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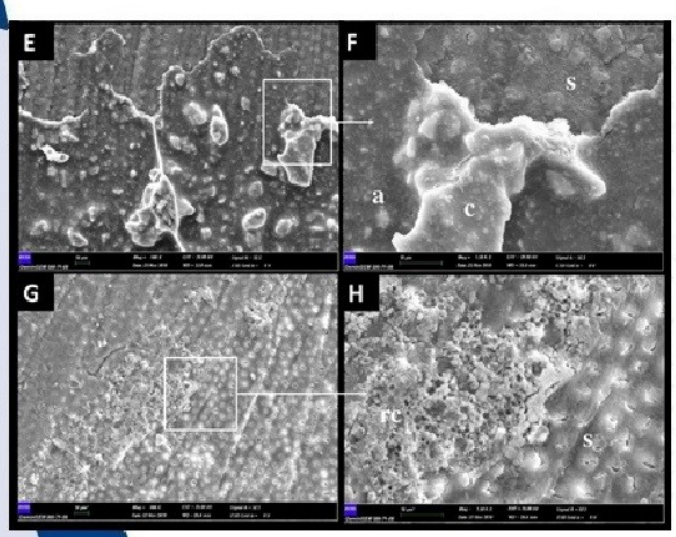

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CDJ publishes original research papers, reviews, and case reports within clinical dentistry, on all basic science aspects of structure, chemistry, developmental biology, physiology and pathology of relevant tissues, as well as on microbiology, biomaterials and the behavioral sciences as they relate to dentistry.

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Evaluation of the Effect of Socioeconomic Status on Oral Hygiene Habits

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Research Article

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ABSTRACT

Objectives: The aim of this study was to evaluate the impact of socioeconomic status on oral hygiene habits.
Materials and Methods: A questionnaire was conducted on 709 adult individuals who applied to Muğla Sıtkı Koçman University Faculty of Dentistry periodontology clinic. Evaluation was performed on participants' sociodemographic characteristics, socioeconomic statuses, and oral hygiene habits. Questions directed at the participants encompass oral hygiene habits, frequency of dental examination, gum health, prevalence of restorations and prostheses, as well as educational level, occupation, and monthly income. The 'Modified Kuppuswamy Socioeconomic Status Scale' was used to assess participants' socioeconomic status. Data from the study were analyzed using the Pearson Chi-square test (p=0.05).
Results: Statistically significant differences were determined between socioeconomic status (SES) groups in the variables of smoking, tooth brushing, toothpaste selection, frequency of dental examination, presence of gum bleeding, dental filling, root canal treatment and previous dental implant treatment (p<0.05). 81.8% of individuals in the low SES group and 95.5% in the high SES group stated that they brush their teeth daily. When selecting toothpaste, 45.5% of participants in the low SES group considered the price, 68.9% in the upper-middle SES group considered the content and 27.3% in the high SES group prioritized dentist recommendations.
Conclusions: Within the limitations of our study, it is evident that socioeconomic factors affect oral hygiene habits and oral health from different perspectives. Further studies involving different populations and larger sample sizes are needed to understand better the precise impact of socioeconomic status on oral hygiene habits.

Keywords: Socioeconomic Status, Oral Hygiene, Oral Health, Financial Income, Education Level

Sosyoekonomik Statünün Oral Hijyen Alışkanlıkları Üzerine Etkisinin Değerlendirilmesi

Research Article

Süreç

Geliş: 17/11/2023
Kabul: 10/09/2024

ÖZ

Amaçlar: Bu çalışmanın amacı; sosyoekonomik statünün oral hijyen alışkanlıkları üzerine etkisini değerlendirmektir.
Gereçler ve Yöntemler: Muğla Sıtkı Koçman Üniversitesi Diş Hekimliği Fakültesi periodontoloji kliniğine başvuran 709 yetişkin bireye anket uygulanmıştır. Bireylerin sosyodemografik özellikleri, sosyoekonomik statüleri ve oral hijyen alışkanlıkları üzerine değerlendirme yapılmıştır. Katılımcılara yöneltilen sorularda oral hijyen alışkanlıkları, diş hekimi muayene sıklıkları, dişeti sağlıkları, restorasyon ve protez prevalansları ile eğitim düzeyi, meslek ve aylık maddi gelir durumları değerlendirilmiştir. Katılımcıların sosyoekonomik statü durumlarının değerlendirilebilmesi için 'Modifiye Kuppuswamy Sosyoekonomik Statü Ölçeği' referans alınmıştır. Çalışmanın verileri, Pearson Ki-Kare testi kullanılarak analiz edilmiştir (p=0,05).
Bulgular: Sosyoekonomik durum (SES) grupları arasında sigara içme, diş fırçalama, diş macunu seçimi, dental muayene sıklığı, diş eti kanaması, dolgu, kök kanal tedavisi ve geçirilmiş dental implant tedavisi değişkenlerinde istatistiksel olarak anlamlı farklılıklar belirlendi (p<0.05). Düşük SES grubundaki bireylerin %81.8'i, yüksek SES grubundakilerin %95.5'i her gün dişlerini fırçaladıklarını belirtti. Diş macunu seçerken, düşük SES grubundaki katılımcıların %45.5'i fiyatı, üst-orta SES grubundakilerin %68.9'u içeriği ve yüksek SES grubundakilerin %27.3'ü diş hekimi önerilerini esas aldıklarını belirtmiştir.
Sonuçlar: Çalışmamızın sınırları dahilinde sosyoekonomik faktörlerin oral hijyen alışkanlıkları ve oral sağlık üzerinde farklı açılardan etkili olduğu görülmektedir. Sosyoekonomik statünün oral hijyen alışkanlıkları üzerindeki etkisinin daha net anlaşılabilmesi için farklı popülasyonlarda ve daha fazla katılımcının olduğu çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Sosyoekonomik Statü, Oral Hijyen, Ağız Sağlığı, Maddi Gelir, Eğitim Düzeyi

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Introduction

It has been accepted that good oral hygiene is an important factor in the improvement of the quality of life. Oral and dental hygiene reflects the necessary physiological, social, and psychological features for a high quality of life.[1] Oral diseases continue to be an important public health issue worldwide. Regular and adequate oral hygiene habits are needed to preserve oral and dental health.[2] It is known that microbial dental plaque accumulating in hard and soft tissues within the mouth due to inadequate oral hygiene causes gingivitis and tooth cavities.[3,4]

Inadequate and/or incorrect oral hygiene habits can be observed in addition to loss of teeth and function deficiencies due to disruptions of professional dental examinations and treatments. Considering the relationship of oral and dental health with the systemic condition of the individual, this situation also can be figured as an issue in terms of public health.[5]

The selection of the materials used by the individual to ensure oral hygiene mechanically and chemically (toothbrush, toothpaste, mouthwash, etc.), method and frequency of use of these materials, and knowledge level about these materials might be affected by socioeconomic situations such as education level, financial situation and occupation of the individual. In addition, it is known that socioeconomic situations also affect routine visits to the dentist.[6,7]

Although studies have shown that socioeconomic status affects oral health at different levels, the general opinion is that people are more prone to oral problems that lead to general and oral health risk factors and therefore a decrease in quality of life.[8]

The main idea of this study arose from the desire to learn about patients' oral hygiene levels and to find out how much they use their financial means to have better oral health. Therefore, the purpose of our study was to evaluate the effect of socioeconomic status (SES) on oral hygiene habits. The hypothesis of our study was that individuals who have higher socioeconomic status will have better oral hygiene habits and higher awareness levels.

Materials and Methods

Our study started by obtaining permission from Muğla Sıtkı Koçman University Medicine and Health Sciences Ethics Committee on 15th July 2023, decision number being 54. The consent form was taken from the patients who applied to the Faculty of Dentistry of Muğla Sıtkı Koçman University periodontology clinic after informing them about the study. 709 individuals participated in this study voluntarily. A comprehensive socioeconomic status and oral hygiene evaluation questionnaire was designed for participants to fill out. With the questionnaire having 25 close-ended questions, oral hygiene habits, frequency of dentist examination, gingival health, restoration and prevalance of prosthesis and education level, occupation, monthly financial income status of the participants were evaluated (Table S1). The oral hygiene habits of the participants were evaluated by considering the frequency of brushing teeth, use of toothpaste, frequency of use of interdental brush and dental floss, and frequency of use of mouthwash. In addition, the factors that were important in the selection of these equipments and materials that are used to ensure oral hygiene were evaluated. Smoking, which may directly be correlated with both oral hygiene and socioeconomic status was also evaluated. The 'Modified Kuppuswamy Socioeconomic Status Scale' was based on the evaluation of the socioeconomic status of the participants.[9]

Table S1. Oral Hygiene Habits Evaluation Questionnaire

Question	Answers
1. Mark which age range you are in.	a) aged 18-25 b) aged 25-40 c) aged 40-65 d) over 65
2. Mark your gender.	a) Female b) Male
3. Mark your education level.	a) Illiterate b) Elementary school c) Middle school d) High school e) University f) Master's Degree g) Doctorate Degree
4. Write your occupation. (If you are retired, write your occupation before being retired.)	
5. Which range includes your monthly financial income?	a) 0-8.500 TL b) 8.500-15.000 TL c) 15.000-25.000 TL d) 25.000-35.000 TL e) 35.000-50.000 TL f) 50.000-70.000 TL g) over 70.000 TL
6. Do you smoke?	a) Yes

7. Do you brush your teeth every day?	a) Yes b) No
8. How many times do you brush your teeth a day?	a) Once b) Twice c) Three times d) More
9. How often do you change your toothbrush?	a) Once in 3 months b) Once in 6 months c) Once a year d) More
10. Which criteria do you consider while choosing your toothbrush?	a) Color b) Brand c) Size and quality of toothbrush bristles d) Recommendation of the dentist
11. Do you use toothpaste while brushing your teeth?	a) Yes b) No
12. Which criteria do you consider while choosing your toothpaste?	a) Flavour b) Price c) Ingredients of the toothpaste d) Recommendation of the dentist
13. Do you clean the interfaces of your teeth? If yes, how often do you clean them?	a) No, I do not b) Once a week c) Every two or three days d) Once a day
14. What do you use to clean the interfaces of your teeth?	a) Toothpick b) Dental floss c) Interdental brush d) Dental floss and interdental brush
15. Do you use mouthwash?	a) Yes b) No
16. Which criteria do you consider while choosing your mouthwash?	a) Brand b) Price c) Flavour d) Recommendation of dentist
17. Do you clean your tongue surface? If yes, how often do you clean it?	a) No, I do not b) Once a week c) Every two or three days d) Once a day
18. How often do you get examined by a dentist?	a) Once in 3 months b) Once in 6 months c) Once a year d) More
19. Do your gums bleed while brushing your teeth or eating?	a) Yes b) No
20. Do you have breath odor?	a) Yes b) No
21. Do you have fillings in your teeth?	a) Yes b) No
22. Do you have teeth treated with root canal treatment?	a) Yes b) No
23. Do you have any tooth deficiency?	a) Yes b) No
24. Do you have a prosthesis which you use within the mouth?	a) Yes b) No
25. Have you ever got a dental implant treatment?	a) Yes b) No

The groups below were created according to the socioeconomic status levels of the participants:

1st group: Low socioeconomic group

2nd group: Upper-low socioeconomic group

3rd group: Middle socioeconomic group

4th group: Upper-middle socioeconomic group

5th group: High socioeconomic group

The answers that were given to the third, fourth, and fifth questions of the questionnaire influenced the grouping of the participants as low, upper-low, middle, upper-middle, and high. These questions demonstrated the education level, occupation, and monthly financial status of the participants

and the scoring was determined accordingly as to specify their socioeconomic status. According to the scoring system based on the 'Modified Kuppuswamy Socioeconomic Status Scale', total points were determined and groups were created according to these points.

According to the answers given to the third, fourth, and fifth questions in the questionnaire, the participants took separate points from education level, occupation, and monthly financial income according to the socioeconomic status scale table below (Table 1) and these points were added up. The total point was determined by adding up these three statuses related to socioeconomic status. The participants that had a total point of 0 to 5 were included in the low socioeconomic group, a total point of 5 to 10 were included in the upper-low socioeconomic group, a total point of 11 to 15 were included in the middle socioeconomic group, a total point of 16 to 25 were included in the upper-middle socioeconomic group, a total point of 26 to 29 were included in the high socioeconomic group (Table 1).

Oral hygiene habits and socioeconomic status of the participants were evaluated and five different socioeconomic groups were compared to each other regarding oral hygiene habits.

The statistical analysis of this study was performed using IBM SPSS 20 statistical analysis software. Data was presented as mean, standard deviation, median, minimum, maximum, percentage, and number. The normal distribution of continuous variables was analyzed using the Shapiro-Wilk test, Kolmogorov-Smirnov test, Q-Q plot, and Skewness & Kurtosis. In comparisons between two independent groups, the Independent Samples t-test was used when the normal distribution condition was met, and the Mann-Whitney U test was utilized when it was not met. The ANOVA test was used when the normal distribution condition was met, and the Kruskal-Wallis test when it was not met when comparing continuous variables with more than two independent groups. Statistical significance was $p<0.05$.

Table 1: Demographic distribution

Status	Point
Education Level	
Doctorate Degree	7
Master's Degree	6
University	5
High school	4
Middle school	3
Elementary school	2
Illiterate	1
Occupation	
Professionals	10
Semi-professionals	6
Bureau/Department Jobs, Store Owners, Farmers	5
Qualified Worker	4
Semi-qualified Worker	3
Elementary Occupations	2
Unemployed	1
Monthly Financial Income	
Over 70.000 TL	12
50.000-70.000 TL	10
35.000-50.000 TL	6
25.000-35.000 TL	4
15.000-25.000 TL	3
8.500-15.000 TL	2
0-8.500 TL	1
Socioeconomic Group	**Total Points**
Low Socioeconomic Group	0-5
Upper-Low Socioeconomic Group	5-10
Middle Socioeconomic Group	11-15
Upper-Middle Socioeconomic Group	16-25
High Socioeconomic Group	26-29

Results

In the focus of 709 participants. it can be seen that 329 of the participants were female (46.5%). while 379 of the participants (53.5%) were male. One of the participants in the study did not report the gender. The highest age frequency was seen between the ages of 40-65 with 373 individuals (52.6%) and the lowest age frequency was seen in the age group over 65 with 19 individuals (2.7%) (Table 2).

Identifying data that were obtained from smoking, oral hygiene habits, and dental status of the participants were given in detail in the table (Table 3). The participants' education levels, occupations and monthly financial incomes were classified into seven categories (Table 4).

Socioeconomic groups were classified into five categories according to the scale obtained from the participants' occupation status, education levels, and monthly financial incomes (Table 5).

Statistically significant differences were determined between SES groups in the variables of smoking, tooth brushing, toothpaste selection, frequency of dental examination, presence of gum bleeding, dental filling, root canal treatment, and previous dental implant treatment ($p<0.05$) (Table 6). However, there were no statistically meaningful differences between SES groups in daily toothbrushing frequency, frequency of changing toothbrush and criteria of choosing toothbrush, interdental cleaning and choosing interdental cleaning tools, use of mouthwash and reason for mouthwash preference, tongue cleaning, breath odor and gingival bleeding, tooth deficiency and presence of prosthetic restoration ($p>0.05$) (Table 6).

In the middle SES group, the smoking rate was statistically significantly higher compared to the low SES group ($p=0.005$). In the high SES group, the daily tooth brushing rate was significantly higher than in the low SES group ($p<0.001$). In the low SES group, the price was a statistically significant factor in toothpaste selection, whereas dentist recommendation was significantly influential in the high SES group ($p<0.001$). The frequency of dental check-ups every six months and annually was significantly higher in the high SES group compared to the low SES group ($p<0.001$). The rate of gum bleeding in the upper low SES group was significantly higher than in the high SES group ($p=0.033$). The rate of fillings in the upper middle SES group was significantly higher compared to the low SES group ($p<0.001$). The rate of root canal treatment in the high SES group was significantly higher than in the low SES group ($p<0.001$). The presence of dental implants in the high SES group was significantly higher compared to the upper low SES group ($p<0.001$).

In participants in the low SES group, 18.2% of them reported smoking, while in individuals in the middle SES group, 42.3% stated that they smoking. Regarding oral hygiene, 81.8% of individuals in the low SES group and 95.5% in the high SES group mentioned brushing their teeth Daily (Table 7). When selecting toothpaste, 45.5% of participants in the low SES group considered the price, 68.9% in the upper-middle SES group considered the content, and 27.3% in the high SES group prioritized dentist recommendations. Looking at the frequency of dental examination, 60.0% of participants in the low SES group had an examination for more than a year, with none having an examination every six months (Table 7). The highest rate of examination every six months was observed in the high SES group at 27.3%. Concerning gingival bleeding, 30.2% of participants in the upper low SES group reported experiencing it, while 18.2% in the high SES group reported gingival bleeding (Table 7). As for dental procedures, 45.5% of participants in the low SES group had fillings, and 88.0% in the upper-middle SES group had them. Root canal treatment was undergone by 40.0% in the low SES group and 68.2% in the high SES group. Regarding previous dental implant treatment, 9.8% of participants in the upper low SES group and 36.4% in the high SES group reported undergoing this procedure (Table 7).

Table 2: Distribution of Age and Gender

Age	**Frequency**	**%**	**Cumulative %**	
18-25	137	19.3	19.3	
25-40	180	25.4	44.7	
40-65	373	52.6	97.3	
65+	19	2.7	100.0	
Total	709	100.0		
Gender	**Frequency**	**%**	**Valid %**	**Cumulative %**
Woman	329	46.4	46.5	46.5
Man	379	53.5	53.5	100.0
Total	708	99.9	100.0	
Loss	1	.1		
Total	709	100.0		

Table 3: Identifying Data on Smoking, Oral Hygiene Habits, and Dental Status

	Yes		**No**	
	N	**%**	**N**	**%**
Smoking	252	35.6	455	64.4
Brushing Teeth	623	88.4	82	11.6
Use of Toothpaste	702	99.7	2	0.3
Use of Mouthwash	225	31.7	484	68.3
Gum Bleeding	165	23.3	543	76.7
Breath Odor	145	20.6	558	79.4
Filling Status	586	83.4	117	16.6
Root Canal Treatment	419	59.3	287	40.7
Tooth Deficiency	406	57.5	300	42.5
Prosthesis	187	26.4	521	73.6
Implant	147	20.8	560	79.2

Table 4: Distribution of Education Level, Occupation and Monthly Financial Income

Education Level		Frequency		%	Cumulative%
Valid	Elementary school	27		3.8	3.8
	Middle school	23		3.2	7.1
	High school	107		15.1	22.1
	Univercity	420		59.2	81.4
	Master degree	116		16.4	97.7
	Doctorate	16		2.3	100.0
	Total	709		100.0	
Occupation		**Frequency**		**%**	**Cumulative %**
Valid	Unemployed	1		.1	.1
	Elementary occupations	138		19.5	19.6
	Semi-qualified worker	13		1.8	21.4
	Qualified worker	34		4.8	26.2
	Bureau/Department jobs. Store owners. Farmers	138		19.5	45.7
	Semi-professionals	70		9.9	55.6
	Professionals	315		44.4	100.0
	Total	709		100.0	
Monthly Financial Income		**Frequency**	**%**	**Valid %**	**Cumulative %**
Valid	0-8500 TL	180	25.4	25.4	25.4
	8500-15000 TL	171	24.1	24.2	49.6
	15000-25000 TL	157	22.1	22.2	71.8
	25000-35000 TL	108	15.2	15.3	87.0
	35000-50000 TL	57	8.0	8.1	95.1
	50000-70000 TL	19	2.7	2.7	97.7
	70000 TL+	16	2.3	2.3	100.0
	Total	708	99.9	100.0	
Loss		1	.1		
Total		709	100.0		

Table 5. Distribution of Socioeconomic Groups

Socioeconomic Group	Frequency	%	Valid %	Cumulative%
Low	11	1.6	1.6	1.6
Upper Low	173	24.4	24.4	26.0
Middle	203	28.6	28.6	54.6
Upper Middle	301	42.5	42.5	97.0
High	21	3.0	3.0	100.0
Total	709	100.0	100.0	

Table 6. Comparison of Variables with Socioeconomic Status

		Socioeconomic Status						
Questions	**Answers**	**Mean**	**Standard Deviation**	**Median**	**Minimum**	**Maximum**	**Z**	***p-value***
Do you smoke?	No	3.28	0.91	4.00	1.00	5.00	-2.809	0.005
	Yes	3.10	0.87	3.00	1.00	5.00		
Do you brush your teeth every day?	No	2.88	0.88	3.00	1.00	5.00	-3.597	<0.001
	Yes	3.25	0.90	3.00	1.00	5.00		
How many times do you brush your teeth a day?	Once	3.22	0.91	3.00	1.00	5.00	0.807	0.848
	Twice	3.20	0.90	3.00	1.00	5.00		
	Three times	3.33	0.82	3.50	2.00	5.00		
	More	3.25	0.96	3.50	2.00	4.00		
How often do you change your toothbrush?	Once in 3 months	3.24	0.91	3.00	1.00	5.00	3.992	0.262
	Once in 6 months	3.22	0.88	3.00	1.00	5.00		
	Once a year	3.02	0.94	3.00	1.00	4.00		
	More	2.82	0.98	3.00	1.00	4.00		
Which criteria do you consider while	Color	2.86	0.77	3.00	2.00	4.00	2.991	0.393
	Brand	3.20	0.87	3.00	1.00	5.00		
	Size and quality of toothbrush bristles	3.22	0.92	3.00	1.00	5.00		

choosing your toothbrush?	Recommendation of the dentist	3.27	0.85	3.00	1.00	5.00		
Do you use toothpaste while brushing your teeth?	Yes	3.22	0.90	3.00	1.00	5.00		
Which criteria do you consider while choosing your toothpaste?	Flavour	3.08	0.83	3.00	2.00	4.00	18.059	<0.001
	Price	2.93	0.92	3.00	1.00	5.00		
	Ingredients of the toothpaste	3.30	0.88	4.00	1.00	5.00		
	Recommendation of the dentist	3.24	0.90	3.00	2.00	5.00		
Do you clean the interfaces of your teeth?	No. I do not	3.12	0.90	3.00	1.00	5.00	6.237	0.101
	Once a week	3.21	0.88	3.00	2.00	5.00		
	Every two or three days	3.27	0.91	3.00	2.00	5.00		
If yes. how often do you clean them?	Once a day	3.40	0.82	4.00	2.00	5.00		
What do you use to clean the interfaces of your teeth?	Toothpick	3.16	0.86	3.00	1.00	5.00	3.740	0.291
	Dental floss	3.22	0.91	3.00	1.00	5.00		
	Interdental brush	3.38	0.83	4.00	1.00	5.00		
	Dental floss and interdental brush	3.33	0.90	4.00	2.00	5.00		
Do you use mouthwash?	No	3.21	0.90	3.00	1.00	5.00	-0.124	0.901
	Yes	3.21	0.91	3.00	1.00	5.00		
Which criteria do you consider while choosing your mouthwash?	Brand	3.31	0.82	4.00	2.00	5.00	4.982	0.173
	Price	3.04	0.90	3.00	1.00	5.00		
	Flavour	3.21	0.87	3.00	1.00	5.00		
	Recommendation of the dentist	3.18	0.96	3.00	1.00	5.00		
Do you clean your tongue surface? If yes. how often do you clean it?	No. I do not	3.23	0.91	3.00	1.00	5.00	0.135	0.987
	Once a week	3.20	0.85	3.00	1.00	5.00		
	Every two or three days	3.22	0.93	3.00	1.00	5.00		
	Once a day	3.19	0.92	3.00	1.00	5.00		
How often do you get examined by a dentist?	Once in 3 months	2.53	0.72	2.50	1.00	4.00	33.968	<0.001
	Once in 6 months	3.40	0.86	4.00	2.00	5.00		
	Once a year	3.36	0.86	4.00	1.00	5.00		
	More	3.17	0.91	3.00	1.00	5.00		
Do your gums bleed while brushing your teeth or eating?	No	3.25	0.90	3.00	1.00	5.00	-2.131	0.033
	Yes	3.09	0.90	3.00	1.00	5.00		
Do you have breath odor?	No	3.22	0.91	3.00	1.00	5.00	-0.084	0.933
	Yes	3.23	0.87	3.00	1.00	5.00		
Do you have fillings in your teeth?	No	2.92	0.98	3.00	1.00	5.00	-3.629	<0.001
	Yes	3.27	0.88	3.00	1.00	5.00		
Do you have teeth treated with root canal treatment?	No	3.07	0.90	3.00	1.00	5.00	-3.502	<0.001
	Yes	3.31	0.88	4.00	1.00	5.00		
Do you have any tooth deficiency?	No	3.17	0.91	3.00	1.00	5.00	-1.366	0.172
	Yes	3.25	0.90	3.00	1.00	5.00		

Do you have a prosthesis which you use within the mouth?	No	3.20	0.89	3.00	1.00	5.00	-0.862	0.389
	Yes	3.27	0.90	3.00	2.00	5.00		
Have you ever got a dental implant treatment?	No	3.13	0.90	3.00	1.00	5.00	-5.359	<0.001
	Yes	3.56	0.82	4.00	1.00	5.00		

Table 7. Distribution of Socioeconomic Status Frequencies Within Variables

Questions	Answers	Low SES Group		Upper Low SES Group		Middle SES Group		Upper Middle SES Group		High SES Group	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Do you smoke?	No	9	81.8%	101	58.7%	116	57.7%	213	70.8%	16	72.7%
	Yes	2	18.2%	71	41.3%	85	42.3%	88	29.2%	6	27.3%
Do you brush your teeth every day?	No	2	18.2%	30	17.3%	27	13.5%	22	7.4%	1	4.5%
	Yes	9	81.8%	143	82.7%	173	86.5%	277	92.6%	21	95.5%
How many times do you brush your teeth a day?	Once	6	54.5%	66	39.3%	79	39.5%	122	41.1%	9	40.9%
	Twice	5	45.5%	93	55.4%	107	53.5%	153	51.5%	12	54.5%
	Three times	0	0.0%	8	4.8%	13	6.5%	20	6.7%	1	4.5%
	More	0	0.0%	1	0.6%	1	0.5%	2	0.7%	0	0.0%
How often do you change your toothbrush?	Once in 3 months	5	45.5%	78	45.1%	93	46.3%	143	47.4%	13	59.1%
	Once in 6 months	3	27.3%	77	44.5%	91	45.3%	136	45.0%	9	40.9%
	Once a year	2	18.2%	15	8.7%	13	6.5%	20	6.6%	0	0.0%
	More	1	9.1%	3	1.7%	4	2.0%	3	1.0%	0	0.0%
Which criteria do you consider while choosing your toothbrush?	Color	0	0.0%	5	2.9%	6	3.0%	3	1.0%	0	0.0%
	Brand	2	18.2%	29	16.8%	39	19.4%	55	18.2%	2	9.1%
	Size and quality of toothbrush bristles	8	72.7%	124	71.7%	135	67.2%	209	69.2%	19	86.4%
	Recommendation of the dentist	1	9.1%	15	8.7%	21	10.4%	35	11.6%	1	4.5%
Do you use toothpaste while brushing your teeth?	Yes	11	100.0%	172	100.0%	196	100.0%	301	100.0%	22	100.0%
Which criteria do you consider while choosing your toothpaste?	Flavour	0	0.0%	7	4.0%	8	4.0%	9	3.0%	0	0.0%
	Price	5	45.5%	45	26.0%	41	20.4%	41	13.6%	2	9.1%
	Ingredients of the toothpaste	6	54.5%	92	53.2%	119	59.2%	208	68.9%	14	63.6%
	Recommendation of the dentist	0	0.0%	29	16.8%	33	16.4%	44	14.6%	6	27.3%
Do you clean the interfaces of your teeth?	No. I do not	6	54.5%	66	38.2%	69	34.3%	102	33.8%	3	13.6%
	Once a week	2	18.2%	58	33.5%	59	29.4%	94	31.1%	6	27.3%
	Every two or three days	3	27.3%	32	18.5%	36	17.9%	57	18.9%	7	31.8%
If yes. how often do you clean them?	Once a day	0	0.0%	17	9.8%	37	18.4%	49	16.2%	6	27.3%
What do you use to clean the interfaces of your teeth?	Toothpick	1	20.0%	44	31.7%	55	32.4%	66	26.9%	4	20.0%
	Dental floss	3	60.0%	72	51.8%	78	45.9%	119	48.6%	11	55.0%
	Interdental brush	1	20.0%	12	8.6%	26	15.3%	38	15.5%	3	15.0%
	Dental floss and interdental brush	0	0.0%	11	7.9%	11	6.5%	22	9.0%	2	10.0%

Do you use mouthwash?	No	8	72.7%	116	67.1%	138	68.7%	208	68.9%	14	63.6%
	Yes	3	27.3%	57	32.9%	63	31.3%	94	31.1%	8	36.4%
Which criteria do you consider while choosing your mouthwash?	Brand	0	0.0%	29	24.2%	37	28.0%	66	34.9%	2	13.3%
	Price	1	20.0%	26	21.7%	26	19.7%	27	14.3%	2	13.3%
	Flavour	1	20.0%	16	13.3%	20	15.2%	30	15.9%	1	6.7%
	Recommendation of the dentist	3	60.0%	49	40.8%	49	37.1%	66	34.9%	10	66.7%
Do you clean your tongue surface? If yes. how often do you clean it?	No. I do not	6	54.5%	95	55.9%	113	56.5%	167	55.7%	15	68.2%
	Once a week	1	9.1%	30	17.6%	36	18.0%	55	18.3%	1	4.5%
	Every two or three days	2	18.2%	14	8.2%	19	9.5%	28	9.3%	2	9.1%
	Once a day	2	18.2%	31	18.2%	32	16.0%	50	16.7%	4	18.2%
How often do you get examined by a dentist?	Once in 3 months	2	20.0%	18	10.7%	17	8.6%	3	1.0%	0	0.0%
	Once in 6 months	0	0.0%	21	12.4%	30	15.2%	53	17.6%	6	27.3%
	Once a year	2	20.0%	34	20.1%	57	28.8%	90	29.9%	9	40.9%
	More	6	60.0%	96	56.8%	94	47.5%	155	51.5%	7	31.8%
Do your gums bleed while brushing your teeth or eating?	No	10	90.9%	120	69.8%	154	76.6%	241	79.8%	18	81.8%
	Yes	1	9.1%	52	30.2%	47	23.4%	61	20.2%	4	18.2%
Do you have breath odor?	No	8	80.0%	140	81.9%	150	75.8%	243	80.5%	17	77.3%
	Yes	2	20.0%	31	18.1%	48	24.2%	59	19.5%	5	22.7%
Do you have fillings in your teeth?	No	6	54.5%	39	22.8%	33	16.6%	36	12.0%	3	13.6%
	Yes	5	45.5%	132	77.2%	166	83.4%	264	88.0%	19	86.4%
Do you have teeth treated with root canal treatment?	No	6	60.0%	82	47.4%	91	45.3%	101	33.7%	7	31.8%
	Yes	4	40.0%	91	52.6%	110	54.7%	199	66.3%	15	68.2%
Do you have any tooth deficiency?	No	2	18.2%	84	48.6%	87	43.9%	115	38.1%	12	54.5%
	Yes	9	81.8%	89	51.4%	111	56.1%	187	61.9%	10	45.5%
Do you have a prosthesis which you use within the mouth?	No	7	63.6%	128	74.0%	156	77.6%	215	71.4%	15	68.2%
	Yes	4	36.4%	45	26.0%	45	22.4%	86	28.6%	7	31.8%
Have you ever got a dental implant treatment?	No	8	80.0%	156	90.2%	168	83.6%	214	71.1%	14	63.6%
	Yes	2	20.0%	17	9.8%	33	16.4%	87	28.9%	8	36.4%

Discussion

Occupation, education, and financial status of individuals mostly indicate their social status. Social status also plays a role in oral and general health. Regular oral hygiene habits have an important role in the prevention of gingival diseases and dental cavities.[10-12] Therefore, inadequate oral hygiene causes results such as tooth deficiency, root canal treatment, filling, and prosthetic restoration needs. In ensuring oral hygiene, the frequency of cleaning of oral tissues as well as the selection of tools used for this cleaning may be affected by socioeconomic situations.[13] These variables were analyzed in this study where we evaluated the effect of socioeconomic status on oral hygiene habits.

