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Aims and Scope

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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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Jaw Cysts: A Retrospective Study in a Turkish Subpopulation

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Research Article

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ABSTRACT

Objectives: Cysts observed in the jaws may be odontogenic or non-odontogenic, depending on the tissue of origin. Although there are different methods to diagnose these lesions, histopathological examination of tissue biopsy of the lesion is accepted as the 'gold standard' in cases where the diagnosis is insufficient. The aim of this study is to retrospectively evaluate the distribution of histopathologically diagnosed jaw cysts according to age, gender and anatomical localization.

Materials and Methods: Pathology results of 436 patients who applied to Zonguldak Bülent Ecevit University Faculty of Dentistry, Oral and Maxillofacial Radiology Clinic between 2016-2021 for any reason and underwent biopsy were retrospectively scanned using digital archives. While classifying the cyst, the criteria published by the World Health Organization (WHO) in 2017 were taken into account. Obtained results were recorded for statistical analysis. IBM SPSS 22.0 Software Package Program (IBM SPSS 22.0 Software Package Program, Inc. Chicago, IL, USA) was used as statistical software in the study.

Results: Of the 436 patients included in the study, 250 (57.3%) were male and 186 (42.7%) were female. The ages of the patients ranged between 7 and 82 years, and the mean age of the patients was 35.5±15.8. As a result of the findings, it was determined that the most common cysts were radicular cysts (53.7%). Radicular cysts were most commonly located in the posterior mandible and anterior maxilla anatomically.

Conclusions: Determining the prevalence, localization and distribution of jaw cysts with the findings obtained as a result of this retrospective study is of great importance in determining the diagnosis and treatment planning of these pathologies.

Keywords: Radicular cyst, biopsy, jaw, odontogenic, lesion.

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Introduction

Pathological spaces lined with epithelium, surrounded by connective tissue, and containing liquid, semisolid, or gaseous material are called cysts. Cysts observed in the jaw and surrounding tissues can be located in the bone as well as in the soft tissues.[1] Cysts observed in the jaw are classified as odontogenic or non-odontogenic according to the source of the epithelium. There are also cysts called pseudocysts that do not contain epithelium.[2] Odontogenic cysts originate from epithelial remnants (epithelial remnants of Malessez, enamel epithelial remnants, or dental lamina remnants) left over from tooth development. In cysts located in the mandible, the fact that the cyst is located above the mandibular canal generally leads to the opinion that it is odontogenic. In contrast, non-odontogenic cysts originate from epithelial remnants in the maxillary, frontal, and palatal processes.[3,4]

Odontogenic cysts are classified as either inflammatory or developmental, depending on the cause of the proliferation of the epithelium from which they originate.[5] Radicular, residual, and inflammatory collateral (paradental) cysts are in the group of odontogenic inflammatory cysts. Developmental cysts include odontogenic keratocysts and dentigerous, lateral periodontal, calcified odontogenic, glandular odontogenic, and gingival cysts.[6] Odontogenic keratocysts and calcified odontogenic cysts were excluded from the category of odontogenic tumors and included in the classification of odontogenic cysts in the classification published by the World Health Organization (WHO) in 2017, since there was not enough evidence to support the inclusion of neoplasm.[7] The high recurrence rate and aggressive growth of odontogenic keratocysts increase the importance of these cysts.[5] Jaw cysts usually grow slowly, and most exhibit similar clinical behaviors. Therefore, definitive diagnosis is accomplished through histopathological evaluation.[8] The aim of this study was to retrospectively investigate the distribution of histopathologically diagnosed odontogenic and nonodontogenic cysts in a clinical archive according to age, gender, and location.

Materials and Methods

In this study, the pathology results of 436 patients preliminarily diagnosed with cysts who applied to Zonguldak Bulent Ecevit University's Faculty of Dentistry, Oral, and Maxillofacial Radiology Clinic between 2016–2021 and underwent biopsies were analyzed using digital archives. The study was approved by the university's Clinical Research Ethics Committee (Decision no.: 2022/11). Cyst diagnoses according to histopathology reports were made following the classification of odontogenic tumors and cysts published by the WHO in 2017.[6]

In panoramic radiographs, the cysts were included in the anterior region if they were between the mandibular and maxillary canine teeth and in the posterior region if they were located behind the premolars and posterior teeth. The anatomical localizations of the lesions were divided into four groups according to whether the cyst center was located in the mandible anterior, mandible posterior, maxilla anterior, or maxilla posterior. As a result of the scans, odontogenic keratocysts and radicular, paradental, dentigerous, calcified odontogenic, lateral periodontal, nasopalatine duct, and nasoalveolar cysts were detected.

Descriptive statistics were applied to the data obtained from the study, and the distribution of cysts according to age, gender, and anatomical region was examined. A one-way ANOVA test was used for group comparisons. The IBM SPSS 22.0 Software Package Program (IBM SPSS 22.0 Software Package Program, Inc., Chicago, IL, USA) was used as the statistical software in the study. A p-value of 0.05 was considered significant for all tests.

Results

Of the 436 histopathology reports obtained from the study, 250 were for males and 186 reported on females. When the distribution of all odontogenic and non-odontogenic cysts by gender was examined, the incidence rate in men (57.3%) was found to be higher than that in women (42.7%). Other than calcified odontogenic cysts, all types of cysts were more common in males. However, no statistically significant relationship was found between any cyst type and gender ($p > 0.05$). In Table 1, the incidence, distribution, and types of cysts are given according to gender.

In the study, 428 (98.6%) of 436 lesions diagnosed as cysts consisted of odontogenic cysts, and eight (1.4%) were non-odontogenic cysts. The three most common odontogenic cysts were radicular cysts (53.7%), dentigerous cysts (38.8%), and odontogenic keratocysts (2.5%), followed by other cysts. The non-odontogenic group included nasopalatine duct cysts (1.1%) and nasoalveolar cysts (0.3%) (Table 1).

While 295 (67.6%) cysts were located in the mandible, 141 (32.4%) were located in the maxilla. As for their locations in the jawbones, the cysts were most commonly found in the posterior mandible (63.5%), while they were also identified in the maxilla anterior (18.8%), maxilla posterior (13.8%), and mandible anterior (4.1%). According to these results, 136 of the most common radicular cysts and 123 of the dentigerous cysts were located in the posterior mandible (Table 2). The distribution of the cysts between the jaws is indicated in Figure 1.

The ages of the patients in the study ranged between 7 and 82 years, and the mean age was 35.5 ± 15.8 years. The most common age range of those who developed cysts was the third decade. Radicular cysts and dentigerous cysts were most common in the third decade, while odontogenic keratocysts were encountered more in the fourth and fifth decades. In the second decade, the incidence of dentigerous cysts was found to be higher than that of radicular cysts (Figure 2).

Discussion

Analyzing histopathological data on oral and maxillofacial lesions seen in particular populations is of great importance in establishing diagnosis and treatment protocols.[9] Such data can be used to prevent future recurrences and morbidities.[10] In this study, the biopsy results of individuals with odontogenic and non-odontogenic cysts were examined, and the distribution of different cyst types in terms of age, gender, and jaws was analyzed.

Consistent with the results of studies conducted in Turkey with different populations, it was determined in the present study that males were more affected by both odontogenic and non-odontogenic cysts, and the male/female ratio was determined as 1.34/1.[11-15] By contrast, Souza *et al.*[16] and da Silva *et al.*[9] stated that females were more affected by jaw cysts in studies conducted with a Brazilian population. It has been reported elsewhere that cysts are seen more frequently in men since the maxillary anterior region is frequently affected by trauma and poor oral hygiene.[12]

In most studies, radicular cysts are the most common jaw cysts, followed by dentigerous cysts and odontogenic keratocysts, and these results are consistent with the present study.[1,10,13,17-19] Butt *et al.*[20] retrospectively analyzed 4,257 biopsy specimens obtained over 19 years. However, they reported that dentigerous cysts (31%) were the most common odontogenic cysts, followed by radicular cysts (22%). This may be due to the difficulty in sending periapical cysts/granulomas to the laboratory after tooth extraction, or it may be due to the lack of biopsy specimens from cases thought to be radicular cysts. They attributed this to the fact that dentigerous cysts usually appear as large lesions that mimic tumors

and that histopathological evaluation is needed for a definitive diagnosis.[20]

Some report that odontogenic keratocysts are more common than dentigerous cysts. Koseoglu *et al.* identified 59% of odontogenic cyst cases as radicular cysts, 27% as odontogenic keratocysts, and 14% as dentigerous cysts.[21] Tekkesin *et al.*[22] conducted one of the studies with the largest number of patients in Turkey, where 5,088 odontogenic and nonodontogenic cyst biopsy specimens were obtained from 42,296 oral cases. In this study, 5,003 odontogenic cysts (11.8%) and 85 non-odontogenic cysts (0.2%) were diagnosed from all oral samples, and the second most common cyst type after radicular cysts (55.09%) was odontogenic keratocysts (20.6%).[22] The authors reported that the Turkish population is likely to form aggressive cysts. It has been stated elsewhere that such heterogeneous results may vary depending on differences in study methodologies and accepted classifications.[14]

In the present study, unlike other cysts, calcified odontogenic cysts were more common (60%) in females and in individuals in their third decade. Grosmann *et al.* reported that nasoalveolar and paradental cysts are more common in females.[1] Franklin *et al.* concluded that dentigerous cysts, odontogenic keratocysts, and paradental cysts are more common in females, unlike in the present study.[10] In the present study, paradental cysts were detected in five (1.1%) cases. All paradental cysts were seen in males and in the posterior mandible. Paradental cysts are inflammatory lesions that usually affect the distal or buccal surfaces of partially erupted mandibular third molars with a history of pericoronitis.[23] According to the results the authors obtained, the incidence of paradental cysts was higher (0.58%) compared to that found in Prockt *et al.*[23], but the incidence found in Jones *et al.*[24] (5.6%) was lower (3.8%) than that in Ochsenius *et al.*[25]

In the present study, the mean age was 35.5 ± 15.8 years, which is lower than that in other studies.[14,17,26] In the present study, radicular and dentigerous cyst cases were most common in individuals in their third decade. Tortorici *et al.* reported in their study that dentigerous cysts are seen at earlier ages than radicular cysts and are more common in the first two decades.[27] Demirkol *et al.*,[15] on the other hand, reported that dentigerous cysts were more common in the third and fourth decades. They thought that this might be due to the slow and asymptomatic growth tendency of the lesions.[15]

In the present study, 295 (67.6%) cysts were located in the mandible and 141 (32.4%) in the maxilla. However, other studies have found the incidence of cysts in the maxilla to be higher than that in the mandible.[1,16,28] Kambalimath *et al.* reported that approximately one-third (33.33%) of identified cysts were located in the mandibular posterior region and secondly in the maxillary anterior region (30%).[28] Kilinc *et al.* reported similar rates for odontogenic cysts in the maxilla anterior (33.5%) and mandible posterior (33.3%).[29] However, in the present study and the general literature, cysts were most commonly localized in the posterior mandible (63.5%) and the maxilla anterior (18.6%).[14,18,30]

In the present study, 58.1% of the radicular cysts were localized in the posterior mandible and 21.4% in the anterior maxilla. These results agree with studies in India[28] and the United Kingdom.[24] Contrary to these results, some researchers have reported that radicular cysts are more common in the anterior maxilla.[5,7,10,31] Radicular cysts result from the proliferation of Malassez epithelial remnants as a result of chronic inflammation of the periradicular tissues. The prevalence of radicular cysts has been associated with a high incidence of caries in most countries where studies were conducted.[13,24,30]

Dentigerous cysts are defined as cysts that affect the crown of an unerupted tooth and adhere to the cervical region.[23] Degeneration of dentigerous cysts into ameloblastoma, mucoepidermoid carcinoma, and squamous cell carcinoma has been reported in the literature, albeit rarely.[32] In this study, dentigerous cysts affected males more often, and they were mostly seen in the posterior mandible (73.6%) and maxilla posterior (13.0%). Ansari *et al.*[5], Hosgor *et al.*[7], and Izgi *et al.*[11] reported that dentigerous cysts are more common in the posterior mandible, which is consistent with the present study. Jones *et al.* reported that the third molar teeth of the mandible are the most frequently impacted teeth and that the incidence of dentigerous cysts in the posterior mandible may be high because of this.[33] Contrary to the present study, Prockt *et al.*[23] detected a slightly higher number of dentigerous cysts in females (52%) and reported that they were located in the anterior maxilla second most frequently. They thought that this might be due to impacted maxillary canine teeth.[23]

In the present study, the incidence of odontogenic keratocysts was found to be lower (2.5%) than in other studies.[1,17,24,25,33] Odontogenic keratocysts were most commonly detected in men and in the posterior mandible, consistent with other studies.[11,14,16,25] In the present study, odontogenic keratocysts were detected most frequently in those in their fourth and fifth decades. However, Kambalimath et al. reported that odontogenic keratocysts were more common in the second and third decades.[28] Some studies, including research conducted in Iranian[34] and Brazilian[1] populations, are in accordance with this result. In the present study, the most common non-odontogenic cyst type was nasopalatine duct cysts, and all of these cases were located in the anterior region of the maxilla. These results are similar to those of Grossmann *et al.*[1]

Conclusions

In this study, biopsy results of Turkish patients with jaw cysts who applied to a clinic within a 5-year period

were evaluated. Jaw cysts were most common between the ages of 21 and 30 and mostly affected males. The mandible posterior and maxilla anterior were the regions where the cysts were most frequently localized. The present study was carried out in a single center, and patients with histopathology results were included in the study. Therefore, multicentre and more comprehensive patient groups are needed to obtain detailed information about the demographic characteristics of patients with odontogenic cysts.

