A new disk was used for each sample.

Twenty samples with standard polymerization in each group were separated as "standard light group". The polished surfaces of the remaining 20 test materials were subjected to additional polymerization for 20 seconds and separated as the "additional light group". All samples were washed under tap water and then dried. Before placing the samples in colorant solutions, they were kept in distilled water for 24 hours in an oven at 37°C (Microtest MST 55, Ostim Ankara) (**Picture 7**).

The first color measurements of the test samples, which were removed from distilled water and dried at the end of 24 hours, were performed using a spectrophotometer device [VITA Easyshade V (Vita Zahnfabrik, Bad Sackingen, Germany)].

For the reliability of the measurement process, the measuring tip of the device was placed at an angle of 90° to the surface. Each color measurement was repeated three times and the average of these measurement results was recorded as L0*, a0* and b0* values according to the CIELAB method. Color measurement samples were numbered. The spectrophotometer device was calibrated for each measurement. After the first measurement, all samples were placed in four different plastic molds with 100 pores in order of number. Tea bags (Lipton, Rize, Turkey), filtered coffee (Nescafe Classic, Nestle, Turkey), mouthwash containing chlorhexidine (Kloroben mouthwash, 0.12% chlorhexidine gluconate, Drogsan, Ankara, Turkey) and red wine (Buzbağ) to provide color change on them. Classic, 13% alcohol, Öküzgüzü-Boğazkere, 2021, Elâzığ, Turkey) prepared solutions were added, and the samples were kept in an oven at 37°C for 1 week.

The tea solution in which the samples will be placed was prepared by brewing a tea bag in 250 ml of boiled water. The coffee solution in which the samples will be placed was prepared by adding 2 grams of coffee to 200 ml of boiled distilled water, mixing and filtering it with filter paper after 10 minutes. All solutions were freshly prepared and refreshed daily.

After one week, the samples removed from the solutions were washed with distilled water and dried with blotting paper. The samples were subjected to color measurement for the second and last time, paying attention to their sequence numbers. The final measurements were repeated three times for each sample, as in the beginning and the averages were recorded. The difference (ΔE value) between the two measurements was calculated using the formula

$$\Delta E^* = [(L1^* - L0^*)2 + (a1^* - a0^*)2 + (b1^* - b0^*)2]½.$$

RESULTS

The data obtained in our study were analyzed with the licensed IBM SPSS 21 package program (License number: 5f551afac84a24ad7a95). While investigating the normal distribution of the variables; Shapiro Wilk's and Kolmogorov-Smirnov tests were used due to the number of units. While interpreting the results; In the case of $p<0.05$ as the significance level, it was accepted that the variables did not come from the normal distribution, and in the case of $p>0.05$, the variables came from the normal distribution.

To determine the effect of the factors on the dependent variable; Two Way ANOVA test was used. Significantly, different groups and interaction levels were determined. When examining the differences between groups; Independent T Test and One-Way ANOVA were used because the variables came from normal distribution. In case of significant differences in One-Way ANOVA, Tukey HSD was used when the variances of the groups were homogeneous, and Tamhane's analysis was used when the variances were not homogeneous.

As a result of the analysis of the effect of the factors on the dependent variable ΔE;

- The effect of the composite group on the dependent variable ΔE was not statistically significant ($p>0.05$).
- The effect of the solution group on the dependent variable ΔE was found to be statistically significant ($p<0.05$). The lowest value for ΔE is in Chlorhexidine solution.
- The effect of the light group on the dependent variable ΔE was not statistically significant ($p>0.05$).
- The interaction effect of Composite and Solution groups was statistically significant on the dependent variable ΔE ($p<0.05$).

- The interaction effect of composite and light groups was not statistically significant on the dependent variable ΔE (p>0.05).
- The interaction effect of solution and light groups was not statistically significant on the dependent variable ΔE (p>0.05).
- The triple interaction effect of Composite, Solution and light groups was not statistically significant on the dependent variable ΔE (p>0.05).

Although there was no statistically significant difference between the coloration values (ΔE) caused by the composite groups (p>0.05), it was determined that the composite resin material with the highest color change was GC, followed by the Spectra material.

Although there was a statistically significant difference between the coloration values (ΔE) caused by the solution groups (p<0.05), it was observed that the solution causing the most color change was wine, followed by coffee and tea, respectively (**Table 1**).

Table 1. Analysis results regarding the difference between solution groups in terms of ΔE values

Solution	ΔE						One Way ANOVA	
	n	Mean	Median	Min	Max	Sd	F	p
Tea	60	2.893	2.99	0.221	6.286	1.544		
Wine	60	4.325	4.142	0.667	11.547	1.921		
Coffee	60	3.24	2.997	0.165	7.024	1.629	24.882	0.001
Chlorhexidine	60	1.889	1.723	0.159	4.484	1.003		
Total	240	3.087	2.852	0.159	11.547	1.779		

According to the results of the multiple comparison test performed to determine which solution the difference originated from; wine solution was found to have a significantly higher coloring value than all other solutions (p<0.05).

It was determined that the chlorhexidine solution had a significantly lower coloring value than all other solutions (p<0.05). It was determined that the difference in coloring value only between the tea solution and the coffee solution was not statistically significant (p>0.05) (**Table 2**).

Table 2. Results of coloration values according to Tamhane's multiple comparison test

I. Solution	II. Solution	P
Tea	Wine	0.001
Tea	Coffee	0.796
Tea	Chlorhexidine	0.001
Wine	Coffee	0.007
Wine	Chlorhexidine	0.001
Coffee	Chlorhexidine	0.001

Although there was no statistically significant difference (p>0.05) between the coloration values caused by the standard and additional polymerization (ΔE), it was determined that the additional polymerization process affected the color change amount of the materials positively.

Although there was a statistically significant difference between the color change values (ΔE) observed in all three composite resin materials kept in different solutions (p<0.05), it was observed that the solution causing the most color change was wine, followed by coffee and tea, respectively. (**Table 3**).

According to the results of the multiple comparison test performed to determine which solution caused the difference between the color change values of the 3M composite resin material; It was determined that the wine solution had a significantly higher coloring value than all other solutions (p<0.05). However, the coloring value of the chlorhexidine solution was found to be significantly lower than the coffee solution (p<0.05). It was determined that the difference between the coloring values of all other solutions was not statistically significant (p>0.05).

According to the results of the multiple comparison test performed to determine which solution caused the difference between the color change values of the GC composite resin material; It was determined that the chlorhexidine solution had a significantly lower coloring value than all other solutions (p<0.05). It was determined that the difference between the coloring values of all other solutions was not statistically significant (p>0.05).

Table 3. Analysis results regarding the difference between solutions in terms of ΔE values in composite groups

Composite	Solution	ΔE						One Way ANOVA	
		n	Mean	Median	Min	Max	Sd	F	P
3M	Tea	20	2.336	2.048	0.672	4.988	1.228	22.503	0.001
	Wine	20	4.838	4.657	2.462	6.922	1.261		
	Coffee	20	2.981	2.715	0.165	6.513	1.703		
	C.hexidine	20	1.808	1.745	1.158	2.734	0.463		
	Total	80	2.991	2.536	0.165	6.922	1.68		
GC	Tea	20	3.538	3.264	0.508	6.286	1.584	7.806	0.001
	Wine	20	4.303	3.822	1.532	11.547	2.532		
	Coffee	20	3.64	3.394	1.109	7.024	1.86		
	C. hexidine	20	1.37	1.082	0.159	4.168	1.027		
	Total	80	3.213	2.983	0.159	11.547	2.113		
Spectra	Tea	20	2.805	2.907	0.221	5.543	1.616	9.903	0.001
	Wine	20	3.833	3.996	0.667	6.68	1.712		
	Coffee	20	3.1	3.047	0.219	5.116	1.275		
	C.hexidine	20	2.489	2.691	0.723	4.484	1.09		
	Total	80	3.057	2.949	0.219	6.68	1.504		

According to the results of the multiple comparison test performed to determine which solution caused the difference between the color change values of the Spectra composite resin material; only the coloring value of the wine solution was found to be significantly higher than the chlorhexidine solution ($p<0.05$). It was determined that the difference between the coloring values of all other solutions was not statistically significant ($p>0.05$) (**Table 4** and **Graphic 1**).