Studies regarding the negative effect of smoking on mouth mucosa, teeth, and gingivae demonstrated that individuals who have low socioeconomic status have higher smoking habits.[14,15] The reason for this may be that individuals who have low socioeconomic status have a social circle that includes smokers and financial income problems.[16,17] It can be seen in our study that individuals who have low and high socioeconomic status have a lower

rate of smoking in comparison with other groups. In this point, this situation may be evaluated in different opinions. This may be due to the individuals of low socioeconomic status having economic incompetence and the individuals in high socioeconomic status having high education levels.

Different results were suggested in the studies evaluating the relationship between toothbrushing, being one of the most effective tools in the insurance of oral hygiene, and socioeconomic status.[18,19,20] It has been observed in our study that the rate of daily toothbrushing rate statistically and meaningfully increased from low socioeconomic group to high socioeconomic group. The reason for this may be that as the education level increases, the awareness of the importance of oral hygiene increases and as the financial income level increases, the access to toothbrushes and toothpaste increases. In addition, in our study, the fact that the price of the material is the most important reason for preference in individuals with low socioeconomic status when choosing toothpaste confirms this. Participants who based their toothpaste selection on dentist advice were largely in the high socioeconomic status group. The reason for this may be related to education level and financial income.

Socioeconomic factors have a role in the formation of inequality in terms of access to and use of dental services. Individuals who have low socioeconomic status have a higher risk of having bad oral health results and therefore they generally need professional dental treatment services more. However, although they need this service more, they generally have limited access to them.[21,22] It has been observed in our study that the frequency of examination statistically and meaningfully increases from low socioeconomic group to high socioeconomic group.

In a study in which the effect of economic conditions on oral health was analyzed, it was found that students whose families have high incomes or lived in cities before university have lower frequencies of filling.[23] As a result of our study, the rate of filling and root canal treatment was found to be statistically significantly lower in individuals with low socioeconomic status. The reason for this may be a lack of treatment for decayed teeth rather than good oral hygiene habits and a low caries rate. The reason for high instances of root canal treatment presence especially in high socioeconomic status groups might result from the fact that individuals try to save their natural teeth by the recommendation of their dentists. In this context, this can be associated with the high education levels of these individuals. In a study, it was observed that individuals over the age of 65 with high income and education levels had more teeth that had root canal treatment compared to individuals with low income and education levels.[24] The results of our study are compatible with the results of this study.

Different results occurred in studies analyzing the relationship between socioeconomic status and tooth loss.[25,26] In a study in which the relationship between dental implant treatment and socioeconomic status was evaluated, higher rates of dental implant treatment were seen in individuals who have high financial income and low education levels.[27] In another study, it was demonstrated that the prevalence of implants increased with the increase in socioeconomic status.[28] In our study, although there was no statistical and meaningful difference between socioeconomic status and tooth loss, a meaningful difference was observed in the presence of dental implants within the mouth. The rate of implant presence was higher in individuals who have the highest socioeconomic status. The reason for this may be that tooth loss was not different in comparison with other socioeconomic status groups, however, oral health awareness is higher which is associated with high education levels and the economic status that can afford the cost of implant treatment is present.

Conclusions

In the consequence of our study, the obtained data shows that it is difficult to give definite judgement about the effect of socioeconomic factors on oral hygiene habits and oral health occurring as a result of these habits. Considering the oral hygiene habits of adults starting in childhood years and the individuals who have changeable socioeconomic status in adulthood, it seems challenging to define any definite conclusion. Previous studies and the study that we have conducted show us that further studies with different populations and more participants are needed so that the effect of socioeconomic status on oral hygiene habits may be understood more clearly.

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Conflict of interest

The authors declare no conflict of interest.

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Evaluation of the Effect of Current Herbal Remineralization Agents on Enamel Using Different Methods

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Research Article

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ABSTRACT

Objectives: In this study, it was aimed to quantitatively evaluate the remineralization capacity of natural medicaments such as ginger, grape seed extract and rosemary, and materials containing casein and hydroxyapatite of initial caries lesions in vitro.

Materials and Methods: 42 enamel samples obtained from human teeth; were divided into six group as; Group-I (10% Casein Phosphopeptide Amorphous Calcium Phosphate [CPP-ACP], GC Tooth Mousse, Group-II (Rosemary Oil), Group-III (ginger+honey), Group-IV (ginger+honey+cocoa), Group-V (grape seed extract) and Group-VI (control group; remineralization solution). After enamel samples were kept in demineralization solution for 72 hours to create initial caries lesion, grouped remineralization agents were applied to enamel samples with caries lesion during the six-day pH cycle. Measurements were made using surface microhardness and DIAGNOdent at three different stages. The data obtained in the research were analyzed using the SPSS 25.0 program. The results were evaluated at the $p<0.05$ significance level.

Results: In surface microhardness measurements, all test materials showed significantly more remineralization than fluoride tooth cream, and grape seed extract was found to be the most successful group ($p\leq0.05$). When all groups were compared with the positive control group, there were significant statistical differences between the groups ($p\leq0.05$). The remineralization capacities of the groups whose activities were examined; grape seed extract> ginger+honey+cocoa>ginger+honey> rosemary oil > GC tooth mousse.

Conclusions: It is thought that rosemary, ginger + honey + cocoa, grape seed extract materials can be used for remineralization in these working conditions where the initial caries lesions can be remineralized after six days.

Keywords: Microhardness, Remineralization, Grape Seed Extract, Ginger, Rosemary.

Güncel Bitki Özlü Remineralizasyon Ajanlarının Mine Üzerine Etkisinin Farklı Yöntemlerle Değerlendirilmesi

Research Article

Süreç

Geliş: 07/03/2024
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ÖZ

Amaç: Bu çalışmada başlangıç çürük lezyonlarının zencefil, üzüm çekirdeği özü ve biberiye gibi doğal medikamentler ile kazein ve hidroksiapatit içeren materyallerin remineralizasyon kapasitesini kantitatif olarak *in vitro* koşullarda değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: İnsan dişinden elde edilen 42 adet mine örneği; Grup-I (%10 Kazein Fosfopeptit Amorf Kalsiyum Fosfat [CPP-ACP], GC Tooth Mousse, Grup-II (Biberiye Yağı), Grup-III (zencefil+bal), Grup-IV (zencefil+bal+kakao), Grup-V (üzüm çekirdeği özü) ve Grup-VI (kontrol grubu; remineralizasyon solüsyonu) olarak altı gruba ayrıldı. Mine örnekleri yapay çürük lezyonu oluşturmak amacıyla 72 saat demineralizasyon solüsyonunda bekletildikten sonra, çürük lezyonu oluşturulan mine örneklerine altı günlük pH döngüsü sürecinde, gruplandırılan remineralizasyon ajanları uygulandı. Üç farklı aşamada yüzey mikrosertlik ve DIAGNOdent kullanılarak ölçümler yapıldı. Araştırmada elde edilen veriler SPSS 25.0 programı kullanılarak analiz edildi. Sonuçlar, $p<0,05$ anlamlılık düzeyinde değerlendirildi.

Bulgular: Çalışma sonucunda DIAGNOdent ölçümlerinde tüm gruplarda remineralizasyon gözlenmekle beraber gruplar arasında istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0.05$). Yüzey mikrosertlik ölçümlerinde ise tüm deney materyalleri florürlü diş kreminden anlamlı derecede daha fazla remineralizasyon göstermiş olup, en başarılı grup olarak üzüm çekirdeği özü bulunmuştur ($p\leq0.05$). Tüm gruplar, pozitif kontrol grubu ile karşılaştırıldığında gruplar arasında belirgin istatistiksel farklılıklar bulunmaktadır ($p\leq0.05$). Etkinlikleri incelenen grupların remineralizasyon kapasiteleri; üzüm çekirdeği özü> zencefil+bal+kakao>zencefil+bal> biberiye yağı > GC tooth mousse şeklinde sıralanmaktadır.

Sonuç: Altı gün sonunda başlangıç çürük lezyonlarının remineralize olabildiği bu çalışma şartlarında biberiye, zencefil + bal + kakao, üzüm çekirdeği özü materyallerinin, remineralizasyon amacıyla kullanılabileceği düşünülmektedir.

Anahtar Kelimeler: Mikrosertlik, Remineralizasyon, Üzüm Çekirdeği Özü, Zencefil, Biberiye.

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Introduction

Advances in technology significantly reduce the progression of initial caries with early diagnosis and treatment, providing protection to dental tissues to a great extent without invasive procedures.[1] Significant progress has been made on remineralizing agents that can be used within scope of preventive dentistry applications. Fluorine is one of the most commonly used agents.[2] Developed as an alternative to flor; demineralization is prevented and remineralization is supported by binding free phosphate and calcium in dental plaque with casein phosphopeptide-amorphous calcium phosphate complex (CPP-ACP), one of major protective factors in milk.[3] Plant-based medications such as ginger and rosemary can also find a place in current studies with antibacterial effects.[4]

Different methods have been used to examine formation and progression mechanism of caries. The gold standard in these methods; although it is a controlled randomized clinical trial model; conducting such a clinical study is challenging in terms of both cost and time. Therefore, alternative models in which oral environment is imitated have been developed. Studies show that the most frequently preferred model is in vitro models.[5] These simulation models are frequently used because they allow testing of hypotheses that cannot be tested in clinical practice, provide reproducible study data, and practically compare the results obtained from different centers. However, its inability to fully imitate complex biological processes associated with caries and natural oral environment has become disadvantage of this method.[6,7]

pH cycle caries model is an artificial caries model that simulates oral environment by imitating demineralization-remineralization cycle of tooth. The biggest advantage of this method, which is used quite frequently to investigate effect of caries-preventing agents on demineralization-remineralization dynamics, is that it allows the evaluation of changes in outermost enamel layer during development of enamel caries.[8]

Systems used in diagnosis of initial caries and in following remineralization-demineralization cycles of lesions have limited reliability. Microhardness testers and scanning electron microscope are the most frequently preferred devices for this purpose in in-vitro research.[9] It is observed that surface microhardness measurement method is frequently used in studies investigating mechanical properties and efficacy of agents used in treatment of initial caries lesions.[10,11] As a working principle, the diamond tip located at tip of the device applies force to sample surface in certain proportions. The penetration depths obtained from different areas of lesion are recorded as Knoop or Vickers hardness values. These values obtained following the recording phase are compared with the values of healthy surface.[12]

Another method, DIAGNOdent (KaVo, Biberach, Germany), developed to diagnosis possible presence of caries on enamel surface early; it is based on laser autofluorescence technology in principle. The fluorescence intensity diagnosed by the digital display is displayed in quantitative form with numerical values. There is a direct correlation between the depth of caries and number seen on screen.[13]

Although chemicals continue to be widely used today, there has been an increasing interest in natural product diversity lately. Plants such as ginger and rosemary; many studies have been conducted showing its anti-inflammatory, antifungal, antiemetic, antibacterial, antiviral and anticariogenic effects.[14-18] While there are a limited edition of studies investigating effects of these agents on cariogenic bacteria in the literature, there is no study investigating their effects on the remineralization mechanism. The aim of this research; was to compare the effectiveness of CPP-ACP tooth cream, with proven anti-caries effect, with herbal medicines such as rosemary, ginger (a mixture with honey and cocoa), grape seed extract, which have come to the fore with their antibacterial activity.

Materials and Methods

Our study was carried out in the research laboratories of Çukurova University Faculty of Science Biochemistry Department and Dicle University Faculty of Dentistry, and ethics committee approval was obtained from Dicle University Faculty of Dentistry Unit Ethics Committee (*Decision Protocol No: 2020-1, (Decision Date: 29.01.2020*).

The enamel samples used in our study were selected from caries-free premolar teeth that had no defects. Soft tissue attachments on root surface of teeth were removed with a periodontal curette and cleaned with a polishing brush without damaging surfaces. Teeth were stored in distilled water containing 0.1% thymol at +4 ºC until the study was started.

The middle 1/3 area of enamel on partially flatter buccal surface of teeth was used for the procedures. The crowns of teeth were separated from roots with a micromotor (NSK FX23, JAPAN) device using diamond separation at low speed, under water cooling.

The prepared samples were embedded in acrylic (Imicryl, Turkiye) blocks with the aid of 3cm x 3cm x 2cm silicone molds with their buccal surfaces exposed. To obtain a smooth flat surface and to facilitate the demineralization stage of samples, the outermost layer rich in fluorine was abraded with silicon carbide papers of 200, 400, 600, 800 and 1200 grit, respectively, for ten minutes.

After etching, the samples were washed with deionized water. To create a control area on the healthy enamel surface, 2mm x 2mm tape was adhered to the center of enamel surface of each tooth and two layers of acid-resistant polish (Nail Care, Flormar, Turkiye) was applied to prevent area around the tape from being affected by the caries model to be applied.

After the sample preparation stage, 42 enamel samples of 2mm x 2mm in size were randomly divided into six groups, with seven enamel samples in each group;

Group 1: GC Tooth Mousse (10% CPP-ACP)
Group 2: Rosemary Oil (RO)
Group 3: Ginger - Honey
Group 4: Ginger - Honey - Cocoa

Group 5: Grape Seed Extract (GSE)
Group 6: Control Group (Remineralization Group)

Surface Microhardness measurements (SMH) were made by Buehler Wilson 1202 Mechanical Instrument Hardness Tester (USA). Using Vickers as measuring tip; a total of three measurements were made at the beginning, after demineralization process and after pH cycle. 42 samples were placed on table parallel to the ground and with surfaces to be evaluated upwards. The areas that the Vickers measuring tip will contact were determined from the selected area on surface to be measured. These points, which are determined with help of 400x magnifying eyepieces in the microscope, are placed in the microhardness device for 15 seconds. Throughout, 300 g of force was applied and measurements were made from three different points in each sample. The diagonal length of diagonal area formed by Vickers measuring tip was measured with measuring system on the device, and SMH calculated on the device was recorded. Following registration process, the average of three measurements for each sample was calculated statistically.

In DIAGNOdent measurements of samples, the fissure probe of DIAGNOdent PEN® (KaVo, Zurich) device, which is used on flat surfaces and fissures, was used. The samples were air-dried for five seconds and the measurement process was completed. For each of samples, three different predominantly observed DIAGNOdent values were recorded.

Preparation of Solutions

The solutions were prepared fresh before experiment.
Demineralization solution:
• 1.5 mM CaCl2,
• 0.9 mM KH2 PO4,
• By preparing 50 mM Aceticacid with pH value of 4.8; kept at room temperature.
Remineralization solution:
• 1.5 mM CaCl2,
• 0.9 mM KH2 PO4,
• 130 mM KCl,
• By preparing 20 mM Hepes solution with pH value of 7.0; kept at room temperature.

Creation of Initial Caries Lesion on Samples

The teeth were kept in demineralization solution for 72 hours.

SMH and DIAGNOdent Measurements After Demineralization

Samples with initial caries lesion; after the demineralization process was completed, it was removed from the solution and washed with distilled water. On the dried sample surfaces; the data were recorded by repeating the measurements with the same technique and devices as it was done in the initial stage.

Remineralization Agents and Application Methods

For the remineralization of the initial caries lesions formed in the enamel samples, a remineralization solution prepared with a pH value of 7.0 for the control group with five different agents was used.
Group 1: Tooth Mousse (GC Corporation, Japan): Dental cream with calcium phosphopeptidamorphic calcium phosphate (CPP-ACP). It was applied to each sample surface with the help of an applicator for four minutes.
Ingredients: water, glycerol, CPP-ACP, D-sorbitol, sodium carboxy methyl cellulose (CMCNa), propylene glycol, silicon dioxide, titanium dioxide, xylitol, phosphoric acid, aroma, zinc oxide, sodium saccharin, ethyl phydroxybenzoate, magnesium oxide, guar gum, propyl p hydroxybenzoate, butyl p-hydroxybenzoate. (lot number: 200908D)
Group 2: Rosemary Oil (RO): (Immu-Nat Herbal Company, Muğla, Türkiye) Standardized oil of rosemary. With the help of an applicator, 1 ml for each sample was applied to the tooth surface for four minutes.
Group 3: Ginger + honey: (Ginger: Arifoglu®, Turkiye/ Honey: Balparmak Plateau Blossom Honey®, Turkiye) Freshly prepared powdered ginger was mixed with honey (8 mg/ml = 8 mg ginger was added for 1 ml honey) to a paste consistency and applied to the surface in the size of a lentil grain for four minutes with the help of an applicator.
Group 4: Ginger + honey + cocoa: (Cocoa: Ülker®, Turkiye) prepared by adding cocoa to the ginger + honey mixture at the same rate as honey (8 mg/ml = 1 mg cocoa was added for 1 ml honey), brought to a paste-like consistency and applied to the surface in size of a lentil grain for four minutes with the help of an applicator.
Group 5: Grape Seed Extract (GSE): concentration amounts 3.75ml/5ml (Immu-Nat Herbal Company, Muğla, Turkiye) 1 ml per sample with the help of an applicator applied to the sample surface for four minutes.
Group 6: Control Group: Only demineralization remineralization procedures were applied to seven sample surfaces in this group, no agent was applied.

Application of pH Cycle to Samples that Simulates Oral Environment

In order to create artificial caries lesions, samples were kept in demineralization solution for 72 hours and then pH cycled at room temperature for a period of six days. The samples were kept in the demineralization solution (30 ml for each sample) for six hours without mixing in one day, washed with distilled water for five seconds, and kept in the remineralization solution (30 ml for each sample) for 18 hours.

Remineralizing agents applied for one minute daily before and after demineralization four times with the help of a small bond brush (Microbrush, medium thickness, USA) daily. After this stage, the sample surfaces were washed with distilled water for five seconds to remove the excess agent. The samples were kept in remineralization solution until they were re-cycled the next day.

Figure 1: The pH cycle applied in the research

SMH and DIAGNOdent Measurements After pH Cycle

After the completion of the six-day pH cycle applied within the scope of study, the samples were washed with distilled water for the last time. On the sample surfaces, which are made ready for analysis by drying; the measurements were repeated with the help of the same technique and devices. All measurements were made by the same specialist dentist (S.G.).

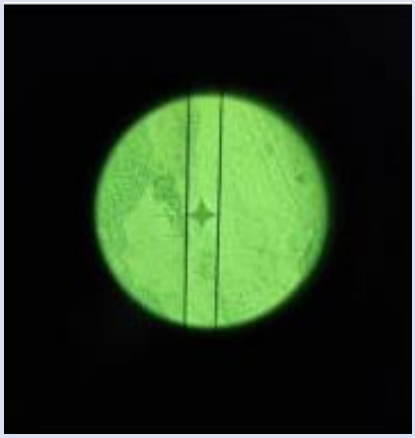

Figure 2: Surface image of the sample examined on the vickers hardness test device

Statistical analysis

The data obtained in research were analyzed using SPSS 25.0 program. Descriptive statistics were used while evaluating data. The results were evaluated at $p<0.05$ significance level.

Results

Results of SMH Analysis

SMH measurements were repeated in three stages, at the beginning of our thesis, after being kept in a demineralization solution for 72 hours and after pH cycle and remineralization agents were applied. Three different measurements were taken from each sample and 126 measurements made from 42 enamel samples were repeated in three stages, and total of 378 SMH measurements were made. The difference between initial and demineralization values was calculated and called as 'delta 1'; the difference between demineralization and remineralization values was calculated and called as 'delta 2'.

A statistically significant difference was found between the initial values, remineralization and demineralization values of each group. There was a statistically significant difference between Vickers delta 1 and delta 2 values according to the groups ($p<0.05$).

While a significant difference was observed between the groups for the initial and post-remineralization Vickers values ($p<0.05$); It was observed that there was no significant difference between the groups for Vickers values after demineralization ($p>0.05$).

It was observed that there was a statistically significant difference between the Vickers values of all groups after demineralization and after remineralization ($p<0.05$). It is

seen that the Vickers values after remineralization are higher than the values after demineralization.

There was a statistically significant difference between Vickers values at baseline, after demineralization and after remineralization in all groups ($p<0.05$). According to results of the multiple comparison test; there is a significant difference between values after demineralization and after remineralization ($p<0.05$).

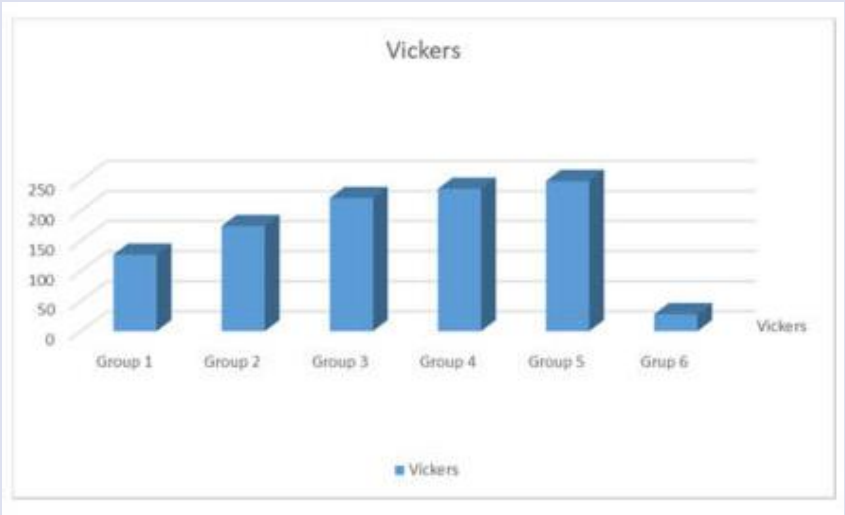

Figure 3: Difference between remineralization and demineralization values (Vickers)

DIAGNOdent Analysis

When Diagnodent delta 1 values of the groups were examined, there was no statistically significant difference between groups, although DIAGNOdent delta 1 values of groups 1, 2, 3, 4 and 5 were lower than the control group ($p>0.05$). It was observed that there was a significant difference between the groups for DIAGNOdent values at baseline and after remineralization ($p<0.05$). It was observed that there was no significant difference between the groups for DIAGNOdent values after demineralization ($p>0.05$).

A statistically significant difference was observed between the initial values of all groups and the DIAGNOdent values after demineralization ($p<0.05$). It is seen that DIAGNOdent values after demineralization are higher than the initial values.

It was observed that there was a statistically significant difference between the DIAGNOdent values of all groups after demineralization and after remineralization ($p<0.05$). It is seen that DIAGNOdent values after remineralization are lower than the values after demineralization.

In all groups; there was a statistically significant difference between the DIAGNOdent values at baseline, after demineralization and after remineralization ($p<0.05$). According to the results of the multiple comparison test; there is a significant difference between the initial, post-demineralization values and post-demineralization and post-remineralization values ($p<0.05$).

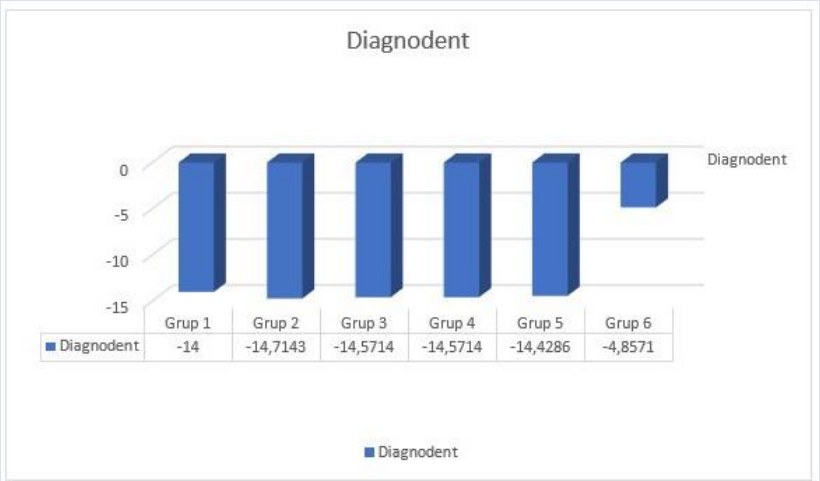

Figure 4: Difference between remineralization and demineralization values (Diagnodent)

Discussion

Current scientific studies are carried out to prevent initial caries lesions with non-invasive methods and to diagnose these lesions with reliable methods at an early stage.[19-22] Different materials such as fluorine, bioactive glasses, theobromine, CPP-ACP and xylitol are used to increase remineralization and prevent demineralization.[23-26]

CCP-ACP; It shows its caries-inhibiting effect by preventing bacterial colonization, increasing the Ca and P ion levels in dental plaque, and binding free Ca and P ions.[27,28] In many studies, it has been reported that CPP-ACP stabilizes Ca and P ions on the enamel surface and provides remineralization.[29,30] Bailey et al., reported that with the use of CPP-ACP for 12 weeks, a significant visible regression of white spot lesions was recorded. In white spot lesions, 27.9% at the end of the four-week period; 65.6% after eight weeks; at the end of 12 weeks, they stated that there was an improvement of 73.8%.[31]

In another recent research examining the surface microhardness of remineralization agents; OCT and SMH measurements were made by applying CPPACP, CPPACP+900 ppm Fluor and agents containing calciumglycerophosphate, magnesiumchloride and 10% xylitol to the enamel surfaces with initial caries, with a 6-day pH cycle. As a result of study; it has been stated that all remineralization agents provide significant remineralization in caries lesions formed in enamel samples.[32,33]

The study, which compared the remineralization capacity of tooth cream containing CPP with ginger, honey, cocoa and rosemary, and toothpaste with NaF, using SMH and FluoreCam methods, draws attention. In this study conducted by Bilgin G, enamel samples with artificial initial caries were used for one minute, three times a day for 21 days; toothpaste with NaF, CPPACP, hydroxyapatite and F, brushed with fluorine varnish, ginger + honey, ginger + honey + chocolate, RO groups. With the statistical evaluation of study; remineralization was detected in all treatment groups, and it was concluded that the remineralization values of the ginger + honey treatment group were more effective than the other groups.[34]

Smullen et al. in their study on RO; the effectiveness of rosemary on plaque inhibition, S. mutans and glycosyltransferase activity was investigated, and it was stated that 80% inhibition of plaque and glycosyltransferase activity was achieved.[35] In a research examining the effect of RO on remineralization; it has been reported that RO significantly increased remineralization on enamel surfaces with artificial initial caries, compared to the positive control group, fluoride toothpaste.[34] Consistent with the results of these researches; it has been concluded that RO we used has a very supportive effect on remineralization according to SMH and DIAGNOdent measurement values, as well as preventing demineralization.