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The authors have no conflicts of interests.

Table 1. Distribution of cysts by age and gender

Histopathological Diagnosis	Frequency (n, (%))	Male (n, (%))	Female (n, (%))	M/F Ratio	Average Age	*p value*
Odontogenic Inflammatory Cysts						
Radicular Cyst	234 (53. 7%)	140 (59. 8%)	94 (40. 2%)	1. 49/1	37. 9±16. 3	
Inflammatory Collateral Cyst (Paradental Cyst)	5 (1. 1%)	5 (100. 0%)	-	M	39. 8±17. 6	
Odontogenic Developmental Cysts						
Dentigerous Cyst	169 (38. 8%)	87 (51. 5%)	82 (48. 5%)	1. 06/1	30. 8±13. 9	
Odontogenic Keratocyst	11 (2. 5%)	8 (72. 7%)	3 (27. 3%)	2. 67/1	42. 4±12. 9	
Calcified Odontogenic Cyst	5 (1. 1%)	2 (40. 0%)	3 (60. 0%)	0. 67/1	31. 0±19. 2	
Lateral Periodontal Cyst	4 (0. 9%)	3 (75. 0%)	1 (25. 0%)	3/1	51. 7±12. 6	
Non-Odontogenic Cysts						
Nasopalatine Duct Cyst	5 (1. 1%)	3 (60. 0%)	2 (40. 0%)	1. 5/1	49. 0±14. 6	
Nasoalveolar Cyst	3 (0. 3%)	2 (66. 7%)	1 (33. 3%)	2/1	43. 7±17. 9	
Total (n, (%))	**436 (100. 0%)**	**250 (57. 3%)**	**186 (42. 7%)**	**1. 34/1**	**35. 5±15. 8**	***0. 252***

Table 2. Distribution of cysts according to anatomical localizations

Histopathological Diagnosis	Mandible (n, (%))		Maxilla (n, (%))		
	Anterior	Posterior	Anterior	Posterior	Total (n, (%))
Radicular Cyst	11 (4.7%)	136 (58. 1%)	50 (21. 4%)	37 (15. 8%)	234 (100. 0%)
Inflammatory Collateral Cyst (Paradental Cyst)	0 (0. 0%)	5(100. 0%)	0 (0. 0%)	0 (0. 0%)	5 (100. 0%)
Dentigerous Cyst	4 (2. 4%)	123 (72. 8%)	20 (11. 8%)	22 (13. 0%)	169 (100. 0%)
Odontogenic Keratocyst	0 (0. 0%)	8 (72. 7%)	2 (18. 2%)	1 (0.9 %)	11 (100. 0%)
Calcified Odontogenic Cyst	0 (0. 0%)	4 (80. 0%)	1 (20. 0%)	0 (0. 0%)	5 (100. 0%)
Lateral Periodontal Cyst	2 (50. 0%)	1 (25. 0%)	1 (25. 0%)	0 (0. 0%)	4 (100. 0%)
Nasopalatine Duct Cyst	0 (0. 0%)	0 (0. 0%)	5 (100. 0%)	0 (0. 0%)	5 (100. 0%)
Nasoalveolar Cyst	0 (0. 0%)	0 (0. 0%)	3 (100. 0%)	0 (0. 0%)	3 (100. 0%)
Total (n, (%))	**18 (4. 1%)**	**277 (63. 5%)**	**82 (18. 8%)**	**60 (13. 7%)**	**436 (100. 0%)**

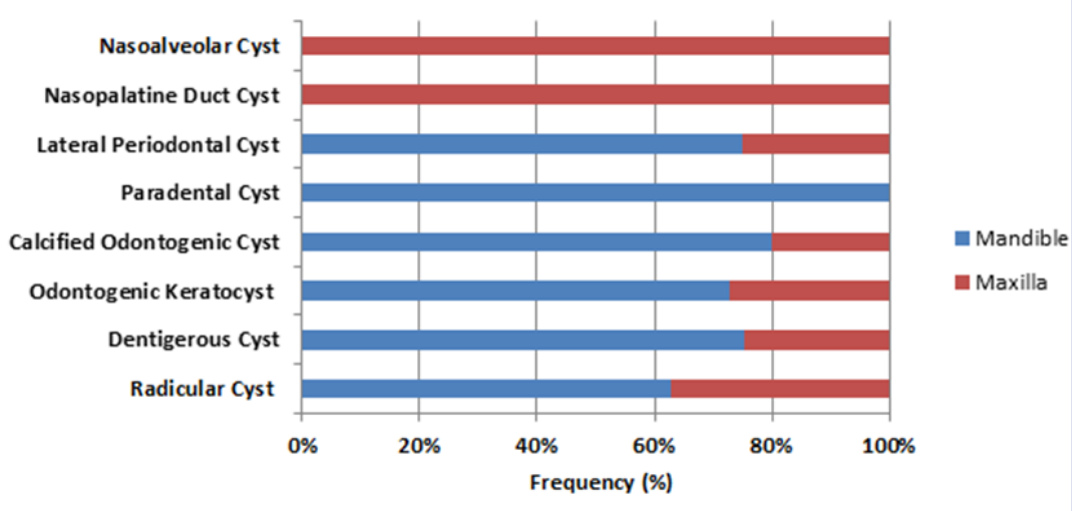

Figure 1. *Distribution of cyts between mandible and maxilla.*

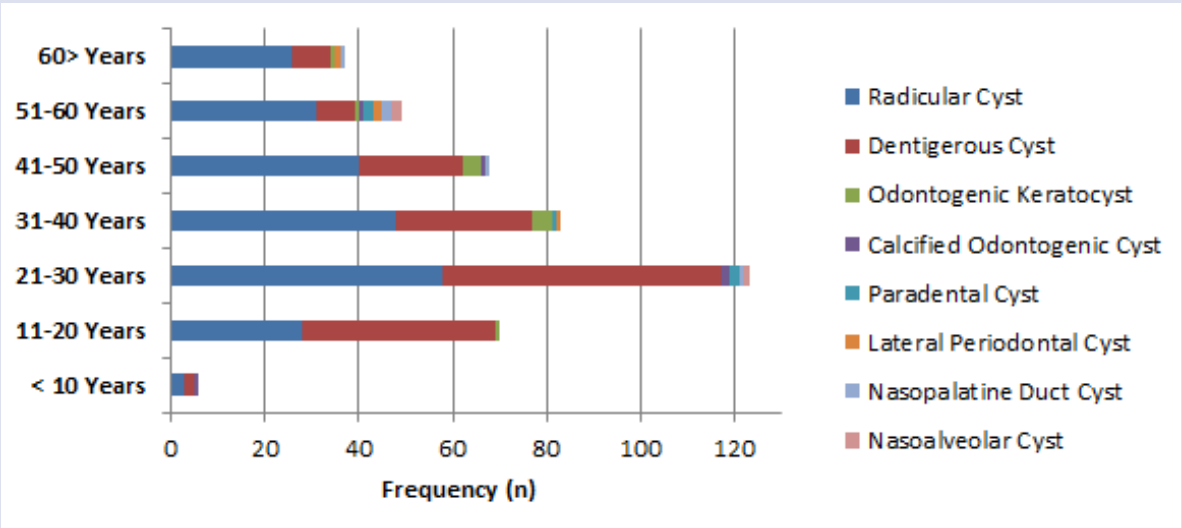

Figure 2. *Distribution of cyts between age groups.*

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Increasing the Awareness of Pediatric Nurses about the Protection and Continuity of the Oral and Dental Health of Children

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Research Article

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ABSTRACT

Objectives: To provide pediatric nurses with knowledge and skills on oral and dental health and to increase their awareness.

Materials and Methods: In the first phase of the study, pre-tests were given to pediatric nurses in Trabzon and Rize central and district hospitals. A Whatsapp group was created with the nurses who completed the tests, and the training video prepared by the researcher was shared. In the second phase of the study, the same questions were applied again as the post-test. The Shapiro–Wilk test was performed to detect normality. Jamovi (Version 1.0.4) software was used for statistical analysis. Owing to a non-normal distribution, a Wilcoxon Rank statistical analysis was conducted to examine the differences between pretest and posttest scores. The Kruskal–Wallis analysis was conducted to determine the relationship between dependent and independent parameters. The probability level for statistical significance was set at p = 0.05.

Results: Of the 91 nurses who completed both the pre-test and the post-test, 83 (91.2%) were female and 8 (8.8%) were male. In all sections in the test category consisting of six different sections (Tooth Decay, Risk Factors in Dental Caries, Prevention of Dental Caries, Oral and Dental Injuries, Children with Special Care Needs, What to Do - How to do?), the success rate was significantly higher in the post-test (p<0.001).

Conclusions: Research emphasizes that neonatal nurses, pediatric nurses and health professionals working in community health centers should be activated and empowered in order to prevent oral and dental health problems of children, and awareness should be increased with scientifically valid educational guidelines. The results of the present study support these views and emphasize the importance of education by showing significant improvement with the training provided to nurses who had insufficient knowledge and awareness about the subject.

Keywords: Pediatric Service Nurses, Pediatric Patients, Oral and Dental Health, Awareness, Education.

Pediatri Servis Hemşirelerinin, Çocukların Ağız Diş Sağlığının Korunması ve Devamlılığının Sağlanması Hakkında Farkındalıklarının Artırılması

Bilgi
 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

Geliş: 14/10/2022
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ÖZ

Amaç: Pediatri hemşirelerine ağız ve diş sağlığı konusundaki bilgi ve beceriyi kazandırmak ve onların farkındalıklarını artırmaktır.

Gereç ve Yöntemler: Araştırmanın birinci aşamasında, Trabzon ve Rize merkez ve ilçe hastanelerindeki pediatri servis hemşirelerine ön test soruları verildi. Testi cevaplayan hemşirelerle oluşturulan Whatsapp grubunda, tarafımca hazırlanan eğitim videosu paylaşıldı. İkinci aşamada; ön test sorularının aynısı, son test olarak tekrar uygulandı. İstatistiksel analiz için Jamovi (Sürüm 1.0.4) yazılımı kullanıldı. Normal olmayan bir dağılım nedeniyle, ön test ve son test puanları arasındaki farkları incelemek için bir Wilcoxon Rank istatistiksel analizi yapılmıştır. Bağımlı ve bağımsız parametreler arasındaki ilişkiyi belirlemek için Kruskal-Wallis analizi yapıldı. İstatistiksel anlamlılık için olasılık seviyesi p = 0.05 olarak ayarlandı.

Bulgular: Hem ön test hem de son testi cevaplayan 91 hemşirenin 83' ü (91,2%) kadın, 8'i (8,8%) erkekti. Altı farklı bölümden oluşan test kategorisindeki tüm bölümlerde (Diş Çürüğü, Diş Çürüklerinde Risk Faktörleri, Diş Çürüğünün Önlenmesi, Ağız ve Diş Yaralanmaları, Özel Bakım İhtiyacı Olan Çocuklar, Ne Yapmalı - Nasıl Yapılır?) eğitim sonrası yapılan son testteki başarı oranı anlamlı ölçüde artmıştı (p<0,001).