Table 4. Results of coloration values according to Tamhane's multiple comparison test

Composite	I. Solution	II. Solution	P
3M	Tea	Wine	0.001
	Tea	Coffee	0.691
	Tea	Chlorhexidine	0.412
	Wine	Coffee	0.002
	Wine	Chlorhexidine	0.001
	Coffee	Chlorhexidine	0.042
GC	Tea	Wine	0.836
	Tea	Coffee	1.0
	Tea	Chlorhexidine	0.001
	Wine	Coffee	0.925
	Wine	Chlorhexidine	0.001
	Coffee	Chlorhexidine	0.001
Spectra	Tea	Wine	0.302
	Tea	Coffee	0.988
	Tea	Chlorhexidine	0.979
	Wine	Coffee	0.577
	Wine	Chlorhexidine	0.034
	Coffee	Chlorhexidine	0.509

When the color change observed in the case of additional polymerization of composite resin materials kept in different solutions was compared with the color change that occurred with standard polymerization, there was no statistically significant difference between the ΔE values ($p>0.05$). However, it was observed that the color of the GC material, which was kept in a single wine, became darker with the application of additional polymerization.

DISCUSSION

Studies carried out to meet the aesthetic expectations of patients have enabled composite resins to find more use in dentistry practice. In line with the goal of increasing the success rate and clinical life of composite restorations, some changes have been made in the filler content and volume of the materials, and their physical and mechanical properties have been improved. However, the long-term discoloration problem in composite resins has not been completely prevented.[4]

Color changes in composite resins can result in restorations being renewed. Restoration renewal processes, on the other hand, can cause loss of workforce and time for both the physician and the patients, as well as the loss of substance in the teeth.[5]

One of the most important reasons for the color change seen in composite restorations is the nutritional habits of the patients. In particular, some beverages such as tea, coffee, cola and wine may cause discoloration in the teeth.[5,6] Some substances in the structure of these drinks are held responsible for the coloration. For example, in the researches; It is mentioned that tannic acid in black tea, melanoid (yellow-colored molecules) in the structure of coffee or alcohol and some pigments in red wine have dyeing ability because they show affinity for the polymer network of composite resins.[7] In addition, the color factors and fluoride in the antiseptic mouthwashes, which are frequently used during periodontal diseases and gingival problems, are also responsible for the color change in composite restorations.[8] Therefore, it is recommended to consider the consumption habits of the patients, especially when deciding on the type of composite resin to be used for anterior restorations.[7]

Coloring solutions such as tea, coffee, cola, and wine are generally used in most studies testing beverage consumption-induced discoloration in composite resins. In a study by Arocha et al., it was reported that the solution causing the most color change in composite resins was red wine, followed by coffee and black tea, respectively.[9]

The amount of tea consumption in our country is quite high compared to other societies.[10] The rapid increase in the number of places where coffee is consumed in recent years has led to an increase in the rate of coffee consumption in our society.[11]

Considering the consumption habits in our country, it was preferred to use tea and coffee as a solution in our current study. Again, mouthwashes containing red wine and chlorhexidine, which we think have a high coloring rate, were also included in our study in order to compare with similar research results.

The resistance of composite resins to coloration It depends on many factors such as the structure of the resin matrix and the amount of water absorption, the size and content of the filler particles, the continuity of the matrix-filler connection of the resin, as well as the surface properties of the material and the success of the finishing and polishing processes.[12] Based on this view, in our study; The color stability of three different composite resin materials containing one microhybrid (3M Filtek™ Z250), one nanohybrid (G-aenial Anterior, GC) and one nanoceramic (Neo Spectra™ ST HV, Dentsply Sirona) was evaluated.

In studies evaluating color stability and water absorption in composite resins, it has been determined that the amount of coloration is related to the rate of water absorption and the retention time in solution. It has been reported that water plays an intermediary role between color pigments and the resin matrix.[13] Studies have shown that in order for composite resins to change color, it is usually sufficient to keep them in solution for about a week.[14] In the researches, it was recommended to keep the composite resin samples in distilled water for one week and then in the coloring solution for 2-3 weeks before being placed in the coloring solution. In similar studies, it was stated that it would be appropriate to measure the color after the samples, which were kept in the coloring solution for about 3 hours, were left in distilled water for 21 hours.[15] It has been reported that the purpose of this process is to remove the unreacted substances in the structure of the composite resin and to ensure the hardening of the resin after polymerization.[16]

Nasim et al.[13] on the other hand, stated that the highest color change period in composite resins kept in coloring solutions for different periods is the first one-week period. In our study, it was deemed appropriate to keep the composite resin samples in distilled water for one day in order to detect the color change, and to keep them in the coloring solution for a similar time period of one week.

While some of the researchers recommended keeping the test samples at room temperature, the majority preferred keeping them at 37°C.[13] Yara Khalid et al.[16] recommended that the samples be kept in an oven at 37°C and stated that the oven device creates a balanced temperature distribution thanks to the fan circulation.

Since it is known that the average intraoral temperature value in humans is about 36.4°C, our samples were kept in an oven at 37°C in our study.

It has been reported that in order to ensure adequate polymerization in composite resins after light treatment, the resin should be at most 2 mm thick, otherwise the resin could not polymerize sufficiently.[17] Studies have found that insufficient polymerization in composite resins increases the coloration of the material, while additional polymerization reduces it.[1,13,18]

Based on this point of view, in order to apply additional light, it is recommended to remove the matrix band and apply light again after the polymerization process, or to apply additional light to the lower surface or both the lower and upper surfaces after the samples are polymerized. However, it has been reported that additional light can be applied after finishing and polishing processes in order to improve the physico-mechanical properties of the composite surface.[19,20] In our study, the composite samples that we placed in 2 mm thick plastic molds were polymerized for 20 seconds with a LED light device (Woodpecker Led-G, China) in accordance with the instructions of the manufacturers. After finishing and polishing the upper surfaces of the materials, additional light was applied to the polished surfaces of half of the samples for 20 seconds.

In many studies, it has been reported that the smoothest surface for composite resins is created by using transparent tape.[21] However, smooth surfaces created using transparent tape often become rough when occlusal adjustments are made to restorations. Therefore, it is recommended to finish and polish the surfaces of composite resins after polymerization. Otherwise, an oxygen inhibition layer containing incompletely polymerized monomers forms on the surfaces of the composite resins, and thus gingivitis, secondary caries, plaque increase and discoloration may occur. The oxygen inhibition layer, which is sensitive to coloration, is also cytotoxic.[22] Patel et al.[7] emphasized that polishing processes on composite resins will create smoother and smoother surfaces and will change color less. For this purpose, discs containing aluminum oxide have been used in many studies.[21,23] In our study; In order to prevent the formation of an oxygen inhibition layer on the composite resin surface and to create smoother surfaces, we performed the polymerization process by placing transparent tapes on both surfaces of the samples. At the same time, light was applied by placing a glass coverslip on the material in all samples in order to create a standard light distance during polymerization. Subsequently, the finishing and polishing processes of all samples were completed using discs containing aluminum oxide.

In dentistry, color measurement in restorations is made by visual methods or by using color measuring devices. Color selection by visual measurement The lighting conditions of the environment, the clothes that the patient wears during color measurement, the make-up, the eyestrain of the dentist or metamerism can prevent reliable measurement. However, the possibility of inconsistent results in color selection made by visual methods has increased the use of color measuring devices. Thanks to these devices, it is possible to make repeatable, consistent and more reliable color measurements.[24]

The biggest advantages of spectrophotometer devices are that they can make consistent measurements for a long time and give results in accordance with standards. Because of these features, they have been the most frequently used devices for color measurement in dentistry.[25]

Directoroğlu et al., as a result of a study in which they evaluated the success of the devices used in color measurement; They stated that the spectrophotometer device can make more reliable measurements compared to the colorimeter device. The reason for this is that colorimeter devices cannot record the spectral reflection and the filter in the device loses its effectiveness over time.[26]

In vivo[27] and in vitro[28,29] studies on the consistency and performance of measurement devices used for the detection of color change have reported that the 'Vita EasyShade' spectrophotometer device gives successful results. In our study, the detection of color change in the samples It is preferable to use the Vita Easyshade V (Vita Easyshade V, Vita Zahnfabrik, Bad Sackingen, Germany) spectrophotometer device as it can measure colors in the 400-700 nm range, allows repeat measurements, provides reliable results and gives the L* a* b* value together with its vita scale counterpart. was done.

It has been stated that standardization of ambient conditions is important in order to make standard measurements with a spectrophotometer device, for example, the lighting condition of the environment where the measurement is made and the color of the ground can have an effect on the results obtained.[30,31]

Based on this point of view, we performed the color measurements of the samples under darkroom conditions, under fluorescent daylight lamp illumination and on a white background. Thus, the effect of ground and lighting conditions on the results was tried to be eliminated. All measurements were made by the same person with the tip of the device placed at an angle of 90 degrees to the sample. At the same time, before measuring for each sample, the device was calibrated in accordance with the instructions for use.