Another material we prefer within the scope of our study is honey. Grobler et al. in their study on oral pathogens, the effect of low pH on enamel is evaluated by SMH and DIAGNOdent. In both of the analysis methods, honey was applied on the enamel for 30 minutes and it was reported that it did not show an erosive effect on the enamel.[36] In the in-situ part of another current study, in which the remineralizing effect of honey was investigated, enamel samples were placed in oral appliances and the participants were given four different types of fluoride toothpaste, fluoride tooth cream, ginger+honey+ chocolate and ginger+rosemary+honey+ chocolate for a 21-day period. group was provided with three minutes of application. The amount of remineralization achieved was measured with FluoraCam and QLF after 21 days. While remineralization was achieved significantly in all groups; it was stated that the highest remineralization was formed by ginger+honey+chocolate mixture and fluoride tooth cream.[34] With the results of these studies; SMH and DIAGNOdent analysis data obtained as a result of the application of honey used in our in-vitro research by mixing it with ginger gives results in accordance with other researches. The fact that this mixture was also found to be a highly effective material on remineralization contributed to the originality of our research.

Among the materials investigated in our study, the in-vitro study in which the effect of theobromine obtained from the cocoa bean on SMH was investigated is remarkable. In this study, enamel sections taken from premolar teeth were used; Distilled water, theobromine 100 mg/L, theobromine 500 mg/L and theobromine 1000 mg/L were administered to four groups for 15 minutes. Samples that were tested for microhardness using SMH; an increase in enamel microhardness was observed after being treated with four theobromine concentrations, and it was stated that the highest increase was demonstrated by theobromine with a concentration of 1000 mg/L.[37] Ooshima et al. evaluated the relationship between cocoa bean shell and S. mutans in their study with rats. In all streptococci species tested within the scope of study, growth decreased and as a result, acid production decreased and in parallel, surface hardness increased as remineralization was supported. Sucrose-dependent cell adhesion of S. mutans was suppressed with using of cocoa; inhibition of insoluble glucan synthesis due to glycosyltransferase activity was achieved.[38] Ooshima et al. following the research of Osawa et al. in their study, they stated that cocoa bean shell can show antibacterial activity even at a concentration of 30µg/mL.[39] SMH and DIAGNOdent analysis data of our research show that the cocoa has a significant effect on remineralization.

Another material we prefer to increase the originality value of research is; grape seed extract. Benjamin et al. reported that collagen matrices treated with GSE were non-toxic and inhibited the enzymatic activity of glucosyltransferase, F-ATPase and amylase in their study.[18] When the studies on GSE were examined, it was observed that there were a limited number of studies investigating the remineralization capacity.[40,41] Mirkarimi et al. applied GSE to demineralized primary teeth and reported a statistically significant increase in SMH.[42] In another recent study investigating the remineralization

capacity of GSE, Jawale et al., on enamel surfaces with artificial initial caries in 96 hours; three different materials, namely CPP-ACP, calcium glycerophosphate and GSE, were applied six times a day for eight days and examined with polarized light microscopy. As a result of research; a significantly thick band of mineral precipitation appeared in surface layer of lesions treated with GSE compared to other groups; it has been reported that GSE has a supportive effect on remineralization process.[43] In a similar study; samples whose dentin surface was etched for 30 seconds; different concentrations of GSE; it was applied for two minutes and subjected to a 15-day remineralization procedure, SMH analysis were performed. Tang et al reported that the most GSE concentration, which provides remineralization is 15%.[44] Bolty et al. in 2023, concluded that chicken egg shell, GSE and propolis had a promising effect on remineralization of initial caries in their study.[45] Another recent study, the remineralizing effect of initial caries was observed in patients using GSE and NaF mouthwash in 1, 3, and 6-month diagnostic measurements.[46] In a recent study in which the remineralization capacity of CPP-ACPF, tricalcium phosphate, and GSE was measured by Vickers, SEM-EDS, and CBCT, it was noted that GSE group showed significantly greater remineralization compared to other groups.[47] With all these reseraches; SMH and DIAGNOdent analysis data of remineralizing effect of GSE obtained as a result of our research show parallelism.

As a result, it was observed that among the materials whose remineralization capacities we examined, CPP-ACP, ginger + honey, ginger + honey + cocoa formula, rosemary oil and grape seed extract showed positive reparative activities on initial enamel lesions.

Conclusions

This research effectively analyzed initial caries can be cured chemically by stop-preventived procedures. According to the study's findings GSE was found to be more effective than other agents. We report that the use of tooth cream containing herbal formulas that repair caries at the initial stage is a non-invasive and supportive method that can be added to routine oral hygiene practices, and we recommend their use.

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Conflict of interest

There is no conflict of interest among participants in this study.

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Knowledge, Attitudes and Practices Related to Tooth Morphology Among Dental Students and Dental Technician Students

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ABSTRACT

Objectives: Students are introduced to the morphological features of primary and permanent human dentition in a dental anatomy course, which is a part of the basic core sciences program in the Department of Dentistry and Dental Prosthesis Technology. The purpose of this study was to compare dental students' (DSs') and dental technician students' (DTSs') knowledge, attitudes, and practices related to dental morphology.

Materials and Methods: Using a 26-item self-administered questionnaire, the DSs and DTSs participated in a descriptive cross-sectional study. Three components made up the questionnaire: four items for demographic profile, ten items for dental morphology knowledge level, seven items for attitude toward tooth morphology, and five items for practice in tooth morphology. There were 274 student answers in all. The data were analyzed using an independent t test and one-way ANOVA. A p value of less than 0.05 was considered to indicate statistical significance for each test.

Results: Between DSs and DTSs, there was a statistically significant difference in their knowledge and practices of tooth morphology ($p<0.001$). However, DTSs knowledge of dental morphology was significantly greater, and DSs practice scores were significantly greater. There was no significant difference in the attitude of tooth morphology between the two groups ($p=0.379$). Both groups had low levels of dental morphology knowledge, with an average of 3.86 correct answers for DTSs and an average of 3.16 correct answers for DSs. In the DSs group, first-year students had a greater knowledge level (4.22±1.63 correct answers) than did the other students.

Conclusions: Knowing the variations in dental morphology knowledge, attitudes, and practices between a dentist and dental technician may help us take preventative measures. While preclinical dentistry students and dental technician students had different levels of expertise, both groups were less knowledgeable about tooth morphology. Both groups had similarly high attitudes toward tooth morphology.

Keyword: Dental Student, Dental Technicians, Knowledge, Anatomy.

Diş Hekimliği Öğrencileri ve Diş Teknisyenliği Öğrencilerinin Diş Morfolojisi ile İlgili Bilgi, Tutum ve Uygulamaları

Research Article

Süreç

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ÖZ

Amaç: Diş Hekimliği ve Diş Protez Teknolojisi Bölümü programlarının temel bilimlerinden olan Diş Anatomisi ve Morfolojisi dersinde öğrencilere süt ve daimi dişlenmenin morfolojik özellikleri tanıtılmaktadır. Bu çalışmanın amacı, diş hekimliği öğrencilerinin (DÖ'ler) ve diş teknisyenliği öğrencilerinin (DTÖ'lerin) diş morfolojisi ile ilgili bilgi, tutum ve uygulamalarını karşılaştırmaktır.

Gereçler ve Yöntemler: DÖ'ler ve DTÖ'ler, kendi kendilerine uygulayabilecekleri 26 maddelik bir anket aracılığı ile tanımlayıcı kesitsel bir çalışmaya katıldılar. Demografik profil için dört madde, diş morfolojisi bilgi düzeyi için on madde, diş morfolojisine yönelik tutum için yedi madde ve diş morfolojisi pratiği için beş madde olmak üzere anketi üç bileşen oluşturdu. Toplamda 274 öğrenci yanıtı alındı. Veriler bağımsız bir t testi ve tek yönlü ANOVA kullanılarak analiz edildi. 0,05'ten küçük bir p değerinin her test için istatistiksel anlamlılığa işaret ettiği kabul edildi.

Bulgular: DÖ'ler ve DTÖ'ler arasında diş morfolojisi bilgi ve uygulamaları arasında istatistiksel olarak anlamlı bir fark vardı ($p<0.001$). Bununla birlikte, DTÖ'lerinin diş morfolojisi bilgisi önemli ölçüde daha fazlaydı ve DÖ'lerinin uygulama puanları da önemli ölçüde daha yüksekti. İki grup arasında diş morfolojisi tutumu açısından anlamlı bir fark yoktu ($p=0,379$). Her iki grubun da diş morfolojisi bilgisi düşük düzeydeydi; DTÖ'ler için ortalama 3,86 doğru cevap ve DÖ'ler için ortalama 3,16 doğru cevap vardı. DÖ grubundaki birinci sınıf öğrencilerinin bilgi düzeyi (4,22±1,63 doğru cevap) diğer öğrencilere göre daha yüksekti.

Sonuçlar: Bir diş hekimi ile diş teknisyeni arasındaki diş morfolojisi bilgisi, tutumları ve uygulamaları arasındaki farklılıkları bilmek, önleyici tedbirler alınmasına yardımcı olabilir. Klinik öncesi diş hekimliği öğrencileri ve diş teknisyenliği öğrencileri farklı uzmanlık düzeylerine sahipken, her iki grup da diş morfolojisi konusunda düşük düzeyde bilgi sahibiydi. Her iki grubun da diş morfolojisine yönelik tutumları benzer şekilde yüksekti.

Anahtar kelimeler: Diş Hekimliği Öğrencisi, Diş Teknisyenleri, Bilgi, Anatomi.

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Introduction

Dental anatomy forms the basis of dental studies. Therefore, a good understanding of dental anatomy is very important in clinical practice.[1] To restore the aesthetics of the smile, professionals must have technical scientific knowledge about current composites, artistic sense, and manual dexterity.[2-5] Without this knowledge, it is impossible to practice dentistry, which helps restore teeth that are missing or broken and maintain dental health. The anatomical shape of the rebuilt teeth must be correct for the restoration of dental function.[6-8] Dentistry demands specialized skills in applying knowledge of dental morphology and anatomy.[9] Dental restorations and prostheses are supposed to achieve an aesthetically acceptable aspect and accomplish functioning in the patient through both direct and indirect oral rehabilitation.[9,10] Dental students must therefore be familiar with tooth anatomy and sculpting procedures.

Given that dental technicians never work directly with patients and are always supervised by a dentist or prosthodontist, dental technicians need to possess a similar level of fundamental knowledge in the anatomical sciences without considering clinical applications.[5] Dental anatomy involves an overview of how teeth work together in a normal occlusion in addition to a descriptive examination of individual teeth. A more comprehensive approach to dental treatment is made possible by knowledge of dental anatomy and an awareness of the principles of proper occlusion. Dental technicians can communicate with other oral health professionals in an effective manner since they are knowledgeable about dental anatomy**.** In recent years, interdisciplinary dental collaboration has gained increasing popularity.[11] Since oral biology enables a complete approach to dental issues, dental technicians and other dental practitioners should be aware of the often-stated statement that "the mouth is connected to the rest of the body". It was determined that the careers of dental technicians and dentists depend on understanding tooth morphology.[5]

The undergraduate dentistry programs in Türkiye cover a total of 5 years of professional education. Conversely, dental technicians who successfully completed a two-year vocational program in dental prosthesis technology were awarded the title of health technician (dental prosthesis). Students are introduced to the morphological features of primary and permanent human dentition in a dental anatomy course, which is a part of the fundamental core sciences program in dental schools and dental prosthesis technology programs. Students learn about the morphology of teeth, how to identify teeth, and how to spot abnormalities in teeth. The course also starts to build the psychomotor abilities needed by students to restore teeth to their proper form and function. Typical activities for practical study sessions included wax, chalk, or soap carving of teeth,[3,12] plastic tooth replicas,[12,13] extracted teeth,[12,14] and sketching two-dimensional (2D) representations of teeth.[12,15,16] The general course was offered as part of the undergraduate dentistry and dental technician program in the first year. Approximately 28 hours of theoretical classes and 84 hours of practical classes are required for this course during the first semester of the dentistry degree. Approximately 42 hours of theoretical classes and 70 hours of practical classes are needed for the dental prosthesis program. According to "Curriculum Guidelines for Dental Anatomy" by Okeson and Buckman,[17] the goal of the dental anatomy course is to provide students with the basic cognitive skills related to tooth morphology.

Knowledge of dental anatomy, which facilitates professional communication between dentists and dental technicians and enables them to speak the same language, should be similar in both professional groups. Thus, clinical and laboratory processes can be better managed. To the best of the authors' knowledge, no study has compared tooth morphology knowledge, attitudes and practices between dentists and dental technicians. This study aimed to evaluate the differences, if any, in the knowledge, attitudes and practices of dental morphology between dental students (DSs) and dental technician students (DTSs).

Materials and Methods

Participation was voluntary, and only data from consenting participants were included in the study. Written informed consent was obtained from the study participants. The study was approved by the Health Sciences Research and Publication Ethics Committee of Bursa Uludağ University, Bursa, Turkiye (reference number: 2024-03-27/2024-03).

The questionnaire was structured with open-ended and closed-ended questions. The questionnaire consisted of three sections: demographic profile (four items), dental morphology knowledge level (ten items), attitudes toward tooth morphology (seven items) and practices related to tooth morphology (five items).

Demographic data were collected regarding gender, age, academic program and term of the students in the first section. In order to assess participants' knowledge of dental anatomy, ten questions covering basic concepts in morphology and dental anatomy were asked in the second section (Supp. 1). In the third and fourth sections, the students were asked to rate their level of agreement with statements describing various aspects of the attitude and practice of dental morphology using a 5-point Likert-type scale with the options of strongly disagree (1), disagree, neutral, agree, and strongly agree (5).[4]

A self-administered questionnaire consisting of 25 closed-ended questions and 1 open-ended question was used in a descriptive cross-sectional study including the DSs and DTSs. A questionnaire survey was conducted with the students who could be reached face to face and the students who could not be reached via the Google Forms link. The online survey remained accessible for a month. After the set deadline, the gathered data were transferred to a Microsoft Excel spreadsheet. A total of 274 student responses were received, including 163 from dental students and 111 from dental technician students. Only preclinical dental students were included in the study**.**

The data were analyzed using Jamovi (V2.3.21, The Jamovi Project, Australia) software. The Kruskal–Wallis test was used to assess the normality of the data. One-way

ANOVA was applied to analyze the differences in knowledge, attitudes and practices between the DSs and DTSs. Furthermore, an independent t test was used to observe whether any differences existed in the above parameters when two groups were compared at a time. In addition, the differences in knowledge, attitudes, and practices among the DSs were analyzed using One-way ANOVA. For all the tests, $p<0.05$ was considered to indicate statistical significance.

Results

Of the 274 students, 93 (33.9%) were men, and 181 (66.1%) were women. The participants' ages ranged from 17 to 46 years, with an average of 20.4 years. The study included 104 (38%) first-year, 104 (38%) second-year, and 66 (24%) third-year students.

Between the DSs and DTSs groups, there was a statistically significant difference in their knowledge and practices of tooth morphology ($p<0.001$) (Table 1). However, DTSs' knowledge scores were significantly greater, and DSs' practice scores were significantly greater. With an average of 3.86 accurate answers for DTSs and 3.16 correct answers for DSs, it was noted that both groups showed poor levels of knowledge regarding dental morphology. There was no significant difference in the attitude of tooth morphology between the two groups ($p=0.379$).

In the DSs group, there was a statistically significant difference in the knowledge of tooth morphology among first-, second- and third-year students ($p<0.001$) (Figure 1). The first-year students answered 4.22±1.63 questions correctly, which was a higher knowledge level than that of the other students. The knowledge levels of second-year (2.80±1.64) and third-year (2.71±1.58) dental students were comparable. However, there was no significant difference in the attitudes or practices related to tooth morphology regarding the term of the students in the DSs group ($p> .05$).

In the DTSs group, there was no significant difference in the knowledge, attitudes or practices of tooth morphology regarding the term of the students ($p>0.05$). The knowledge, attitudes, and practices of first- and second-year dental technician students were comparable (Figure 2).

In response to a specific question about attitudes toward tooth morphology, 65.03% of DSs and 63.96% of DTSs strongly agreed that providing the necessary aesthetics increases the confidence and satisfaction of patients, which is the greatest challenge in practice. The majority of participants strongly agreed that knowing tooth morphology will help them in their daily clinical/laboratory work (57.06% of DSs and 63.06% of DTSs), that knowing the anatomic landmarks of the teeth strengthens the communication network between the dentist and the dental technician (57.67% of DSs and 55.86%), and that the morphology of each tooth plays an important role in determining occlusion (54.6% of DSs and 58.56% of DTSs). A total of 38.65% of the DSs agreed that the current curriculum was effective in helping them gain sufficient dental anatomy knowledge, whereas 35.14% of the DTSs were neutral. However, the results were not statistically significant for the "attitude" set of questions ($p>0.05$).

The DSs group (32.7±5.81) had greater tooth morphology scores than did the DTSs group (15.9±4.65) ($p<0.001$). The majority of participants in both groups gave neutral answers to all questions with respect to the practice of tooth morphology (Table 2). A total of 33.74% of the DSs were neutral, and the authors disagreed that they could modify crown restoration for primary teeth according to morphological needs.

Table 1. Comparison of knowledge, attitudes and practices related to tooth morphology between dental students (DSs) and dental technician students (DTSs).

	DSs	DTSs	p value
Knowledge	3.17±1.73	3.86±1.40	<0.001
Attitude	28.7±5.26	28.1±5.72	0.379
Practice	32.7±5.81	15.9±4.65	<0.001

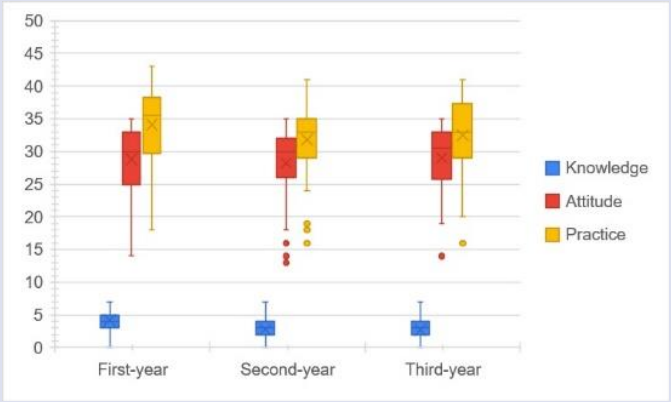

Figure 1: Comparison of knowledge, attitudes and practices scores related to tooth morphology among first-, second- and third-year dental students

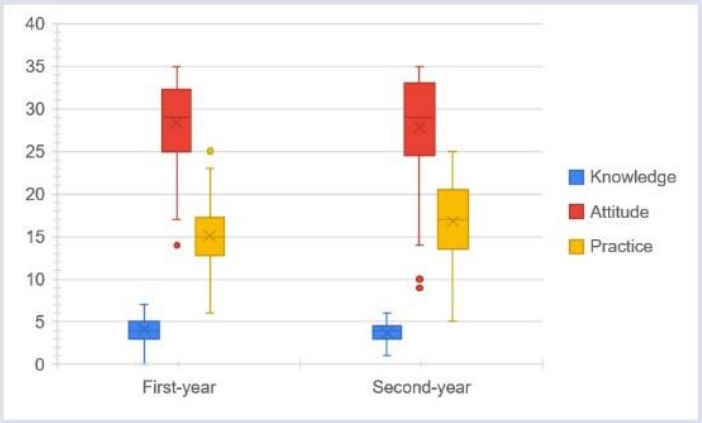

Figure 2: Comparison of knowledge, attitudes and practices scores related to tooth morphology between first- and second-year dental technician students

Table 2. Responses of dental students (DSs) and dental technician students (DTSs) regarding knowledge, attitudes and practices related to tooth morphology

Parameters	Questions	n (%)									
		Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
		DSs	DTSs	DSs	DTSs	DSs	DTSs	DSs	DTSs	DSs	DTSs
Attitude	Knowing tooth morphology will help me in my daily clinical/laboratory work.	93 (57.06)	70 (63.06)	39 (23.93)	14 (12.61)	23 (14.11)	14 (12.61)	7 (4.29)	8 (7.21)	1 (0.61)	5 (4.50)
	The current curriculum was effective in helping me gain sufficient dental anatomy knowledge.	32 (19.63)	26 (23.42)	63 (38.65)	26 (23.42)	40 (24.54)	39 (35.14)	23 (14.11)	11 (9.91)	5 (3.07)	9 (8.11)
	Dental carving sessions are a practical training that enables effective recording and preservation of information of tooth morphology.	61 (37.42)	40 (36.04)	43 (26.38)	35 (31.53)	35 (21,47)	17 (15.32)	18 (11.04)	12 (10.81)	6 (3.68)	7 (6.31)
	Knowing the anatomic landmarks of the teeth strengthens the communication network between the dentist and the dental technician.	94 (57.67)	62 (55.86)	36 (22.09)	26 (23.42)	23 (14.11)	12 (10.81)	9 (5.52)	6 (5.41)	1 (0.61)	5 (4.50)
	The morphology of each tooth plays an important role in determining occlusion.	89 (54.60)	65 (58.56)	46 (28.22)	31 (27.93)	20 (12.27)	10 (9.01)	7 (4.29)	3 (2.70)	11 (0.61)	2 (1.80)
	Knowledge of tooth morphology plays an important role in forensic cases and investigations.	63 (38.65)	44 (39.64)	46 (28.22)	17 (15.32)	34 (20.86)	25 (22.52)	17 (10.43)	19 (17.12)	3 (1.84)	6 (5.41)
	Providing the necessary esthetics increases the confidence and satisfaction of patients, which is the greatest challenge in practice.	106 (65.03)	71 (63.96)	32 (19.63)	20 (18.02)	17 (10.43)	14 (12.61)	8 (4.90)	5 (4.50)	0	1 (0.90)
Practice	Subconscious knowledge of tooth morphology has transformed into a good tooth sculptor	28 (17.18)	20 (18.02)	34 (20.86)	23 (20.72)	62 (38.04)	30 (27.03)	33 (20.25)	26 (23.42)	6 (3.68)	12 (10.81)
	Can effectively carry out the stages of crown restoration for permanent teeth because of knowing the morphology of each tooth in detail	18 (11.04)	22 (19.82)	51 (31.29)	20 (18.02)	55 (33.74)	34 (30.63)	33 (20.25)	24 (21.62)	6 (3.68)	11 (9.91)
	Can modify the crown restoration for primary teeth	12 (7.36)	20 (18.02)	24 (14.72)	22 (19.82)	55 (33.74)	32 (28.83)	55 (33.74)	28 (25.23)	17 (10.43)	9 (8.11)

according to morphological needs.										
There is no scope for deviation from the normal while carving or restoring the lost tooth structure	19 (11.66)	20 (18.02)	37 (22.70)	30 (27.03)	61 (37.42)	33 (29.73)	35 (21.47)	19 (17.12)	11 (6.75)	9 (8.11)
Confident to apply tooth morphology knowledge as an investigative tool in forensic sciences	23 (14.11)	22 (19.82)	35 (21.47)	25 (22.52)	65 (39.88)	32 (28.83)	33 (20.25)	16 (16.41)	7 (4.29)	16 (14.41)

Discussion

Anatomy studies provide dental technicians and dentists a deeper understanding of how tissues function, which helps them with diagnosis, treatment planning, and making referrals when needed.[5] Conventional teaching methods for dental anatomy include textbooks, manuals, lectures, big three-dimensional models, preserved tooth samples, and sectioned natural teeth that display the internal structure.[3] In addition, issues with traditional teaching methods have been underlined again and time again. During the initial years of dental school, dental anatomy and sculpture are taught in a time-constrained manner away from preclinical and clinical settings. Dental anatomy is taught early in most dentistry programs in Türkiye; thus, by the time students need to apply this information in a clinic, they have already lost part of it. This may depend on the commitment to be continuously updated on the issue, which causes gaps in student successes during the transition to the clinical year.[3] According to the current study, first-year dental students had greater knowledge of dental morphology than did second- and third-year dental students. As a result, teaching strategies should focus on helping dental students retain their knowledge of dental anatomy and morphology over time. The study's teaching method, which is restricted to the first semester of the dental course, is based on a conventional step-by-step geometrical approach. de Azevedo *et al*.[18] still gave preclinical dental students a reinforcement theoretical session in an effort to help them remember significant anatomical and morphological concerns, and as a result, they saw an improvement in their ability to carve. In this way, innovative methods that modify teaching and take into account students' learning preferences are added to conventional teaching methods.[19,20]

The results of the current study indicated that DSs and DTSs had poor knowledge of tooth morphology. This may be due in part to the numerous obstacles faced in teaching the basic sciences in the dental field. These difficulties include an increase in the number of students enrolled, a decrease in the amount of time spent teaching, increased access to discipline-specific resources, and an expanding focus on relevant clinical applications.[5,21] Another reason may be that since preclinical dentistry students do not perform clinical applications on patients, they may not need to recall their dental anatomy knowledge. Likewise, dental technician students may not need to use their dental anatomy knowledge due to the limited practice of prosthetics in the laboratory. However, both groups need to update their dental morphology knowledge with reminder courses and have applications that can use this information.

It is essential to maintain knowledge regarding the complex interaction between teeth and anatomical tissues when performing restorative and prosthetic procedures.[5,22] Consequently, it is important to improve the way dental anatomy courses are taught, especially the skill of carving, which is necessary to accurately replicate teeth while taking shape, function, and aesthetics into account. According to previous studies, almost 80% of dental students thought that tooth morphology through session activities such as carving helped them better comprehend dental anatomy.[23-25] The majority of participants in this study (63.80% of DSs and[27] at enables effective recording and preservation of tooth morphology information.

Regarding attitudes toward tooth morphology, there was no significant difference between the DSs and DTSs groups or within the groups in terms of DSs or DTSs. The majority of the DSs and DTSs responded favorably to the attitudes of comprehending and implementing their knowledge of tooth morphology. Overall, 54.60% of the DSs and 58.56% of the DTSs strongly agreed that the morphology of each tooth plays an important role in determining occlusion. As shown in a study by Sierpinska *et al*.,[26] the occlusal morphology of molars and premolars significantly affects the duration of occlusion. The majority of the participants in the current study had this awareness. In the current study, 38.65% of the DSs agreed that the current curriculum was effective in helping them gain sufficient dental anatomy knowledge, whereas 35.14% of the DTSs were neutral. In a self-reported study, Abu Eid *et al*.[15] reported that while tooth carving has helped to improve manual dexterity, the dental anatomy curriculum still needs to be improved.

Collaboration between the dental technician and dentist is more important because the two professions work together more often.[27] Effective teamwork between the dentist and dental technician is crucial for achieving optimal outcomes from removable partial denture therapy.[28] A dental technician should be able to recall the information covered in dental anatomy and interact with the other members of the team at a suitable level when discussing prosthetic rehabilitation.[5] In the current study, DSs (57.67%) and DTSs (55.86%) also strongly agreed that knowing the anatomic landmarks of the teeth strengthens the communication network between the dentist and the dental technician. Similarly, they agreed that knowing tooth morphology will help them in their daily clinical/laboratory work.

Dental students outperformed dental technician students in the current study in terms of their practice with tooth morphology. The following theories could be put up as to why DTSs are novices who lack confidence, have fewer practical sessions than DSs, have little experience in the lab, and are under time constraints due to limited posting hours in the lab; they are constantly focused on passing exams and have a mindset of meeting departmental quotas; they are preoccupied with completing an immediate goal and are unsure of how to react when things do not go as planned; and they require a recipe for action. When faced with difficult situations related to dental morphology, DTSs believe they might not be able to accomplish.

Tooth dimensions and nonmetric factors are utilized in forensic anthropology and odontology to determine ethnicity and gender. Furthermore, individual or distinctive dental morphological characteristics are employed to compare premortem and postmortem dental results in forensic dental identification instances.[29] In the current study, dental students (38.65% of DSs) and dental technician students (39.64% of DTSs) both strongly agreed that knowledge of tooth morphology plays an important role in forensic cases and investigations. But DSs (39.88% neutral) and DTSs (28.83% neutral) were unconfident in applying their knowledge of tooth morphology as an investigative tool in the forensic sciences. In light of these results, it is intended that students expand their practices in this area. This can be accomplished by including the content of the forensic odontology course in the dental anatomy and morphology course rather than as a separate course, as is currently done**.**

Within the findings of the present study, differences were shown between dental students and dental technician students in terms of dental morphology knowledge and practice. In universities and dental clinics, interprofessional education for dentists and dental technicians can be extended beyond attending lectures and creating treatment plans for patients with removable dentures to include actual dental therapy. Incorporating shared learning into the curriculum can assist students understand communication and their individual roles while also teaching them the value of teamwork by allowing them to work as members of teams and other professions.[30]

There were several limitations of the current study. The effects of dental morphology teaching strategies on the knowledge, attitudes, and practices of dental students and dental technician students were not assessed in this study. There was no comparison of the two groups' tooth carving ability, which is correlated with theoretical knowledge of dental morphology. The limited number of dental technicians included in the study prevents the generalization of the results to the group. This study included only preclinical dentistry students. Future studies can reveal the dental morphology knowledge, attitudes and practice levels of clinical students and compare these characteristics between preclinical and clinical dental students as well as dental technician students.

Conclusions

One of the basic core sciences courses in the dental school and dental prosthesis technology program curricula is dental anatomy. Knowing the variations in knowledge, attitudes, and practices of dental morphology between a dentist and dental technician may help us take preventative measures. While preclinical dental students and dental technician students had different levels of practice, both groups were less knowledgeable about tooth morphology. First-year dental students had greater knowledge than second- and third-year students. Dental students had more practices in tooth morphology than did dental technician students. Both groups had similarly high attitudes toward tooth morphology.

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Conflict of interest

The authors declare no conflict of interest.