Sonuçlar: Araştırmalar; çocukların ağız ve diş sağlığı sorunlarının önüne geçilmesi amacı ile; yeni doğan hemşireleri, çocuk hemşireleri ve toplum sağlığı merkezlerinde çalışan sağlık profesyonelleri dinamiklerinin harekete geçirilmesi gerektiğini vurgulamakta ve bu konuda bilimsel geçerliliği olan eğitim rehberleri ile farkındalık bilincini desteklemektedir. Çalışma sonuçlarımız bu görüşleri destekler nitelikte olup, konu hakkında yetersiz bilgi ve farkındalığı olan hemşirelere verdiğimiz eğitim ile birlikte anlamlı iyileşmeyi göstererek eğitimin önemini vurgulamaktadır.

Anahtar Kelimeler: Pediatri servis hemşireleri, Çocuk hastalar, Ağız ve Diş Sağlığı, Farkındalık, Eğiti.

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Introduction

Worldwide, the most common chronic disease affecting children's health is dental caries, which remains a serious problem, particularly in low-income populations.[1,2] The prevalence of dental caries is high in children of certain ethnic or racial groups, particularly those who live in areas with limited access to dentist.[3] Some of the factors that contribute to the progression of dental caries include low socio-economic level, limited access to dental care, and a lack of guidance regarding expectations. Studies emphasize that newborn nurses, pediatric nurses, and health professionals working in public health centers should play a key role in preventing oral and dental health problems in children, and awareness should be raised through scientifically valid education guides on the subject.[4,5] On the contrary, studies have shown that nurses receive inadequate training in oral and dental health care and have insufficient knowledge in this area.[1,6] However, nurses constitute a large part of the health professions and play an important role in primary health care. Although the importance of healthcare professionals in systemic health is widely recognized, their role in oral health care is often overlooked.[7,8] Awareness and knowledge of dentistry is still insufficient among many patients and healthcare professionals.[9]

Sharing responsibility for children's oral health with primary health care providers creates opportunities for joint initiatives in target populations that are at high risk for other health and social problems. Therefore, oral recommendations for preventive measures in general health check-ups using an approach that considers common health determinants are quite productive.[10] A comprehensive collaborative approach to this issue requires professional cooperation.[10,11] Comprehensive approaches are certainly becoming more important and effective in less developed public dental services and healthcare systems; for example, involving vaccination staff in public health centers to provide oral health instructions to parents has been successful in reducing caries in young children.[12]

Oral and dental health is an important component of general health. Oral and dental health should not be ignored in children who are hospitalized or receiving treatment in order for them to regain their overall health; therefore, nurses' knowledge and skills in dental and oral health should be increased.[12,13] There are studies in the literature that assess pediatric nurses' oral health habits, oral and dental health knowledge, and pediatric oral health knowledge, but there are no studies that compare pediatric oral health knowledge among nurses before and after comprehensive training. The aim of this study was to provide pediatric nurses with the knowledge and skills needed for oral and dental health and to increase their awareness of this issue. It will be possible to avoid difficult and expensive dental treatments by allowing pediatric nurses to identify and prevent oral and dental health problems that may occur during certain stages of the child's life as well as by increasing parental awareness of this issue. When all of these factors are socially disseminated throughout Turkey, it will be possible to monitor oral health in a professional capacity starting from the first years of life.

Materials and Methods

Type of Research

This research was conducted using the "Single Group Pretest–Posttest Model," which is one of the quasi-experimental research methods.[14]

Location and Characteristics of the Research

The research was conducted in central and district state hospitals in Trabzon (Karadeniz Technical University Health Practice and Research Center [Farabi Hospital], Arakli Bayram Halil State Hospital, Akçaabat Hackalı Baba State Hospital, S.B.U. Kanuni Training and Research Hospital, Of State Hospital, Sürmene State Hospital, Vakfikebir State Hospital) and Rize (Recep Tayyip Erdoğan University Training and Research Hospital, İshakoğlu Çayeli State Hospital). All of these hospitals, which are secondary and tertiary care facilities, have an inpatient pediatric unit and nurses who work in it. The working hours of the nurses were 08.00–16.00 and 16.00–08.00, with more than one nurse on duty during the 16.00–08.00 shift.

Population and Sample of the Research

The study population consisted of 91 nurses working in the pediatric services of Trabzon and Rize central and district hospitals between 01/03/2019 and 31/12/2019.

To determine the sample size, a pilot study was conducted with five nurses who met the research criteria over a 1-month period (from 01.01.2019 to 01.02.2019). Based on this pilot study, sample size and power were calculated using the G*Power software (G*Power, Ver. 3.0.10, Universität Kiel, Germany, http://www.psycho.uniduesseldorf.de/aap/projects/gpower/). With power = 95%, type 1 error $\alpha = 0.05$, and type 2 error $\beta = 0.05$, the minimum number of individuals required to determine the difference between pre- and post-training test results at dz = 0.75 effect width was determined as 26. Considering the possible dropouts during and after the training, the sample size was increased by 20% (n = 6). According to these results, the total sample size was calculated to be 32 individuals. The study sample consisted of 91 nurses who agreed to participate in the study between 01/03/2019 and 31/12/2019 and met the inclusion criteria.

Ethical Considerations

Ethical approval was obtained from Recep Tayyip Erdogan University, Faculty of Medicine, Non-Interventional Ethics Committee, with decision number 2019/39. Necessary permission from Trabzon and Rize central and district hospitals, which have inpatient pediatric services, was obtained from the health directorates of the provinces, and approval was obtained from the head physician of each district hospital.

Preparation of Educational Materials

Training material was obtained by requesting the "Open Wide: Oral Health Training for Health Professionals" and "Health Professional's Guide to Pediatric Oral Health Management" [15] training modules from Georgetown University National Maternal and Child Oral Health Resource Center, and these modules were translated into Turkish. The material consists of six different modules. Module 1: Dental Caries, Module 2: Risk Factors for Dental Caries, Module 3: Prevention of Caries, Module 4: Oral and Dental Injuries, Module 5: Children with Special Care Needs, and Module 6: What to do and How?

The researcher created the training video, which was prepared through verbal and visual narration, and recorded the contents in the training booklet.

Data Collection

The researcher prepared pretest and posttest questionnaires to collect research data. The questionnaire included questions on the sociodemographic characteristics of the nurse and information about the modules in the training booklet. The content of the module was obtained by a professional translator translated into Turkish by a professional translator of the end-of-module questions in the training modules "Open Wide: Oral Health Education for Health Professionals" and "A Health Professional's Guide to Pediatric Oral Health Management" requested from Georgetown University National Maternal and Child Oral Health Resource Center. A total of 37 questions were divided into six different categories. The distribution of the questions in each category is shown in Table 1.

The posttest was administered 1 month after the training according to the principles of adult education. The pretest and posttest were administered to the caregivers by the researcher during face-to-face interviews. Before starting the training, nurses were informed about the questionnaire, and then the pretest was administered. The training booklet was given to the nurses immediately after the pretest. In the same session, the training video was sent to the nurses via Whatsapp, allowing nurses working at a busy tempo to watch the video and read the booklet. One month after the training, the questionnaire form was administered again as the posttest.

Each correct answer was given a score of "1," and each incorrect answer was given a score of "0." The total score ranged from 0 to 37 points.

Statistical Analysis

The Jamovi (Version 1.0.4) software was used for statistical analysis. A descriptive analysis of the study population's demographic attributes was conducted. The Shapiro–Wilk test was performed to detect normality. Owing to a non-normal distribution, a Wilcoxon Rank statistical analysis was conducted to examine the differences between pretest and posttest scores. The Kruskal–Wallis analysis was conducted to determine the relationship between dependent and independent parameters. The probability level for statistical significance was set at p=0.05.

Results

Of the nurses participating in the study, 91.2% were females (n = 83) and 8.8% were males (n = 8). The mean age of the participants was 35.4 ± 7.2 years. The demographic characteristics of the nurses are shown in Table 1.

In all modules of the training booklet, a statistically significant difference was found between the pretest and posttest scores ($p<0.001$) (Table 2) (Figure 1).

The statistical relationship between nurses' sociodemophic characteristics and pretest and posttest scores is shown in Table 3.

Discussion

Pediatric nurses, pediatricians, and other healthcare professionals who deal with children are far more likely than dentists to encounter pre-school children who need preventive oral measures. Therefore, non-dental health professionals should be trained to identify risk factors for early childhood caries and other oral health problems as well as to make appropriate decisions about timely and effective intervention and referrals.[2] Hallas et al.[2] stated that pediatric nurses in primary care received postgraduate education through the doctoral program recommended by the American College of Nurses[16] until 2015. The core curriculum was published by the Programs of the Association of Child Health and Diseases Nursing Faculties, which covered oral health topics in a broad framework.[17] These topics cover evaluation of the oral cavity, including primary and permanent dentition; recommendations suggesting a first dentist visit; common oral health problems, such as recognizing malocclusions, cavities, and dental injuries; recommendations for brushing and oral hygiene; advice on the use of pacifiers and bottles and the prevention of dental problems; focusing on children's oral health needs and dental hygiene; and oral and dental health issues for children with special needs such as cleft palate. An integral part of this curriculum is the management of clinical practice by nurses. In this sense, the primary emphasis is on the development of expertise in physical assessment skills, including oral cavity examination and evaluation.[2,17] To the best of our knowledge, no education curriculum in undergraduate and graduate programs of pediatric nurses in Turkey addresses both theoretical and practical issues related to oral and dental health.

Several publications have emphasized the importance of pediatric nurses' knowledge of children's oral health problems.[2,18,19] Sohn et al.[20] stated that before developing detailed educational strategies for nursing students, the lack of knowledge about oral health should be clearly addressed. Although Pesaresi et al.[21] reported similar results, they stated that knowledge and awareness of "recognizing caries lesions" and "protecting from caries" are especially low. Pediatric nurses' lack of basic knowledge of oral health care for children has been associated with a lack of training in oral and dental health during continuous education [18-21].

Kressin *et al.*[22] gave pediatricians and clinical nurses a 1-hour training on early childhood caries (ECC) and stated that correct answers about ECC increased from 66% to 79% after the training program. Tüzüner et al.[19] conducted a study in Turkey where they taught senior nursing students about the oral and dental health of newborns and infants and stated that the correct answers in the posttest increased significantly compared to the pretest. Kahriman et al.[18] evaluated pediatric nurses' knowledge of the oral and dental health of newborns and infants and found that nurses' knowledge level was low. They found that this was associated with education level, years of professional work, and whether the nurses had received previous oral and dental health education. In the same study, most nurses (88.7%) stated that they did not receive professional training on the oral and dental health of newborns and children. In the present study, 86.8% of pediatric nurses stated that they had not received any training on oral and dental health, which is consistent with the result of Kahriman et al.[18] The correct answers given in the pretest by 13.2% of nurses who had received training before being introduced to the "Risk factors in prevention of caries" module were significantly higher than those who had not received any training. According to the literature, education level is a significant factor, but professional experience does not significantly affect knowledge.[23] Perassi et al.[21] also stated that there is no significant relationship between knowledge, socio-economic status, and years of professional experience. In the present study, no significant difference was found between the pretest and posttest in terms of education level. Kahriman et al.[18] found that increasing knowledge with increasing education levels and years of vocational training was associated with better experience and awareness of nurses.

Consistent with other studies, in the present study, the number of correct answers in the pretest was significantly lower in all modules compared to the posttest. The answers given to the risk factors module in the pretest revealed a significant difference in terms of age, gender, and whether the nurses had previously received oral and dental health education. In terms of age, there was also a significant difference in the 3 and 6 modules of the pretest.

The study's training modules included not only dental caries but also oral and dental injuries, children with special care needs, and what to do these cases. Different experts in the field developed and standardized English–Turkish and Turkish–English translations of these training modules. Quasi-experimental research designs examine causal hypotheses and changes in outcomes before and after an intervention.[14] A pretest and posttest on pediatric ward nurses were used to assess the effectiveness of these standardized training modules. The posttest results showed that these standard training modules are effective, as evidenced by an increase in pediatric ward nurses' level of knowledge and awareness of children' oral and dental health. As a result, applying this comprehensive education model to wider audiences in the future will be beneficial.