CIE Lab and CIEDE 2000 systems are generally used to calculate the color change that occurs in restorative materials. In many studies on the subject; It has been reported that the CIE Lab system is used more frequently and is more successful in detecting color differences. However, in the literature, the success of the CIEDE 2000 system in detecting much smaller color differences is mentioned.[32,33] In our study, the analysis of color change in composite resin materials was performed using the CIEDE 2000 system.

The color change in the materials is determined by mathematically calculating the difference (ΔE) between the first measurement and the last measurement. The human eye has the capacity to detect color differences (ΔE) up to a certain threshold value. In studies, different ideas have been put forward about the limit value of clinically detectable color difference (ΔE). There are studies that think that the critical ΔE value for visible color change in the clinical setting should be 3.3[34] or 3.7.[35] As a result of a research conducted by Johnston and Kao on color change; It was stated that if the ΔE value is less than 1, the change

cannot be detected, if it is between 1-2 values, the observers can partially notice the change, and if it is greater than 2, all observers can notice the color change.[36] According to a study by Ragain and Johnston, it was reported that dentists were able to detect a clinical ΔE color difference of 1.78, whereas this value was 2.69 for patients.[37]

In a study by Paravina et al.[38] emphasized that the ΔE value should be greater than 3.7 in the CIE Lab system and 3.1 in the CIEDE 2000 system in order for color stability to be considered clinically unsuccessful.

Similarly, in our study using the CIEDE 2000 system, values with ΔE greater than 3.1 were considered clinically unsuccessful in the color change analysis.

Reis et al.[35] in their study, stated that the structure of the material and the amount of organic matrix filler are important in the color change of composite resins. In composite restoration applications, it is emphasized that the reason for the discoloration of the interfaces where the finishing and polishing processes cannot be fully performed, which is difficult to access, is usually related to the organic matrix. However, it has been reported that composite resins containing urethane dimethacrylate (UDMA) have higher staining resistance than resins containing triethyleneglycol dimethacrylate(TEGDMA).[40]

In the surface roughness and color change studies of Lainovic et al.[41] using two microhybrid (Filtek Z250, Gradia Direct) and two nanohybrid (Filtek Z550, Tetric EvoCeram) composite resins; It has been reported that nanohybrid composites are more rough and discolored compared to microhybrid composites. It has been thought that the presence of large filler structures in nanohybrid composites, surface irregularities and defects during polishing may cause this situation.

Ertaş et al.[39] as a result of a study in which they examined the coloration level of composite resins with microhybrid and nanohybrid structures placed in water, cola, tea and red wine solutions, it was reported that Filtek Z250 and Filtek P60 microhybrid composite resin materials, which do not contain TEGDMA in the matrix content, undergo the least coloration (lowest ΔE).

In our study with similar solutions, it was determined that the microhybrid Filtek Z250 composite material exhibited less coloration compared to other composites. We believe that the better color stability in Filtek Z250 composite resins is due to the replacement of TEGDMA structure with hydrophobic UDMA.

In the study of Güler et al.[42] to compare the color stability of composite resin samples kept in different beverages; It was observed that the amount of coloration caused by red wine was above the clinically acceptable level (ΔE>3.1) in all groups and the coloration value caused by tea was below this level in all groups. The amount of coloration caused by the coffee solution has been reported to be above this level in some composite groups.

As a result of many researches; It has been reported that the amount of coloration caused by tea and coffee solutions on composite resins is at a clinically acceptable level (ΔE<3.1). However, there are also studies claiming the opposite (ΔE>3.1).[43] The reason why the results are different It has been attributed to the differences in the way the solutions are prepared and the application procedures.[44]

In our study, the clinical acceptability of the discolorations produced by tea and coffee solutions varied according to the materials used and application procedures.

In a study by Yapar et al., they kept dimethacrylate-based composite resins in tea, coffee, cola and red wine solutions for a week; explained that the solution causing the most coloration was red wine (ΔE>3.1), followed by coffee and tea, respectively.[32,45]

According to the results of another study by Barutcigil et al.[1] It was stated that red wine caused the most coloration in composite resins, followed by coffee, tea and distilled water, respectively.

Falkensammer et al.[46] In a similar study using red wine, black tea and chlorhexidine-containing mouthwash, they found that red wine caused the most coloration on composite resins, while mouthwashes containing chlorhexidine showed less coloration than red wine and tea in all study groups. It has been stated that the acidic structure of red wine and the presence of color pigments that change over time play a role in the emergence of this result. The amount of coloration caused by chlorhexidine-containing mouthwashes was found to be clinically acceptable (ΔE <3.1).

It is stated that the acidic nature of red wine, as well as its alcohol content, impairs the surface integrity of the composite resin and causes surface coloration. For all these reasons, it is stated that the composite restoration surfaces become rougher and the absorption of color pigments becomes easier.[47]

Consistent with these studies, in our study, it was determined that the solution that caused the most coloration was red wine, followed by coffee, tea and chlorhexidine-containing mouthwash, respectively. The amount of coloration caused by the red wine solution was found to be clinically unacceptable (ΔE>3.1). It was determined that the mouthwash containing chlorhexidine caused less coloration compared to all other solutions, and this amount of color change was at a clinically acceptable level (ΔE <3.1).

Although it has been reported that the additional polymerization process in composite resins positively affects the mechanical properties of the resin, there are also studies claiming the opposite.[45] It is thought that the reduction of the resin polymerization rate and the limitation of the degree of conversion after a certain time limit the positive effect of the addition polymerization.[48-50] As a result of this study, in which we investigated the effect of the addition polymerization process on the color stability of different types of composite resins; It was found that the addition polymerization process reduced the surface coloration.

CONCLUSION

1. In our study, it was determined that the samples applied an additional polymerization process showed less coloration. It has been observed that the addition polymerization process affects the mechanical properties of the composite resins positively and thus the color stability can be better.
2. In order to prevent the discoloration problem seen in composite restorations in the clinic, it is recommended that physicians perform additional polymerization after the finishing and polishing stages.
3. In our study, the solution causing the most coloration among all composite groups was red wine; The mouthwash containing chlorhexidine was the solution that caused the least coloration.

4. Considering the aesthetic concerns of the patients, polishing and polishing processes should be done very well, especially in the anterior region restorations. In addition, the consumption habits of the patients should also be considered. Suggestions such as rinsing the mouth with water and brushing the teeth can be given to the patients after the coloring foods are consumed.
5. In our study, the samples showing the least coloration were the microhybrid-based Filtek™ Z250 composite resin. It is thought that the structure of the material and the amount of organic matrix filler are important in the color stability of composites and resins. For this reason, the content of the material to be used in aesthetic restorations should be considered.

ETHICAL DECLARATIONS

Ethics Committee Approval: This study does not contain any human or animal materials. It is an in vitro study under laboratory conditions. Therefore, it does not require an ethics committee approval.

Informed Consent: This study is in vitro study under laboratory conditions. Therefore, it does not require informed consent.

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Review

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Use of fiber-containing materials in restorative dentistry

İbrahim Halil Avcılar, Şeyhmus Bakır

Department of Restorative Dentistry, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey

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Corresponding Author: İbrahim Halil Avcılar, dtibrahimavclr@gmail.com

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ABSTRACT

It is aimed at providing chewing function in restorative treatment in dentistry, to protect the tooth structure based on the minimally invasive approach and to meet the aesthetic expectations of the patient. Studies including application techniques are carried out to improve the mechanical and physical properties of composite resins and to reduce polymerization shrinkage. The success of composite restorations has increased with the use of fibers and fiber-reinforced composite resin materials, and the indications of composite resins as direct restoration material have expanded thanks to the production of newly developed fiber-reinforced composite resin materials and their use with the biomimetic restoration technique. In this review, information about the properties and types of fiber structures, advantages, disadvantages, and application areas is explained.