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Comparison of a Self-Adhesive Resin Cement, a Conventional and a Bulk-Fill Resin Composite for Luting of Indirect Restorative Materials; the Effect of Thickness and Material Factors on Translucence, Monomer Conversion and Resin-Dentin Bond Strength

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Research Article

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ABSTRACT

Introduction: In tis study, it was aimed to determine the effect of thickness and material factors on monomer conversion, translucency, and resin-dentin bond strength in luting indirect restorative materials (IRM) of different thicknesses using a resin cement, a conventional and a bulk-fill resin composite.

Materials and methods: Samples of lithium disilicate glass-ceramic material (IPS e.max) and ceramic-resin hybrid material (Lava Ultimate) in 2 and 4 mm thicknesses, were luted using RelyX U200 (a self-adhesive resin cement), X-tra fil (a bulk-fill resin composite) and Z250 (a conventional microhybride resin composite) to the dentin surface and subjected to bond strength test after thermal cycle. In addition, the translucency parameter (TP) of the prepared blocks and the degree of conversion (DC) of the luting materials were investigated. The data was statistically analyzed.

Results: The bond strength of X-tra fil and Z250 was statistically higher than RelyX U200 ($p<0.05$). Thickness (2mm vs 4mm) and material factor (E.max vs Lava) did not change the bond strength ($p>0.05$). The increase in thickness decreased the TP of IRMs and the DC of resins underlying Lava ($p<0.05$). The material factor did not affect TP and DC ($p>0.05$).

Conclusion: Conventional and bulk-fill resin composites can be alternative luting materials to resin cements. Thickness increase did not change bond strength, while decreased TP, and DC only for Lava Ultimate.

Keywords: Bond strength; Indirect restorative material; Luting agent; Monomer conversion; Thickness; Translucency.

İndirekt Restoratif Materyallerin Yapıştırılmasında Bir Self-Adeziv Rezin Siman, Bir Geleneksel ve Bir Bulk-Fil Rezin Kompozitin Karşılaştırılması; Kalınlık ve Materyal Faktörlerinin Şeffaflık, Monomer Dönüşümü ve Rezin-Dentin Bağlanma Dayanımı Üzerine Etkisi

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Süreç

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ÖZ

Amaç: Bu çalışmada farklı kalınlıklardaki indirekt restoratif materyallerin (IRM) simantasyonunda kullanılan bir rezin simanı, bir geleneksel ve bir bulk-fil kompozit rezinin dentin bağlanma dayanımı ve monomer dönüşümü üzerine materyal kalınlığı, şeffaflık ve materyal tipi faktörlerinin etkisini belirlemek amaçlanmıştır.

Gereç ve yöntemler: İki farklı kalınlıktaki (2 mm ve 4 mm) lityum disilikat cam-seramik materyal (IPS e.max) ve seramik-rezin hibrit materyal (Lava Ultimate) örnekleri, dentin yüzeyine RelyX U200 (bir self-adeziv rezin siman), X-tra fil (bir bulk-fil rezin kompozit) ve Z250 (bir geleneksel mikrohibrit rezin kompozit) kullanılarak yapıştırılmıştır ve termal döngü uygulaması sonrası bağlanma dayanım testine tabi tutulmuştur. Ayrıca, hazırlanan blokların şeffaflık parametresi (TP) ve yapıştırma materyallerinin monomer dönüşüm derecesi (DC) araştırılmıştır. Elde edilen veriler istatistiksel olarak analiz edilmiştir.

Bulgular: X-tra fil ve Z250'nin bağlanma dayanımları istatistiksel olarak RelyX U200'den anlamlı derecede daha yüksekti ($p<0,05$). Kalınlık (2 mm'ye karşı 4 mm) ve malzeme faktörünün (E.max'a karşı Lava), bağlanma dayanımını anlamlı derecede değiştirmediği bulunmuştur ($p>0,05$). Kalınlığın artması, IRM'lerin TP'sini ve altında bulunan rezinlerin DC'sini azaltmıştır ($p<0,05$). Malzeme faktörü, TP ve DC'yi etkilememiştir ($p>0,05$).

Sonuç: Geleneksel ve bulk-fil rezin kompozitler, rezin simanlara alternatif yapıştırma materyali olarak kullanılabilir. Kalınlık artışı bağlanma dayanımını değiştirmezken, sadece Lava Ultimate için TP ve DC'yi azaltmıştır.

Anahtar kelimeler: Bağ kuvveti; İndirekt restoratif materyal; Yapıştırma ajanı; Monomer dönüşümü; Kalınlık; Şeffaflık.

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Introduction

Dental restorations can be performed using two methods including direct or indirect. Indirect restorations have some advantages compared to direct method that is finished in the mouth in one session. Since the layering processes are skipped, shrinkage during polymerization of each layer is eliminated.[1] Finishing and polishing procedures, and reconstruction of the occlusal anatomy are realized more ideally, so the restorations which is more esthetic, and in which plaque control is easy can be achieved. More functional restorations can be obtained, especially in teeth with excessive tissue loss, since optimum contact relations with adjacent teeth and ideal occlusal relations with opposite teeth are provided.[1,2] In addition, more ideal polymerization and less residual monomer release can be achieved with additional polymerization techniques (such as heat, pressure or light).[1,3,4]

The success of indirect restorations depends on various factors, including material selection. Ceramic, hybrid, and resin composites are commonly used as indirect restorative materials (IRM).[1,2,5] All-ceramic materials have high esthetic properties, but processing and repairing of these materials are quite difficult. Moreover, due to their high elastic modulus, they can cause fractures in themselves and the remaining tooth tissues with the wedge effect and wear on the opposite tooth.[2,5] On the other hand, resin materials have some deficiencies such as low abrasion and mechanical strength, water absorbtion and discoloration, and their esthetic properties are not as good as ceramics. For this reason, hybrid materials were developed to take advantages of both materials.[2]

The selected luting material is another factor affecting the success of indirect restorations. Resin cements and resin composites are frequently used for this purpose nowadays.[6-8] Due to the discoloration of resin cements over time, insufficient mechanical properties and inability to fill the possible micro-macro gaps between the restoration and tooth tissue because of their viscosity, many practitioners prefer to lute the indirect restorations with traditional composite resins. However, in cases that the restoration and the underlying luting agent have a thick layer, the polymerization of the resin composite is compromised. Therefore, it may be advantageous to use a bulk-fill composite resin with better light transmittance instead of conventional composite resin as a luting material.[9]

The thickness of restorative materials also affects success.[10] When performing an indirect restoration in the posterior region, the vertical depth in all regions of the cavities is often not the same. For this reason, while the IRM used is shaped thicker in some regions, it is formed thinly in some regions. Even if the light curing is applied from all surfaces of the tooth, there may always be areas where the light cannot reach, especially in the central part of the base of the restoration or in the gingival step regions, which are far from the light device. When high-thickness restorations such as endocrowns are required, the properties of the luting material such as hardness, elastic modulus, flexural strength, monomer release, polymerization and bond strength may be compromised by preventing the light to reach the luting agent under the IRM.[10-12] Although ceramic and hybrid materials can allow light transmission due to their glass content, optimal restoration thickness for light transmission is not extensively studied.[10,13]

In the present study, it was aimed to investigate the parameters of the restorative material type, restorative material thickness and luting material that affect the bond strength of indirect restorations. In the literature, resin cements were mostly preferred in studies testing the bond strength of the IRMs, and the information about how these materials will behave when conventional and bulk-fill composites are used for cementation is insufficient. Additionally, few studies evaluate the effect of thickness on polymerization and bond strength of luting agents. Therefore, this study tested the bond strengths and polymerization levels of different thicknesses of IPS e.max (a lithium-disilicate ceramic block) and Lava Ultimate (a hybrid material) using self-adhesive resin cement, conventional microhybrid resin composite, and bulk-fill resin composite as luting materials.

Materials and Methods

Preparation of teeth

In this study, 144 caries-free human lower third molarteeth were used. The teeth were kept in 0.5% chloramine T solution at 4 ^{o}C for a week following extraction for disinfection. The samples were then stored in distilled water at 37 ^{o}C until use. Each tooth was embedded in a self-cure acrylic resin using standard cylindrical molds up to 2 mm below the cemento-enamel junction. The occlusal enamel portions of the teeth were removed using a low speed cutting device (Isomet 1000, Buehler, Lake Bluff, IL, USA) under water cooling. The tooth surfaces were examined under a stereomicroscope (DV 4; Zeiss, Jena, Germany) at 25X magnification to check whether the enamel tissue exist or not. Then the tooth surfaces were grounded using silicon carbide papers of 400, 600 and 800 grit, respectively, to form a standard smear layer.

Preparation of the ceramic and hybrid blocks

Two different CAD-CAM restoration materials, resin nano-ceramic (Lava Ultimate, 3M ESPE, St. Paul, MN, USA) and lithium disilicate ceramic (IPS e.max, Ivoclar Vivadent AG, Schaan, Liechtenstein), were used in the present study. Prism-shaped samples of 3mmx3mmx2mm and 3mmx3mmx4mm dimensions were obtained from each block by using a cutting device (Struers Minitom, Struers, Copenhagen, Denmark) under water cooling. All surfaces of the samples were grounded with 600 and 800 grit sandpaper to eliminate surface irregularities. Then, the outer (oral) surfaces of the samples were subjected to additional polishing with a 1200 grit sandpaper. Glazing

and sintering procedures of all samples were performed by the same technician in accordance with the manufacturer's instructions.

Determination of the experimental groups

All materials used in this study, their manufacturers, contents, and batch numbers are given in Table 1. IPS E. max and Lava Ultimate blocks (2 mm and 4 mm) were luted with the following materials;

1. X-tra fil bulk-fill composite (VOCO, Cuxhaven, Germany).
2. Filtek Z250 micro-hybrid composite (3M ESPE, St. Paul, MN, USA).
3. RelyX U200 self-adhesive resin cement (3M ESPE, St. Paul, MN, USA).

Table 1. Manufacturers, types, compositions, and batch numbers of the materials used in this study.

MATERIALS	TYPE	COMPOSITIONS	Batch
Lava Ultimate (3M ESPE, St. Paul, MN, USA)	Resin nano-ceramic	80% nanoceramic (SiO_2 (20 nm), ZrO_2 (4-11 nm)), and 20% resin matrix (Bis-GMA, UDMA, Bis-EMA, TEGDMA)	N842170
IPS e.max CAD (Ivoclar Vivadent AG, Liechtenstein)	Lithium disilicate ceramic	57%-80% SiO_2, 11%-19% Li_2O, 0%-13% K_2O, 0%-11% P_2O_5, 0%-8% ZrO_2, 0%-8% ZnO, 0%-5% Al_2O_3, 0%-5% MgO, pigments	V46355
Single Bond Universal (3M ESPE, Neuss, Germany)	Universal adhesive	10-MDP phosphate monomer, Vitrebond, copolymer, HEMA, Bis-GMA, dimethacrylate resin, silane, ethanol, water.	3424447
Filtek Z250 (3M ESPE, St. Paul, MN, USA)	Microhybrid composite	Bis-GMA, Bis-EMA, TEGDMA, UDMA; 60% silica / zirconia particles	N924423
X-tra fil (Voco, Cuxhaven, Germany)	Bulk-fill composite	Inorganic fillers in a methacrylate matrix (%83.5), Bis-GMA, UDMA, TEGDMA	1717238
RelyX U200 (3M ESPE, St. Paul, MN, USA)	Self-adhesive resin cement	Organic: acidic monomers, TEGDMA, acids, dimethacrylates, photoinitiators Inorganic (%70): glass fillers, SiO_2, pigments, sodium persulfate, glass fibers,	664323
Bis-silane (Bisco, Schaumburg, IL, USA)	Silane	3-(trimethoxysilyl) propyl-2-methyl-2-propenoic acid (5-10wt%), Ethanol	A:1600007289 B:1600007290
Porcelain etch (Ultradent, South Jordan, UT, USA)	Hydrofluoric acid	%9 Hydrofluoric acid	BFBKJ

Bis-GMA, Bisphenol glycidyl methacrylate; Bis-EMA, ethoxylated bisphenol-A dimethacrylate; UDMA, urethane dimethacrylate; TEGDMA, Triethylene glycol dimethacrylate; HEMA, 2-hydroxyethyl methacrylate; MDP, Methacryloyloxidecyl dihydrogen phosphate.

Cementation procedures

- Surface preparation of the indirect restorative material

Inner surfaces of resin nano-ceramic samples were roughened with 50 µm Al_2O_3 powder for 20 s. Hydrofluoric acid (9%) was applied to both IRMs (air-abraded resin nano-ceramic surfaces and lithium disilicate ceramic surfaces) for 60 s. After the acid was washed and dried, silane was applied to the surfaces of the specimens for 30 s.

- Preparation of the tooth surface

In groups using resin composite as luting agent, a universal adhesive (Single Bond Universal, 3M ESPE, Neuss, Germany) was applied to both the tooth and specimen surfaces following the application of silane, according to the manufacturer's instructions. This procedure was not performed on the groups using RelyX U200, a self-adhesive resin cement, as luting agent.

Before the cementation procedures, a silicone frame was made to the tip of the light-curing device to prevent light scattering (Figure 1a). At the tip of the silicone, the gaps of 1.5 mm and 3.5 mm in depth (3mmx3mm) were formed in which the IRM would be placed (Figure 1b). After the surface-treated specimens were placed in the sockets on the silicone, the luting material was applied to the surfaces of the indirect restorative material, and the specimens were then placed on the tooth surface (Figures1c and 1d). After the samples were pre-polymerized for 3 s using an LED light device (Valo Cordless, 1000 mW/cm^2, Ultradent, South Jordan, UT, USA), the excessive luting materials were cleaned with a sharp scalpel (no.12). The samples were then re-polymerized for 60 s.

Thermal aging

Following the cementation of the IRMs, the samples were subjected to 5000 thermal cycles in a thermal aging device (Julabo FT 400, Julabo GmbH, Seelbach, Germany) between 5 ºC- 55 ºC (with a 30 s dwell time). In the groups in which pre-test failure was observed after the thermal cycle, new samples were prepared as much as the missing sample, and the thermal cycle procedure was also applied to these new samples.

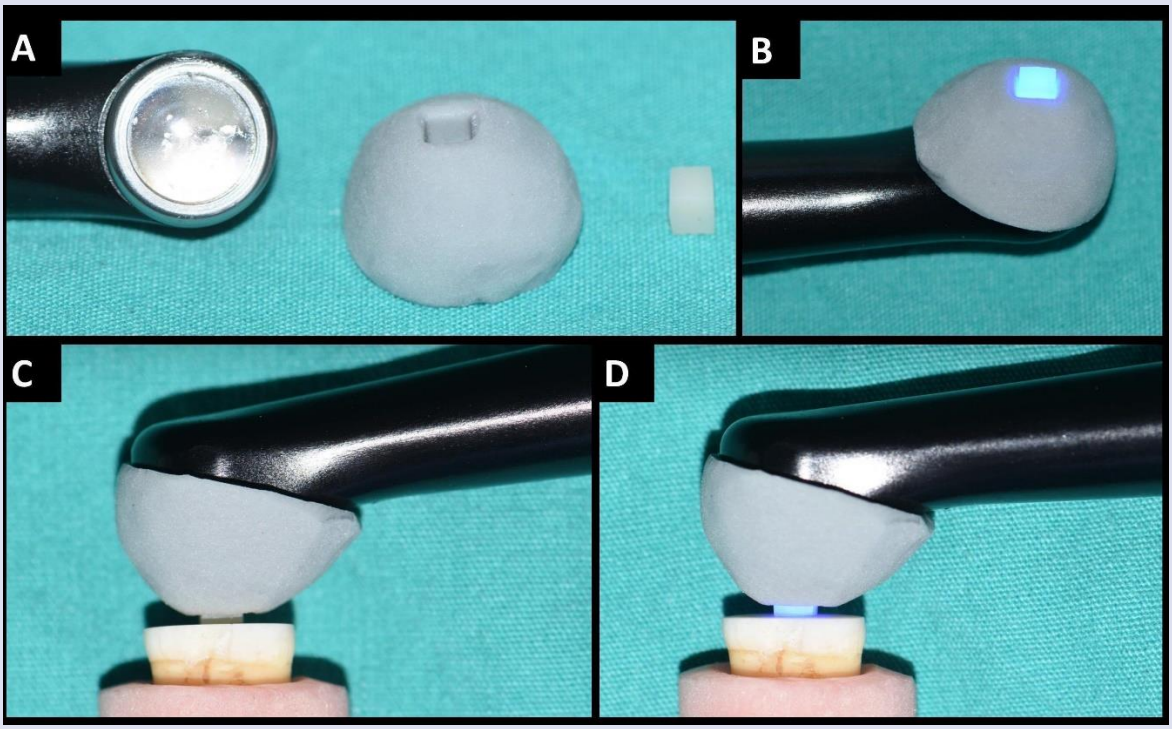

Figure 1: Modification of LED device and a simulation of application of the indirect restorative materials to the dentin surface.

Shear bond strength test

A shear bond strength test was applied to the specimens using a universal testing machine (Model 3345K7023; Instron Corp., USA). The specimens were fixed to the test device with the tooth-restoration interface perpendicular to the ground. A parallel shear force was applied to the bonding interface using a knife-edged blade with a head speed of 1 mm/min.

The maximum force at failure was recorded in Newtons (N) and the N values were converted to Megapascals (MPa) using the following formula:

Shear bond strength (MPa) = P / a^2

P is the force at break (N), and a^2 is the base area of the samples (mm^2).

The analysis of failure types

After the bond strength test, the fractured surfaces were examined with a stereomicroscope (Stemi 1000, Zeiss, Germany) under 40x magnification. The failure types were classified as adhesive failure (between the resin-block or the resin-dentin), cohesive failure (in dentin, in resin cement or within the block) and mixed failure.

Field Emission Scanning Electron Microscopy (FE-SEM)

The fractured surfaces of three samples from each group were also examined using a scanning electron microscope (FE-SEM) (GeminiSEM 500, Zeiss, Oberkochen, Germany). Before the FE-SEM analysis, the samples were fixed on an aluminum block with adhesive tape, the sample surfaces were coated with 45 A° thick Au-Pd and the surface images of the samples were taken at different magnifications (500-1500x).

Measurement of translucency values of the blocks in different thickness

Translucency measurements were realized on the 10mmx10mmx2mm and 10mmx10mmx4mm sized samples which were taken from Lava Ultimate and IPS e.max blocks (A2/LT) using a cutting device (Struers Minitom). After the finishing, polishing, sintering and glazing procedures of the samples, color measurements (L*a*b) of each sample was performed on a standard white and black background using a spectrophotometer device (Vita Easyshade compact, Vita Zahnfabrik, Bad Sackingen, Germany). Three measurements were taken from each sample and the averages were recorded. The translucency parameter (TP) was calculated with the following formula;

$$TP= [(L^*_w-L^*_b)^2 + (a^*_w-a^*_b)^2 +(b^*_w-b^*_b)^2]^{1/2}$$

"L*w, a*w, and b*w" represent L*, a*, and b* values measured on a white background, respectively. "L*b, a*b, and b*b" show the L*, a*, and b* values measured on a black background.

Degree of conversion (DC)

The surface treatment procedures (sandblasting, acid-etching, bonding) were performed as mentioned in the shear bond strength test. The polymerized resin samples in 0.2±0.05 mm thickness that were sandwiched between the IRM and dentin were taken, and the DCs of the luting materials were measured from the upper surface of each resin material (composite resin or resin cement) facing the

blocks. In addition, the resin samples to be used as the control group were polymerized by slightly compressing between two glasses. The thickness of each sample was verified after polymerization using a digital vernier caliper (INOX IP54 calipers, Micro Precision Calibration Inc, CA, USA).

Fourier Transform- Infrared Spectrophotometer (FT-IR, PerkinElmer 400 FT-IR/FT-FIR Spectrometer Spotlight 400 Imaging System, PerkinElmer, Waltham, MA, USA) was used for DC measurement of the luting materials. The spectra of the samples placed on the Attenuated Total Reflectance (ATR) cell of the device were measured before and 10 minutes after polymerization.

After each measurement, the ATR platform and measurement tip were cleaned with ethanol. All measurements were carried out in the 450-4000 cm^{-1} wavelength range. After one reference measurement, 20 additional scans were performed for each sample at 4 cm^{-1} resolution. The graphs of the molecular bond structure of the samples were obtained and by using the absorbance values corresponding to the aromatic C = C bonds around 1608 cm^{-1} wavelength and the aliphatic C = C bonds around 1638 cm^{-1} wavelength of polymerized and nonpolymerized samples, the DCs of resin materials were calculated with the following formula (Figure 2);

$$DC\ (\%) = \left(1 - \frac{(1638\ cm^{-1}/1608\ cm^{-1})\ after\ curing}{(1638\ cm^{-1}/1608\ cm^{-1})\ before\ curing}\right) x100$$

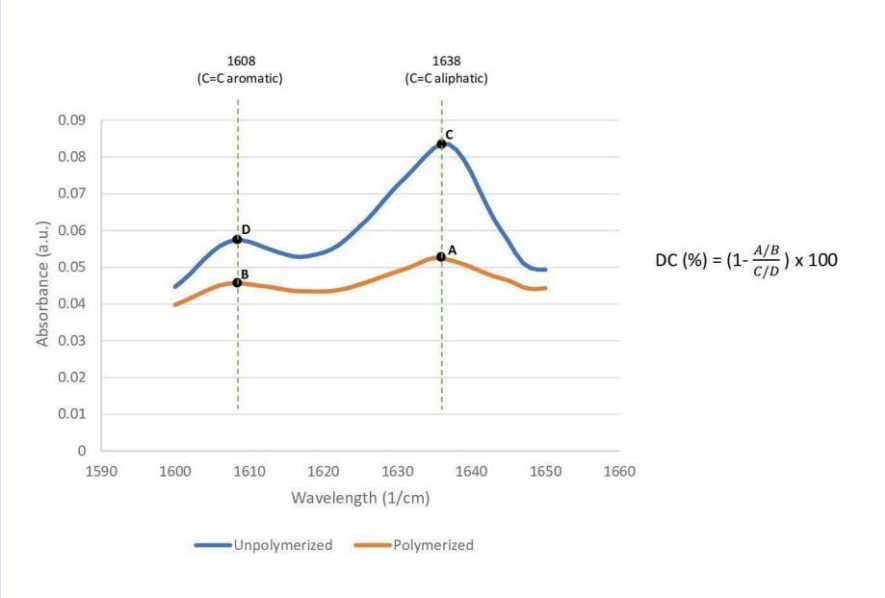

Figure 2: Calculation of the degree of conversion using the peak absorbance values corresponding to the aromatic C=C double bonds around 1608 cm-1 and the aliphatic C=C double bonds around 1638 cm-1 on FT-IR.

Statistical analysis

Statistical analysis of the obtained data was performed using a SPSS 22.0 (IBM Inc, Chicago, IL, USA) program. The Kolmogorov-Smirnov test was used for the analysis of the normality of the data distribution. Three-way analysis of variance (ANOVA) was used to analyze the effect of indirect restorative material type, indirect restorative material thickness, the type of luting materials on shear bond strength and DC. The Chi-Square test for the analysis of fracture types and Tukey Post-hoc test to detect significant differences between the groups were used. The significance level for all comparisons was determined as ($p<0.05$).

Results

Shear Bond Strength Test

The means of shear bond strength values, standard deviations and statistical differences according to the luting materials, the IRMs and thickness factor are given in Tables 2 and 3.

Three-way ANOVA analysis showed that the luting material had an effect on the bond strength. In pair-wise comparisons, it was found that Rely X U200 resin cement showed significantly lower bond strength than Z250 and X-tra fil ($p<0.05$). However, there was no statistically significant difference between the Z250 and X-tra fil groups ($p>0.05$).

When Lava Ultimate and IPS e.max restorative materials were compared, no statistical difference was observed between the two IRMs in terms of shear bond strength to dentin ($p=0.546$). In addition, no statistically significant difference was observed between the thickness of 2 mm and 4 mm ($p=0.322$).

Table 2. The means of SBS values (MPa), standard deviations (SD) of the groups, and statistical differences between the groups according to luting materials, restorative materials, and the thicknesses of the materials

	Subgroups	N	Mean (MPa)	SD	P Values
Luting Materials	Z250	48	7.1^{A}	2.1	0.000
	X-tra fil	48	5.6^{A}	1.9	
	RelyX U200	48	2.3^{B}	0.9	
Restorative Materials	Lava	72	4.7	2.5	0.546
	e.max	72	5.3	2.7	
Thickness	2 mm	72	4.5	2.5	0.322
	4 mm	72	5.5	2.7	

The different uppercase letters indicate statistical differences between the groups.

Table 3. The means of SBS values (MPa), standard deviations (SD) of the groups, and statistical differences between the groups.

Restorative Materials	Thickness	N	Luting Materials	Mean SBS	SD
e.max	**2 mm**	12	Z250	6.9^{de}	2.3
		12	X-tra fil	5.9^{cd}	1.7
		12	RelyX U200	2.3^{ab}	0.7
	4 mm	12	Z250	8.1^{e}	2.3
		12	X-tra fil	5.6^{cd}	1.9
		12	RelyX U200	3.1^{ab}	0.6
Lava	**2 mm**	12	Z250	6.4^{de}	1.3
		12	X-tra fil	4.1^{bc}	0.9
		12	RelyX U200	1.6^{a}	0.5
	4 mm	12	Z250	7.3^{de}	1.6
		12	X-tra fil	6.6^{de}	1.9
		12	RelyX U200	2.3^{ab}	0.8

The different superscripts letters indicate statistical differences between the groups.

Analysis of the Fracture Types

The fracture types and distribution of the groups are shown in Table 4. SEM images of the fractured surfaces of the groups are given in Figure 3. While a total of 12 (25%) pre-test failures were observed in the RelyX U200 group in this study, no pre-test failure was observed in the X-tra fil and Z250 groups. In the examinations under the stereomicroscope, adhesive type fracture (76.4% between resin-dentin and 6.2% between resin-IRM) was observed in 82.6% of the samples, and followed by cohesive (14.6%) and mixed (%2.8) fracture type, respectively. It was observed that all of the cohesive type fractures were in the body of luting material. When the luting materials were compared, while no statistical difference was observed between Z250 and X-tra fil in terms of the number of adhesive, cohesive and mixed failure ($p>0.05$). It was found that RelyX U200 resin cement had greater number of adhesive failure, fewer number of cohesive and mixed failure than the other two groups ($p<0.05$).

Table 4. The distribution of failure modes of the groups.

Luting Materials	*Subgroups*	*Adhesive (%)*		*Cohesive (%)*			*Mixed (%)*	*Pre-test failure*
		Between dentin-LM	**Between IRM-LM**	**Within dentin**	**Within LM**	**Within IRM**		
Z250	e.max 2 mm	9 (%75)	3 (%25)	-	-	-	-	-
	e.max 4 mm	10 (%83)	-	-	-	-	2 (%17)	-
	Lava 2 mm	8 (%67)	-	-	1 (%8)	-	3 (%25)	-
	Lava 4 mm	8 (%67)	-	-	1 (%8)	-	3 (%25)	-
X-tra fil	e.max 2 mm	7 (%58)	-	-	2 (%17)	-	3 (%25)	-
	e.max 4 mm	9 (%75)	3 (%25)	-	-	-	-	-
	Lava 2 mm	9 (%75)	-	-	-	-	3 (%25)	-
	Lava 4 mm	10 (%83)	-	-	-	-	2 (%17)	-
RelyX U200	e.max 2 mm	10 (%83)	2 (%17)	-	-	-	-	-
	e.max 4 mm	10 (%83)	-	-	-	-	2 (%17)	-
	Lava 2 mm	11 (%92)	1 (%8)	-	-	-	-	5
	Lava 4 mm	9 (%75)	-	-	-	-	3 (%25)	7

IRM; indirect restorative material, LM; luting material

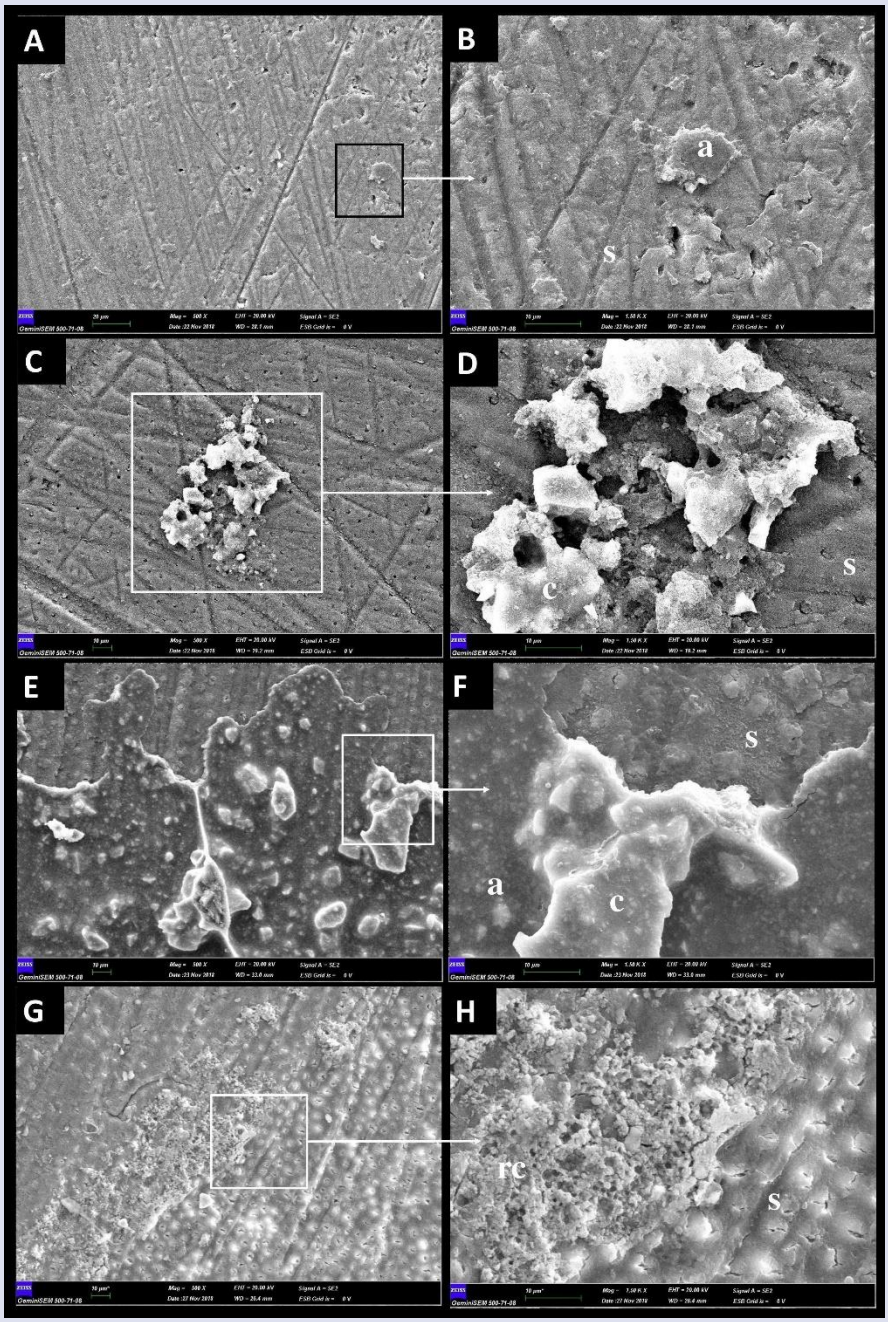

Figure 3: A, B; SEM image of an "adhesive" type failure of X-tra fil-2 mm-Lava group at 500x (A) and 1500x (B) magnification. C, D; SEM image of an "mixed" type failure of X-tra fil-4 mm-Lava Ultimate group at 500x (C) and 1500x (D) magnification. E, F; SEM image of an "mixed" type failure of X-tra fil-2 mm-IPS e.max group at 500x (E) and 1500x (F) magnification. G, H; SEM image of an "mixed" type failure of RelyX U200-4 mm-Lava Ultimate group at 500x (G) and 1500x (H) magnification. (s: smear layer, a: adhesive remnant, c: composite resin, rc: resin cement)

Translucency assessment of the blocks in different thicknesses (2 mm and 4 mm)

The L*, a*, b* and TP values obtained after the measurements of the blocks on white and black background are given in Table 5. Lava Ultimate showed the highest translucency value of 2 mm (11.1), followed by IPS e.max of 2 mm (9.5). Lava Ultimate 4 mm (2.8) and IPS e.max 4 mm (2.4) showed lower translucency values.