There are certain limitations to this study. Quasi-experimental research methods are often used when it is not possible to divide individuals or groups into treatment and control groups.[14] A lack of randomization in pediatric ward nurses, a small sample size, and a lack of long-term test results and motivation to follow-up are other limitations of the study. These issues should be addressed in future studies on this subject. We believe that there is a need for additional research utilizing a multidisciplinary approach in the process of integrating oral and dental health into secondary and tertiary health services.

Conclusions

According to the results of the present study, standardized training programs can be used effectively to increase pediatric nurses' knowledge of children's oral and dental health. Developing appropriate health policies and incorporating oral and dental health education into nursing curricula will play an important role in raising awareness of both preventive and curative dental care among pediatric nurses who provide close care to children in secondary and tertiary health institutions.

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Conflicts of Interest statement

There is no conflict of interest

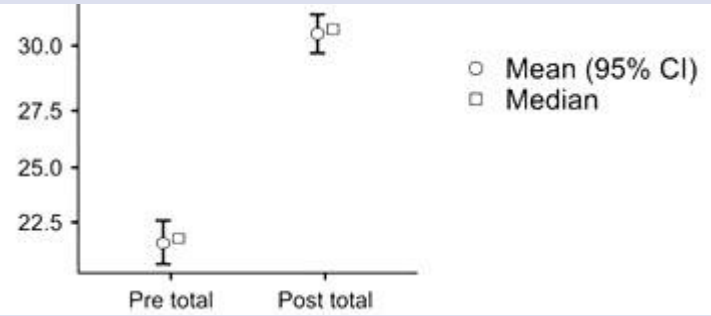

Figure1. Mean and median values of total correct answers in pretest and posttest

Table 1. Descriptive analysis of the demographic characteristics of pediatric nurses

	Total (N=91)
Age	
Mean (SD)	35.4 (7.2)
Range	20.0 - 47.0
Gender	
Male	8 (8.8%)
Female	83 (91.2%)
Marital status	
Single	67 (73.6%)
Married	24 (26.4%)
Education level	
High school	6 (6.6%)
University	85 (93.4%)
Professional experience	
Mean (SD)	13.5 (7.7)
Range	1.0 - 29.0
Have you received any training on oral and dental health?	
Yes	12 (13.2%)
No	79 (86.8%)

Table 2. Differences of pre and post scores according to training patterns (Wilcoxon Rank Statistical Analysis)

				95% Confidence Interval	
Training Modules	**p**	**Mean difference**	**SE difference**	**Lower**	**Upper**
Mod 1	< .001	-1.5	0.15	-2	-1.5
Mod 2	< .001	-1.5	0.15	-1.5	-1
Mod 3	< .001	-1.5	0.13	-1.5	-1
Mod 4	< .001	-3	0.22	-3.5	-3
Mod 5	< .001	-1.5	0.11	-2	-1.5
Mod 6	< .001	-1.5	0.13	-2	-1.5
Total	< .001	-9	0.52	-10	-8

Table 3. Presentation of Kruskal-Wallis Analysis that tested the relationship between dependent factors and scores.

	Age range			**Gender**					**Have you received oral health education before?**		
	<39	>38	p	Female	Male	p	High Sch.	Univ	p	Yes	No	p-
Pre test-Mod 1	4 (2-6)	4 (0-6)	0.208	3,5 (2-6)	4 (0-6)	0.537	3 (2-6)	4 (0-6)	0.584	4,5 (0-6)	4 (2-6)	0.692
Pre test-Mod 2	5 (1-6)	4 (0-6)	0.011*	3 (3-5)	5 (0-6)	0.015*	5 (3-6)	5 (0-6)	0.767	5 (0-6)	5 (1-6)	0.007*
Pre test-Mod 3	3 (1-6)	2.5 (0-5)	0.004*	3 (1-5)	3 (0-6)	0.590	2 (1-5)	3 (0-6)	0.539	3 (1-6)	3 (0-5)	0.625
Pre test-Mod 4	5 (1-10)	5 (0-7)	0.175	2,5 (2-7)	5 (0-10)	0.083	5 (2-8)	5 (0-10)	0.198	5.5 (1-10)	5 (0-10)	0.250
Pre test-Mod 5	2 (0-4)	3 (0-4)	0.291	3 (0-4)	3 (0-4)	0.582	3 (2-4)	3 (0-4)	0.065	2.5 (1-4)	3 (0-4)	0.825
Pre test-Mod 6	4 (0-5)	3 (0-5)	< .001*	3 (0-5)	3 (0-5)	0.733	3 (1-4)	3 (0-5)	0.304	3 (0-5)	3 (0-5)	0.799
Pre test-Total	23 (14-34)	20,5 (6-28)	0.002*	17,5 (14-29)	22 (6-34)	0.114	21 (15-29)	22.5 (6-34)	0.540	24 (6-34)	22 (6-33)	0.194
Post test-Mod 1	6 (3-6)	5 (2-6)	0.868	6 (5-6)	5 (2-6)	0.029*	5 (4-6)	5.5 (2-6)	0.315	5 (4-6)	6 (2-6)	0.538
Post test-Mod 2	5 (4-6)	6 (4-6)	< .001*	5 (5-6)	5 (4-6)	0.828	5 (4-6)	6 (4-6)	0.060	5 (4-6)	6 (4-6)	0.388
Post test-Mod 3	5 (3-6)	4 (2-6)	0.328	4.5 (3-6)	4 (2-6)	0.376	5 (4-6)	4 (2-6)	0.200	4 (3-6)	4 (2-6)	0.761
Post test-Mod 4	8 (3-10)	8 (5-10)	0.037*	8 (8-10)	8 (3-10)	0.055	8 (6-9)	8 (5-10)	0.198	8 (5-10)	8 (3-10)	0.954
Post test-Mod 5	4 (1-5)	4 (3-4)	0.156	4 (3-4)	4 (1-5)	0.531	4 (3-4)	4 (1-5)	0.912	4 (4-4)	4 (1-5)	0.150
Post test-Mod 6	5 (2-5)	4,5 (1-5)	0.130	4.5 (3-5)	5 (1-5)	0.831	5 (3-5)	5 (1-5)	0.685	5 (3-5)	5 (1-5)	0.761
Post test-Total	31 (22-35)	31,5 (21-35)	0.594	32 (29-35)	31 (21-35)	0.083	31 (29-35)	31 (21-35)	0.240	31.5 (25-34)	31 (21-35)	0.863

Median (Min-max), * indicates significance (p<0.05)

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Evaluating the Perspectives of the Faculty of Dentistry Students on Pediatric Dentistry: A Survey Study

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Research Article

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This study was presented as an oral presentation at the ''Sivas Cumhuriyet University 2st International Dentistry Congress'' held between 22-24 September 2022.

History

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ABSTRACT

Objectives: *This study aims to evaluate the approach of the students of the faculty of dentistry who look after children in their internships to pediatric dentistry, which includes preventive dentistry.*
Materials and Methods: *A questionnaire consisting of 20 questions was prepared. The questionnaire was administered to the students online in a stress-free environment away from the exam environment. The data were coded and analyzed in a computer environment. Categorical divisions are expressed as numbers and percentages. The chi-square test was used to compare the evaluations of the participants according to their ancestry and class.*
Results*: 55.9% of the participants said they liked caring for pediatric patients. While 72.8% of them stated they were nervous when their child looked After graduation, 67.6% answered that they could think of treating pediatric patients routinely in their professional life. However, not very often, while 25% of them said yes, and 7.4% of them did not think unless it was necessary. Although women are more anxious when a child is sick, they prefer to look after a child more than men (p<0.05). There was no significant difference according to the class of the participants in choosing to treat the child or adult patient (p>0.05). There is no statistically significant difference in the participants' evaluations regarding the institutions that they think provide the best pediatric dentistry service according to class and gender (p>0.05). Dentistry faculties were the most frequent response for both classes and genders.*
Conclusions: *Despite the large population of children and young people in our country, it has been observed that future dentist candidates are not willing enough for these treatments. Increasing their knowledge and experience in treating pediatric patients during their education will help more pediatric patients be treated.*
Keywords: *Dentistry students, Pedodontics, Preventive dentistry.*

Diş Hekimliği Fakültesi Öğrencilerinin Çocuk Diş Hekimliğine Bakış Açısını Değerlendirmek: Anket Çalışması

Bilgi
 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

Geliş: 04/11/2022
Kabul: 21/11/2022

ÖZ

Amaç: *Bu anket çalışmasının amacı; stajlarda çocuk hasta bakan diş hekimliği fakültesi öğrencilerinin, koruyucu diş hekimliği de içerisine alan çocuk diş hekimliğine yaklaşımını değerlendirmektir.*
Gereç ve Yöntemler: *Amaca yönelik olarak 20 sorudan oluşan bir anket formu hazırlandı ve anket, öğrencilere sınav ortamından uzak stressiz bir ortamda online olarak uygulandı. Veriler bilgisayar ortamında kodlandı ve analiz edildi. Kategorik veriler, sayı ve yüzde olarak ifade edilmiştir. Katılımcıların insiyetlerine ve sınıflarına göre verilen sorulara ilişkin değerlendirmelerinin karşılaştırmasında ki-kare testinden yararlanılmıştır.*
Bulgular: *Katılımcıların %55,9'u çocuk hasta bakmayı sevdiklerini belirtmişlerdir. %72,8'i çocuk hasta bakarken tedirgin olduğunu belirtirken, %16,9'u çocuk, %83,1'i yetişkin hastayı tedavi etmeyi tercih etmektedir. Mezuniyet sonrasında meslek hayatlarında rutin olarak çocuk hasta tedavi etmeyi, %67,6'sı çok sık olmamakla birlikte düşünebilirim yanıtını verirken, %25'i evet, %7,4'ü ise mecbur kalmadıkça kesinlikle düşünmüyorum yanıtını vermiştir. Çocuk hasta bakarken kadınların daha tedirgin olmasına rağmen, çocuk hasta bakmayı erkelere göre daha çok tercih etmektedir (p<0,05). Çocuk veya yetişkin hastayı tedavi etmeyi tercih etme durumlarında katılımcıların sınıflarına göre anlamlı bir farklılık bulunmamaktadır (p>0,05). Katılımcıların sınıflarına ve cinsiyete göre çocuk diş hekimliği hizmetinin en iyi verildiğini düşündükleri kurumlara ilişkin değerlendirmelerinde istatistiksel olarak anlamlı bir farklılık bulunmamaktadır (p>0,05). Her iki sınıf ve cinsiyet için en sık verilen yanıt diş hekimliği fakülteleri olmuştur.*
Sonuçlar: *Ülkemizde çocuk ve genç nüfusunun fazla olmasına rağmen, geleceğin diş hekimi adayları, bu tedavilerde yeteri kadar istekli olmadıkları görülmüştür. Öğrenimleri süresince çocuk hastaları tedavi etmeye yönelik bilgi ve tecrübelerinin arttırılması, ileride daha çok sayıda çocuk hastayı tedavi edilebilmelerine yardımcı olacaktır.*
Anahtar Kelimeler: *Diş hekimliği öğrencileri, Pedodonti, Koruyucu diş hekimliği.*

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Introduction

The American Academy of Pediatrics and the American Academy of Pediatric Dentistry recommend starting dentist visits one year with the eruption of teeth.[1,2]

To complete the permanent teeth eruption and ensure the dental arch's integrity, the primary teeth must remain healthy in oral planning. Regular visits to the dentist prevent children from needing more difficult and costly treatments at an early age.[3]

The traditional treatment of tooth loss caused by tooth decay and gingival diseases is symptomatic. It contributes little to oral health when the patient's oral hygiene problem is not resolved. However, if this treatment approach dominates the clinical process, long-term and costly treatment options will come to the fore due to continuous restoration repetitions. Preventive/protective applications that focus on the biological causes of the disease instead of such interventional approaches, on the one hand, target small-level interventional applications; on the other hand, a significant reduction in treatment time and costs is achieved. In this context, the "Minimal intervention" treatment concept in modern dentistry focuses on dentists' diagnosis, control, and protection concepts rather than intervention.[4-7]

To realize the importance of preventive/preventive approach in clinical dentistry practices and to be able to apply it in this clinic, it is essential that future dentist candidates have received the necessary training and practiced at a sufficient level on the "minimal intervention" treatment approach, which can be performed with minimal intervention in dentistry, before graduation.[8]

In our country, approximately one-third of the population comprises children in the '0-17' age group.[9]

According to the data of the Turkish Statistical Institute, while oral and dental health problems are seen in the first place in children aged 7-14, one of the most critical public health problems in children has been reported as dental caries.[10]

In light of these data, due to the lack of a sufficient number of pedodontists in our country, dentists must act more willingly in treating pediatric patients. However, it is seen that physicians mostly avoid treating children before school age.[11] Generally, this patient group is directed to pediatric dentists.[12]

The reasons for these should be investigated, and studies should be carried out.[3]

Survey studies are a fast, practical, and economical method of obtaining data on the adult population.[13] However, it will help us to see at what stage we are in the subject of such studies and to plan what we can do accordingly.[14]

Our aim in this study is to evaluate the approach of the students of the faculty of dentistry who look after children in their internships to pediatric dentistry, including preventive dentistry.