Keywords: Fiber reinforced composite, direct restorations, polyethylene fiber

INTRODUCTION

Although a decrease in the prevalence of dental caries has been observed worldwide in recent years, untreated caries still affect approximately 35% of the world's population. Direct and indirect restorations are at the forefront of our dental caries treatment procedures. Direct posterior restorations are preferred more than indirect restorations due to the possibility of finishing the treatment in a single session, being more economical, and requiring less preparation on the tooth.[1]

The primary goal of dental treatments is to restore the lost function and appearance of teeth or dental hard tissues with appropriate materials, while preserving the integrity of the tooth and its surrounding tissue.[2] When choosing a restorative material; It should be considered that it is the material that causes the least material loss in the tooth, is the most suitable for the structure of the tooth in terms of morphological and mechanical properties, and is biocompatible with the oral tissues.[3,4]

With the introduction of resin-based composites into dentistry, significant advances have been made in restorative dentistry. Due to the advantages of composite resins such as being aesthetic and biocompatible, not containing mercury, having low thermal conductivity, allowing minimally invasive restorations and supporting the dental tissues left after caries removal, they are preferred more and more by physicians.[5] Operative Dentistry Academy European Department (AODES), while accepting composite resins as the restorative material that should be preferred together with the appropriate adhesive in minimally invasive procedures applied to posterior teeth, they report that the structural properties of these materials still do not reach a sufficient level.[6] Restoration size is inversely proportional to the lifetime of composite resin restorations. It is more common for restorations to fail due to fracture, especially in teeth with excessive crown destruction.[7]

In recent years, the use of fiber-reinforced composite resin restorations in dentistry has become popular in order to increase the application of composite resins in these treatments, whose use with the direct method in large restorations in the posterior region is limited due to their mechanical properties.[8] Studies on fiber reinforcement of materials in dentistry date back to 60 years. Glass fibers were first used to strengthen acrylic resins in the 1960s. In the following years, different types of fibers have been developed in order to increase the physical and mechanical properties of composite resins.

Fibers have advantages, such as low modulus of elasticity, good resistance to compression forces, translucency, and resin-adhesive bonding. In addition, fibers increase the resistance of restorative materials to mechanical forces as stress breaker and stress dispersant and reduce polymerization shrinkage. The success of composite restorations has increased with the use of fiber-reinforced composite materials, and the indications of composite resins as direct posterior restoration material have expanded, thanks to the production of new fiber-reinforced composite materials with innovations in their structures and their use with the biomimetic restoration technique.[9]

The combination of polymer matrix and fiber structure constitutes the basic structure of fiber-reinforced composite resins. The stresses that occur in the matrix structure as a result of the forces coming to the restoration are transmitted

to the fibers and thus, the fractures that may occur in the restoration or the tooth can be prevented.[10]

In vitro studies on fiber reinforced composite resin applications in dentistry continue and adequate clinical studies are needed. Fibers are widely used in the strengthening and repair of denture bases, fixed bridges applied to anterior and posterior teeth, implant-based prostheses, fixed placeholder construction, as endodontic posts, periodontal splint applications, indirect applications such as inlay-onlay, high-level restorations in vital and non-vital teeth. Its use is increasing in stressed areas.[11]

FIBER REINFORCED COMPOSITE RESINS (FRCS)

Fiber is a cylindrical, thin and flexible fibrous structure that is 100 times longer than its diameter. Fiber reinforced composites;[12] FRC, like conventional composite resins, consists of organic matrix and inorganic filler phase. Organic matrix; polymethyl methacrylate (PMMA), UDMA, TEGDMA, epoxy or Bis-GMA structure. Fibers placed in various lengths, diameters, structures, and directions added to the organic matrix structure form the inorganic filler phase.[13] The fatigue resistance of fiber-reinforced composites is very high because the resin matrix surrounding the fibers stabilizes the geometric structure of the fiber material and holds the fiber in a predetermined position to provide optimal strength. Fibers play an important role in transmitting force from the composite to the fibers by binding to the polymer matrix. Thus, the fibers ensure a balanced distribution of stresses throughout the restoration.[14]

The first studies on fiber reinforcement in clinical dentistry date back to 60 years ago. Glass fibers were first used to reinforce polymethyl methacrylate in the 1960s. In 1973, a report was published on affixing the crowns of avulsed or extracted anterior teeth to the lateral teeth in a single session using acid etching technique and fiber.[15]

The properties of composite fillers continue to be improved by reducing the size of the filler particles and using these fibers. Fiber-reinforced composites are used as dentin replacement, and the double-layered resin composite structure is accepted as a biomimetic restoration system by mimicking the dentin-enamel complex.[16]

Advantages of Fiber Reinforced Composite Resins

- Restorations made with fiber reinforced composites both at the bedside
  It can be produced in the laboratory as well.
- Compared to metals, they have non-corrosive, translucent, high bonding properties and ease of repair, and show superior aesthetic properties.
- They are ideal materials for the restoration of teeth that have lost excessive substance after endodontic treatment.
- The depth of polymerization can be up to 4-5 mm.
- Offers a minimally invasive, low-cost alternative to traditional restorative treatments.
- It prevents crack propagation in a restored tooth.
- It offers interesting applications in adhesive bridges, as splint material, in the provision of aesthetic custom-made posts and cores.
- They have very favorable mechanical properties and their strength-to-weight ratio is superior to most alloys.

Disadvantages of Fiber Reinforced Composite Resins

- The most common problems encountered in fiber-reinforced composite restorations are wear of the composite veneer, chipping of the composite veneer, fractures due to delamination and secondary caries, and occlusal wear. However, most problems can be repaired easily, quickly and economically.
- Mechanical properties of fiber reinforced composites decrease after hydrolytic aging.
- Exposed fiber in the mouth may cause local tissue reaction.
- Since the radiopacity of the fiber material is insufficient, it becomes difficult to diagnose secondary caries radiographically.
- Due to the application of the composite in layers, it may cause separations between the fiber material and the composite in areas that cannot fully polymerize.

Fiber-reinforced composites have the potential to be used in many applications in dentistry and are expected to gain increasing application and popularity in dentistry.[17]

Fiber Types Used in Dentistry

Classification of fibers used in dentistry;

1. **By type of fiber:** Carbon fibers, aramid fibers, polyethylene fibers, glass fibers, nylon fibers
2. **By the orientation of fiber:** unidirectional continuous fibers, bidirectional continuous fibers, short-particle discontinuous fibers
3. **By on whether the fiber is pre-infiltrated with the monomer or not:** pre-infiltrated fibers, non-pre-infiltrated fibers[18]

By Type of Fiber

Carbon fiber: Although the color of carbon fiber, which has good physical and chemical properties, is black, it has been used in dentistry for many years, although it is not aesthetically acceptable. Since such fibers show good bending and bending strength when placed perpendicular to the direction of the applied stress, the placement of the fibers is formed crosswise and perpendicular to each other during the production of the fibers. Unidirectional and knitted ones are frequently used in implant-supported prostheses.[19]

Carbon fibers have been replaced by other fiber systems due to the disadvantages of carbon fibers such as poor aesthetics, potential toxicity of carbon, difficulty in processing the fiber and inability to fully adapt the fiber into the resin, and studies showing that other fiber types are more successful than carbon fibers.[20]

Aramid fiber: Aramid fiber is known as phenylene terephthalamidesynthetic aramid polymer fiber.[19] The trade name of this fiber, which is an organic compound and low density, is "Kevlar". Due to its microfibril structure, it has lower resistance to pressure and bending forces than other fibers, while it has a high resistance to tensile.[20] Kevlar fibers do not require a binding agent because their wettability is very good. Although aramid fibers are more aesthetic than carbon fibers, they are not preferred in areas where aesthetics are at the forefront due to the yellow color of the material and their use is limited.[12]

Polyethylene fiber: In recent years, ultra-high molecular weight polyethylene (UHMWPE) fiber reinforcement systems, one of the fiber systems used to increase the

durability and impact resistance of resin-based composites, are gaining popularity.[21] Polyethylene fibers have advantages such as easily shaped, translucency, low density and biocompatibility. They can be produced as monofilament or as knitted fiber. They cannot be used with high-temperature polymerized composites due to their structural deterioration after 140°C.[22]

One of the most important disadvantages of polyethylene fibers is the problem of adhesion with polymer composite. The reason for this is that polyethylene fibers have low surface energies and low wettability due to their hydrophobicity. In recent years, it has been tried to increase the adhesion of the polymer structure to the polyethylene fibers by applying plasma to the surfaces of polyethylene fibers.[23]

Among the most commonly used brands are ribbond and connect. Since both brands are not pre-saturated with resin, they are polyethylene fibers that must be saturated with resin in order to be used.[24] Ribbond; It is widely used as a post-core material, as a substructure material in temporary and permanent bridges, and in the repair of acrylic bases. The braided structure of the ribbons provides versatile support to the composite resin, while being colorless and translucent allows color control of the resin in which it is embedded.[25]

Glass fiber: Glass fibers are the most widely used fiber type. The lattice consists of dispersed or linear fiber bundles and reinforcing dental polymers in different forms. Unidirectional glass fibers are composed of 1000-200,000 single glass fibers and the glass content is kept at 20% of the composition. Glass fibers have a higher density than other (carbon, aramid, polyethylene) fibers.[26]

It has been stated that glass fibers are the most suitable fiber for use due to their resistance to heat, humidity and oil, high mechanical properties, cheapness, easy availability, good polishability, aesthetics because of their white color, translucent feature and dentin bonding capacity. Glass fiber is biomechanically similar to teeth and alveolar bone. The coefficient of thermal expansion is close to that of composite resins.