Table 5. L, a and b values of the Lava Ultimate and IPS e.max blocks over the white and black backgrounds, the correspondent translucency parameters (TP)

			Optical properties			
Materials	**Thickness**	**Background**	**L***	**a***	**b***	**TP**
Lava	2 mm	White	85.3	0.2	22.4	11.1
		Black	77.2	-1.5	15	
	4 mm	White	79.1	-0.5	17.9	2.8
		Black	77.2	-1.4	16	
e.max	2 mm	White	84.5	0.7	23.5	9.5
		Black	78.3	-1.2	16.5	
	4 mm	White	79.1	0.3	20.3	2.4
		Black	78.3	-0.7	18.3	

Degree of conversion (DC)

The means of the DCs, standard deviations and statistical differences of the groups are given in Tables 6 and 7. When the FT-IR analysis results were evaluated statistically, a significant difference was found between the DCs of the luting materials ($p<0.05$). X-tra fil showed significantly higher DC than Z250 ($p<0.05$). No statistically significant difference was observed between Z250 and RelyX U200 in terms of monomer conversion ($p>0.05$). When the restorative materials were compared among themselves, the mean DC of the luting materials in the Lava Ultimate groups was found to be similar to IPS e.max ($p>0.05$). When DC of restorative materials were compared according to thickness parameter, only Lava Ultimate 4 mm specimens were found to show significantly lower DC than other groups ($p<0.05$), while no statistically significant difference was observed between the other groups ($p>0.05$).

Table 6. The means of degree of conversions (DC), standard deviations (SD) of the groups, and statistical differences between the groups (D) according to luting materials, restorative materials, and the thicknesses of the materials.

	Subgroups	**N**	**DC (%)**	**SD**	**D**
Luting materials	Z250	20	46.8	2.6	b
	X-tra fil	20	52.9	3.3	a
	RelyX U200	20	51.6	3.9	a, b
Restorative materials	e.max	30	51.8	3.1	X
	Lava	30	49.1	3.4	X
Thickness	e.max 2 mm	15	52.9	2.7	A
	e.max 4 mm	15	50.7	2.4	A
	Lava 2 mm	15	53.9	2.9	A
	Lava 4 mm	15	44.2	2.3	B

Different letters show the differences within the groups according to luting materials, restorative materials and thicknesses of the materials.

Table 7. The means of degree of conversions (DC), and standard deviations (SD) of the groups.

Luting Materials	**Subgroups**	**N**	**DC (%)**	**SD**
Z250	Control	5	54.3	3.2
	e.max 2 mm	5	48.7	3.4
	e.max 4 mm	5	48.1	3.1
	Lava 2 mm	5	50.3	2.9
	Lava 4 mm	5	40.1	2.1
X-tra fil	Control	5	64.8	4.3
	e.max 2 mm	5	55.9	3.9
	e.max 4 mm	5	51.3	3.7
	Lava 2 mm	5	54.9	3.4
	Lava 4 mm	5	49.3	3.6
RelyX U200	Control	5	59.4	4.3
	e.max 2 mm	5	54.1	3.3
	e.max 4 mm	5	52.7	2.9
	Lava 2 mm	5	56.4	2.6
	Lava 4 mm	5	43.3	2.5

Discussion

Today, IRMs are frequently used in the restoration of teeth with extensive hard tissue loss due to caries. There are different types of these materials such as all-ceramic, resin-added ceramic or ceramic-added resin (hybrid).[1,2,5] When the different chemical compositions of the materials produced by different manufacturers are taken into account, it is not possible to say that all the restorative materials used have the same optical properties such as light transmission, absorption, scattering and reflection. The polymerization of light or

dual-curing resin materials used for luting of these materials and their adhesion properties, mechanical strength may be indirectly affected by these optical properties.[10,14,15] It should be also kept in mind that the vertical thickness of the prepared restoration is not uniform in all regions of the cavity. Especially gingival step regions of restorations and some restorations like endocrowns present deeper vertical thickness that can prevent the light transmission.

Recently, the researchers have looked for alternative luting materials to resin cements due to their disadvantages such as discoloration, low mechanical properties due to insufficient filler content, low adhesion ability, and inability to ideally fill the gaps in the restoration-tooth interface.[16,17] However, in the literature, there are very few studies testing alternative luting materials.[6,7] Composite resins which have higher filler content compared to resin cements, can be an alternative luting material due to their superior mechanical properties, long-term esthetic stability, and most importantly, their ability to fill the micro and macro gaps between the indirect restoration and the tooth tissue.[6] For this reason, the effect of the material and thickness factors on the DC (polymerization potential) and adhesion of three different resin materials (a bulk-fill, a conventional resin composite and a resin cement) was compared in the present study. In our study, RelyX U200, a self-adhesive resin cement, showed lower shear bond strength than Z250 and X-tra fil. In consistent with the results of our study, in two studies conducted by Kameyama et al.[6] (comparing a conventional resin composite with a resin cement (Variolink II, Ivoclar)) and Urcuyo Alvarado et al.[7] (comparing a preheated resin composite with RelyX U200), traditional resin composites were found to be more successful. The manufacturer claims that RelyX U200 resin cement which is a self-adhesive resin cement does not require additional etching and adhesive application steps. However, in the present study, low bond strength of RelyX U200 may have resulted from the inability of this material to sufficiently penetrate the collagen network and tubules and the hydroxyapatite complex structure in dentin.[18] Moreover, Yin et al.[18] reported that the use of a universal adhesive to dentin prior to the application of RelyX U200 increased the bond strength of resin to dentin. So, the lack of additional chemical bonding provided by functional monomers such as Vitrebond copolymer and 10-MDP of the adhesive resin used in the present study could be another reason of low bond strength of RelyX U200.[19,20] In addition, self-adhesive resin cements have higher water absorption and dissolution properties than paste-like resin composites due to their more hydrophilic structure originating from the acidic monomers that they contain,[16] and therefore RelyX U200 groups may be affected extensively by thermal cycle procedure in this study.

In the present study, it was observed that the effect of Lava Ultimate and IPS e.max on the bond strength of the luting materials to dentin was similar as mentioned in a study by Frankenberger et al.,[8] which found similar effects of both Lava Ultimate and IPS e.max CAD materials on bond strength. In another study that Lava Ultimate and IPS e.max were used, higher bond strength was observed in Lava Ultimate groups, and the researchers argued that Lava Ultimate offers higher bond strength due to the chemical similarity of the resin in its content with the luting cement.[21] However, in our study, the high bond strength between the resin and the IRM was not important, since most of the failure types during the test occurred between the resin and dentin.

The thickness of the IRMs may adversely affect the polymerization of the resin by changing the optical properties of the light passing through the material, affecting the power, wavelength and intensity of the light reaching the underlying resin. Consequently, compromising of polymerization may jeopardize the mechanical properties of the resin and the bond strength to dentin.[10-12] However, when the thickness parameter was evaluated in the present study, the effect of 2 and 4 mm thicknesses on the bond strength was found to be similar. This may be due to the fact that both thicknesses allowed light transmission at a level that did not affect the bond strength.

In the present study, in order to test the bond strength of luting materials to dentin, the use of them with an IRM and then breaking off the luted IRMs was preferred instead of applying them directly on the dentin tissue. This method is more similar to clinical use. However, the bond strength values may have been found to be relatively low in general due to the facts that the light has to pass through a IRM before reaching the dentin, the thermal expansion differences of the IRMs and the luting agent due to the thermal changes during the thermal cycle, and the degradation of the luting material due to contact with water from all sides. Especially the high number of pre-test failures observed in RelyX U200 groups after the thermal cycle supports this situation.

Studies have reported that samples with mostly cohesive and mixed failure offer higher bond strength than specimens with adhesive failure.[22,23] In addition, it has been reported that the incidence of pre-test failure is high in cases that the bond strength is low.[24] In the present study, the highest pre-test failure and adhesive failure were observed in the RelyX U200 group. This can be attributed to the low mean bond strength offered by this group. Chrisostomo et al.[24] reported that low bond strength and high pre-test failure were observed if acid and adhesive resin were not used before RelyX U200 and another self-adhesive resin cement (MaxCem Elite, Kerr) on enamel. In addition, in the present study, it was found that the majority of the adhesive failures (76.4%) occurred at the resin-dentin interface. This situation may show that the luting materials bonded to the blocks better than they did to the dentin. These results are consistent with the findings of the study conducted by Wahsh et al.[21]

In studies evaluating the bond strength of resin to dental tissues, thermal cycle and water storage are generally used for the aim of aging of the samples.[25,26] In the present study, 5000 thermal cycles was preferred,

which corresponds to approximately 6 months of aging.[27] In fact, since the bond surface area of the prepared samples is large (9mm^2), it would be expected to observe more cohesive or mixed failure types. However, we think that the bonding weakened significantly due to the simultaneous water absorption, dissolution and bonding interface degradation with the thermal aging effecting of the adhesive resin from all sides, due to the absence of dentinal walls or a cavity preparation. In addition, the bond strength could be negatively affected by the mismatches in the coefficient of thermal expansion of the luting material, dentin and IRM.[28]

The DC of resin materials determines the polymerization quality,[29] so it is a parameter that affects the physico-chemical and mechanical strength of the material. If the IRMs do not allow light to reach underlying resin, the resin's monomer conversion is adversely affected.[10] This reduces the bond strength of resin to dentin and IRM, as well as its mechanical strength.[10-12] In the present study, the DC of the adhesive resins, the translucency properties of IRMs and the correlation between the two parameters were also evaluated to support the bond strength test.

Previous studies have reported that bulkfill resin composites have higher monomer conversion degrees than conventional resin composites.[30,31] Similarly, in the present study, X-tra fil, a bulk-fill resin composite, showed higher monomer conversion compared to RelyX U200 and Z250. The manufacturer of X-tra fil resin composite, decreased the specific surface between fillers and the organic matrix increasing the filler size, consequently reduced the light scattering.[32] X-tra fil has high translucency despite its high filler loading, which is related to the increased filler size and by the improved refractive indices of the filler particles and the resin matrix.[30,33] However, X-tra fil showing high DC did not offer high bond strength. It was observed that there was no direct correlation between DC and bond strength of RelyX U200 resin cement, which showed lower DC than X-tra fil but similar to Z250. This suggests that the other factors such as depth of penetration, mechanical strength, water absorption and dissolution are also effective on bond strength.

In the present study, the mean DCs of the luting materials in Lava Ultimate 2 mm and IPS e.max 2 mm groups were found close to each other. However, the mean DC of Lava Ultimate samples in the 4 mm groups was lower than that of IPS e.max. On the other hand, TP values of IPS e.max and Lava Ultimate were found close to each other in both 2 mm and 4 mm groups. Different factors such as ceramic, glass and resin ingredients in the chemical content of the materials, filler particle size and shape can also affect optical parameters such as light transmission, absorption and scattering.[14] Therefore, there may not be a direct correlation between DC and TP. Similar to the findings of our study, Jesus et al.[14] stated that there was no direct relationship between DC and TP in a study that they conducted with IPS e.max blocks with different translucency values.

It can be predicted that increasing in the thickness of the IRM will allow less light transition and consequently affect the polymerization of the luting material.[15] When the effect of the thickness parameter on the degree of conversion was evaluated in the present study, it was found that the 4 mm thick Lava Ultimate blocks caused lower DC of the luting material compared to the other groups. Ilie et al.[15] reported that one of the factors determining the polymerization quality of the resin material was the surface hardness, and they investigated the effect of thickness on TP and surface hardness. The researchers reported that TP and hardness decreased with the increase in thickness. Although similar results were not found in present study, the fact that any further increase in thickness (> 4mm) of IRMs could compromise the polymerization of resin should not be ignored.

The present study is an in-vitro study performed by ignoring the factors such as humidity, changes both in temperature and pH in oral environment, patient habits, the effects of muscles functioning during chewing and swallowing, the effect of saliva, pulpal temperature and pressure, malocclusions. Therefore, additional in-vivo and in-vitro studies are needed to support the study results.

Conclusions

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

1. Conventional resin composites and bulk-fill resin composites can be alternative luting materials to resin cements.
2. Thickness increase of IRMs did not change BS, while decreased the TP, and the DC only for Lava Ultimate.
3. IPS e.max did not affect DC and BS up to 4 mm, but TP decreased by thickness increase.
4. Lava Ultimate did not affect BS up to 4 mm, but DC and TP decreased by thickness increase.

Acknowledgments

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Conflict of interest

The authors declare no competing interests.

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Bibliometric Analysis of In-vitro Studies on 'Orthodontics' and 'Aesthetic and Conservative Treatment' in the TR Index Journals

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Research Article

History

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ABSTRACT

Introduction: The aim of this study is to evaluate *in-vitro* titled studies in the field of orthodontics and aesthetic and conservative treatment published in TR Index journals.

Materials and Methods: A systematic search of the TR Index database (https://trdizin.gov.tr/) was conducted, focusing on studies that utilized the keyword "*in-vitro*". Inclusion criteria were limited to dental journal publications in English, Turkish, and other languages within the specified period. Data extraction and analysis included journal name, publication year, author institutions, departments, article type, article language, and citation count.

Results: A total of 140 *in-vitro* titled studies were identified across various dental specialties. After excluding 83 studies that did not align with the scope of 'orthodontics' and 'aesthetic and conservative treatment', 57 studies were included in the final analysis. Of these, 9 studies were related to 'orthodontics', and 48 studies focused on 'aesthetic and conservative treatment'. The journals with the highest number of *in-vitro* titled studies over the past three years were Turkiye Clinics Journal of Dental Sciences (13 studies), Cumhuriyet Dental Journal (8 studies), and Selcuk Dental Journal (8 studies). The language of publications, whether Turkish or English, did not significantly impact citation counts (p = 0.562).

Conclusions: *In-vitro* research have a significant for providing critical insights into materials and treatments in both 'orthodontics' and 'aesthetic and conservative treatment'. However, there is a need to increase orthodontic-related *in-vitro* studies. The findings suggest that the language of publication does not impact citation rates, indicating a broad acceptance of research across different languages.

Keywords: Bibliographic Databases, Bibliometric Analysis, Dental Aesthetic, In Vitro Techniques, Orthodontics.

TR Dizin Dergilerinde 'Ortodonti' ve 'Estetik ve Konservatif Tedavi' Alanlarındaki *İn-Vitro* Çalışmaların Bibliyometrik Analizi

Research Article

Süreç

Geliş: 17/04/2024
Kabul: 05/09/2024

ÖZ

Amaç: Bu çalışmanın amacı, TR Dizin dergilerinde yayımlanan 'ortodonti' ve 'estetik ve konservatif tedavi' alanındaki *in-vitro* başlıklı çalışmaları değerlendirmektir.

Gereç ve Yöntemler: Bu çalışmada; ulusal veri tabanı olan TR Dizin'de (https://trdizin.gov.tr/) sistematik bir arama yapılmış ve "*in-vitro*" anahtar kelimesini kullanan çalışmalar incelenmiştir. Dahil edilme kriterleri, 2021-2023 yılları arasında İngilizce, Türkçe ve diğer dillerde yayımlanan diş hekimliği dergisi yayınları ile sınırlandırılmıştır. Yayınlar dergi adı, yayın yılı, yazar kurumları, bölümleri, makale türü, makale dili ve atıf sayısına göre sınıflandırılmıştır.

Bulgular: Diş hekimliği uzmanlık alanlarında yapılan incelemelerde toplam 140 *in-vitro* başlıklı çalışma tespit edilmiştir. "Ortodonti" ve "estetik ve konservatif tedavi" alanlarına dahil olmayan 83 çalışma analiz dışında bırakılmış ve nihai değerlendirmeye 57 çalışma dahil edilmiştir. Bu çalışmaların 9'u "ortodonti" alanında bulunurken, 48'i "estetik ve konservatif tedavi" alanında yer almaktadır. Son üç yılda en fazla *in-vitro* çalışmaya yer veren dergiler, 13 çalışma ile Türkiye Klinikleri Diş Hekimliği Bilimleri Dergisi, 8'er çalışma ile Cumhuriyet Üniversitesi Diş Hekimliği Fakültesi Dergisi ve Selçuk Üniversitesi Diş Hekimliği Fakültesi Dergisi olmuştur. Ayrıca, makalelerin Türkçe veya İngilizce dilinde yayımlanmasının atıf sayıları üzerinde istatistiksel olarak anlamlı bir etkisi bulunmamıştır (p = 0.562).

Sonuçlar: *In-vitro* araştırmalar, 'ortodonti' ile 'estetik ve konservatif tedavi' alanlarında kullanılan malzemeler ve tedavi yöntemleri konusunda önemli bilgiler sunmaktadır. Ancak, ortodonti alanında yapılan *in-vitro* çalışmaların sayısının artırılması gerekmektedir. Elde edilen bulgular, yayın dilinin atıf sayıları üzerinde bir etkisi olmadığını ve farklı dillerdeki çalışmaların da yaygın bir şekilde kabul gördüğünü ortaya koymaktadır.

Anahtar Kelimeler: Bibliyografik Veritabanları, Bibliyometrik Analiz, Dental Estetik, İn Vitro Teknikler, Ortodonti.

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Introduction

Orthodontics and aesthetic dentistry represent two intertwined specialties within the dentistry, each playing a pivotal role in the comprehensive care of patients.[1] Orthodontics is a dental specialty that corrects misalignments and positions teeth properly to establish a balanced bite and promote long-term oral health.[2] In recent years, the advancements in orthodontic technology, including clear aligners and digital treatment planning, have further enhanced the ability to provide precise and effective treatments that not only improve function but also contribute to aesthetic outcomes.[3] Aesthetic dentistry focuses on improving the visual features of the smile by enhancing dental appearance through color correction, form modification, and overall teeth presentation.[4] With the growing demand for aesthetic treatments, innovations such as minimally invasive veneers and teeth whitening have become integral components of modern dental practice.[5] The disciplines work together effectively, combining practicality with beauty to meet clinical needs and satisfy patients' desire for aesthetically pleasing results.[6–8] The relationship between orthodontics and aesthetic dentistry highlights the comprehensive approach to oral health, aiming to attain both ideal dental function and an attractive oral appearance, demonstrating the holistic approach to patient care in modern dentistry.[8,9] This synergy is increasingly recognized as essential in achieving optimal outcomes for patients, where both functional and aesthetic aspects are considered from the outset of treatment planning.

In-vitro studies in dentistry refer to research conducted outside of a living organism, typically in a controlled laboratory environment such as in test tubes, petri dishes, or other culture systems.[10,11] In dentistry, *in-vitro* studies play a significant role in advancing research and understanding various dental materials, techniques, and biological aspects of oral health.[12–15] By simulating oral conditions using cells, tissues, or synthetic models, *in-vitro* studies provide a foundation for clinical research, allowing for the controlled testing of hypotheses before transitioning to *in-vivo* settings.[10,16–18] The most significant advantages of *in-vitro* studies include their repeatability and the ability to simulate *in-vivo* conditions within a shorter timeframe, all while eliminating risks to human health.

In-vitro studies are vital for evaluating dental materials such as fillings, crowns, and implants by testing their strength, durability, and biocompatibility.[19,20] These studies also explore oral microbiology, examining how oral bacteria contribute to tooth decay and gum disease, and their interactions with dental materials.[21] Additionally, *in-vitro* research helps understand tooth movement and the effectiveness of orthodontic appliances.[22] The increasing complexity of dental materials and techniques has made *in-vitro* studies indispensable for ensuring the safety and efficacy of new treatments. It's crucial for the initial testing of new dental drugs for safety and efficacy, and for studying dental erosion caused by acidic substances or mechanical actions.[23,24] This research provides essential insights into dental health and treatment advancements, contributing to the development of more effective and patient-friendly dental care options.

Bibliometric analysis is a crucial tool for evaluating the scientific field, offering quantitative measures such as publication and citation counts, and h-index to assess researchers' or organizations' productivity and influence.[25–27] It allows for the objective evaluation of research effectiveness, identifies trends, emerging fields, and shifts in scientific interests, revealing collaboration patterns among scholars and institutions.[28] With the increasing emphasis on evidence-based practice, bibliometric analysis has become essential in identifying the most impactful research and guiding future investigations.[29] This analysis supports informed decision-making in research funding, policy development, and resource distribution, relying on bibliometric indicators for resource allocation decisions.[30–32] It facilitates comparisons across institutions, countries, and disciplines, identifying strengths and areas for improvement.[28,33–35] Bibliometric data is also vital for academic evaluations related to promotions, tenure, and hiring, and helps uncover under-researched areas or gaps in literature, thereby increasing transparency and aiding in systematic literature reviews and meta-analyses by pinpointing key papers and authors in specific fields.[27,36-38]

The TR Index was created following international standards to provide researchers with access to national and scientific data. It operated under the name of National Databases-UVT until the end of 2013. The TR Index, curated by ULAKBİM, comprises journals in the primary domains of science and social sciences, as well as the subdomains of dentistry, pharmacy, engineering, basic sciences, health sciences, veterinary, social sciences, and humanities. In the Turkish academic system, publishing in national journals indexed in the TR Index is often a requirement for academic promotion, which has led to an increase in the number of publications in these journals. This requirement, while promoting scientific output, also highlights the need to ensure that the quality of research remains high despite the growing quantity of publications.[39] This index is a valuable resource for conducting bibliometric analyses, particularly in fields like dentistry, where national and international research trends are crucial for advancing the discipline. The objective of this study is to assess the research conducted on orthodontics and aesthetic and conservative treatment through in vitro experiments as published in the dental publications indexed in TR Index.

Materials and Methods

This study is a bibliometric analysis of published literature and does not involve direct research on human participants or animals. Accordingly, informed consent and ethical approval were not applicable for this study.

The research was designed and conducted with a commitment to the highest ethical standards, in alignment with the principles of the Declaration of Helsinki for ethical research.

All studies are listed in the national database TR Index (https://trdizin.gov.tr/) using the keyword "*in-vitro*" and accessed the website in 13rd December 2023. Only publications in dental journals were included among all publication types in English, Turkish and other languages in 2021, 2022, and 2023. The publications were categorized based on the journal name, publication year, author institutions, departments, article type, article language, and number of citations. This information was then saved in the Excel software package (Microsoft Office Professional Plus 2020, USA). As a result of the examination of the records obtained, publications in the field of orthodontics and aesthetic and conservative treatment were included in this study (Figure 1).

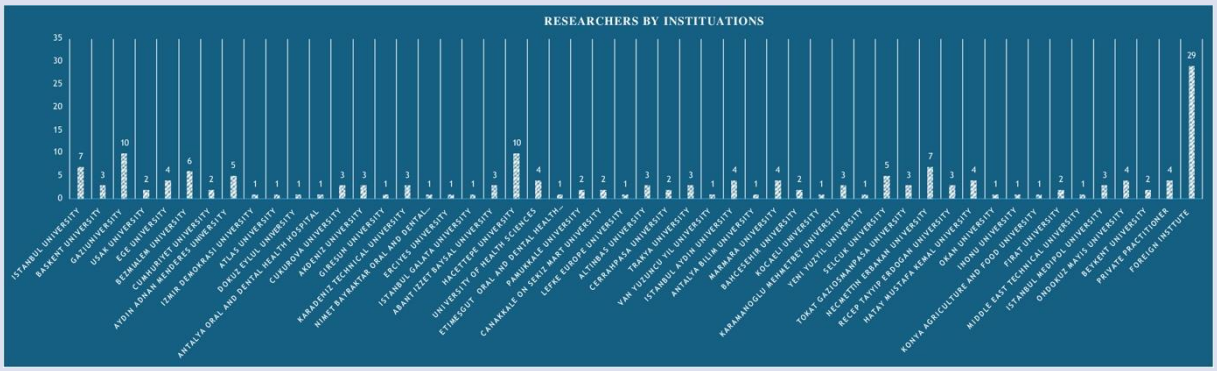

Figure 1: The distribution graph of researchers categorized by instituations

Statistical analysis

Statistical analyses were performed with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package program.

In addition to descriptive statistical methods (mean, standard deviation, median, interquartile range), the distribution of variables was examined with the Shapiro-Wilk normality test, and the Mann Whitney U test was used to compare paired groups for variables that did not show normal distribution. The results were evaluated at a significance level of $p<0.05$.

Results

A total of 140 studies employing the *in-vitro* approach were identified. The studies were assessed based on their respective domains, and 83 of them were subsequently eliminated from the study. The excluded papers pertain to the fields of oral and maxillofacial surgery (4), endodontics (35), pedodontics (10), prosthodontics (28), periodontology (5), and oral diagnosis and radiology (1). Nine studies pertaining to orthodontics and forty-eight studies pertaining to aesthetic and restorative dentistry were accessed. Total of 57 studies are included as research articles (Table 1).

In 2021, 2022 and 2023, it was seen that the most publications were made in 2022 (n = 24). While it was determined that 44 publications received no citations, it was determined that there were 8 publications with 1 citation, 2 with 2 citations, 1 with 3 citations, 1 with 4 citations, and 1 with over 5 citations. The number of publications and citations by year are shown in Table 2.

When the journal citation counts examined, it was seen that the most citations were in European Oral Research (n = 14). It was determined that they were followed by Turkish Journal of Orthodontics (n = 5), International Dental Research (n = 4), and Selcuk Dental Journal (n = 3), respectively. Table 3 shows the number of publications and citations by journal. It was determined that European Oral Research was the journal with the most cited publications in the field of orthodontics and aesthetic and restorative dentistry related to *in-vitro* studies, thanks to a study with 11 citations (Table 3).

27 of the studies were prepared in Turkish and 30 in English. As a result of the Mann–Whitney U test, it was determined that the language did not make a significant difference in the number of citations (p = 0.562) (Table 4).

Detailed data on *in-vitro* studies in orthodontics in the TR Index shown in table 5 and in aesthetic and conservative treatment shown in table 6. The most cited *in-vitro* study in the field of orthodontics is study of Recen et al., published in the journal European Oral Research in 2021 and cited in 11 times (Table 5). The most cited *in-vitro* study in the field of aesthetic and conservative treatment is study of Yıldırım-Bilmez et al., published in the journal International Dental Research in 2021 and cited in 4 times (Table 6).

A total of 57 '*in-vitro*' titled studies were analyzed across various TR Index dental journals within the last three years. Only one of these studies was a 'review' article, while the remaining studies were identified as 'original research' articles. No 'case reports' or 'short communications' were found in the analysis. The journals with the highest number of *in-vitro* titled studies were Turkiye Clinics Journal of Dental Sciences, Cumhuriyet Dental Journal, and Selcuk Dental Journal. Turkiye Clinics Journal of Dental Sciences published the highest number

of *in-vitro* titled studies, with a total of 13 articles. Cumhuriyet Dental Journal and Selcuk Dental Journal both published 8 studies each, making them the next most prolific journals in this area (Table 5 and 6).