Materials and Methods

The universe of this study consisted of 4th and 5th-grade students studying at Fırat University Faculty of Dentistry and caring for patients. It was aimed to reach almost the entire universe. For this purpose, a questionnaire consisting of 20 questions was prepared, and the questionnaire was administered to the students online in a stress-free environment away from the exam environment.

Ethics Committee Approval

The research has received approval from the Clinical Research Ethics Committee of Fırat University (Date: 07.06.2022 No: 8998).

Statistics

This study used IBM SPSS Statistics (Version 22.0. Armonk, NY: IBM Corp.) for statistical analysis. Categorical data were expressed as numbers and percentages. The chi-square test was used to compare the participants' evaluations of the questions given according to their gender and class. The statistical significance level in the study was accepted as $p<0.05$.

Results

The findings of the research conducted with 136 participants are presented below. According to the results, 62.5% of the participants are in 4th-grade, and 37.5% are 5th-grade students. 46.3% of the participants are men, and 53.7% are women. (Table 1)

55.9% of the participants stated that they like caring for pediatric patients. Do you get nervous when the child is sick? 72.8% of the participants answered yes to the question. When the participants were asked whether they like to care for a child or an adult patient, 16.9% replied as children and 83.1% as adults. When asked whether they would routinely consider treating pediatric patients after graduation, 67.6% of them answered that they could think of it. However, not very often, while 25% of them answered yes and 7.4% of them said I don't unless they have to. (Table 2)

Do you think that fissure sealant is an effective preventive method against caries? To the question, 21.3% of the participants sometimes answered, and 78.7% said yes. Do you think fluoride applications are effective against caries? To the question, 39% of the participants responded sometimes, and 61% answered absolutely yes. (Table 3)

97.8% of the participants said they recommend other preventive methods to their patients and parents. When asked about the education they received in pedodontics, 53.7% of them found it sufficient, while 46.3% stated that it was not. While 46.3% of the participants indicated that they obtained professional knowledge about preventive dentistry from dental faculties, 23.5% said that they received it from books, and 15.4% from their colleagues.

77.2% of the participants think there will be environments where they can apply protective measures to pediatric patients after graduation. The rate of participants who stated the importance of brushing their teeth in pediatric patients and their parents was 77.9%.

While the rate of participants who think that pediatric dentistry service can be provided in the best hospitals and

dental faculties is 53.7%, the rate of participants who believe it can be supplied in practice is 44.9%. 66.9% of the participants stated they had dental treatment as a child. The rate of participants who positively described the dental experience they had as a child is 69.1%. The rate of participants who think that the physician's approach is effective in childhood dental experience is 82.4%. 69.1% of the participants use pre-treatment behavior guidance techniques.

There was no statistically significant difference between the participants' liking to care for pediatric patients according to their gender ($p>0.05$). 55.6% of male and 56.2% of female participants said they liked it. (Table 4)

There is a significant difference according to the gender of the participants in the state of being uneasy when the child is sick ($p<0.05$). The rate of those who stated that they were nervous is higher in women.

There is a significant difference according to the gender of the participants in terms of choosing to treat a child or adult patient ($p<0.05$). The rate of those who stated that they prefer to take care of children is higher in women.

According to the gender of the participants, there is no statistically significant difference between the status of thinking of treating pediatric patients routinely in their professional life after graduation ($p>0.05$). The answer given by male and female participants at the highest rate was I can think, although not very often.

There was no statistically significant difference between the patients and their parents recommending other preventive methods according to the gender of the participants ($p>0.05$). However, the answer given by female and male participants at the highest rate was yes.

There is a significant difference between the participants' status of seeing the education they have received in the field of pedodontics as sufficient ($p<0.05$). Male participants consider the training they receive to be more than enough than female participants.

According to the gender of the participants, there is no statistically significant difference between their thinking of improving themselves in the field of pedodontics after graduation ($p>0.05$).

There was no statistically significant difference in the status of the participants explaining the importance of tooth brushing to the pediatric patients they treated and their parents according to their gender ($p>0.05$). However, the most frequent answer for participants of both genders was yes.

There is no statistically significant difference in the participants' evaluations regarding the institution where the individual protection programs are best given according to their gender ($p>0.05$). For participants of both genders, the most frequent response was practice.

There is no statistically significant difference in the participants evaluations regarding the institutions they think provide the best dental service according to their gender ($p>0.05$). However, for respondents of both genders, the most frequent response was dental faculties.

There is a significant difference based on gender in the state of the participants thinking that there will be environments where they can apply protective methods to pediatric patients after graduation ($p<0.05$). In addition, female participants have a higher positive response rate.

There is a significant difference according to the classes of the participants in the state of being uneasy when the child is sick ($p<0.05$). The rate of those who stated they were nervous is higher among the participants in the 4^{th}- grade.

There was no statistically significant difference between the answers the participants gave to the other questions according to their classes ($p>0.05$).

Discussion

Many dentists prefer to treat older children than younger patients. Especially in children under the age of three, it has been observed that the number of dentists to treat patients in this age group has decreased because the procedures take more time, the financial return is low, and they are tiring.[15,16] It has been stated that dentists do not feel comfortable and experienced during the treatment of these patients and do not prefer to perform the treatment because less opportunity is given to treating young and maladaptive patients during their education.[12,15]

However, suppose students do not have clinical proficiency at graduation. In that case, they may be reluctant to treat pediatric dentistry patients later in their practice, thus placing a more significant burden on the small number of pedodontists.[12]

For this reason, we aim to evaluate the students' approach to pedodontics in our study.

Esra O.Z *et al.* observed that 10.8% of physicians were unwilling to treat pediatric patients. The rate of treating pediatric patients between the ages of 0-3 was 9.2%

In our study, 55.9% of the participants stated that they liked looking after a child patient, and 72.8% indicated that they were uneasy when looking after a child. It was observed that 16.9% of the students preferred to care for children and 83.1% for adult patients. After graduation, 67.6% answered that they could think routinely, although not very often, and 7.4% said they do not believe unless they have to. On the other hand, although women stated that they were more anxious while taking care of children, it was observed that women preferred to look after children more than men. In addition, there is a significant difference in the state of being uneasy when the child is looking at the patient according to the classes of the participants ($p<0.05$). The rate of those who stated they were nervous is higher among the participants in the 4^{th} grade. We think this is due to the lack of clinical experience of 4^{th} -grade students.

It is predicted that female dentists are more likely to treat pediatric patients. Our study supports this. In some studies, no differences were observed between the gender of the physicians and the age groups of the pediatric patients treated.[3,17]

Kayalıbay *et al.*[18] reported that young dentists applied more preventive treatment. It was also reported that it was used more frequently among physicians who graduated in the last five years compared to those who had previously graduated.[3,19]

Contrary to these studies, in a survey conducted in 2004, the relationship between the professional experience of physicians and fissure sealant applications was not found to be statistically significant.[17]

In our study, students who think that fissure sealant is an effective preventive method against caries answered 21.3% sometimes and 78.7% that. On the other hand, those who think that fluoride applications are really effective against caries gave the answer 39% sometimes and 61% definitely. Therefore, we believe that students do not fully integrate their knowledge of preventive dentistry into clinical practice.

In our study, 97.8% of the participants recommended other preventive methods to their patients and parents. We see that the rate is relatively high and promising. 77.2% of the participants think there will be environments where they can apply protective measures to pediatric patients after graduation. The rate of participants who stated that they told the importance of brushing their teeth to pediatric patients and their parents were 77.9%. Regarding where the individual-level protection programs can best be given, 46.3% of the participants answered practice, 41.9% in hospitals, and dentistry faculties.

While the rate of participants who think that pediatric dentistry service can be provided in the best hospitals and dental faculties is 53.7%, the rate of participants who believe it can be supplied in practice is 44.9%. In addition, the rate of participants who think that the physician's approach is effective in the dental experience they had as children is 82.4%. 69.1% of the participants use pre-treatment behavior guidance techniques. There was no difference according to gender and class.

In another study, it was determined that the students suggested brushing without asking about the teeth-brushing habits of the patients. Students think that preventive practices may affect the success of their operational treatment for their patients.[14] It shows parallelism with our study.

In a study, 63.5% of the students (n=99) stated that they obtained professional knowledge about preventive medicine from theoretical courses.[14] In our study, 46.3% of the students indicated that they received professional knowledge about preventive dentistry from dental faculties, % 23.5% stated that they obtained it from books, and 15.4% from their colleagues. In addition, male participants consider the training they receive to be more sufficient than female participants.

Conclusions

Despite the high population of children and young people in our country, it has been observed that future dentist candidates are not willing enough for these treatments. Therefore, increasing their knowledge and experience in treating pediatric patients during their education will help them treat more pediatric patients.

Acknowledgments

No support was received from any institution.

Conflicts of Interest Statement

There is no conflict of interest with this manuscript's research results and publication.

This study was presented as an oral presentation at the 2nd International Dentistry Congress of Sivas Cumhuriyet University Faculty of Dentistry (22-24 September 2022) with the title of **"Evaluating the Pediatric Dentistry Perspective of the Faculty of Dentistry Students: Survey Study."**

Table 1: Demographic characteristics of participants

		F	%
Grade	4th- grade	85	62.5
	5th -grade	51	37.5
Gender	Male	63	46.3
	Female	73	53.7

Table 2: General views of the participants -1

		f	%
Do you love treating child patients?	Yes	76	55.9
	No	60	44.1
Do you get nervous while treating a child patients?	Yes	99	72.8
	No	37	27.2
Do you prefer to treat a child patient or an adult patients?	Child	23	16.9
	Adult	113	83.1
Do you think of treating pediatric patients routinely in your professional life after graduation?	I can think about it, although not very often	92	67.6
	Yes	34	25.0
	I definitely don't think so unless I have to	10	7.4

Table 3: General views of the participants -2

		f	%
Do you think that fissure sealant is an effective preventive method against caries?	Sometimes	29	21.3
	Definitely yes	107	78.7
Do you think fluoride applications are really effective against caries?	Sometimes	53	39.0
	Definitely yes	83	61.0
Would you recommend other preventive methods to your patients and their parents?	Yes	133	97.8
	No	3	2.2
Do you consider the education you have received in the field of pedodontics sufficient?	Yes	77	56.6
	No	59	43.4
Do you plan to develop yourself more in the field of pedodontics after graduation?	Yes	73	53.7
	No	63	46.3
From which sources do you get professional information about preventive dentistry?	Dental faculties	63	46.3
	The internet	15	11.0
	Books	32	23.5
	My colleagues	21	15.4
	Social media	2	1.5
	Meetings and congresses	3	2.2
Do you think there will be environments where you can apply protective methods to your pediatric patients after graduation?	Yes	105	77.2
	No	31	22.8
Do you explain the importance of tooth brushing to the pediatric patients you treat and their parents?	Sometimes	27	19.9
	Yes	106	77.9
	No	3	2.2
Where can individual protection programs best be delivered?	Oral and dental health centers	16	11.8
	Dentistry faculties in hospitals	57	41.9
	Private clinics	63	46.3