Widely used glass fiber brands in the market Vectris (Ivoclar, Liechtenstein), Splint-It (Jeneric/Pentron, Germany), GlasSpan (Exton, USA), Fiber Kor (Jeneric/Pentron, Germany) Stick (Stick Tech, Finland), StickNet (Stick Tech, Finland) and EverStick (Stick Tech, Finland).[27]

GlasSpan is a woven glass fiber system that can be used in post-core, periodontal splint and temporary bridge applications. It is not saturated with resin and does not require special equipment.[28] Stick fibers can be used directly in the mouth. Stick fibers are a system with a diameter of 10-12 μm and contain an average of 100,000-180,000 glass fibers and 45% fiber. Surface treatment is carried out by saturating silanized porous polymers. Polymethyl methacrylate (PMMA) chains surrounding the BIS GMA matrix increase the matrix's ability to bond to the product and its placement. In addition to the similarly produced StickNet material, EverStick, the latest material produced by the same company, is densely compacted in a polymer monomer matrix, pre-silanized glass fiber, 55% SiO_2 22% CaO, 15% Al_2O_3, 6% B_2O_3, and the whole structure is surrounded by a PMMA capsule. It is a composite material containing very small amounts of metal oxides.[29]

Nylon fiber: Nylon fibers are polyamide fibers. Polyamides are high molecular weight thermoplastic polymers. Polyamides have high strength, elasticity, hardness, and wear. They maintain their good mechanical properties even at high temperatures. They have high fracture strength and bending strength at low temperatures and are resistant to solvents. Polyamide-based denture base material can be used in patients allergic to PMMA resin or where flexibility is desired. The most important advantage of the polyamide-based denture base material is its shock absorption resistance and resilience for repetitive stresses.[30]

By the Orientation of Fiber

Long fiber reinforced composites are called continuous fiber composites, while short fiber reinforced composites are called short particle/discontinuous fiber composites. Composites in which two or more fiber types are in a single matrix structure are called hybrid fiber composites. Fibers can be placed in the matrix structure of continuous fiber composites in either one direction (rovings and threads) or two directions (weave/weave).[31]

The orientation of the fibers can change the properties of a fiber-reinforced polymer from isotropic to anisotropic or even orthotropic. Continuous unidirectional fiber-reinforced polymers impart anisotropic properties to the composite, while continuous duplex fibers impart orthotropic properties, while randomly oriented fibers impart isotropic properties. Unidirectional longitudinal fibers exhibit superior mechanical properties along their long axis and are often preferred when the direction of greatest stress is known. Discontinuous fibers can be found as aligned or randomly oriented short particle fibers. If the direction of the force is unknown or there is a force vector in more than one direction, omnidirectional woven or randomly oriented fibers may be preferred.[32,33]

By on Whether the Fiber is Pre-Infiltrated with the Monomer or Not

It can also be defined as the saturation of the fiber with the polymer matrix or the monomer infiltration into the fiber structure. The saturation process is the homogeneous coating of each surface of the fiber in the resin matrix with monomer. Adequate saturation of the fiber fibers with the appropriately selected resin ensures better mechanical and physical properties of the fiber-reinforced restoration. In order for the reinforcement to be successful, the forces from the resin matrix must be transmitted to the fiber infrastructure. If insufficient saturation occurs in the fiber reinforced composite, water absorption increases in these regions and the mechanical properties of the composite weaken due to the harmful hydrolytic effect of water. Another problem is the invasion of the oral microflora into the formed microcavities and the resulting color change. It is therefore preferred that the process be carried out by the manufacturer of the fiber product.[34]

This can be done by the manufacturer beforehand or later by the physician/laboratory technician. EverStick C&B and Quartz Splint UD are examples of pre-saturated fibers, while Ribbond is examples of non-pre-saturated fibers.[35]

Usage Areas of Fiber Reinforced Composite Resins

Usage areas of fiber reinforced composite resins;[36]

- Direct adhesive restorations
- Indirect adhesive restorations
- Fixed bridge
- Anterior and posterior single full crowns
- Lamina crowns
- Partial crowns

- Telescopic crowns
- Anterior and posterior extracoronal-intercoronal bridges
- Implant supported fixed and movable bridges
- Periodontal splint
- Implant-supported dental prosthesis
- Endodontic post core construction
- Fixed placeholder in pedodontics
- Strengthening or repairing removable prostheses
- Fixed partial prosthesis applications
- Immediate temporary and long-term temporary bridge

Fiber Reinforced Products and Compounds Used in Dentistry

Table 1. Fiber-reinforced products and compounds used in dentistry[37]

Product	Manufacturer	Fiber Type	Fiber Orientation
Pre-infiltrated Fibers Prepared in the Laboratory			
Fiber Kor	Jeneric/Pentron	S-glass	Linear
Vectris	Ivoclar	E-glass	Linear
Pre-infiltrated Fibers Prepared in the Clinic			
EverStickC&B	Stick Teck/Turku	E-glass	Linear
Quartz Splint UD	RTD	Quartz	Linear
Splint-it	Jeneric/Pentron	Glass	Linear/Mesh
Clinically Prepared Non-Pre-infiltered Fibers			
Connect	Kerr	Polyethylene	Mesh
Ribbond	Ribbond	Polyethylene	Mesh
Glasspan	Exton	S-glass	Linear
Stick	Stick Teck/Turku	E-glass	Linear
Stick Net	Stick Teck/Turku	E-glass	Linear

Factors Affecting Mechanical Properties of Fiber Reinforced Composite Resins

1. Distribution direction of fibers
2. Quantity and volume of fibers, surface widths and position
3. Saturation of fibers with resin
4. Adhesion of fibers to the matrix
5. Surface Treatments Applied to Fibers

Distribution Direction of Fibers

Unidirectional rod-shaped fibers consist of fiber bundles running parallel to each other in one direction. Unidirectional fibers provide anisotropic properties by improving the mechanical properties of composites in one direction. Unidirectional fibers show the highest resistance to forces from the parallel direction, while their resistance to forces from the perpendicular direction is low.

Fibers in the form of a web/weave (weave) are fibers that are formed by arranging them in different directions longitudinally and transversely. It is orthotropic because it is a knitted fiber and provides support to the composite resin from all directions. It allows the restoration to be strengthened in all directions. Therefore, it is appropriate to use in situations where the direction of the incoming force cannot be predicted before.[38]

If random/chopped fibers are randomly oriented as in short fibers, they exhibit equal mechanical properties in all directions when three-dimensional isotropic. If the direction of the force is unknown or there is a force vector in more than one direction, omnidirectional woven or randomly oriented fibers may be preferred.[39]

Quantity and Volume of Fibers

The amount of fiber in the polymer matrix can be expressed as a percent by weight or volume. It has been shown in studies that the increase in the amount of fiber increases the impact strength of the polymer matrix. It has been determined that the fiber reinforced restorations have lower compressive and tensile strengths than expected if the volume is low, even if the fiber content is high.[40] It has been shown that the fiber length, as well as the volumetric ratio of the fiber in the polymer matrix, affect the abrasion resistance of composite resins.

Saturation of Fibers with Resin

It can also be defined as the saturation of the fiber with the polymer matrix or the monomer infiltration into the fiber structure. The saturation process is the homogeneous wetting of each surface of the fiber in the resin matrix with the monomer. Adequate saturation of the fiber fibers with the appropriately selected resin ensures better mechanical and physical properties of the fiber-reinforced restoration.[41] It is very important to saturate the fibers with the monomer matrix surrounding them so that the load on the restoration can be transferred from the resin matrix to the fibers.[42] If the fiber bundles are not sufficiently saturated with the resin matrix, the fiber There are gaps between the bundles and it has been reported that the durability of the restoration against forces from the transverse direction decreases due to these gaps. In addition, the mechanical properties of composites reinforced with insufficiently saturated fiber, such as flexural strength and modulus of elasticity, are adversely affected, which can lead to fluid absorption from the voids, microorganism penetration and color change.[12,41]

Fiber fibers can be saturated in two ways: pre-saturated and saturated. Pre-unsaturated fibers are fiber in which the dentist or technician manually wets the fiber fibers with a low-viscosity resin prior to the procedure. However, manual resin impregnation is a demanding and time-consuming application. Due to application errors, voids and pores may occur that may cause water absorption. Pre-saturation process was applied to the pre-saturated fibers with different techniques as fabrication at the production stage. It does not require the dentist or technician to pre-saturate the resin before the application, thus reducing the technical sensitivity.[43]

Adhesion of Fibers to the Matrix

The connection of the fibers to the polymer matrix has an important place in the durability of FRCs. The chemical bond between the polymer matrix and the fiber is the covalent bond. With the adhesion, the resulting stresses are transmitted from the matrix to the fibers. Good connectivity between the fiber and the matrix is effective in dissipating the incoming forces.[34]

Surface Treatments Applied to Fibers

The adhesion of the fiber to the matrix is one of the most important variables affecting the mechanical properties of FRC. Various surface treatments are suggested during production or prior to used to improve adhesion between fiber and polymer matrix. These transactions are; dental adhesive use, plasma spraying, flame burning and radiation applications. Polymer surfaces often cause bonding and finishing problems due to their high hydrophobicity and low surface energy. With the application of plasma, the surfaces of polymers can be improved in terms of hydrophilicity by forming oxygen-containing functional groups such as carbonyl group (C=O) and hydroxyl group (-OH).