Figure 1 illustrates the distribution graph of researchers categorized by instituations. The instituations with the highest number of researchers conducting *in-vitro* studies are foreign institutes (n = 29). This is followed by Hacettepe (n = 10) and Gazi (n = 10) Universities.

Table 1. The distribution of *in-vitro* studies conducted by dentistry departments in TR Index over the past three years

	Year			
	2021	**2022**	**2023**	**Total**
Oral and Maxillofacial Surgery	1	3	0	4
Endodontics	20	13	2	35
Pedodontics	3	4	3	10
Aesthetic and Restorative Dentistry	19	21	8	48
Prosthodontics	11	9	8	28
Orthodontics	3	3	3	9
Periodontology	3	1	1	5
Oral Diagnosis and Radiology	1	0	0	1
Total	61	54	25	140

Table 2. Number of publications and citations by year 2021, 2022 and 2023

Year		**2021**	**2022**	**2023**	**Total**
Number of Publications		22	24	11	57
Number of Citations	**0**	16	20	8	44
	1	2	3	3	8
	2	1	1	0	2
	3	1	0	0	1
	4	1	0	0	1
	5 and over	1	0	0	1

Table 3. Journal citation counts

Journals	**Number of Citations**						
	0	**1**	**2**	**3**	**4**	**5 and over**	**Total**
European Oral Research	1	1	1	0	0	1 (11)	14
Turkish Journal of Orthodontics	0	3	1	0	0	0	5
Europen Annals of Dental Sciences	1	0	0	0	0	0	0
International Dental Research	3	0	0	0	1	0	4
Journal of Dental Faculty of Ataturk University	3	1	0	0	0	0	1
Cumhuriyet Dental Journal	7	1	0	0	0	0	1
Current Research in Dental Sciences	3	0	0	0	0	0	0
Turkiye Clinics Journal of Dental Sciences	12	1	0	0	0	0	1
Journal of Necmettin Erbakan University Faculty of Dentistry	1	1	0	0	0	0	1
Journal of Ege University Faculty of Dentistry	4	0	0	0	0	0	0
Turkish Endodontic Journal	1	0	0	0	0	0	0
Acta Odontologica Turcica	1	0	0	0	0	0	0
Selcuk Dental Journal	7	0	0	1	0	0	3
Total	0	8	4	3	4	11	30

Table 4. Assessment of the relationship between the number of citations of in-vitro studies published in Turkish and English in the fields of 'orthodontics' and 'aesthetic and conservative treatment'

	Number of Citations	**Median (IQR)**
Turkish (n=27)	0.21±0.63	0 (0-0)
English (n=30)	0.40±0.99	0 (0-0)
p	0.562	

*Mann Whitney U Test p value (*p<0.05)*

Table 5. Detailed data on in-vitro studies in orthodontics in the TR Index journals

Authors	Journal	Year	Number of Citations	Institute	Language	Research Type
Ibarra N., Saez M., Rojas V., Oyonarte R.	European Oral Research	2023	0	Foreign Institutions	English	Original Research
Uzunçıbuk H., Oztas S.E.	Turkish Journal of Orthodontics	2023	1	Istanbul University	English	Original Research
Gundog H., Ozcirpici A., Pamukcu H.	Turkish Journal of Orthodontics	2023	1	Baskent University	English	Original Research
Avan-Arslan B., Baloş-Tuncer B., Ulusoy M.Ç., Tuncer C., Yıldırım E., Bodur O.C.	Turkish Journal of Orthodontics	2022	1	Gazi University	English	Original Research
Titiz Skeskin-Erdogan Z., Tuna E.E., Aras A.	Turkish Journal of Orthodontics	2022	2	Usak University, London College University, Ege University	English	Original Research
Kılıc B., Doruk C.	Europen Annals of Dental Sciences	2022	0	Bezmialem University, Cumhuriyet University	English	Original Research
Ozant Y., Ay-Unuvar Y.	International Dental Research	2021	0	Aydın Adnan Menderes University	English	Original Research
Trakyalı G.	Journal of Dental Faculty of Ataturk University	2021	0	Istanbul Yeni Yuzyıl University	English	Original Research
Recen D., Yıldırım B., Othman E., Çömlekoğlu M.E., Aras I.*	European Oral Research	2021	11	Izmir Demokrasi University, Uşak University, Jacksonville University, Ege University	English	Original Research

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Table 6. Detailed data on in-vitro studies in aesthetic and conservative treatment in the TR Index journals

Authors	Journal	Year	Number of Citations	Affiliation	Language	Research Type
Adham A., Ali A.	Cumhuriyet Dental Journal	2023	0	Foreign Institution	English	Original Research
Kalaivani M., Prasad D., Manoharan I., Sruthipriya M., Balachandran J., Pavankumar M.	European Oral Research	2023	1	Foreign Institution	English	Original Research
Keleş Z.H., Ozan G.	Current Research in Dental Sciences	2023	0	Atlas University, Istanbul University	Turkish	Original Research
Altınışık H., Erten H.	Current Research in Dental Sciences	2023	0	Gazi University, Dokuz Eylul University	English	Original Research
Yıldız B., Batmaz S.G., Dündar A., Barutçugil Ç.	Turkiye Clinics Journal of Dental Sciences	2023	0	Antalya Oral and Dental Health Hospital, Cukurova University, Akdeniz University	Turkish	Original Research
Naiboglu P., Kosar T.	Turkiye Clinics Journal of Dental Sciences	2023	0	Giresun University, Karadeniz Technical University	English	Original Research
Dogan A.N., Arslan S.	Turkiye Clinics Journal of Dental Sciences	2023	0	Nimet Bayraktar Oral and Dental Health Hospital, Erciyes University	Turkish	Original Research
Sarıalioğlu-Güngör A., Örcün M.E., Dönmez N.	Journal of Necmettin Erbakan University Faculty of Dentistry	2023	0	Istanbul Galata University, Bezmialem University, Abant Izzet Baysal University	Turkish	Original Research
Öz F.D., Gürgan S.	Turkiye Clinics Journal of Dental Sciences	2022	0	Hacettepe University	Turkish	Original Research
Baysal-Canyurt M., Aybala-Oktay E., Aydın N., Karaoğlanoğlu S.	Turkiye Clinics Journal of Dental Sciences	2022	0	University of Health Sciences	Turkish	Original Research

Altun B., Öz F.D., Bolay Ş.	Turkiye Clinics Journal of Dental Sciences	2022	0	Etimesgut Oral and Dental Health Hospital, Hacettepe University	English	Original Research
Cabadağ Ö.G., Misilli T.	Turkiye Clinics Journal of Dental Sciences	2022	0	Pamukkale University, Canakkale On Sekiz Mart University	English	Original Research
Lukarcanin J., Sadıkoğlu I. S., Turkun S., Turkun M.	Journal of Ege University Faculty of Dentistry	2022	0	Private Practitioner, Lefke Europe University, Ege University	English	Original Research
Durukan S.M., Gümüştaş B., Sismanoglu S.	International Dental Research	2022	0	Altınbas University, Cerrahpasa University	English	Original Research
Batmaz S.G., Susgun-Yildirim Z.	Turkiye Clinics Journal of Dental Sciences	2022	0	Cukurova University	Turkish	Original Research
Buyukgoze-Dindar M., Tekbas-Atay M.	International Dental Research	2022	0	Trakya University	English	Original Research
Aisa A., Bala O., Akgul S.	Journal of Ege University Faculty of Dentistry	2022	0	Gazi University	English	Original Research
Athira P., Dhanapal P., Kottoor J., Sagır M., Babu B.P.	Turkish Endodontic Journal	2022	0	Foreign Institution	English	Original Research
Moosavi H., Rezaee F., Afshari S., Sekandari S., Ahrari F.	Cumhuriyet Dental Journal	2022	0	Foreign Institution	English	Original Research
Bilgili D., Ozarslan M.	Cumhuriyet Dental Journal	2022	0	Van Yuzuncu Yil University, Akdeniz University	English	Original Research
Murrja E., Herguner-Siso Ş., Aydemir M., Ozturk H.N.	Cumhuriyet Dental Journal	2022	0	Istanbul Aydın University	English	Original Research
Kaya S., Ozel-Bektas O.	Cumhuriyet Dental Journal	2022	0	Antalya Bilim University, Cumhuriyet University	English	Original Research
Eyupoglu G.B., Serin-Kalay T.	Cumhuriyet Dental Journal	2022	0	Karadeniz Technical University	English	Original Research
Deniz Ş.B., Oğlakçı B., Elizguzeloglu-Dalkılıç E.	Acta Odontologica Turcica	2022	0	Marmara University, Bezmialem University	Turkish	Original Research
Berkman M., Altuntaş E., Tuncer S., Karabay F., Demirci M., Tekçe N.	Cumhuriyet Dental Journal	2022	1	Bahcesehir University, Marmara University, Istanbul University, Kocaeli University	English	Original Research
Kolus T., Tutku-Celik A.C., Ulker H.E.	Journal of Ege University Faculty of Dentistry	2022	0	Karamanoglu Mehmetbey University, Yeni Yuzyıl University, Selçuk University	Turkish	Original Research
Tonga G., Hatırlı H., Şirin-Karaarslan E.	Turkiye Clinics Journal of Dental Sciences	2022	0	Tokat Gaziosmanpasa University	Turkish	Original Research
Gonder H.Y., Elmacı İ., Karaköy H.	Journal of Necmettin Erbakan University Faculty of Dentistry	2022	1	Necmettin Erbakan University	Turkish	Original Research
Yıldız-Telatar G., Atıcı-Bedir M.G., Bedir F.	Current Research in Dental Sciences	2022	0	Recep Tayyip Erdogan University	Turkish	Original Research
Yıldırım-Bilmez Z., Seker O., Kose H.D., Gozuyesıl-Aslan B.*	International Dental Research	2021	4	Hatay Mustafa Kemal University	English	Original Research
Gurses M., Tagtekin D., Yanıkoglu F.	Selcuk Dental Journal	2021	0	Selcuk University, Marmara University	Turkish	Original Research
Fidan M., Dereli Z.	Selcuk Dental Journal	2021	0	Necmettin Erbakan University	Turkish	Original Research
Tutku-Celik A.C., Kolus T.	Selcuk Dental Journal	2021	0	Karamanoglu Mehmetbey University	Turkish	Original Research
Kaynar Z.B., Dogan T., Donmez N., Kazak M.	Journal of Dental Faculty of Ataturk University	2021	0	Okan University, Bezmialem University, Bahçeşehir University	Turkish	Original Research

Hatırlı H., Kılınç E., Şirin-Karaarslan E.	Journal of Dental Faculty of Ataturk University	2021	1	Tokat Gaziosmanpasa University	Turkish	Original Research
Fidan M., Dereli Z.	Selcuk Dental Journal	2021	0	Necmettin Erbakan University	Turkish	Review Article
Ozan G., Mert-Eren M., Vatansever C.	Selcuk Dental Journal	2021	0	Istanbul University, Altınbas University	English	Original Research
Atalay C., Uslu-Tekce A., Meral E., Yazıcı A.R., Ertan A.A.	Selcuk Dental Journal	2021	0	Hacettepe University	Turkish	Original Research
Yılmaz-Savas T., Savas A., Tuncdemir A.R.	Selcuk Dental Journal	2021	0	Selçuk University	Turkish	Original Research
Dayı B., Sezlev-Bilecen D., Eroksuz H., Yalçın M., Hasırcı V.	European Oral Research	2021	2	Inonu University, Konya Agriculture and Food University, Fırat University, Private Practitioner, Middle East Technical University	English	Original Research
Yılmaz N.A., Yavaşer R., Karagozler A.A.	Journal of Ege University Faculty of Dentistry	2021	0	Aydın Adnan Menderes University	Turkish	Original Research
Cilingir A., Mert-Eren M., Dikmen B., Gurbuz O., Ozsoy A.	Turkiye Clinics Journal of Dental Sciences	2021	0	Trakya University, Altınbas University, Istanbul Medipol University	Turkish	Original Research
Serinsoz F., Ertas E., Guler E.	Turkiye Clinics Journal of Dental Sciences	2021	0	Private Practitioner, Ondokuz Mayıs University	Turkish	Original Research
Turkyılmaz G., Tuncer T.N., Aytac-Bal F.	Turkiye Clinics Journal of Dental Sciences	2021	1	Abant İzzet Baysal University, Beykent University	Turkish	Original Research
Tastan E., Guler E., Aytac-Bal F.	Turkiye Clinics Journal of Dental Sciences	2021	0	Private Practitioner, Ondokuz Mayıs University, Beykent University	Turkish	Original Research
Dursun M.N., Atalay C.	Journal of Atatürk University Faculty of Dentistry	2021	0	Fırat University, Hacettepe University	Turkish	Original Research
Cabadag O.G., Misilli T., Gonulo N.	Selcuk Dental Journal	2021	3	Pamukkale University, Canakkale On Sekiz Mart University, Ondokuz Mayıs University	Turkish	Original Research
Azih N.F., Maqbool M., Halim M.S., Ab-Gnahi Z., Noorani T.	Cumhuriyet Dental Journal	2021	0	Foreign Institution	English	Original Research

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Discussion

Orthodontics primarily deals with correcting teeth alignment and bite issues.[10] The straightening and proper alignment of teeth, achieved through orthodontic treatments like braces or clear aligners, significantly enhance the aesthetic appearance of a person's smile.[40,41] This improvement in appearance is a primary concern of aesthetic dentistry as well. Orthodontic treatments can reduce the need for more invasive aesthetic procedures by correcting the natural teeth's position and bite. Properly aligned teeth are easier to clean, reducing the risk of decay and gum disease, which can have aesthetic implications like staining and tooth loss. In many cases, a comprehensive treatment plan will include both orthodontic and aesthetic/conservative procedures.[1,41] Both orthodontics and aesthetic dental treatments significantly contribute to improving a patient's self-esteem and confidence by enhancing their smile. Orthodontics and aesthetic and conservative dental treatments are closely related in their goals to enhance oral health, function, and appearance. They often work hand in hand, where orthodontics lays the groundwork for aesthetic procedures, and both contribute to a patient's overall dental well-being and self-confidence.[1,40–42] For this reason, current studies from the last three years in the field of orthodontics and aesthetic and conservative treatment were evaluated together in our study.

In-vitro studies are conducted in a laboratory setting where researchers can precisely control the experimental conditions.[43] This allows for the isolation and study of specific variables without the interference of external factors. Due to the controlled conditions, *in-vitro* studies can be replicated easily, allowing for the verification and validation of results.[43] They enable quick assessment of outcomes. Unlike *in-vivo* studies that may take months or years to yield results, *in-vitro* studies can provide insights in a shorter period. They allow for the initial assessment of the safety and efficacy of new treatments and materials

before progressing to *in-vivo* or clinical trials. Conducting *in-vitro* studies is generally less expensive than clinical trials, making preliminary research more accessible and feasible. As they do not involve live human or animal subjects, *in-vitro* studies bypass many ethical concerns and regulatory hurdles associated with clinical trials.[24]

In this investigation, we examined the *in-vitro* studies included in the TR Index for these specific reasons. According to the results of the study, the branches of dentistry that performed the most *in-vitro* studies were aesthetic and restorative treatment (48), endodontics (35) and prosthodontics (28), while oral diagnosis and radiology (1) and oral and maxillofacial surgery (4) were indicated a lower frequency of *in-vitro* research. These results may indicate that areas of dentistry where a wider variety of materials are used place more emphasis on *in-vitro* studies. Furthermore, it can be inferred that there is a need for an increase in *in-vitro* investigations in the field of orthodontics, as the range of materials being utilized continues to expand daily.

When the results of our study are analyzed, it is seen that most of the studies included in the article relate to shear bond strength. The focus on shear bond strength in orthodontic research underscores its key role in treatment efficacy and safety, highlighting its importance in the durability of orthodontic bonding materials.[44] This emphasis supports the orthodontic field's goal to refine adhesives that withstand treatment stresses without harming tooth structure.[45] It also drives material innovation and suggests expanding research to include patient comfort, enamel health, and new technologies.[46] However, broadening research beyond shear bond strength could offer a fuller view of treatment impacts and advancements in orthodontics.

National bibliometric studies offer advantages for both the examination of existing research and the collection of demographic information. Assessing the scientific efficacy of a researcher or institution can be accomplished by gaining access to a national database.[33,36,47] In this study, because of the publications examined in TR Index, it was seen that the most *in-vitro* publications in the field of orthodontics and aesthetic and conservative treatment were made in 2021 (n = 22) and 2022 (n = 24). The coronavirus disease 2019 pandemic-induced stay-at-home measures are believed to have had a beneficial impact on academic productivity, particularly in the realm of laboratory investigations.[48,49] The most *in-vitro* publications were in Turkiye Clinics Journal of Dental Sciences (n = 13), Cumhuriyet Dental Journal (n = 8) and Selcuk Dental Journal (n = 8). These journals are believed to be more favored by scholars due to their effectiveness in promoting academic accomplishment, facilitating article review, and shortening publication processes.

It is important to address how editorship gatekeeping and insider bias may be connected to broader issues such as nepotism, power dynamics, and academic inbreeding.[39] So that it is essential to ensuring that publication practices remain fair and transparent, as biased practices can distort the scientific record and hinder the advancement of knowledge.[39] However, since the authors selected journals considering the scope of the published research, this may have contributed to the higher concentration of *in-vitro* titled studies in certain journals.

When the number of citations was evaluated, the year with the highest number of cited publication (number of citations = 11) was determined as 2021. The study conducted by Recen et al. in the field of orthodontics garnered a total of 11 citations and European Oral research, where this study was published, was the journal with the highest number of cited publications. Despite the belief that publishing the paper in English would enhance accessibility, no significant difference was observed in the number of citations between Turkish and English articles. Based on our research, we determined a low number of citations for publications focused on *in-vitro* investigations. Nevertheless, our analysis was limited to research published during the past 3 years. Therefore, we expect a rise in the number of citations in the future as other studies in the same subject are included into the existing literature. Upon analyzing the distribution of researchers based on institutes, it became evident that the majority of researchers originated from foreign institutes. This may be due to the fact that in studies conducted in a foreign country, a large number of researchers are together in one study. However, upon analyzing national research, it becomes evident that there are a maximum of five writers each study.

Online sites are highly efficient for gathering extensive publication data. Nevertheless, it is imperative to exercise caution while choosing the source. Google Scholar is a convenient and efficient tool for evaluation, as it provides a superior means of locating papers and is very accessible.[50,51] Nevertheless, it is organized in a manner that includes details about the author, irrespective of their affiliation with an organization. Hence, Google Scholar fails to generate precise metadata. The present study involved conducting research using the TR Index national database and evaluating the information from the articles.

Since our work includes up-to-date data and there is a lack of research in this particular area, it is anticipated to be valuable for researchers and eligible for inclusion in TR indexed journals. While there have been bibliometric studies investigating the TR Index articles, we have not discovered any study in the literature that specifically focuses on the keywords used in our analysis. This attribute makes our study unique.

This study has some limitations. Bibliometric studies involve analyzing a minimum of 100 publications or studies released over a span of at least 10 years. These studies summarize extensive bibliometric data to reveal the structure of academic activity and identify developing patterns within a specific study topic or field.[33,36,47] Although the number of data is more limited for the present study, this study examines studies in two different fields of dentistry, orthodontics and aesthetic and conservative treatment. Hence, further investigations may incorporate more extensive data. Also, it's important to note that bibliometric analysis should be used

cautiously and in conjunction with qualitative assessments. Our analysis exclusively focused on studies whose titles contained the term '*in-vitro*'. Nevertheless, this study did not encompass *in-vitro* investigations conducted in the field of orthodontics, aesthetic and conservative treatment, and other domains of dentistry. Hence, it may be asserted that not all *in-vitro* investigations in the TR Index could be assessed. For future research, a more comprehensive investigation can be designed by finding *in-vitro* studies that are focused on the most used keywords.

Conclusions

In-vitro studies are essential in advancing dental research, particularly in orthodontics and aesthetic and conservative dentistry. Evaluating and promoting '*in-vitro*' titled studies in TR Index journals can help enhance the visibility and importance of national research in dentistry. Despite the limitations of our study, the findings contribute to a better understanding of research trends in Turkish dentistry journals and highlight areas for further exploration.

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Three-Dimensional Analysis of Age and Eichner Index-Related Volumetric Changes in Mandibular Condyles

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ABSTRACT

Introduction: The impact of condyle volume is influenced by the presence of posterior occlusal support and age. This study aimed to retrospectively explore how age, Eichner index, and gender influence condyle volume in three dimensions, through the classification of occlusal support using the Eichner index.

Material and Methods: Cone-beam computed tomography (CBCT) images of 232 patients (107 males and 125 females) aged 18-76 years were retrospectively analysed. ITK-SNAP open-source software was utilized to measure volume of condyles with semi-automated segmentation. CBCT images were analyzed based on age, gender, and the status of posterior occlusal support. Posterior occlusal support status was assessed by categorizing it into three groups according to the Eichner index: A) indicating no loss of posterior occlusal support; B) representing one to three units of occlusal support loss; and C) denoting four units of posterior occlusal support loss. For normality, Kolmogorov Smirnov test was performed and Pearson test was used to determine the correlations of continuous variables. Student's t test was used to investigate the difference between age and gender, and paired t test was used to evaluate the difference between left and right volume. $P < 0.05$ was considered significant.

Results: There was no statistically significant difference between the mean right and left condyle volume ($p>0.05$). The mean condyle volume was higher in males than females, but this difference was not statistically significant ($p>0.05$). A statistically significant negative correlation was detected between age and condyle volume ($p<0.05$). Age and Eichner index were statistically significantly positively correlated ($p<0.05$). A statistically significant negative correlation was determined between condyle volume and Eichner index ($p<0.05$).

Conclusion: Volumetric measurement of the condyles using CBCT and comparison with Eichner index is crucial to assess abnormalities and bony changes affecting the TMJ in association with occlusal support and to examine and prevent complications. Although it was found that the condyle volume decreased significantly with increasing age and decreasing occlusal support, no significant difference was revealed between genders in the present study.

Keywords: Condyle volume, semi-automated segmentation, posterior occlusal support, Eichner index, cone-beam computed tomography.

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Introduction

The condyle is an essential region of temporomandibular joint (TMJ) and mandible's primary growth centre and is capable of multi-directional growth and remodelling. In this way, which can response to continual stresses through bone remodelling and influence the size of mandible in adults.[1] During the process of abnormal TMJ loading or sustainable physical stress exceeds adaptive ability, alterations in mandibular bone occur for non-functional remodelling. Advancing age and functional changes cause morphologic and histologic differentiation in the TMJ.[2,3] Significant effects on mandibular growth and development are observed due to changes in adult masticatory function. These include reconfiguration of the articular elements in TMJ, alterations in position between articular disc and mandibular condyle, contributions from parafunctional habits, and changes in occlusion.[1,3] Decreased mandibular growth may produce some changes such as condylar volume, ramus height and retrusion of the mandible. Condylar volume alterations may be mostly detected with arthritis, asymmetry, anterior disc displacement and decreased masticatory function as a result of tooth loss.[2,4]

The maximum bite force, an essential indicator in the assessment of masticatory muscles, correlates with muscle cross-sectional area.[5] Occlusal force is greatly affected by the declining frequency of natural teeth in mouth; therefore, patients with artificial dentition have been shown to have less masticatory muscle strength.[6,7]

The Eichner index is one of the most extensively used dental indices in epidemiological studies and is most effective

in establishing intermaxillary contacts and enhancing functional dental occlusion. In this index, posterior teeth are categorised according to the presence or absence of occlusal contact between premolars and molars.[8,9] There are many studies supporting the interpretation of masticatory ability with Eichner index and confirming that occlusal force is reduced more in the group with reduced occlusal support. The classification of occlusal supports was performed according to the Eichner index.[10,11] The Eichner index divides molar teeth into four support areas.[12]

Numerous diagnostic imaging techniques are available to evaluate TMJ structures. Furthermore, cone-beam computed tomography (CBCT) is is preferable three-dimensional (3D) imaging technique for optimal visualization of bony components, which is partially cost-effective, low radiation and short acquisition time.[13-15]

In the current study, ITK-SNAP version 4.0.2 (Penn Image Computing and Science Laboratory), which processes 3D models with manual and semi-automated segmentation, was used to perform condylar volume measurement.[15,16]

The purpose of this study was to restrospectively investigate the effect of age, Eichner index and gender on mandibular condyle volume by classifying the effects of masticatory force according to the Eichner index using CBCT.

Materials and Methods

Ethical approval was provided from Clinical Research Ethics Committee prior to commencement of the study (Protocol No: 2024/76). The images used in the present study were acquired between 2022 and 2024 at the Department of Dentomaxillofacial Radiology, Lokman Hekim University Faculty of Dentistry, using a NewTom VGi EVO (QR, Verona, Italy) CBCT device. Images were from the tomography archive and asymptomatic patients who underwent CBCT examination for various indications were selected. Multiplanar images were acquired from 12x8, 15x12, 16x16, 17x19 and 24x19 FOV (field of view) with a voxel size of 0.3 mm^3 and a slice thickness of 1 mm. Inclusion criteria for this study were CBCT scans obtained from patients aged 18-76 years between 2020 and 2022. Exclusion criteria included patients with syndromes or facial growth disorders, presence of distortion, magnification, artifacts or foreign bodies in the study area on CBCT images, metabolic bone diseases, cysts, tumors or fracture lines in the study area, trauma and odontogenic infections in the maxillofacial region. CBCT images of 232 patients (107 males and 125 females) aged 18-76 years (mean age: 44.12±16.01) were retrospectively assessed.

Classification According to the Eichner Index

The CBCT images included in the study were classified according to the Eichner index regarding the condition of the posterior occlusal supports. The Eichner index categorises the molars into four support areas and classifies them as follows:[10-12]

A1) Four support zones are present and there are no missing teeth.
A2) Four support areas are present, but there is a missing tooth on one side of the jaw.
A3) Four support areas present, but missing teeth on both sides.
B1) The patient has sufficient number of support teeth to form three support areas.
B2) The patient has enough support teeth to form two support areas.
B3) The patient has a number of support teeth sufficient to create only one support area.
B4) Only anterior contact is present, no support area in the molar region.
C1) There is at least one tooth without a support area in both mandible and maxilla.
C2) There is at least one tooth in the mandible or maxilla without a support area.
C3) Complete edentulism prevails on both sides of the jaw.

Condylar 3D Reconstruction and Volume Measurement

ITK-SNAP (Penn Image Computing and Science Laboratory) open source software was used to measure the volume of the mandibular condyles. CBCT DICOM datasets were transmitted into ITK-SNAP and visualized in coronal, sagittal and axial slices. Mandibular condyles were characterized by semi-automatic segmentation (Figure 1). Afterward, manual segmentation was conducted to ensure precision. The superior and inferior borders of condyle volumes were identified in coronal, sagittal, and axial views. The disappearance of the sigmoid notch marked the recognition of the inferior border. The region where the area of the coronal portion increased, rather than declined, marked the onset of sigmoid area. Consequently, mandibular condyle could be dimensioned using the standard method without incorporating sigmoid area. This was in agreement with Bayram *et al.*[17], Safi *et al*.[1] and Tecco *et al.*[18]. The volume of mandibular condyles was automatically measured by program in cubic millimeters. The volume of each condylar side was measured separately.

The data obtained were recorded as age, gender and posterior occlusal support. Posterior occlusal support status was splited into three categories according to Eichner index (A: no loss of posterior occlusal support; B: one to three units of occlusal support loss; C: four units of posterior occlusal support loss) (Figure 2).[12,19]

All assessments were conducted by two dentomaxillofacial radiologists, one with five years of experience (EMAO) and the other with seven years of experience (AA). To ensure inter-observer and intra-observer calibration and reliability of the evaluations, 20% of the images were reviewed by the same observers two weeks after the initial assessment. The mean of the results from the initial and subsequent measurements was then utilized for statistical analysis.

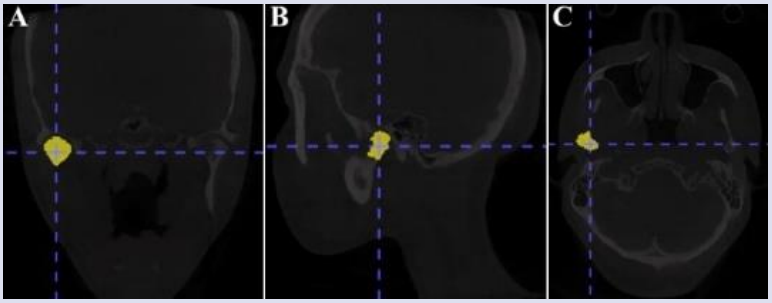

Figure 1: The volumetric analysis performed using ITK-SNAP software is demonstrated in CBCT image; A. Coronal section, B. Sagittal section, C. Axial section.

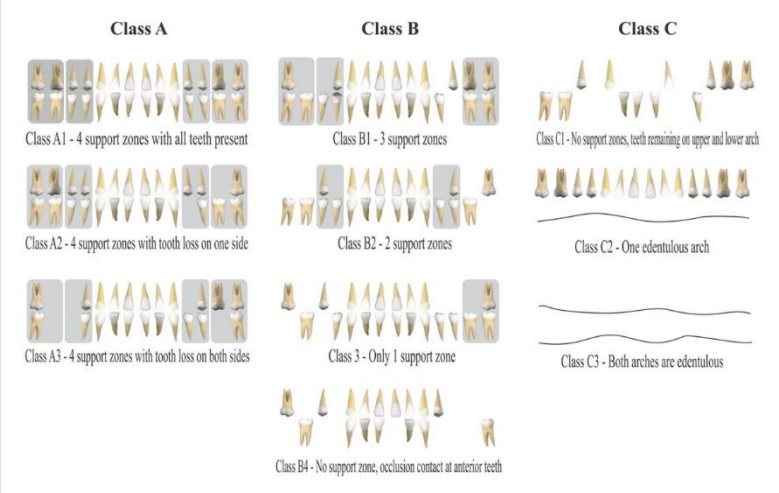

Figure 2: Eichner index classification; A1) four support areas, no missing teeth; A2) four support areas, missing teeth on one side of the jaw; A3) four support areas, missing teeth on both sides of the jaw. B1) three support areas; B2) two support areas; B3) one support area; B4) only anterior contact; no tooth support in the molar region. C1) at least one tooth without support area in mandible and maxilla; C2) at least one tooth without support area in mandible or maxilla, C3) complete edentulism on both sides of the jaw.