Table 4: Comparison of the opinions of the participants by gender

			Gender		Total	p
			Male	Female		
Do you love treating child patients?	Yes	N	35	41	76	0.540
		%	55.6%	56.2%	55.9%	
	No	N	28	32	60	
		%	44.4%	43.8%	44.1%	
Do you get nervous while treating a child patients?	Yes	N	38	61	99	0.002*
		%	60.3%	83.6%	72.8%	
	No	N	25	12	37	
		%	39.7%	16.4%	27.2%	
Do you prefer to treat a child patient or an adult patients?	Child	N	5	18	23	0.009*
		%	7.9%	24.7%	16.9%	
	Adult	N	58	55	113	
		%	92.1%	75.3%	83.1%	
Do you think of treating pediatric patients routinely in your professional life after graduation?	I can think about it. although not very often	N	44	48	92	0.779
		%	69.8%	65.8%	67.6%	
	Yes	N	14	20	34	
		%	22.2%	27.4%	25.0%	
	I definitely don't think so unless I have to	N	5	5	10	
		%	7.9%	6.8%	7.4%	

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Antibiofilm Effect of Different Irrigation Solutions Activated with KTP Laser

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Research Article

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History

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ABSTRACT

Objectives: *The aim of this study was to evaluate the antimicrobial efficacy of Potassium Titanium Phosphate (KTP) laser-activated irrigation solutions on intraradicular Enterococcus faecalis biofilms in in-vitro conditions by using a scanning electron microscope.*

Materials and Methods: *120 single-root, single canal permanent mandibular premolar human teeth were used. Sterilization and disinfection of the teeth were performed. Enterococcus faecalis biofilms were obtained after 4 weeks by re-inoculation procedures. Each group was divided into 6 groups consisting of 20 roots and root canal disinfection protocols were applied using irrigation solutions with 5.25% NaOCl, saline, super-oxidized water solution, 8 ppm ozonated water, 2% CHX, 17% EDTA, all activated by KTP laser. It was smear-planted to a solid medium which split as before and after the disinfection applications for the aim of Counting Microorganism colonies from root canals and data were evaluated statistically. In this statistical evaluation one way ANOVA and Tukey tests were used. Before and after the irrigation procedures for the presence and elimination of biofilm the root canals were processed for scanning electron microscopy and biofilm was examined on the standard images.*

Results*: As a result of the statistical comparison performed among all groups, while NaOCl ensures the highest amount of elimination as a positive control group, the lowest amount of bacterial elimination was detected in the saline group that applied as the negative control group ($p<0.05$). None of the experimental groups achieved the whole elimination of Enterococcus faecalis biofilm. While there was no statistically significant difference between super-oxidized water and aqueous ozone groups that indicated the strongest antibiofilm effect ($p>0.05$), EDTA showed the lowest antibiofilm effect ($p<0.05$).*

Conclusions: *The use of 5.25% NaOCl solution activated by KTP laser, which shows the highest antibiofilm efficiency among the study groups, in clinical applications is very effective in terms of biofilm elimination in root canal treatments and is especially promising in the success of long-follow-up treatments. However, the KTP laser activation procedures of super-oxidized water solution and 8 ppm ozonated water may be insufficient as a safe disinfection method.*

Keywords: *Biofilm, laser-activated irrigation, Enterococcus faecalis, KTP laser.*

KTP Lazer ile Aktive Edilen Farklı İrrigasyon Solüsyonlarının Antibiyofilm Etkisi

Bilgi
 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

Geliş: 16/11/2022
Kabul: 16/12/2022

ÖZ

Amaç: *Bu çalışmanın amacı, Potasyum Titanyum Fosfat (KTP) lazer ile aktive edilen irrigasyon solüsyonlarının intraradiküler Enterococcus faecalis biyofilmleri üzerindeki antimikrobiyal etkinliğinin taramalı elektron mikroskobu kullanarak in vitro koşullarda değerlendirilmesidir.*

Gereç ve Yöntemler: *Bu çalışmada 120 tek kök tek kanallı daimi mandibular küçük azı insan dişleri kullanıldı. Dişlerin sterilizasyon ve dezenfeksiyon işlemleri yapıldı. Enterococcus faecalis biyofilmleri re-inokülasyon prosedürleri ile elde edildi. Her grup 20 kökten oluşan 6 gruba ayrıldı ve tamamı KTP lazer ile aktive edilen %5,25'lik NaOCl, serum fizyolojik, süper okside su solüsyonu, 8 ppm ozonlu su, %2'lik CHX, %17'lik EDTA ile irrigasyon protokolleri uygulandı. Kök kanallarından Mikroorganizma kolonilerinin sayımı amacıyla dezenfeksiyon uygulamaları öncesi ve sonrası olarak ayrılan katı besiyerine smear ekilmiş ve veriler istatistiksel olarak değerlendirilmiştir. Bu istatistiksel değerlendirmede tek yönlü ANOVA ve Tukey testleri kullanılmıştır. Biyofilm varlığı ve ortadan kaldırılması için irrigasyon işlemlerinden önce ve sonra kök kanalları taramalı elektron mikroskobu için işlendi ve standart görüntüler üzerinde biyofilm incelendi.*

Bulgular: *Tüm gruplar arasında yapılan istatistiksel karşılaştırmalar sonucunda NaOCl pozitif kontrol grubu olarak en yüksek miktarda eliminasyonu sağlarken, en düşük bakteri eliminasyonu negatif kontrol grubu olarak uygulanan serum fizyolojik grubunda tespit edilmiştir ($p<0,05$). Deney gruplarının hiçbiri, Enterococcus faecalis biyofilminin tamamen ortadan kaldırılmasını sağlamadı. Antibiyofilm etkinliği açısından en güçlü etkiyi gösteren süper okside su ile ozonlu su grupları arasında istatistiksel olarak anlamlı bir fark bulunmaz iken ($p>0,05$); en düşük antibiofilm etkiyi EDTA grubu göstermiştir ($p<0,05$).*

Sonuçlar: *Çalışma grupları arasında en yüksek antibiyofilm etkinliği gösteren KTP lazer ile aktive ettiğimiz % 5,25' lik NaOCl solüsyonunun klinik uygulamalarda kullanılmasının kök kanal tedavilerinde biyofilm eliminasyonu açısından oldukça etkili ve özellikle uzun takipli tedavilerin başarısında umut vericidir. Ancak süper oksitlenmiş su solüsyonu ve 8 ppm ozonlu suyun KTP lazer aktivasyon prosedürleri güvenli bir dezenfeksiyon yöntemi olarak yetersiz kalabilir.*

Anahtar Kelimeler: *Biyofilm, Lazer ile Aktive Edilen İrrigasyon, Enterococcus faecalis, KTP Lazer.*

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Introduction

The elimination of resistant microorganisms in deep areas of the root canal system is the main problem in today's treatment protocols. One of the main goals of endodontic treatment is the elimination of microorganisms that cause periapical periodontitis from the infected root canal system.[1] The most common bacterial species in resistant and secondary infections is *Enterococcus faecalis* (*E. faecalis*). The fact that *E. faecalis* has never been isolated or has been isolated at low levels in teeth that have not previously applied root canal treatment proves that this bacterial species is one of the main bacterial species that cause root canal treatment failures.[2,3] In the successful implementation of the shaping and cleaning of the root canals; It has been stated that the complete removal of the vital and necrotic pulp tissue, affected dentin tissue and other residues in the root canal and disinfection of the root canal cavity play a very important role.[4]

The use of lasers in endodontics increases the success rate of root canal treatment. Laser beams are used to remove debris and smear layer in endodontics, to penetrate the dentin tissue more and to reach the areas that cannot be reached in the complex structure of the root canal system more than traditional methods, and to eliminate the disadvantages of the chemomechanical preparation.[5,6] It is claimed that lasers can reach the inaccessible areas of the root dentin tubules and progress to a depth of more than 1000 µm, showing a specific antibacterial effect and eliminating these negative factors by ensuring that all microorganisms in the deep layers can be eliminated.[7]

In light of all this information, this study aims to evaluate the antimicrobial activities of the irrigation activation procedure with potassium titanium phosphate (KTP) laser activation on the *E. faecalis* biofilm layer formed in the root canal by scanning electron microscopy in vitro.

Materials and Methods

The study was initiated after the ethics committee approval dated 14.07.2015 and numbered 2015-07/08 was obtained from Cumhuriyet University Clinical Research Ethics Committee. The present study was carried out by Sivas Cumhuriyet University Faculty of Dentistry, Department of Endodontics clinic, and Sivas Cumhuriyet University Faculty of Pharmacy, Department of Pharmaceutical Microbiology clinic.

In the present study, 120 permanent human mandibular premolar teeth, which were extracted for orthodontic or periodontal reasons, without caries, and without restoration, were used. The pulp tissue in the root canals was removed using tirnerf (Vereinigte Dentalwerke GmbH & Co. KG, Munich, Germany) and the canal path was determined by entering the root canals with #15 K-File (Mani Inc., Tochigi, Japan) hand instruments. The length of the canal tool was measured by advancing until the tip of the canal tool was visible in the apical opening, and the working length was determined for each root by retreating 1 mm from this measured length. Root canals were shaped using ProTaper Next rotary files (Dentsply Maillefer, Ballaigues, Switzerland) using X1, X2, and X3 files respectively, and the apical third of all canals were standardized with X3. During the preparation, the canals were irrigated with 1 ml of 5.25% NaOCl solution after each file use. To remove the smear layer formed during preparation, the root canals are then were irrigated using sequentially 17% EDTA (AppliChem GmbH, Germany), 5.25% NaOCl, and distilled water and were dried with a paper point. Before microbiological applications, the glass bottles in which we will place the teeth were packed in groups of 10 and sterilized at 121 °C for 20 minutes (min) by placing them in an autoclave to ensure sterilization (Melag, Euroclave 23V-S, Germany). Then, randomly selected teeth were sent to Ethylene Oxide (EtO) sterilization, 10 in each package. As a result, to use in the present study, first of all, all teeth were root canal preparations, disinfection, and sterilization processes were completed and placed in sterile glass bottles with rubber caps. Following these processes, 120 teeth, which were purified from microorganisms and placed in the bottles, were obtained. The teeth placed in the bottles were divided into 6 groups for *E. faecalis* inoculation, with 20 teeth in each group.

Contamination with *E. faecalis* Biofilm

E. faecalis (ATCC 29212) strains were cultured on blood agar (Brain-heart infusion agar, Acumedia Manufactures, Inc., Lansing, Michigan, USA) and were incubated at 37 °C for 24 hours (h). Before each experiment, 0.5 McFarland turbidity was set with a kristalspecTM device. Then was subcultured on Trypticase soy broth (Detroit, Michigan, USA) and incubated aerobically at 37 °C for 24 h. The turbidity of *E. faecalis* culture was adjusted to No. 0.5 Mc Farland Standard. The value of 10 µl of bacterial suspension (Final concentration of about 1.5 X 10^8) was transferred to the mechanically expanded lumen of the root canal using a sterile micropipette except for 10 canals which were preferred as negative control and then kept at 37 °C for 24 h. The entrance of root canals was sealed with temporary filling material (Cavit; 3M ESPE, USA). All samples were stored at 37 °C for 10 days in a humidity atmosphere and the reinoculation procedure was repeated every 72 h with fresh culture on the first, fourth, seventh, and tenth days. The biofilm's scanning electron microscopy (SEM) micrograph was examined at 10,000x magnification, as shown in Figure 1.

Experimental and Control Groups with Activation Procedures

Samples in which *E. faecalis* biofilm was obtained in root canals were randomly selected to have 20 teeth in each group. Then, root canals were disinfected with six types of irrigation solutions each activated by the 2 Watt (W) KTP laser applications. The same KTP laser activation procedure was applied to irrigation solutions groups formed as 5.25% NaOCl, physiological saline, super-oxidized water solution, 8 ppm ozonated water, 2% CHX, 17% EDTA, and this standard application is as follows;

Root canals of 20 teeth infected with *E. faecalis* are irrigated with these irrigation solutions with a flow rate of 2.5 ml/min for 15 seconds (s), followed by laser activation with a 200 µm diameter fiber optic tip of the 2W KTP laser for 15 s with continuous circular movements from the apex to the coronal done. This cycle was repeated 6 times. The total volume of the irrigant was 7.5 ml. The total time of the protocol was determined as 3 min and then the remaining bacteria in the root canal were counted.