Silane coating agents are used to provide adhesion between the glass fibers and the polymer matrix. Silane coating agents are condensed onto the glass surface at a temperature higher than room temperature.[12]

Studies on Fiber-Reinforced Composite Resins

Bijelic-Donova et al.[44] In their study, they showed that the fracture resistance values of short fiber reinforced composite resins are higher compared to conventional composite resins.

Türkeş et al.[45] In his study, it was reported that if the woven polyethylene fiber is placed in the composite resin, the resistance of the restoration against the incoming pressure forces increases.

Hiremath et al.[46] in their in vitro study, it was concluded that restorations with polyethylene ribbond fiber can be evaluated as an alternative to crown restorations, since the fracture resistance values are very close to natural teeth.

Garlapati et al.[47] showed in their study that EverX-Posterior has superior fracture resistance. EverX-Posterior is a short E-glass fiber reinforced composite that can control polymerization shrinkage and marginal leakage due to the orientation of the fibers.

In the study of Tekçe et al.[48] polyethylene ribbond fiber reinforced composite and short fiber reinforced composite EverX-Posterior were compared and as a result, the fracture resistance values of the two materials were found to be similar. In addition, in this study, the fracture values of EverX-Posterior materials were found to be higher than the average maximum bite force of 700-900 N in the molar regions and the forces that can reach up to 965 N during trauma and hard foreign body bite.

In their in vitro study by Eapen et al.[49] it has been shown that the use of short fiber reinforced composites in the restorations of endodontically treated teeth can preserve the remaining tooth tissue with higher fracture resistance. They reported that the use of a short fiber reinforced composite substructure under the composite resins in areas exposed to high stresses with endodontically treated teeth in order to mimic enamel and dentin in natural teeth will make the restoration more durable and resistant to fracture.

Tanner et al.[50] reported that no secondary caries formation was observed in posterior teeth restored with fiber-reinforced composite in a two-and-a-half-year follow-up study. It has been reported that the decrease in the amount of polymerization shrinkage with the presence of fibers and the associated risk of micro-leakage reduce the risk of secondary caries, especially in FRCs.

CONCLUSION

The use of fiber-reinforced composite materials in dentistry is gradually increasing, and their use with traditional composite materials expands the limits of indications in restorative procedures. The contribution of these materials to the field of biomimetic dentistry will continue with the increasing success rate in composite restorations and the production of new fiber-reinforced composite materials by improving their structures.

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Gingival and periodontal diseases in children

Gülnur Sağlam[1], Ahmet Dağ[2]

Department of Periodontology, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey

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Corresponding Author: Gülnur Sağlam, gulnur.saglam@dicle.edu.tr

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ABSTRACT

Periodontal diseases, one of the most important health problems in societies, affect children as well as adults. Gingivitis is more common in childhood than periodontitis. Bone and attachment loss in children is not common, but may be associated with a systemic disease or an isolated dental condition. Early diagnosis and treatment of periodontal diseases in childhood and identification of patients at risk are very important in terms of preventing diseases that may occur in the future.

Keywords: Child, gingivitis, periodontal diseases, periodontitis

INTRODUCTION

Periodontal diseases in adults usually begin in early childhood. The role of dentists in the early diagnosis and treatment of periodontal diseases is very important.[1] If left untreated, these diseases seen in children negatively affect the child's nutrition and development.[2]

There are significant differences between periodontal tissues in childhood and adults.[3]

Periodontium in Primary Dentition

In the milk dentition period, the gums show some differences compared to the adult gums. The tissues are pale pink. The attached gingiva in children is less keratinized than the attached gingiva in adults. The thinness of the keratinized layer causes the underlying veins to be more visible. Stippling pattern occurs around 3 years of age and is detected in 56% of children aged 3-10 years. Little difference has been reported between the maxillary and mandibular arches or between boys or girls during childhood.[4]

Figure 1. Normal gingival appearance in a 5-year-old child.[1]

Differences Between Periodontal Structures in Children and Adults

In children, the interdental gingiva is wide in the buccolingual direction and narrow in the mesiodistal direction. In the interproximal areas, the papilla is observed as flattened. It is consistent with the morphology of the primary dentition. The structure and composition of the gums are similar to those of adults. The consistency of the gingiva is softer, the gingival margin is thick and roll-shaped. Although the gingiva is pale pink, it appears more red during the teething period. It is seen that the depth of the probing pocket is shallower in primary teeth compared to permanent teeth. Depth increases posteriorly and is approximately 1-2 mm.[3,4]

The width of the attached gingiva on the vestibule surfaces of anterior teeth is greater than that of posterior teeth. While the width of the buccal surfaces decreases from anterior to posterior, some data indicate a narrowing in the region of the canine teeth. On lingual surfaces, the situation is reversed; There is an increase in width from anterior to posterior. During the transition to permanent dentition, gingival width increases with age. The junctional epithelium is thicker in primary teeth. Thicker epithelium reduces the passage of bacteria and their toxins.[4]

Characteristics of Periodontal Tissues in Childhood

Radiographically, the lamina dura is more prominent, and the periodontal ligament space is wider. In children, the thickness of the periodontal membrane is increased. The density and amount of these fibers, which are irregular and loose, are less. Cementum is thinner and less calcified in primary teeth. In children, the alveolar bone is thinner. The bone marrow spaces are wider. The amount of calcification is less and the lymph and blood vessels are more. The alveolar crest is flatter, 1-2 mm from the enamel-cementum boundary. In children, alveolar bone contains more organic matter.[5,6]

EPIDEMIOLOGY

In developed countries, the incidence of gingivitis in children aged 6-11 is around 73%. This rate increases from 6 to 11 years of age.[7] In many studies, it has been shown that there is a significant increase in the prevalence of gingivitis with adolescence.[8] It is observed that there is an increase of 50-99% in the incidence of gingivitis during adolescence.[8] It has been reported that the prevalence of gingivitis is lower among girls than boys and this is probably related to oral hygiene.[9]

CLASSIFICATION OF PERIODONTAL DISEASES IN CHILDREN AND ADOLESCENTS

The clinical classification of periodontal diseases in children and adolescents determined by the American Academy of Periodontology is as follows;[10]

1. Gingival Diseases
   - Gingival diseases induced by dental plaque
   - Gingival diseases not induced by dental plaque
2. Aggressive periodontitis
3. Chronic periodontitis
4. Periodontitis as a manifestation of systemic diseases
5. Necrotizing periodontal diseases

GINGIVAL DISEASES

Gingival Diseases Due to Dental Plaque

The most common periodontal infection among children and adolescents is plaque-induced chronic gingivitis. Studies have reported a 70% incidence in children after the age of seven. Swelling, bleeding and redness in the marginal gingiva are the first signs. Although the progression of these diseases to periodontitis is rare, the treatment of gingival diseases in children is important. Dental plaque resulting from poor oral hygiene is the primary cause of gingivitis. There is no strong correlation between dental plaque scores and gingival index in children. The same oral hygiene conditions cause milder disease development in children compared with adults.[11,12] The presence of gingivitis in school children may be caused by different dietary habits, the presence of mixed dentition, incorrect and uncontrolled oral hygiene practices, and malocclusion.[13]

The severity of gingivitis in children is mild compared to adults. This difference in the severity of gingivitis may be related to the nature of the dental plaque, differences in the immune system and the difference in the periodontium with adults. Dental plaque in children contains less amount of periodontal pathogen. The decreased vascularity of the gingival connective tissue and the formation of a thicker barrier limit the severity of infections. The incidence of gingivitis increases with age. While the prevalence of gingivitis is at its lowest level in pre-school, it peaks in puberty, especially between the ages of 14-16. Hormonal factors have a serious effect on this increase.[14,15]