Statistical analysis

The normality of the study group's data was assessed using the Kolmogorov-Smirnov test, confirming a normal distribution. Correlations among continuous variables were assessed using Pearson test, whereas differences based on age and gender were analyzed using Student's t-test. Furthermore, Paired t-test was employed to compare the left and right sides of the TMJ. A significance level of $p < 0.05$ was set. All statistical analyses were performed using SPSS Statistics 29.0 (IBM Corp, Armonk, NY).

Results

We observed a strong correlation (0.87-0.92) among all repeated measurements, suggesting reliable intra- and inter-observer consistency in the assessments. The mean volume of the right condyle was 1520.6 ± 409.7 mm^3, and for the left condyle, it was 1492.5 ± 412.7 mm^3. There was no statistically significant difference between the mean volumes of the right and left condyles ($p>0.05$). The comparison of condyle volumes between males and females is presented in Table 1. Although the mean condyle volume was higher in males compared to females, this difference was not statistically significant ($p>0.05$). Eichner index distribution of the patients was 44.8% in group A, 33.6% in group B and 21.6% in group C. While a significant difference was detected between Eichner index and age and condyle volumes, no statistically significant relationship was found with gender. A statistically significant negative correlation was observed between age and condyle volume ($p<0.05$). Age and Eichner index had a statistically significant positive correlation ($p<0.05$). A statistically significant negative correlation was observed between condyle volume and Eichner index ($p<0.05$). Correlations between variables are shown in Table 2.

Table 1. The comparison of condyle volumes between males and females is demonstrated.

	Female (n=125)		Male (n=107)	
Volume (mm^3)	**Right**	**Left**	**Right**	**Left**
Mean±S.D.	1493.1±386.7	1497.7±401.8	1552.8±434.6	1486.5±426.9
Min.-Max.	814-2373	751-2331	827-2586	689-2664

S.D.: Standard Deviation, Min.: Minimum, Max.: Maximum

Table 2. Correlations between variables are displayed

	Pearson Correlation-P			
	Age	**Left Condyle Volume**	**Right Condyle Volume**	**Eichner index**
Age	------	-0,820 - p<0.001	-0,853 - p<0.001	0.816 - p<0.001
Left Condyle Volume	-0,820 - p<0.001	------	0,901- p<0.001	-0,824 - p<0.001
Right Condyle Volume	-0,853 - p<0.001	0,901- p<0.001	------	-0,837- p<0.001
Eichner index	0.816 - p<0.001	-0,824 - p<0.001	-0,837- p<0.001	------

P < 0.05

Discussion

Physiologic and pathologic changes as a result of changing mechanical and functional forces cause life-long remodeling processes thanks to the adaptability of the bone and soft tissue structures of the TMJ.[1,20,21] Changes in the number of teeth with age and changes in masticatory function may cause changes in the morphologic and histologic structure as well as volume of condyle.[20-22] Alexiou *et al.*[23] have reported that the degree of bone changes in the mandibular condyle progressively increases with age. In the present study, we concluded that condyle volume decreases with age and that edentulism is associated with a decrease in condyle volume.

Radiologic examination of TMJ and condyle anatomy is important for investigating TMJ anatomical morphology in the identification and therapeutic planned treatment of TMJ diseases.[13] CBCT is an important imaging tool widely used for the evaluation of the condyles, involves a lower radiation dose than computed tomography (CT) and provides images in a relatively short time.[13,24] Several studies have been performed on CBCT to establish segmentation of condyles.[1,14,15,17] Various techniques are employed to obtain volumetric data of regions of interest. In this study, we utilized semi-automated segmentation of mandibular condyles with the open-access software ITK-SNAP. Semi-automated segmentation merges the efficiency and consistency of automated segmentation with the ability to manually designate the region of interest, thereby reducing user-dependent errors and saving time.[25,26] Semi-automatic segmentation was chosen in this study due to the fact that it integrates automated and manual segmentation of the regions of interest. Semi-automatic segmentation is guided by the user and has an crucial role in the precise assessment of the volume measured.

Bayram *et al.*[17] performed volume measurement of the mandibular condyle using the Cavalieri principle on CBCT images of 5 dry mandibles. Safi *et al.*[1] measured the condyle volume from CBCT images of 195 patients using ITK SNAP software (Penn Image Computing and Science Laboratory). Şallı *et al.*[15] utilized CBCT images of 345 patients and measured the condyle volume with ITK SNAP software. Tecco *et al.*[18] used Mimics 9.0 software (Materialise NV Technologielaan, Leuven, Belgium) to measure condylar volume and surface on CBCT images of 150 Caucasian young adults. Serindere *et al.*[14] performed volume and surface area measurements on CT images of 125 patients using InVesalius software (CTI, Campinas, SãoPaulo, Brazil). In the current study, the condyle volume of 232 patients was analyzed using CBCT and ITK SNAP software similar to Safi *et al.*[1] and Şallı *et al.*[15].

Bayram *et al.*[17] reported that the mean condyles volume varied between 1378 and 2877 mm^3 in their study. Saccuci *et al.* [6] analysed the mandibular condyle volumes of 200 young patients aged 15 to 29 years and found that the mean right and left condyle volumes were 2464-2606 mm^3, respectively. Safi *et al.*[1] detected the mean right condyle volume as 2326 and the mean left condyle volume as 1982 mm^3 in 107 young patients aged 18-25 years; the mean right condyle volume as 2324 and the mean left condyle volume as 2227 mm^3 in 88 patients aged 46-55 years. Şallı *et al.*[15] observed the mean right and left condyle volume of 84 young patients aged 18-25 years as 1730.2-1754.6 mm^3, and the mean right and left condyle volume of 261 patients aged 45-70 years as 1703.6-1682.9 mm^3, respectively. Serindere *et al.*[14] found that the mean right and left condyle volume was 1565-1557 mm^3 in 125 patients between 18-70 years of age. Tecco *et al.*[18] determined the mean right and left condyle volume as 693.6-666.9 mm^3 in 150 young individuals aged 15-29 years, respectively. Most of the studies in the literature focus exclusively on the young population. In their present study, the mean right and left condyle volumes in 232 patients aged 18-76 years were 1520.6-1492.5 mm^3, respectively. It is similar to the results of Serindere *et al.*[14] who had a similarly wide age range to the current study.

Tecco *et al.*[18], Safi *et al.*[1] and Saccucci *et al.*[6] reported that the volume of the right condyle was greater than that of the left, with statistically significant differences between the condylar volumes of the two sides. Conversely Şallı *et al.*[15], Liu *et al.*[27] and Serindere *et al.*[14] observed that although the volume of the right condyle was larger than the left, there was no statistically significant disparity between the two sides. Our study's

findings align with those of Şallı *et al.*[15], Liu *et al.*[27] and Serindere *et al.*[14] indicating a higher volume in the right condyle but no significant difference compared to the left. This variation in right and left condyle volumes across the literature is believed to stem from inherent asymmetry in human body structures and differences in chewing habits.[1,18]

There are studies showing that decreases in condylar bone volume and trabecular bone are observed in females, particularly in the postmenopausal period, with osteoporosis which develops due to estrogen deficiency.[18,27-29] Safi *et al.*[1] found that males exhibited significantly greater condyle volumes than females in both young and elderly age groups. It was concluded by Tecco *et al.*[18] that the difference between condyle volumes in males and females was statistically significant, with males having larger condyle volumes than females. In the study of Şallı *et al.*[15] condyle volumes were observed to be larger in male patients than in females. In the study of Serindere *et al.*[14] condyle volume was significantly higher in males than in females. In comparison to the literature, condyle volume was higher in males than females in this study, however this difference was not statistically significant contrary to the literature.

Although numerous studies have investigated age-related morphological and morphometric alterations in TMJ, there remains contention surrounding the direct correlation between remodeling and age.[1,23]Alexiou *et al.*[23] suggested that the extent of bony changes in the mandibular condyle escalates with advancing age. Safi *et al.*[1] observed that condyle volume of the older group was lower than the younger group, however, this difference was not statistically significant. Şallı *et al.*[15] found that condyle volume of the elderly group was lower than the younger group, but this did not constitute a significant difference. Serindere *et al.*[14] concluded that condyle volume decreased with increasing age and this resulted in a statistically significant difference. In concordance with the literature, in our study, it was detected that condyle volume showed a negative and significant correlation with age.

Cartilage growth of the mandibular condyle and mandibular morphology are affected by mastication.[6,18,30] Loss of occlusal support leads to a decrease in masticatory function and thus to a change in mechanical forces. Moreover, loss of occlusal support can be the reason for bony changes in condyle.[18,30] Previous research has indicated that the most important morphological changes in TMJ structures are associated with conditions involving early occlusal contacts and tooth loss.[18] Loss of posterior teeth constitutes a significant etiological factor in functional alterations of the stomatognathic system.[18,31] In the current study, the tooth support status of our study group was classified according to the Eichner index, a classification system based on the occlusal support of natural posterior teeth. In the findings of Safi *et al.*[1], Ahmed *et al.*[31] and Şallı *et al.*[15], there was no correlation between Eichner index and condylar volume. In contrary to the literature, a statistically significant difference was determined between posterior occlusal support and condylar volume on both sides in this study.

In the literature, the relationship between orthodontic anomalies and condylar volume has been evaluated; *Saccucci et al.*[32] investigated the condylar volumes of skeletal S1, S2 and S3 patients with healthy TMJ using CBCT; a larger condylar volume was observed in skeletal class III subjects than in skeletal class II and skeletal class I subjects. In the study of *Ceratti et al.*[33] comparing vertical growth pattern and condylar volume changes, it was determined that individuals with hyperdivergence had relatively larger condylar volumes than those with hypodivergence. Similarly, smaller condyles were detected in individuals with increased total gonial angles showing post-rotation growth pattern compared to individuals with horizontal growth pattern in which total gonial angle was larger. There are also studies showing that TMJ morphology has a strong correlation with skeletal morphology.[5] It is known that there are differences in the force vector against the condyle during mastication in different individuals.

Changes in the shape and severity of orthodontic anomalies are likely to result in imbalances in masticatory force and differences in the force to the condyle.[32,34] The evaluation of the three-dimensional structure of the condyle head allows us to have clinical information about how force distributions should be made in the planning of orthodontic and orthognathic surgical treatments.

The decrease in condylar volume that occurs with age is particularly important in trauma, surgical interventions to the maxillofacial region and TMJ in elderly patients. Furthermore, we consider that the rehabilitation of mastication with the replacement of missing teeth can prevent this volume loss and minimise the complications that may occur in elderly patients.

There are several limitations of this study. Magnetic resonance imaging (MRI) is the ultimate method for examining the TMJ and diagnosing TMJ diseases; it acquires multiple static images in series, providing excellent routine static images.[35,36] It also allows analysis of disc position and condyle movement during the dynamic process of mouth opening and closing.[35,36] Additionally, the current clinical symptoms of the patients regarding TMJ are not known since this is a retrospective study, and the changes occurring on the MRI have not been reviewed. The changes in the TMJ of the patients before and after edentulism could not be investigated in the study. Further studies in larger populations are needed to include patients' systemic diseases and examine their effects on volumetric change, to evaluate the clinical symptoms occurring in the TMJ, and to analyze the changes that occur after masticatory rehabilitation.

Conclusions

Whereas significant differences were found between age, condyle volume and Eichner index, no significant difference was found between genders, in spite of the volumetric difference observed. Volumetric measurement of the mandibular condyles and their analysis in

comparison with the Eichner index is an important feature derived from CBCT to assess abnormalities and bony changes affecting the TMJ in relation to occlusal support and to examine and prevent complications. Relying on CBCT images, ITK-SNAP software has enabled substantial and beneficial segmentation methods to assess condyle volumes in three dimensions.

Conflict of Interest

There were no conflict of interest.

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Ethics

Human and animal rights statement All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

Ethical Statement

Ethical approval was obtained from Lokman Hekim University Non-interventional Clinical Research Ethics Committee (Protocol No: 2024/76).

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Investigation of Cytotoxic Effects and Antimicrobial Activities of Light-cured and Self-cured Universal Adhesive Systems

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Research Article

History

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ABSTRACT

Introduction: This study aimed to compare the cytotoxicity and antimicrobial activity of a light-cured adhesive system and a self-cured adhesive system from the same company.

Materials and Methods: A Tokuyama BOND force II (Light-cured) adhesive system (TF2B) and a Tokuyama Universal Bond (Self-cured) adhesive system (TUB) were selected for the study. The cytotoxicity evaluation of these two systems on cell cultures was performed using MTT assay and Agar Diffusion assay in L929 fibroblast cells. Disk diffusion method and broth microdilution (MIC) method were used to evaluate their antimicrobial activity. The experiments were performed on 6 pathogenic bacteria and 1 yeast fungus.

Results: According to MTT test results, both adhesive systems have no significant toxic effect on healthy cells (L929). However, when TUB and TF2B were compared with each other, it was found that TF2B had almost no toxic effect. In the agar diffusion test, when the two bonds were compared with each other, a weak color lightening was observed only around the first concentration of TUB. No visible melting was detected in other concentrations of TUB and TF2B. Both adhesive systems failed to reach MIC values effectively on the test microorganisms. Since the results were far above the MIC values of the reference antibiotics, it was determined that they did not have antimicrobial effects. Disk diffusion results similarly showed that both bonds did not form an inhibition zone on the test microorganisms.

Conclusions: In dentistry, cytotoxic effects of universal adhesive systems on living cells can be observed. Self-cured and Light-cured adhesive systems did not show toxic effects on L929 cells. In addition, antimicrobial effects on test microorganisms were not detected. The cytotoxicity of the materials can be tested on different cells.

Keywords: Universal Adhesive Systems, Cytotoxicity, Antimicrobial.

Light-cured ve Self-cured Üniversal Yapıştırıcı Sistemlerinin Sitotoksik Etkilerinin ve Antimikrobiyal Aktivitelerinin Araştırılması

Research Article

Süreç

Geliş: 16/07/2024
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ÖZ

Amaç: Bu çalışmanın amacı, aynı firmaya ait light-cured adeziv sistem ile bir self-cured adeziv sistemin toksisitelerinin karşılaştırılması ve antimikrobiyal etkinliklerininin incelenmektir.

Gereç ve Yöntem: Çalışmada bir Tokuyama BOND force II (Light-cured) adeziv sistem (TF2B) ve bir Tokuyama Universal Bond (Self-cured) adeziv sistem (TUB) seçilmiştir. Bu iki sistemin hücre kültürleri üzerinde sitotoksisite değerlendirilmesi L929 fibroblast hücrelerinde MTT testi ve Agar Difüzyon testi kullanılarak gerçekleştirildi. Antimikrobiyal etkinliklerinin değerlendirilmesi amacıyla disk difüzyon yöntemi ile sıvı mikrodilüsyon (MIC) yöntemi kullanılmıştır. Deneyler 6 patojen bakteri ve 1 maya mantarı üzerinde gerçekleştirilmiştir.

Sonuçlar: MTT testi sonuçlarına göre sağlıklı hücreler üzerine (L929) her iki adeziv systemin de belirgin bir toksik etkisi yoktur. Ancak TUB ve TF2B birbirleri ile kıyaslandığında TF2B' nin hemen hemen hiç toksik etkisinin bulunmadığı tespit edilmiştir. Agar difüzyon testinde ise iki bond birbiriyle karşılaştırıldığında ise TUB'un sadece ilk konsantrasyonunun etrafında zayıf bir renk açıklığı görülmektedir. TUB ve TF2B'nin diğer konsantrasyonlarında ise gözle görülebilir bir erime tespit edilememiştir. Adeziv sistemlerin her ikisi de test mikroorganizmaları üzerinde etkili MIC değerlerine ulaşamamıştır. Referans antibiyotiklerin MIC değerlerinin çok üstünde sonuçlar elde edildiği için antimikrobiyal etkilerini bulunmadığı tespit edilmiştir. Disk difüzyon sonuçları da benzer şekilde her iki bondun da test mikroorganizmaları üzerinde inhibisyon zonu oluşturmadığını göstermiştir.

Öneriler: Diş hekimliğinde, üniversal adeziv sistemlerin canlı hücrelere sitotoksik etkileri gözlenebilir. Self-cured ve Light-cured adeziv sistemleri L929 hücreleri üzerine toksik etki göstermemiştir. Ayrıca test mikroorganizmaları üzerinde antimikrobiyal etkileri tespit edilmemiştir. Adeziv sistemlerin sitotoksisitesi farklı hücreler üzerinde de test edilebilir.

Anahtar Kelimeler: Üniversal Adeziv Sistemler, Sitotoksisite, Antimikrobiyal.

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Introduction

Today, the increasing importance given to aesthetics and the increasing awareness of human health provide physicians with a more sensitive restoration. In light of these developments, a new resource is added to the literature every day with the studies of both clinicians and academicians on aesthetic materials. In adhesive dentistry, the effects on the durability, aesthetic properties, and toxicity of materials developed with new technologies compared to existing dental materials are investigated. In various studies in the literature, it has been determined that residual monomer is released during and after polymerization of adhesive systems.[1]

Since 2010, universal adhesives have been produced rapidly and in various forms.[2] The basic principle of universal adhesives, which can be used in three different modes, is to make a simpler application by including etch-rinse and self-etch adhesive systems. In the literature, there are different studies on the bonding of universal adhesives to dentin. Although adhesive systems are similar to each other in terms of the monomers they contain, universal adhesive systems are different from other adhesive systems with their monomers that can form chemical and micromechanical bonds.[3] Universal adhesives are known to contain monomers such as HEMA, Bis-GMA, UDMA and PENTA as well as biphenyl dimethacrylate (BPDM) and polyalkenioc acid. HEMA and UDMA, which are hydrophilic monomers, provide better resin infiltration, increase bond strength, and ensure adequate polymerization of the monomers. It is known that residual monomers released from adhesive agents that are not sufficiently polymerized can cause toxic effects. It has been reported that this can be prevented by adding hydrophobic monomers such as Bis-GMA and PENTA into the adhesive systems.[4]

LED light sources, which provide light at a wavelength of 455-486 nm, contain electrons in two separate conductors. This wavelength range is sufficient for the activation of initiators in resin-containing systems.[5] Easy to use and long-lasting, LED light sources do not require filters, unlike halogen light sources.[6]

In addition to having mechanical, physical, functional, and aesthetic properties, it is also very important that the materials produced in adhesive dentistry are biocompatible. Biocompatibility is the cariogenic effect of a material on living tissue after its application to living tissue.[7] Non-biocompatible materials can alter the functioning of metabolism during contact with tissue and cause cell death.[8] Studies on the harmful effects of dental materials in the literature are increasing due to the application of resin-based materials and newly developed treatments.[9]

The first document on the examination of biocompatibility of materials used in dentistry was reported by the American Dental Association (ADA) in 1926. The ADA, the International Dental Association (FDI) and the International Organization for Standardization (ISO) classified biocompatibility tests in three different methods by a joint declaration in 1982.[10] These tests are in-vitro tests (primary or primary tests), in-vivo animal tests (secondary tests) and usage tests. A declaration has been published by both national (TSE 8227) and international (ISO 10993) organizations to standardize these tests. This standardization specifies how samples should be prepared, how materials should be applied and which tests are appropriate.[11]

These tests, which are performed in culture dishes outside of a living organism, are based on material culture contact. The biocompatibility of the material tested in in-vitro tests is determined by the number, growth rate, and metabolic activity of the cells in contact with the material.[12] In-vitro tests are rapid, easy to standardize, and low-cost tests.

This study aimed to compare the toxicity and antimicrobial activity of a light-cured adhesive system and a self-cured adhesive system from the same company. Accordingly, cytotoxicity evaluation was performed on L929 mouse fibroblast cells and antimicrobial activities were performed on pathogenic gram positive and gram negative bacteria and yeast fungi.

Materials and Methods

One light-cured adhesive system and one self-cured adhesive system were selected for cytotoxicity evaluation on cell cultures (Table 1). In addition to these two different experimental groups, a positive control group containing only the L929 fibroblast cell line without any material, which was kept in the same cell culture medium as the groups, was added. The contents and manufacturers of the adhesive systems used are shown in Table 1.

Table 1. Chemical contents and manufacturers of the adhesive systems used

Adhesive systems	Components	Manufacturer	pH
Tokuyama Universal Bond (Self-cured)	Phosphoric acid monomer (3D-SR monomer), MTU-6 HEMA Bis-GEMA, TEGDMA, Acetone-MPTES Borate Peroxide Acetone, Isopropyl alcohol, water	Tokuyama Dental Corp (Kaliforniya, ABD)	2.2
Tokuyama BOND force II (Light-cured)	Self-reinforcing 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate), Bis-GMA, TEGDMA, HEMA, alcohol, water	Tokuyama Dental Corp (Kaliforniya, ABD)	2.8

Preparation of Samples

In order to obtain the cytotoxic values of the adhesive systems used; preparation of test samples, sterilization, preparation of cell culture and evaluation by MTT and Agar diffusion method were performed respectively. All procedures were evaluated using solid disc samples in accordance with ISO 10993-5 protocol to ensure standardization. Light-cured adhesive system (Tokuyama BOND force II) (TF2B) was applied to the surface with TF2B using a single applicator according to the manufacturer's protocol and waited for 10 seconds. Afterwards, it was polymerized with LED (Valo Led, Ultradent) light device for 10 seconds. Self-cured adhesive system (Tokuyama Universal Bond) (TUB) was poured into the mixing chamber with one drop each of TUB ingredients A and B in accordance with the manufacturer's instructions. It was mixed thoroughly with a disposable applicator. TUB was applied to the surface using a disposable applicator. It was dried with gentle air for 30 seconds to ensure homogeneous film thickness. Using an oil-free air/water syringe, weak air was continuously applied to the TUB surface until the flowing TUB remained in the same position without any movement. The surface was finished with soft air.

The norm ISO 10993 (2018 edition) requires the evaluation of the chemical and physical properties of a medical device, including endodontic materials. This name summarizes a series of standards published mostly by ISO and the European Committee for Standardization (CEN). This series includes guidelines for selecting appropriate test methods to assess various aspects of biocompatibility. Nine biological tests are listed in ISO 10993 for biological evaluation and risk assessment of implanted materials. Based on this standardization system, comprehensive implantation assessments support systemic toxicity assessments (acute, subacute and chronic).[13]

ISO 7405 is a biocompatibility standard specifically related to ISO 10993-1 for dental materials, including endodontic materials. The various tests in these two standards are similar. Furthermore, ISO 7405 defines dental bioactive endodontic materials as materials capable of stimulating apical hard tissue formation applied by various methods (retrograde or orthograde treatments).[14]

Cytotoxicity assay

L929 (Mouse healthy fibroblast) cell line was used in this study. L929 cell line was grown in 25 cm^2 and 75 cm^2 flasks in a carbon dioxide incubator containing 5% CO_2 and 95% humidity. "Dulbecco's Modified Eagle's Medium (DMEM), 10% fetal bovine serum (FBS), and 1% antibiotic (100 IU/mL penicillin-streptomycin-PS) were used as a medium for the cells. The cells were passaged twice a week until the cell density required for the cytotoxicity test was obtained and the cells were kept in a humid atmosphere at 37 ºC. The cells were detached from the flask with 0.05% trypsin solution. Samples prepared according to ISO 10993.5 and ISO 10993.12 (Standardization IOF, 2009, 2012) were fully immersed in DMEM+FBS+PS medium under sterile conditions at 37°C for 24 hours. The samples in the medium were diluted in culture medium at twofold serial concentrations (100, 50, 25, 12.5, 6.25, 3.125 µg/ml). Cytotoxicity was evaluated using an MTT assay. L929 cells were seeded in 96-well plates and incubated for 24 hours. Samples of different concentrations dipped in the medium of both materials were added to the wells. After 24 hours of incubation, MTT solution (20 µl, 5 mg/ml) was added to each well and incubated for another 4 hours in a 37°C incubator. Then, 150 µl DMSO was added to dissolve formazan crystals. Absorbance was measured with a microplate reader at 570 nm.[15-17]

Agar diffusion test

According to ISO 10993-5 and ISO 7045 (Standardization IOF, 2009, 2011), agar diffusion test as a barrier test method for cytotoxicity was performed for non-specific cytotoxicity of its components that can leach from the samples after agar diffusion.

Neutral red dye (powder), a vital dye, was dissolved in PBS at 4 mg/ml and a stock solution was prepared. Cells were seeded in 6-well plates at a density of 1x 10^5 and incubated for 24 hours. At the end of the period, the medium was removed and the medium containing DMEM and 5% agar prepared for agar diffusion analysis was added to the 6 plates. After 60 minutes of solidification time, the samples prepared for cytotoxicity analysis were placed in the center of the wells. Blank disks and DMSO-impregnated disks were placed in the wells for positive and negative controls. Cells were stained with neutral red stock solution (0.01% in phosphate-buffered saline) diluted 1:100 with culture medium. After 24 hours of incubation, the plate was examined under an inverted microscope (Olympus, JAPAN). Neutral red stain, which stains viable cell nuclei, was used to determine the viability of the cells surrounding the material.[16,18,19]

Antimicrobial assay

The antimicrobial activity of two different bond samples against some bacteria and one yeast was determined by the Kirby-Bauer disk diffusion test and broth microdilution method.[20,21] *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus aureus* 29213, *Bacillus cereus* ATCC 11778, *Enterococcus faecalis* ATCC 29212, *Streptococcus mutans* ATCC 25175, *Escherichia coli* ATCC 25922, *Candida albicans* ATCC 10231 were used as test microorganisms.

Disk diffusion assay

Mueller-Hinton Agar (MHA; Difco, Detroit, MI, USA) medium was used in this method, which was performed by Kirby-Bauer disk diffusion test.[20] After adjusting 0.5 McFarland turbidity suspensions for each bacterium and yeast in 0.85% sterile saline solution, Mueller-Hinton Agar was inoculated onto the surface of the plates using a sterile swab. After the medium surface dried, two different bond samples were placed on the agar plates

and incubated at 35 ± 1 °C for 18 ± 2 hours. After incubation, zone diameters were measured and evaluated according to EUCAST recommendations.[21] Amoxicillin-clavulanic acid (30µg, Oxoid), meropenem (10µg, Oxoid), amikacin (30µg, Oxoid), levofloxacin (5µg, Oxoid), vancomycin, (5µg, Oxoid) imipenem (10µg, Oxoid) were used as reference antibiotics and fluconazole (25µg, Oxoid) was used as reference antifungal. Our experiments were performed in three replicates.

Broth Microdilution assay

Broth Microdilution Method was used to determine the MIC (Minimum Inhibitory Concentration) values of the bond structures against the bacteria and yeast used in our experiments. Bond structures were dissolved in 10% DMSO (Dimethyl Sulfoxide) at 20.48 mg/ml. Cation-adjusted Mueller Hinton liquid medium (CAMHB, Becton Dickenson BBL, Sparks, MD, USA) was used for the preparation of dilutions and 0.5 McFarland turbidity of microorganisms. Our experiments were performed in 96-well "U" bottom microplates. After two-fold serial dilutions, concentrations of $5x10^5$ cfu/ml for bacteria and $0.5\text{-}2.5\text{-}2.5x10^3$ cfu/ml for yeast were obtained in each well by the addition of bacteria and yeast suspensions adjusted to 0.5 McFarland turbidity. With the addition of bacteria, the concentrations of bond structures ranged from 1024 ug/ml to 2 ug/ml. After dilutions, the microplates were incubated at 35 ± 1 °C for 18 ± 2 hours and the well containing the lowest antibiotic concentration in which no growth was observed was considered as the MIC value.[21] Wells containing only CAMHB medium were considered as sterilized control and wells containing medium and bacteria were considered as growth control. Our experiments were performed in three replicates. Linezolid, levofloxacin, and amikacin were used as reference antibiotics and fluconazole was used as reference antifungal.

Statistical analysis

One Way Anova test as well as as Tukey test were used for statistical analysis of the findings. For this purpose, the SPSS 16.0 (SPSS, Chicago, IL, USA) statistical program was used and a $p<0.05$ value at a 95% confidence interval was considered significant between groups.

Results

The cytotoxic effect of the materials on healthy cells (L929 cell line) was evaluated using MTT and Agar Diffusion test. Medium was used as positive control and DMSO was used as negative control.