Microbiological Count and SEM Examination

After the irrigation activation procedures were applied to the root canals of the teeth contaminated with *E. faecalis*, the samples were taken into glass tubes with 5 ml BHI, after waiting for 5 min, sterile paper cones numbered 40 were placed in the root canals moist with the irrigated solution. After the Eppendorf tubes were vortexed for 5 min, samples were taken with sterile plastic specials and the second half of the bloody medium was inoculated. The inoculated petri dishes were kept in an oven at 37 ºC for 24 h and then counted according to the Colony Forming Units (CFU) classification. The antibacterial activity indicators of the study groups were recorded by calculating the bacterial counts obtained as a result of the first and last bacterial sowing. Two of the roots in the experimental and control groups to be used as imaging samples were randomly divided into two vertically with sterile separators, and the used parts were fixed in 4% glutaraldehyde for 3 h at 4 °C before imaging. Then, it was exposed to dehydration by keeping it in ethanol solutions at increasing concentrations (40%, 50%, 70%, 80%, 90%, 100%). After drying the dehydrated samples at room temperature, they were coated with gold-palladium and examined by SEM.

Statistical Analysis

The data of our study were evaluated by uploading them to the SPSS (Ver:22.00) program. While evaluating the data, one-way ANOVA and Tukey test was applied**.**

Results

The logarithms of the counting results obtained after the application were taken and the minimum, maximum, mean and standard deviation, and median (median) values are shown in Table 1. In the present study, statistically significant differences were found between the NaOCl and saline groups used as the control groups and the other 4 experimental groups ($p<0.05$). While the ozonated water and superoxide water groups did not show a statistically significant difference ($p>0.05$), the differences between these groups and the other experimental groups were found to be statistically significant ($p<0.05$). Among the experimental groups, super oxidized water and ozonated water showed the strongest antibacterial effect statistically in infected root canals ($p<0.05$).

Discussion

This study aims to evaluate the antimicrobial activities of irrigation with KTP laser activation on *E. faecalis* biofilms formed in root canals by scanning electron microscopy in vitro.

In our study, *E. faecalis* biofilms were formed in vitro for 1 month as a monoculture on the root dentin walls of an extracted single root, single canal teeth. The presence of *E. faecalis* biofilms formed in the first step and the penetration of *E. faecalis* into the dentinal tubules were determined by scanning electron microscopy. In the second stage, the biofilm elimination efficiency of irrigation solutions activated by the KTP laser on *E. faecalis* biofilms formed in the canal was determined. The purpose of using the *E. faecalis* biofilm is that this bacterium is highly resistant to chemical and mechanical processes and is one of the main factors of treatment failures. *E. faecalis* is a facultative anaerobic gram (+) test microorganism that causes resistant apical inflammation and is found in monocultures.[8] *E. faecalis* is the bacterium that is the main factor in failures after root canal treatment.[9] Because of the low nutritional conditions and resistance to drugs used during root canal treatment, it can maintain its vitality in difficult conditions.[10]

Pinheiro et al.[8] isolated *E. faecalis* in 52.94% of unsuccessful root canal treatments. They explained these rates by the fact that the vital and virulence factors of *E. faecalis* are high, and that they consume the nutrients in the environment in a way that does not allow other microorganisms to live by showing more intense invasion into the dentinal tubules compared to other microorganisms.

In studies on biofilm, the time required for biofilm formation varies. Biofilms were formed for periods ranging from 24 h to 6 weeks, and the efficacy of antimicrobial agents was evaluated.[11,12] However, no standardization could be determined regarding the biofilm formation time in the studies. In our study, fresh *E. faecalis* suspension was injected into the roots every other day for 4 weeks to form a mature biofilm.

Within the scope of our study, the SEM technique was used to view our biofilm samples formed in dental tissue. Scanning electron microscopy has been frequently used in the literature to observe biofilm formation within the tooth.[13, 14] Yañez *et al.*[15] reported that the use of SEM techniques in imaging provides excellent depth of field and is quite suitable for describing morphology. Laser dentistry is mainly used in surgery, periodontal procedures, and operative procedures. However, the use of lasers in the field of endodontics has a very high potential.

Our study, it was aimed to activate different irrigation solutions used in endodontic treatments with the KTP laser, which has a halved wavelength Nd:YAG laser system, and thus to evaluate the antibiofilm efficacy of this disinfection procedure in root canals.

There are not enough studies about KTP laser in the literature. Therefore, since the KTP laser is a halved Nd:YAG laser system; Some studies in the literature related to the Nd:YAG laser system are included in our discussion.[16,17]

Nd:YAG lasers are frequently preferred devices for removing the smear layer, removing debris, cleaning, shaping, disinfecting the root canal system, and covering the apical region after apicectomy. It has been found that Nd:YAG laser reduces periapical inflammation, accelerates the drying of the root canal lumen, and has a bactericidal effect while removing dentin.[16, 17] Gutknecht *et al.*[18] determined that the Nd:YAG laser applied at a pulse frequency of 15 Hz at an energy level of 1.5 W produced an antibacterial effect of 97.12-99.91%.

In a study, it was reported that Nd:YAG laser beams showed a high antimicrobial effect on gram-positive and gram-negative microorganisms in the dentin distant from the canal. It has been stated that microorganisms such as *E. faecalis* are very sensitive to laser beams[19]. Schoop et al.[20] When the KTP laser was applied to *E. faecalis* with 1 W, there was a significant decrease in the number of microorganisms, while the effectiveness was higher when they applied 1.5 W, so in the present study, it was thought that it could make irrigation more effective and the KTP laser was applied at 2W power. To provide a more homogeneous effect on the dentin surface, the laser beam must be applied from the lateral parts of the fiber optic cable, not only from the end. Therefore, in our study, the fiber optic tip was applied with circular movements from apical to coronal.

The cleaning efficiency of the laser-activated irrigation technique; depends on the dynamics of the steam bubble formed as a result of pulse beats. While each pulse of the laser accelerates the fluid flow, a constant flow rate is observed in conventional irrigation. Therefore, laser activation is more successful than conventional irrigation. For this reason, we activated different irrigation solutions with the KTP laser in our study.

In the efficiency of the irrigation solution; concentration, application volume, application time, temperature, and pH level have been reported to be important.[21] All of the irrigation solutions tested in our study were used at room temperature, in the same volume, and at the most effective concentrations known.

According to the results of our study, 5.25% NaOCl, which we activated with a 2 W KTP laser, which we used as the positive control group, was found to be the most effective agent in eliminating *E. faecalis* biofilm in both culture methods and SEM examinations.

Retamozo et al.[22] used 450 dentin samples obtained from bovine incisors in their study to determine the sufficient NaOCl concentration and irrigation time to disinfect dentin samples infected with *E. faecalis*. After infecting these samples with *E. faecalis*, they applied NaOCl solution at concentrations of 1.3%, 2.5%, and 5.25% for 5, 10, 15, 20, 25, 30, 35, and 40 min. At the end of their study, they reported that they obtained the most effective result with the application of 5.25% NaOCl solution for 40 min, and the application of 1.3% and 2.5% NaOCl at the same time was insufficient to eliminate *E. faecalis*. They emphasized that a high concentration of NaOCl and a long application time are needed to ensure the complete elimination of *E. faecalis*-contaminated dentin. In our study, NaOCl was used at a rate of 5.25%.

In a study comparing the antibacterial activity of 980 nm wavelength diode laser and 5.25% NaOCl against *E. faecalis*; Compared with the diode laser, NaOCl was reported to be successful in eliminating 99.87% of *E. faecalis*.[23]

In a study evaluating the antimicrobial activities of NaOCl, MTAD, and Tetraclean against *E. faecalis* biofilm, the only solution that could destroy *E. faecalis* biofilm within five min was 5.25% NaOCl, and MTAD and Tetraclean were totally eliminated. It has been stated that they need a longer period.[24]

In another study evaluating the effectiveness of various irrigation solutions against E. facealis, which is in planktonic and biofilm form; It has been reported that NaOCl, used at a rate of 3%, is the most effective agent and eliminates *E. faecalis* in both forms in 2 min.[25]

In light of the results of these studies, the antimicrobial activity of 5.25% NaOCl on the *E. faecalis* biofilm was examined as the positive control group, and the results of our study were similar to the results of the present study mentioned above.[26- 28]

Although the saline solution, which we used as the negative control group in our study, was found to be the most ineffective agent among all groups, it caused a decrease in the number of bacteria in parallel with the literature studies.

Although it is said that EDTA is a chemical agent that does not have an active antimicrobial effect, it is known that it causes a decrease in the number of bacteria in the canal by removing the inorganic component of the smear layer formed on the root canal walls.[29]

In a study examining the antibacterial activities of 17% EDTA, 2% CHX, 0.2% cetrimide, MTAD, and QMix against *E. faecalis* biofilm formation on dentin blocks for 2 min, the antibacterial activity of 17% EDTA against *E. faecalis* biofilm formation was higher. found low.[30]

In the study, in which the antimicrobial activities of 5.25% NaOCl, 10% citric acid, 17% EDTA, 3% H2O2, 0.2% cetrimide and saline solution as the control group, against *E. faecalis* and E. coli in root canals were evaluated, % in both groups. 17% EDTA solution has been reported to have the lowest antimicrobial activity.[31] Parallel results were also obtained in our study. The fact that the antibiofilm effect is less than the other experimental groups can be attributed to its low antimicrobial property.

In a study examining the effects of various irrigation solutions against *E. faecalis* biofilm in root canals, no significant difference was found between the application time of 2% CHX solution used for 1 and 5 min, and the rate of destruction of *E. faecalis* biofilm by 2% CHX was found 60.49%.[32] In a study evaluating the effects of NaOCl, EDTA, citric acid, phosphoric acid, and 2% CHX against *E. faecalis* biofilm, NaOCl was found to be the most effective agent; followed by 2% CHX; EDTA, citric acid, and phosphoric acid were found to be ineffective against *E. faecalis* biofilm.[33]

In parallel with the literature information mentioned above, the 2% CHX solution, which we used in our study, was found to be more successful in eliminating *E. faecalis* biofilm than the 17% EDTA solution, while it was found to

be less successful compared to the other experimental groups.

There are also studies in the literature that do not show parallelism with the results of our study. *E. faecalis* was inoculated into the canals of single-rooted maxillary teeth for 60 days, and then, in a study examining the antibacterial activities of ozonated water, gaseous ozone, 2.5% NaOCl, and 2% CHX washing solutions, none of the washing solutions used in 20 min. It has been reported that it has no antimicrobial effect against *E. faecalis* during the contact period. In our study, however, the 5.25% NaOCl solution that we used completely eliminated the *E. faecalis* biofilm, while the 2% CHX solution caused a decrease in the biofilm layer. We think that the different findings are due to the different incubation times and the method of obtaining the bacteria.[34]

Super oxidized water is a solution that has been widely used in recent years because it is non-toxic, biocompatible, safe for patients and the environment, and inexpensive.[35] However, there are few studies in the literature evaluating the antimicrobial effect of super-oxidized water.

In a study investigating the in vitro efficacy of super oxidized water against various microorganisms including *E. faecalis* 29212 strain at different concentrations, Medilox super oxidized water was found to be effective in all standard and clinical strains at 1/1 dilution for 1 min and at all other test times.[36]

There are significant limitations to the application of lasers within the root canal system. Laser energy from the optical fiber tip or laser guiding tip travels directly through the root canal before it has a chance to reach the lateral canals. Therefore, it is not always possible to maintain a uniform contact area along the canal surface using a laser. Many researchers have shown that during the interaction between the laser and the tooth structure, photon energy is converted into heat energy. This heating effect must be carefully controlled to avoid damage to the vital cells of the surrounding tissues.[37] Successful endodontic treatment depends on the elimination of all microorganisms. Continuity of infection is the most important cause of failure in endodontic treatment. Fabricius et al.[38] showed that bacteria can survive for many years in treated root canals and stated a significant relationship between nonhealing apical periodontitis and the presence of bacteria. For these reasons, the major role of the disinfection procedure applied during root canal treatment in the success of the treatment should always be considered.

Conclusion

Activation of ozonated water and super-oxidized water irrigation solutions with KTP laser showed strong antibacterial activity. However, it could not completely eliminate the bacteria in the canal. Considering the logarithmic growth of bacteria, it is obvious that bacteria can reach their maximum numbers again in a suitable environment in a very short time as a result of not being able to be completely eliminated. It is known that the prognosis for recovery will be successful if the bacteria can be completely eliminated during root canal treatment. Therefore, the activation of these irrigations with a 2 W KTP laser for disinfection in root canals will not provide the expected success. For this reason, we think that laser-activated disinfection systems can only be used as supportive treatment in root canal treatment.