Clinical features: Inflammation is generally limited to the marginal gingiva and progresses in different directions over time. Changes occur in the color, size and consistency of the gums, and they resemble those in adults. As the disease progresses, which starts with redness, swelling and bleeding in the gums, chronic changes such as fibrotic tissue becoming and hyperplasia can be observed. In the absence of severe gingival hypertrophy or hyperplasia, there is no significant increase in pocket depth and bleeding. In histological evaluation; It has been shown that especially cellular inflammatory cells (polymorphonuclear leukocytes, mast cells, plasma cells) are infiltrated into the junctional epithelium and there is a loss of collagen in the regions.[4,16,17]

In children and young adults with similar levels of dental plaque, inflammatory reactions are more pronounced in adults. Predominance of T lymphocytes and fewer B lymphocytes and plasma cells in children makes the host response different. In children, due to the thicker junctional epithelial barrier, decreased permeability and becoming a more difficult barrier for bacterial toxins makes it difficult to develop inflammation.[18,19]

Eruption gingivitis: Gingival inflammation that occurs during tooth eruption is called eruption gingivitis. In fact, it occurs as a result of increased plaque accumulation in areas where milk teeth fall out and permanent teeth begin to erupt. The areas where the teeth start to erupt are very sensitive and the bristles of the brush cause irritation in these areas. It is quite difficult to maintain hygiene in these areas.[20]

In primary teeth, the increase in the depth of the gingival sulcus over time and the apical migration of the junctional epithelium facilitate the eruption of the tooth. During rubbing, degenerative changes occur in the junctional epithelium and the permeability of the epithelium increases.[20] Sulcus development is incomplete, the gingival margin is not keratinized. As a result of inflammatory changes, the normal form of the gingiva changes and a distinctive gingival enlargement image occurs.[4,8] During the eruption of the teeth, food entrapments may exacerbate the condition and pericoronal abscess or pericoronitis may develop in the erupting tooth. Providing effective plaque control will reduce these reactions occurring in the gingiva.[12]

Puberty gingivitis: Different factors, such as plaque scores, dental caries, tooth eruption, crowding, and mouth breathing, affect the severity and incidence of gingivitis in adolescents.[11] However, the severity and prevalence of gingivitis reaches its highest level as a result of the serious increase in steroid hormones between the ages of 9-14, which coincides with the pre-pubertal and pubertal period. This increase has a temporary effect on the condition of the gums and ends after adolescence.[4] Gums contain receptors with a high affinity for estrogen and progesterone. Estrogen receptors are located in the basal layer of the epithelium, spinous layer, connective tissue endothelium, and fibroblast cells in small vessels.[8] These hormones increase vascular permeability and may cause damage to the endothelium. In addition, it affects the migration of leukocytes to the inflamed tissue, the incorporation of the subgingival flora, and the formation of granulation tissue.[20]

The relationship between increased levels of steroid hormones in the circulation and gingivitis during adolescence was evaluated and it was observed that inflammation increased at an earlier age (10-13) in girls.[8] Estrogen and progesterone levels were found to be associated with an increase in *P. intermedius* rates during this period, and in vivo studies have shown that *P. intermedius* uses these hormones as a food source.[20]

Pubertal gingivitis is characterized by marked inflammation, bluish-red discoloration, edema, gingival

enlargement, and spontaneous bleeding, especially in the interdental areas.[8,16] In addition to an effective oral hygiene regimen at home, elimination of local factors and professional prophylaxis will be very effective.[16]

Gingival growths due to drug use: As a result of the use of cyclosporine, calcium channel blockers and phenytoin, gingival enlargement may occur and its prevalence in children is quite high. The clinical and microscopic features of growth induced by different drugs are similar. Growth begins in the interdental space and spreads to completely cover the marginal gingiva. In cases where the severity of the disease increases, the gingiva may enlarge to cover the incisal and occlusal surfaces. Gingival enlargement is common throughout the mouth, but more severe in the maxillary and mandibular anterior region. Gingival enlargement is usually seen in the area of the teeth, not in the edentulous areas. When the teeth are extracted, the growth disappears. Mucosal hyperplasia has also been reported in edentulous mouths, but is very rare. There is a direct relationship between the severity of growth and the amount of plaque. Removal of dental plaque and maintaining oral hygiene can reduce the severity of lesions.[21-23]

Growths cause aesthetic problems, chewing, speaking, driving problems, tissue traumas, secondary infections, and periodontal diseases. First of all, the attachments on the teeth should be removed and the patient should be taught to brush and floss correctly. Operations such as gingivectomy and gingivoplasty may be necessary to correct the gingival contours and ensure the full applicability of hygiene procedures. The patient and their relatives should be informed that the growths may recur after the surgical procedure, and the importance of an effective plaque control in controlling the process should be emphasized. Gingival enlargements tend to disappear spontaneously within a few months after discontinuation of the drug. A decision can be made to change the drug, if appropriate, by asking the patient for a medical consultation.[16,24]

Oral Lesions Independent of Plaque

Recurrent aphthous stomatitis, primary herpetic gingivostomatitis, recurrent herpes simplex infections, common oral candidiasis, angular cheilitis and geographic tongue are the most common oral lesions in children. The incidence of these lesions is approximately the same between children and adults.[24,25]

Primary herpetic gingivostomatitis: Primary herpetic gingivostomatitis is a viral disease that usually occurs acutely in early childhood and its causative agent is Herpes simplex virus (HSV) type-1. PHG often affects children younger than 10 years of age, more frequently in children aged 2 to 4 years, and then younger people aged 15-25.[16] In the vast majority of cases, 99%, there are no symptoms or the resulting symptoms are attributed to teething. In the remaining 1%, severe inflammation and ulceration of the lips and mucosa may develop. The disease has an incubation period of about 1 week. The clinical features of the disease are fever, headache, cervical lymphadenopathy, diffuse inflammation characterized by significant swelling, bleeding, and erythema in the marginal and attached gingiva. The vesicles burst, forming large ulcers. Patients have difficulty in chewing and swallowing due to severe pain. For this reason, it is very important to take plenty of fluids in order not to develop dehydration. PHG is an infectious disease that usually regresses spontaneously within 12-20 days.[24,25] Healing occurs spontaneously within 10-14 days without leaving a scar.

In the treatment of PHG, prevention of bacterial superinfections is important in terms of early healing of ulcerations. Therefore, dental plaque must be carefully removed.[26] For patients with herpetic gingivostomatitis, if acyclovir oral suspension therapy is administered at 15 mg/kg starting within the first 3 days, a significant reduction in the duration of contagiousness and symptoms in affected children has been reported.[16]

Candidiasis: It is caused by an overgrowth of *Candida albicans*, an opportunistic fungus found in the oral cavity and different parts of the body. The rate of C. albicans can reach 50%-80% in the total mouth fungus population. It has proteinase-containing strains that can invade the keratinized epithelium and is the most common fungal infection in the oral mucosa.[26] It is generally transmitted from the mother during birth to infants, and its incidence increases after long-term antibiotic or steroid use in older children. In addition, it is frequently seen in diabetes, hypoparathyroidism and chemotherapy patients. HIV-infected children and adolescents are prone to develop oral candidiasis.[16] Oral candidiasis is rarely seen on the gums in healthy individuals. It can be seen in different types in the oral mucosa, such as pseudomembranous candidiasis (thrush), erythematous candidiasis, plaque type, nodular.[26] Clinically, it is in the form of diffuse plaques in the form of whitish patches that can be easily removed from the mucosa with the help of a tool or cloth.[26] In topical treatment, antifungals such as nystatin, amphotericin B, and miconazole are applied.[24]

Recurrent herpes simplex: Primary infections are usually transmitted by direct contact with a lesion or with infected body fluids (saliva, exudates of active lesions). HSV Type 1 binds to specific surface receptors of cells and infects the oral mucosa. After primary infection, it settles in the ganglia of neurons via sensory and autonomic nerves. The virus specifically settles in the trigeminal ganglion, where it remains latent for life.[16,27] Reactivation of the virus in the sensory ganglion causes cutaneous and mucocutaneous recurrent herpetic infection. Reactivation may occur spontaneously or may be triggered by a number of factors.[16]

In general, HSV type-1 is responsible for infections in the orofacial region, and the virus is found at a rate of 30-60% in children. Primary HSV infections in children are usually asymptomatic or are too mild to be noticed. Recurrent infections occur as a result of triggering factors, such as sunlight, fatigue, emotional stress, trauma, fever, and immunosuppression. The most common secondary recurrent infections are herpes labialis.[28] Lesions typically occur at the mucocutaneous junction called the vermillion, especially on the lips. In this region, symptoms such as paresthesia, itching, pain, and burning sensation are observed in 46-60% of patients. Lesions rapidly become vesicular, then burst into ulcers or crusted pustules.[28,29]