MTT Cytotoxicity assay

The cytotoxic activity of Tokuyama Bond irradiated and non-irradiated materials and the percentage viability of cells after 24 hours of incubation were determined according to the MTT assay results based on the formula in reference sources (Figure 1).[22]

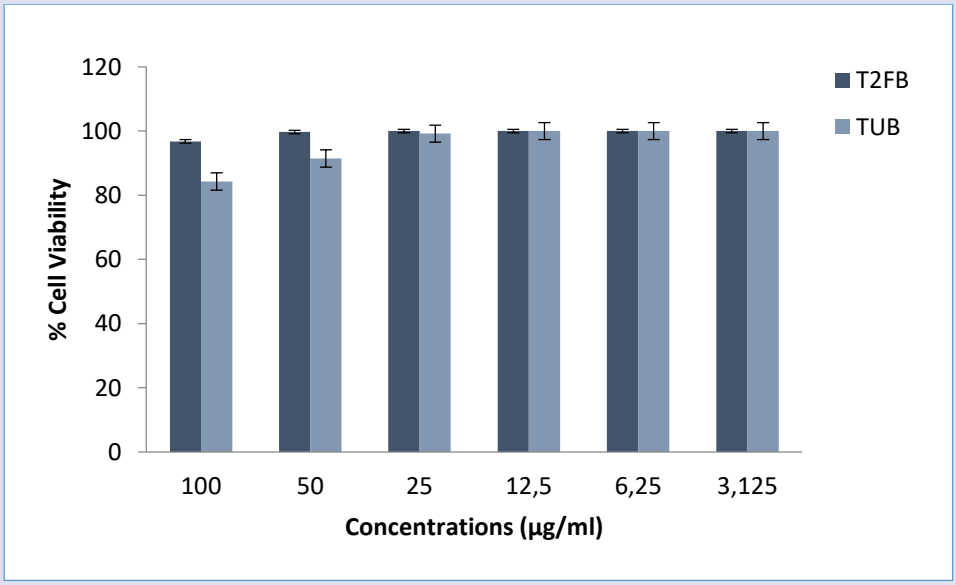

Figure 1: Cell viability of Tokuyama Universal BOND (self-cured) – (TUB) and Tokuyama BOND force II (light-cured) – (TF2B)

At the first concentration, cell viability of TF2B was 96.8%, while that of TUB was 84.3%. Both materials reached 100% cell viability by the third concentration. Both adhesive systems have no significant toxic effect on healthy cells. However, when TUB and TF2B were compared with each other, it was found that TF2B had almost no toxic effect.

Agar diffusion test (Neutral Red assay)

The viability of L929 cells around the BONDs was determined as Zone index (ZI) or Lysis index (LI) with a neutral red stain, which stains live cell nuclei (Table 2). Materials above 40% or No:3 melt index are considered toxic.[22,23]

Table 2. Description of zone index (ZI) and lysis index (LI) in the agar diffusion assay

ZI or LI	Decolorization zone diameter	Cell lysis
0	No detectable	No detectable
1	There is lightening within the borders.	Less than 20%
2	There is lightening around 5 mm.	20–40%
3	There is a lightening around 10 mm.	40–60%
4	There is lightening more than 10 mm in the surrounding area	60–80%
5	The total culture is decolorized	More than 80%

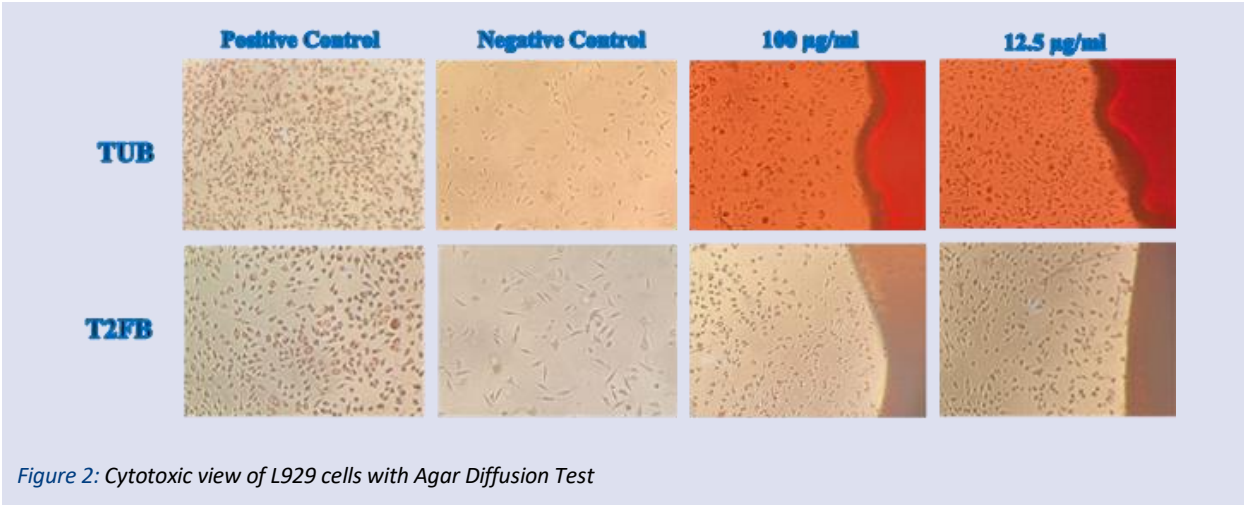

Figure 2: Cytotoxic view of L929 cells with Agar Diffusion Test

Table 3. Bonds of zone index (ZI) and lysis index (LI) in the agar diffusion assay

Material	Scala	Cell Lysis Index
TUB – 100 µg/ml	1	Less than 20% cell lysis
TUB – 12.5 µg/ml	0	No cell lysis detectable
TF2B – 100 µg/ml	0	No cell lysis detectable
TF2B – 12.5 µg/ml	0	No cell lysis detectable
Control - DMSO	4	60-80% cell lysis
	0	No cell lysis detectable

TUB = Tokuyama Universal BOND (self-cured)
TF2B = Tokuyama BOND force II (light-cured)

A melting index with a scale of 3 or higher, i.e. a toxic area, was not observed around the bonds placed on the cells. When the two bonds are compared with each other, only the first concentration of TUB shows a weak discoloration around it. No visible melting was detected in other concentrations of TUB and TF2B (Table 3, Figure 2). Agar diffusion test results and cytotoxicity results were found to be compatible with each other.

Antimicrobial Assay

MIC and Disk diffusion test were used for antimicrobial activity determination. The antibiotics selected as the control group for 6 bacteria and 1 yeast fungus used in the test are given in Table 4 together with the MIC results.

Table 4. MIC results of Tokuyama bonds; TUB and TF2B.

Microorganisms (Bacteria and Yeasts)	TUB MIC (µg/mL)	TF2B MIC (µg/mL)	Antibiotics MIC (µg/mL)	Antibiotics used
Escherichia coli	>1024	>1024	2	Amikacin
Pseudomonas aeruginosa	>1024	>1024	2	Amikacin
Staphylococcus aureus	>1024	>1024	2	Linezolid
Enterococcus faecalis	>1024	>1024	2	Levofloxacin
Bacillus cereus	>1024	>1024	2	Linezolid
Streptococcus mutans	>1024	>1024	2	Levofloxacin
Candida albicans	>1024	>1024	0.25	Fluconazole

TUB = Tokuyama Universal BOND (self-cured)
TF2B = Tokuyama BOND force II (light-cured)

Both Tokuyama bonds did not reach effective MIC values on the test microorganisms. Since the results were far above the MIC values of reference antibiotics, it was determined that they did not have antimicrobial effects. Disk diffusion results are shown in Figure 3. Accordingly, it was observed that both bonds did not form an inhibition zone on the test microorganisms.

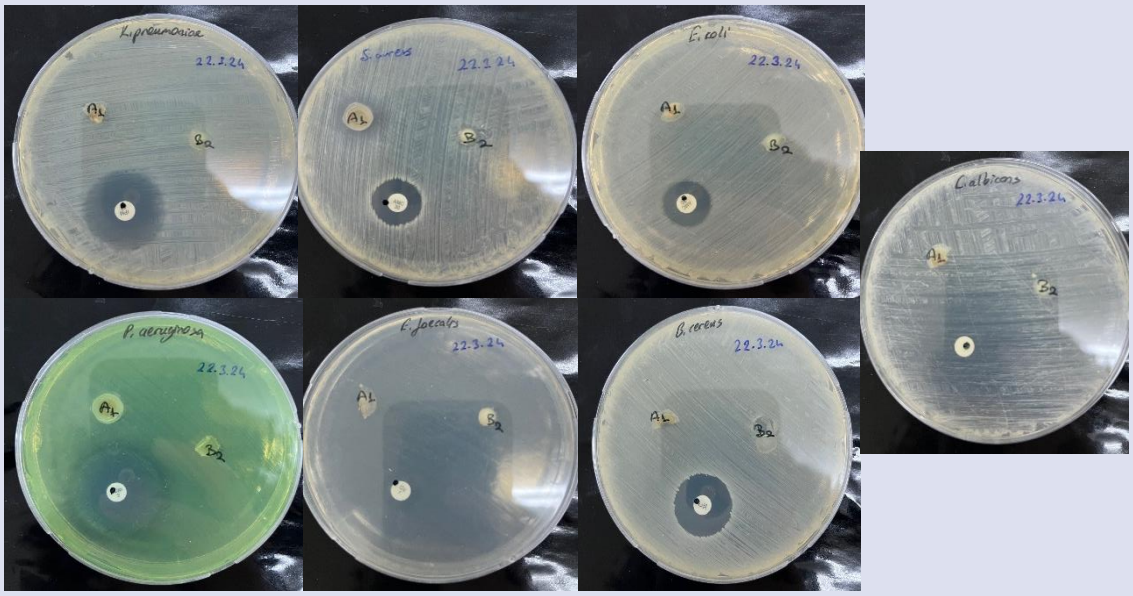

Figure 3: Disk diffusion results of Tokuyama bonds; TUB and TF2B.

Discussion

Today, with the development of technology, many different adhesive materials have been introduced to the market. Biocompatibility studies have become increasingly important in newly developed materials.[24] Studies in the literature have shown that different monomers are released from resin-based dental materials before or after polymerization.[25] The monomers released from materials with different compositions determine biocompatibility.[26] In our study, the cytotoxic effects of adhesive systems on L929 mouse fibroblast cell lines were examined. The cytotoxic effects of adhesive systems widely used in restorative dentistry vary.[27]

It is known that different universal adhesives available in the market have different ingredients such as biphenyl dimethacrylate (BPDM), CQ, MDP, polyalkenioc acid, acetone and ethanol as well as monomers such as HEMA, Bis-GMA, UDMA and PENTA, different pH and polymerization methods.[28] Studies have shown that all these parameters have an effect on the cytotoxicity of the agent used.[29] Among the adhesives, Tokuyama Universal Bond is the only system with two different forms that polymerize chemically and with LED.

Animal experiments and cell culture tests are commonly used to evaluate the cytotoxicity of dental materials. However, animal experiments are controversial, long-lasting and expensive methods.[30] Cell culture tests have become an alternative to animal experiments due to their advantages such as low cost, controllability, and ease of construction.[31] Cell culture is widely used for dental materials whose biocompatibility will be evaluated, especially in in-vitro tests in restorative dentistry.[32] Direct contact of the medical materials with the cell culture or indirect application of the extract liquids obtained by soaking the material in a suitable liquid (>24 hours) to the cell culture is recommended in the International Organization for Standardization (ISO 10993-5) (10993 1999), which regulates the test methods to be used in the cytotoxicity evaluation of materials.[15]

Adhesive systems do not have direct contact with the pulp under in-vivo conditions. However, acute toxic effects due to residual monomer release before or after polymerization can reach the pulp through dentinal tubules, which increase in diameter as they approach the pulp.[33] Adhesive systems applied directly to dentin, in particular, may cause pulpal inflammation and necrosis of pulpal cells due to insufficiently polymerized monomers.[34] The cytotoxic effects of inadequately polymerized adhesive systems placed directly into culture media are determined by morphological changes in cells, changes in viability, disruption of cell membrane integrity, and changes in enzyme activity. The cytotoxic effects of many adhesive systems have been investigated and it has been reported that the monomer diversity of adhesive systems causes different cytotoxicities.[35] The high rate of polymerization of adhesive systems reduces possible biological risks. Therefore, the light devices used during polymerization are important. In a study by Ergün et al. the cytotoxic effects of LED and halogen light sources on three different adhesive systems were investigated.[36] In another study, the cytotoxicity of an adhesive system was evaluated on L929 mouse fibroblast cells by both LED light devices and chemical polymerization.[34] In both studies in the literature, the number of cells remaining in the experimental group polymerized with an LED light device was higher, i.e. the cytotoxic effects were found to be lower.[34, 36] Self-cured and light-cured polymerized adhesive systems were included in our study to compare the effect of different polymerization techniques on cytotoxicity value.

According to the results of our study, the toxic effect of Tokuyama Bond light-cured adhesive system (TF2B) on L929 healthy fibroblast cells was found to be very low. The self-cured adhesive system (TUB) had almost no toxic effect on the cells.

Conclusions

In our study to compare the biocompatibility and antimicrobial effects of self-cured and light-cured adhesive systems, both systems showed no toxic effect on healthy fibroblast (L929) cells. In MTT and agar diffusion test results, it can be said that self-cured (TUB) material has a negligible toxic effect compared to light-cured (T2FB) material. In addition, it was determined that both adhesive systems did not have antimicrobial effects on the test microorganisms according to MIC and disk diffusion results. The cytotoxicity of adhesive systems can be tested on different cells. Biocompatibility studies can be increased with different adhesive systems.

Conflict of Interest

The authors declare that they have no conflicts of interest in the publication.

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Gingival Augmentation of the Edentulous Site Before Implant Placement Using a Transposed Pedicled Gingivectomy Tissue: A Novel Surgical Case Report

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Case Report

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ABSTRACT

The amount of keratinized gingiva around teeth/prostheses is a crucial factor to consider before placing the crowns and bridges around implants or edentulous teeth. Keratinized gingiva around teeth, edentulous sites or implants is an important as it improves aesthetics, helps to maintain good oral hygiene around prosthesis, and prevents post-operative exposure of implant threads. The presence of adequate keratinized tissue around implants/prostheses is vital for good peri-implant health and should be augmented before implant treatment to improve the overall prognosis of the implants. The attached gingiva can be augmented using a free gingival graft (FGG) or AlloDerm®. However, procurement of FGG is surgically demanding as it requires procurement of the tissue graft from the palate. Moreover, it creates a second surgical site with an increased risk of post-operative discomfort and bleeding. To overcome these limitations, this case report presents a novel non-invasive simple, surgical technique to augment keratinized tissue using partially excised pedicled gingivectomy tissue for augmentating attached gingiva before prosthetic rehabilitation.

Keywords : Mucogingival surgery, Minimally invasive surgery, Implant, Attached gingiva, Gingivectomy, Gingiva, Edentulous.

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Introduction

The periodontium is the attachment apparatus that anchors the teeth in the jaws and facilitates effective masticatory function.[1] The periodontium has two main components: the gingiva and the supporting apparatus. Gingiva has three main components: papillary, marginal, and attached gingiva.[1] The attached gingiva is the most critical portion, as it protects the underlying structures from external forces, enhances aesthetics, and supports good oral hygiene. The amount of attached gingiva varies among individuals and different teeth. For example, the attached gingiva is maximum in anterior teeth (3-4 mm) and least in the premolar region (1-

1.8 mm).[2] The amount of keratinized gingiva is influenced by the patient's periodontal biotype', the gingiva's thickness, and the alveolar bone's morphology.[3] Thin periodontal biotypes that exhibit narrow zones of keratinized gingiva are more prone to gingival recession.[3,4,5] The amount of keratinized gingiva also diminishes following the extraction of teeth due to the remodeling of the underlying alveolar bone.[6]

The presence of a minimum width of keratinized gingiva is required for good periodontal and peri-implant health.[7] The presence of adequate attached gingiva helps to brace the marginal gingiva, protects the underlying bone, and improves gingival aesthetics. Augmenting attached gingiva around deficient areas around implants is important since an adequate amount of peri-implant keratinized tissue is needed to prevent soft tissue recession and exposure of the implant surface.[8] Previous studies have shown that individuals with 2 mm of keratinized tissue and 1 mm of attached gingival width of about 1mm are important to maintain periodontal health.[3,4] However, some authors have stated that in the presence of optimal oral hygiene measures, a minimum amount of keratinized tissue is not a requisite for periodontal and peri- implant health.[3,4] Some reports have shown that individuals with inadequate peri-implant keratinized tissue tend to high risk of developing peri-implant diseases.[9] The chances of a peri-implant recession and exposure to implant threads are increased in patients with inadequate keratinized tissues.[10] A 10-year prospective study showed that implant sites lacking keratinized tissue exhibit increased plaque accumulation and greater gingival recession.[8] A recent systematic review and meta-analysis also emphasized the importance of augmenting keratinized tissue around implants; procedures aimed at augmenting the zone of keratinized tissue around implants and prostheses should be planned before implant placement and prosthetic rehabilitation to achieve better peri-implant soft tissue health, better plaque control, and good marginal bone

support.[11] Based on this evidence, the evaluation, and augmentation of keratinized gingiva around the edentulous the area before implant placement or around the existing implant becomes important to predict the dimensions of future peri-implant mucosa.[12,13] Although many studies discuss the importance of a prosthesis with optimal contact, contour, and margins; the presence of adequate attached gingiva around the prosthesis is often overlooked or unconsidered in the treatment plan.

Gingival augmentation is usually done by using an autogenous free gingival graft (FGG) or commercially available AlloDerm®.[14] The FGG is most often harvested from the hard palate, retromolar pad, or an edentulous site.[15] However, the major drawbacks involved with the procurement of FGG are the need for an additional surgical site, prolonged surgical time increased patient discomfort, risk of post-operative bleeding, and limited availability of donor tissue.[16] Additionally, in many patients, a whitish color scar or patch appears at the site of the graft due to inadequate color matching.[16] The procurement of soft tissue graft is also a technique-sensitive procedure as it requires good clinical surgical skills. To overcome these problems, the present case report presents a novel, simple, and minimally invasive surgical procedure to augment the attached gingiva on an edentulous site planned for implant by using the partial gingivectomy tissue graft.

Methods

A 49-year-old female was referred to the Department of Periodontology with a chief complaint of a dislodged crown for the mandibular left first premolar. The patient was systemically healthy without any oral abusive habits. The patient was currently not on any medication or therapy. Her dental history included a scaling procedure performed six months ago. The root canal treatment was done, and the crown was placed for the left mandibular first premolar (34). The crown was dislodged a month back (Figure 1). On the first visit, clinical examination revealed supragingival and subgingival calculus along with an amalgam restoration in the root canal-treated first premolar. The gingiva was inflamed with a grade 1 score for gingival bleeding. There was inadequate clinical crown height with a crown-to-root ratio of 1:2.

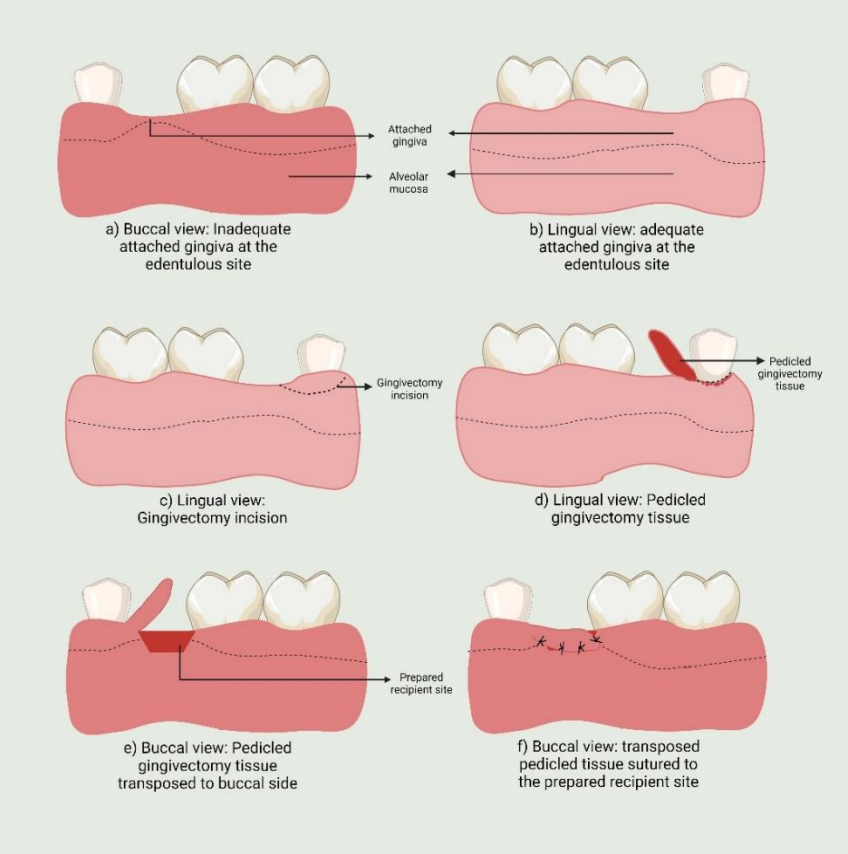

Figure 1: Schematic representation of the surgical technique to augment the attached gingiva on the partially edentulous site.

A crown lengthening procedure was planned for the tooth followed by re-restoration with a post and core procedure. The rehabilitation of the edentulous site was planned with endosseous implants. However, before implant placement, we noticed an inadequacy of the attached gingiva in both the tooth's buccal aspect and the edentulous region where a dental implant was to be placed to replace the missing teeth. The patient was

informed and educated about the problem and written consent was obtained. The patient was also informed about the use of FGG for gingival augmentation for the edentulous site, to which the patient denied the procurement of a free gingival graft from the palate. Since the gingivectomy tissue is usually discarded, we planned to use the same tissue excised for crown lengthening on the lingual side for gingival augmentation. However, instead of excising the tissue completely and using it as a gingival unit, we planned to transpose the tissue as a pedicle to maintain the blood supply from one end and adapt it onto the de-epithelized bed onto the edentulous site. The surgical plan involved increasing the width of the attached gingiva while simultaneously increasing the crown height. This was achieved with an apically positioned flap on the buccal aspect and an external bevel gingivectomy on the lingual aspect of the tooth.

Surgical Procedure

The procedure was performed under local anesthesia (infiltration) with 2% lignocaine hydrochloride with 1:80,000 adrenaline. A crevicular incision using a No. 15c Bard Parker blade was made on the buccal aspect of the tooth. A mesial vertical releasing incision was given. An external bevel incision was given a 15C blade on the lingual side, 3 mm away from the lingual marginal gingiva from the mesial to the distal end of the tooth. The distal end of the incision continued as a distal vertical releasing incision on the buccal aspect. A full-thickness mucoperiosteal flap was reflected on the buccal aspect using a periosteal elevator and osseous reduction of the marginal bone was done with a small round bur under copious irrigation. The excised tissue from the lingual side with the distal end still attached to the buccal flap was rotated and transposed onto the buccal side as a wing of the buccal flap. The edentulous area, distal to 34, was de-epithelialized using a surgical blade. The partially excised gingivectomy tissue was transposed on the de-epithelized bed (Figure 1 and Figure 2). The flap was sutured apically on the buccal aspect using an interrupted suturing technique (3-0 sutures, Ethicon Mersilk, Johnson and Johnson, USA) and winged gingival tissue was sutured distally to 34 onto the de-epithelized bed as one unit. A periodontal dressing was placed (CoePak, GC American INC, USA), and a postoperative analgesic (Ibuprofen 400 mg thrice a day) for the two days was advised. The patient was instructed not to brush in the surgical area for a week and was advised to rinse with warm saline water 2-3 times a day for a week. The patient was asked to inform in case of excessive pain, bleeding, or swelling. The patient was recalled after 15 days for the removal of sutures.

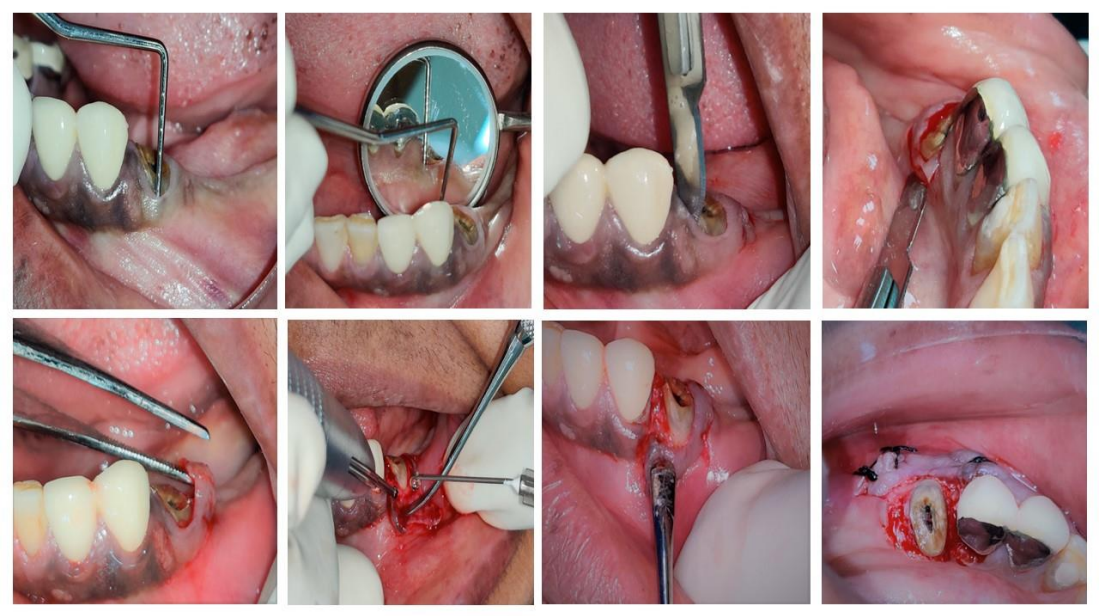

Figure 2: Clinical pictures explaining the steps of the surgical procedure where the partially excised gingivectomy tissues are transposed onto the buccal aspect for gingival augmentation:
Fig 2A: Pre-operative images showing the inadequate crown height of the left mandibular premolar along with the edentulous area with inadequate attached gingiva on the buccal side.
Fig 2B: Pre-operative images showing the inadequate crown height of the left mandibular premolar along with the edentulous area with inadequate attached gingiva on the buccal side.
Fig 2C: Sulcular incision given with 15C blade on the buccal side
Fig 2D: External bevel incision on the lingual side
Fig 2E: Lingual tissue was reflected and transposed to the buccal side
Fig 2F: Osseous re-contouring done with a round bur
Fig 2G: Apical repositioning of the flap and with lateral position of transposition of the gingival tissue obtained from the lingual side
Fig 2H: Flap approximated with interrupted suturing using 3-0 silk suture

Results

After 15 days, the pedicled gingival tissue extension was successfully taken up by the recipient bed without any signs of gingival inflammation or necrosis [Figure 2 and Figure 3]. An increase in the width of the keratinized gingiva was noted at base 34 and the edentulous area. Reevaluation at 15 days, 6, and 12 months revealed excellent blending and firm attachment of the pigmented tissues with an increase of 2-3 mm in width of the attached gingiva [Figure 3]. No postoperative complications were reported at the surgical site immediately after the surgery and even at 12 months follow- up good healing and plaque control was observed.

Figure 3: Clinical images showing the increase in the width of the attached gingiva
Fig 3A: Preoperative clinical image at baseline
Fig 3B: Post-operative clinical image at 6 months
Fig 3C: Post-operative clinical image at 12 months

Discussion

The presence of adequate attached gingiva around the implant and tooth prosthesis is vital and should be evaluated before any prosthetic rehabilitation. Although FGG is considered the gold standard for gingival augmentation, many times patients deny procurement of graft from the palate, and seek simpler and non-invasive options. The use of gingivectomy tissues as gingival graft has been documented as a viable alternative to free gingival graft for gingival augmentation. Jenabian et al (2016) compared the efficacy of the gingival unit graft compared to FGG and found that the gingival unit graft produced higher satisfaction aesthetically, higher healing index ($P < 0.001$), higher root coverage percentage at one month after surgery ($P=0.011$) and greater reduction of recession width three months after surgery ($P=0.007$). However, the reduction in vertical height of the recession was not significantly greater with gingival unit graft compared to FGG.[17] The use of gingival unit graft has higher patient acceptance and less surgical demand compared to FGG.

This modification is similar to the gingival unit graft, where a gingival tissue will be excised and discarded for crown lengthening or aesthetic reasons, instead of discarding the excised tissue, one can utilize it for gingival augmentation in the same patient. This technique was designed based on the concept of utilizing the gingival unit, with the additional advantage of maintaining the blood supply by keeping one part of the excised gingivectomy tissue and transposing it to an adjacent site. Unlike gingival tissue, transposing the partially excised gingivectomy tissue as a pedicle graft provides faster healing as the blood supply to the donor tissue is maintained. This technique can be attempted for shallow single-tooth recession with interdental spacing, where the excised gingivectomy tissue from the lingual side can be transposed to the buccal side and sutured as graft. This would reduce the post-operative discomfort of the patient and steer away from the complications of increased risk of bleeding as seen in the FGG. It can also be performed for coverage of implant thread by transposing the gingival tissue from the adjacent tooth from the lingual to the buccal aspect. However, this technique can only be used adjacent to a natural tooth that has adequate keratinized tissue around it, and when interdental space for transferring the donor tissue from the lingual side to the buccal side (wide embrasures, spacing between the teeth, edentulous areas) is optimal. The choice to excise partial or full thickness depends on the gingiva phenotype and the lingual tissues' thickness.

Conclusions

The present technique was effective in augmenting keratinized tissue at an edentulous site planned for an implant. The augmented gingival tissue was healthy, and the width was maintained even after one year. However, one should note that the success of this technique does not confirm its effectiveness as future studies should explore and compare the efficacy of this technique compared to FGG via performing prospective clinical studies with long-term follow-ups.

Conflict of Interest

No potential conflict of interest to report

Funding

Nil.

Patient consent

Verbal and written signed consent was taken before the surgery/ rehabilitation.

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