Recurrent aphthous stomatitis (RAS): The most common form of RAS in childhood is minor aphthae.[28] Patients often refer to these ulcerative lesions as "cancers". RAS lesions can sometimes be 0.5 to 1.0 cm in diameter, or appear as oval and irregular ulcers ranging in size from 1 to 3 mm. Small lesions heal in 7 to 10 days, while larger lesions take weeks to heal with scarring.[16] Trauma, emotional stress, problems with

menstruation, nutrition, and endocrinopathies predispose to the emergence of RAS. Although there is no specific treatment for RAS, topical tetracycline, chlorhexidine gluconate or other mouthwashes, topical corticosteroids or immunomodulators can be used in the clinical management of the disease.[24,30]

Angular cheilitis: Inflammation begins at the corners of the lips. Over time, erosion, ulceration, fissure develops, and it is a very painful condition. *Candida albicans* and *Staphylococcus aureus* have been reported to cause angular cheilitis. Angular cheilitis and other oral candidiasis infections are very common in HIV-infected children. Factors such as immunodeficiency, vitamin B2 deficiency, decrease or loss of vertical dimension for various reasons, and trauma predispose to these infections.[16,24]

Geographic tongue (benign migratory glossitis): Geographic tongue is a benign inflammatory condition. It is characterized by a desquamation of superficial keratin and filiform papillae in the tongue. It affects approximately 1-2% of the population. Although its etiology is unknown, it has been suggested that it correlates with nutritional deficiencies and emotional stress. This condition is usually limited to the dorsum and lateral of the tongue. Sometimes the lesions become symptomatic and a burning sensation occurs in the tongue.[31,32] It is seen that the complaints are sometimes quite severe, and sometimes completely reduced. Patients with symptoms may be advised to stay away from acidic and spicy foods.[24] Topical or systemic antihistamines can be used in geographic tongue lesions.[16]

Periodontal diseases in childhood: Epidemiological studies have shown that all children and adolescents in the world are affected by different forms of gingivitis. Bone and attachment loss is not common in children. However, the incidence of gingivitis in children 7 years and older is more than 70%. In epidemiological studies conducted in the USA, severe attachment loss in one or more teeth in children and young adults was found to be approximately 0.2-0.5%.

When different forms of periodontal diseases are compared; chronic periodontitis is more likely to occur in adults, and aggressive periodontitis in children and adolescents.[12,33]

AGGRESSIVE PERIODONTITIS

Aggressive periodontitis is known for the clinical signs of periodontitis to appear at a very early age, to show a strong tendency to pass in the family, and to show a large amount of attachment and bone loss in a short time. Pathogenic microflora, abnormalities in host defense mechanism, phagocyte abnormalities and hypersensitive macrophage phenotype are the main causes of the disease. It is divided into subgroups as localized and generalized. The prevalence of the localized form, which is more common in young people compared to the generalized form, is between 0.1% and 15%. In the 14 -17 age group, the rate of generalized aggressive periodontitis is 0.13%.[16,34]

Localized Aggressive Periodontitis (LAgP)

The disease begins around puberty. In these patients, the loss of attachment in the interproximal areas should not exceed two teeth, except for the permanent first molars and incisors. Studies so far have shown that in most cases of LAgP coexisting *Aggregatibacter* (*Actinobacillus*) spp., *Bacteroides* spp. and *Eubacterium* spp.

It has also been proven that cases of LAgP are associated with defects in the function of neutrophils. In these patients, the host response to the infecting agent is very severe, increasing the extent of destruction.

Clinical examination of patients with Localized Aggressive Periodontitis (LAgP) shows that the amount of plaque and calculus is too low to be associated with the severity of inflammation. No clinical signs of systemic diseases are observed in patients.[24,35]

Generalized Aggressive Periodontitis (GAgP)

It mostly affects individuals under the age of 30. It usually affects the entire dentition and is known as a disease of young adults. Except for the permanent incisor and permanent first molars, there must be at least three other permanent teeth affected. There is no strong antibody response to the infecting agent as in LAgP. Affected teeth have a high proportion of *Porphyromonas gingivalis* in the subgingival flora. In addition, chemotaxis defects in neutrophils are observed in these patients.[1,36]

In the treatment of aggressive periodontitis, successful results are obtained with the use of systemic antibiotics in addition to detection, subgingival curettage, root surface straightening and periodontal surgeries.

Studies have shown that the use of tetracycline alone or in combination with metronidazole in aggressive periodontitis gives very successful results. Amoxicillin-metronidazole combination may be preferred in younger children because tetracycline causes discoloration in teeth.[37] It has been reported that LAgP patients respond quite well to the treatments, while GAgP patients do not give the desired response to both periodontal treatments and antibiotics. The characteristic structure of the pathogenic flora may necessitate the use of alternative antibiotics. When there is no response to standard treatments, laboratory tests should be performed by taking plaque samples from GAgP patients and pathogens resistant to routinely used drugs should be determined.

There are some retrospective studies suggesting that the presence of bone loss in primary teeth may be an early sign of localized aggressive periodontitis. Therefore, periodontal evaluation should be done carefully in children.[12,38,39]

CHRONIC PERIODONTITIS

Children are not as susceptible to this form of periodontitis as adults, but more rarely, it can affect children and adolescents. The disease usually progresses at a low or moderate rate. In some periods, there may be an exacerbation of destruction attacks. It is divided into two as localized or generalized according to the ratio of the affected areas. If the relevant areas are less than 30%, they are called localized, and if they are more, they are called generalized. clinical attachment loss of 1-2 mm; mild clinical attachment loss of 3-4 mm; moderate, losses of 5 mm and above; it is classified as severe.[12,40,41]

Before chronic periodontitis, the patient must have a history of gingivitis. However, it is very difficult to determine the exact stages in the transition from gingivitis to periodontitis. Factors such as an increase in pathological bacteria, immune system-related conditions, genetic susceptibility of patients may be possible causes.

The general approach to chronic periodontitis is to eliminate the existing inflammation, stop the progression

of the disease and provide the patient with a stable oral environment. Providing personal plaque control, periodontal initial treatments such as detection, subgingival curettage, root surface straightening, mouthwashes are important in the treatment of the disease.[34] Electric toothbrushes can be recommended for mentally or physically handicapped children and for children who cannot use brushes effectively.[4]

PERIODONTITIS AS A SIGN OF SYSTEMIC DISEASES

Hypophosphatasia, Papillon-Lefevre Syndrome, leukemias, Chediak-Higashi syndrome, histiocytosis X, Acrodynia, Down syndrome, AIDS, Leukocyte adhesion defect, neutropenia, insulin-dependent diabetes are systemic diseases that cause periodontitis in children.[16] Defects in neutrophils and immune cell functions play a role in increased susceptibility to periodontitis and other infections.[43] It can occur in localized or generalized forms. Severe bone loss is seen around the teeth in the affected areas in patients.[41]

The percentage of potent periodontopathogens such as *A. actinomycetemcomitans*, *P. intermedia*, *E. corrodens* and *Capnocytophaga* increased in the affected areas.[41]

Necrotizing Periodontal Diseases

The presence of acute pain in the interdental areas, as well as areas of necrosis and ulceration resembling a crater in the form of punch holes, are among the important symptoms. Easily bleeding pseudo-membranes cover the lesions. Spirochete invasion and presence of *P. intermedia* on necrotic surfaces have been shown in studies.[24] Systemic findings such as fever and lymphadenopathy may often accompany necrotizing periodontal diseases. Children may become prone to these diseases due to viral infections, nutritional deficiencies, various systemic diseases, fatigue and stress.[41] In the presence of systemic findings, it is recommended to use antibiotics such as metronidazole and penicillin.[42] However, it has been shown that the effect of mechanical debridement with ultrasonic devices is more positive and faster.[24]

CONCLUSION

Periodontal diseases are among the most common diseases affecting children and adolescents. It is well known that bacterial plaque plays a role in the primary etiology of periodontal diseases, but when evaluating periodontal diseases in patients affected by early-onset periodontitis, diseases that may affect the host's defense mechanism should definitely be considered.[42]

To best manage periodontal diseases, dentists should have sufficient knowledge of the diagnostic features, occurrence, prevalence, microbiology and treatment of these diseases.[34] Periodontal evaluation of routine dental check-ups in childhood will ensure early prevention of diseases that may occur in the future. If the disease is already present, early treatment, teaching the child to brush correctly, and increasing the family's awareness of oral hygiene will reduce the prevalence of the disease in societies.

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