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Conflict of Interest

The authors declare no conflict of interest

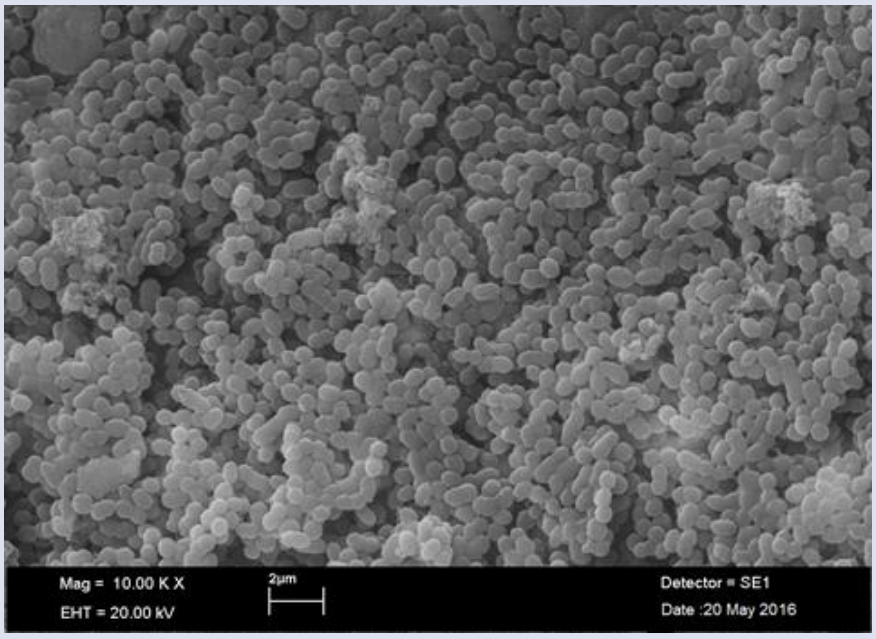

Figure 1. SEM images of Enterococcus faecalis biofilms obtained from the root canal at 10,000x magnification after four weeks

Table 1. The minimum, maximum, mean and standard deviation, median values with statistical comparisons between groups with log CFU count values obtained after activation procedures

Groups		Minimum	Maximum	Mean±standard deviation (Log CFU mL^{-1})	Median
Group 1	Saline	4.000	7.000	6.36±1.03	7.000
Group 2	NaOCl	0.000	0.000	0.00±0.00	0.000
Group 3	Super-Oxidized Water	0.700	1.100	0.86±0.13[a]	0.800
Group 4	Ozonated Water	0.600	1.500	1.10±0.27[a]	1.000
Group 5	CHX	1.400	2.600	1.77±0.35	1.800
Group 6	EDTA	2.200	3.300	2.71±0.35	2.600

Superscripts with the same letters ([a]) indicate no sign of the difference between groups. ($p<0.05$)

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The Effect of Photodynamic Therapy Applied with Different Photosensitizers on Dentin Hardness in Comparison with Conventional Irrigation

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Research Article

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History

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ABSTRACT

Objectives: *The aim of this study was to examine the effect of photodynamic therapy (PDT) using toluidine blue O (TBO), curcumin (CUR) and methylene blue (MB) photosensitizers on root canal dentin microhardness by comparing it with sodium hypochlorite (NaOCl) + ethylenediamine tetraacetic acid (EDTA).*
Materials and Methods: *The root canals of 100 human premolar teeth were shaped by the R25 file (Reciproc; VDW, Munich, Germany). The working length of the teeth was determined by using a #10 K-file, keeping it 1mm shorter than the tooth apex. The R25 file was used to prepare the root canals. After every three pecking motions, irrigation was performed and a total of 10 mm of distilled water was used. The specimens were randomly distributed according to the disinfection method; NaOCl+EDTA, PDT with TBO, PDT with CUR, PDT with MB and distilled water (DS) (n=20). Grooves were prepared on the buccal and lingual surfaces of the prepared teeth, parallel to the long axis of the tooth, without touching the root canals. The roots were divided into two parts by means of a cement spatula placed in these grooves. Root canal dentin microhardness was evaluated by the Vickers test method. Three measurements were made by applying 300 g of force for 15 seconds and the average was calculated. It was recorded as the Vickers hardness value. The data were analyzed by using the one-way ANOVA and Dunnett's post hoc tests (α=0.05).*
Results*: All photosensitizer groups showed significantly higher microhardness value than the groups of DS and NaOCl + EDTA (p<0.05). There were no differences the groups of photosensitizers (p>0.05).*
Conclusions: *The use of 5.25% NaOCl solution activated by KTP laser, which shows the highest antibiofilm efficiency among the study groups, in clinical applications is very effective in terms of biofilm elimination in root canal treatments and is especially promising in the success of long-follow-up treatments. However, the KTP laser activation procedures of super-oxidized water solution and 8 ppm ozonated water may be insufficient as a safe disinfection method.*

Keywords: *PDT with CUR obtained the highest radicular dentin microhardness.*

Farklı Işığa Duyarlılaştırıcılar ile Uygulanan Foto Dinamik Terapinin Konvansiyonel İrrigasyon ile Karşılaştırılarak Dentin Sertliğine Etkisi

Bilgi
 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

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ÖZ

Amaç: *Bu çalışmanın amacı, toluidin mavisi O (TBO), kurkumin (CUR) ve metilen mavisi (MB) ışığa duyarlılaştırıcılar kullanılarak yapılan fotodinamik tedavinin (PDT) kök kanal dentin mikrosertliği üzerindeki etkisini sodyum hipoklorit (NaOCl) + etilendiamin tetraasetik asit (EDTA) ile karşılaştırarak incelemektir.*
Gereç ve Yöntemler: *100 adet insan premolar dişinin kök kanalları R25 eğesi (Reciproc; VDW, Münih, Almanya) ile şekillendirildi. Dişlerin çalışma uzunluğu, diş apeksinden 1 mm daha kısa tutularak #10 K-file kullanılarak belirlendi. Kök kanallarını hazırlamak için R25 eğesi kullanıldı. Her üç gagalama hareketinden sonra irrigasyon yapıldı ve toplam 10 mm distile su kullanıldı. Numuneler dezenfeksiyon yöntemine göre rastgele dağıtıldı; NaOCl+EDTA, TBO ile PDT, CUR ile PDT, MB ve distile su ile PDT (DS) (n=20). Hazırlanan dişlerin bukkal ve lingual yüzeylerine, dişin uzun eksenine paralel olacak şekilde, kök kanallarına dokunmadan oluklar hazırlandı. Bu oluklara yerleştirilen siman spatülü ile kökler iki parçaya bölündü. Kök kanal dentin mikrosertliği Vickers test yöntemi ile değerlendirildi. 15 saniye boyunca 300 g kuvvet uygulanarak üç ölçüm yapıldı ve ortalaması hesaplandı. Vickers sertlik değeri olarak kaydedildi. Veriler, tek yönlü ANOVA ve Dunnett'in post hoc testleri (α=0,05) kullanılarak analiz edildi.*
Bulgular: *Tüm ışığa duyarlılaştırıcı grupları, DS ve NaOCl+EDTA gruplarından önemli ölçüde daha yüksek mikrosertlik değeri gösterdi (p<0,05). Işığa duyarlılaştırıcı grupları arasında fark bulunmadı (p>0,05).*
Sonuçlar: *CUR ile PDT, en yüksek radiküler dentin mikrosertliği gösterdi.*

Anahtar Kelimeler: *Kürkümin, Mikrosertlik, Fotodinamik Tedavi, Işığa Duyarlaştırıcılar.*

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Introduction

Conventional methods for treating diseases like periapical infection and permanent pulpitis include root canal therapy. Three major objectives of root canal therapy are proper instrumentation, disinfection and obturation of root canal system. A smear layer and plugs of organic and inorganic tissue fragments of calcified tissue, as well as organic components like pulp tissue debris, odontoblastic processes, microorganisms, and blood cells, are produced by endodontic instrumentation in the dentinal tubules.[1] Because of its efficiency in destroying bacteria and dissolving organic tissue, sodium hypochlorite (NaOCl), a chemotherapeutic irrigation chemical, is recognized as the "gold standard" for root canal irrigation.[2] NaOCl, on the other hand, had a high toxic level for periradicular tissues and was unable to remove the smear layer. Moreover, it decreased radicular dentin microhardness.

It has been claimed that chelating or decalcifying solutions, such as ethylene diamine tetra acetic acid (EDTA), are effective at removing the smear layer.[3] However, it has been observed that these chemical substances modified the Calcium/Phosphorus (Ca/P) ratio of the dentin surface as well as the chemical nature of human dentin.[4] Changes in the Ca/P ratio could modify the proportion of organic and inorganic components, which would then alter the dentin's hardness characteristics.[5]

For both cleaning out root canals and eliminating the smear layer with a low-intensity laser, photodynamic treatment (PDT) stands out as an effective equivalent option.[2] It has been demonstrated that PDT has the potential to be just as successful as NaOCl in disinfecting root canals when comparing both of them in terms of the antibacterial efficiency in root canal therapy.[6,7] Methylene blue (MB) and toluidine blue O (TBO), two of the most popular and extensively studied phenothiazines (synthetic non-porphyrin chemicals) used in PDT, shown adequate antibacterial activity for root canal disinfection.[6,8,9] Curcumin (CUR), the primary ingredient in turmeric powder and another photosensitizer, has lately been employed in the PDT.[9,10] CUR was a potentially microbial-reducing anionic, polyphenolic, and lipophilic chemical that might act as a photosensitizer.[10-12]

The microhardness of root canal dentin was impacted by the irrigation and disinfection procedures,[13,14] and photosensitizers used in PDT may have an impact on the structure of radicular dentin by precipitating or changing the collagen matrix.[6,15-18] However, there is no knowledge in the literature the effect of photosensitizers on the radicular dentin microhardness after root canal disinfection with PDT. Therefore, the purpose of this *in vitro* study was to explore the effect of PDT using three different photosensitizers (MB, TBO and CUR) on the radicular dentin microhardness in comparison with NaOCl. The null hypotheses tested was the different photosensitizers had no influence on the the radicular dentin microhardness.

Material and Methods

This study was approved by the Çukurova University Faculty of Medicine Clinical Research Ethics Committee's report numbered 2020/105.53 Based on previous study,[19] a power analysis using G*Power 3.1 (Heinrich Heine University, Düsseldorf, Germany) showed that minimum sample size of 17 for each group provided a power of 80% to detect significant differences at a 0.05 significance level. Thus, 20 specimens for each group were used in the present study.

The root canal treatments of 100 human premolar teeth were performed by shaping with the Reciproc system (Reciproc; VDW, Munich, Germany). The study's inclusion criteria included teeth extracted for periodontal or orthodontic reasons that did not exhibit cracks, fractures, inclinations, or resorption along the root and had a single straight canal and apex. The periapical radiographs of the teeth were used to determine the canal diameter at the bucco-lingual and mesio-distal directions. Teeth having canal diameters greater than 1 mm were disqualified from the study. An ultrasonic scaler was used to remove adherent debris, plaque and periodontal ligament on teeth.

The working length of the teeth was determined by using a #10 K-file, keeping it 1mm shorter than the tooth apex. The R25 file (Reciproc; VDW, Munich, Germany) was used to prepare the root canals. After every three pecking motions, irrigation was performed and a total of 10 mm of distilled water was used and the root canals were dried by using sterile paper points (Dentsply Sirona, York, PA, USA). The specimens were randomly distributed according to the final disinfection method; NaOCl+EDTA, PDT with TBO, PDT with CUR, PDT with MB and distilled water (DS) (n=20).

Group NE: The root canals were irrigated with 5 ml of 2.5% NaOCl for 1 min, with 5 ml of 17% EDTA for 1 min and with distilled water for 1 min, respectively.

Group MB: The root canals were filled with MB (50 mg/l) and kept in the dark for 5 min before irradiation. A diode laser (SiroLaser Advance Plus; Dentsply Sirona, Bensheim, Germany) providing monochrome light at 660 nm wavelength was applied to the dentin surface with a fiber optic tip of 320 µm at a power of 100 mW for 90 s in continuous mode with helical movements in the apical-cervical direction.[16] Total energy dose of 9J was given to each canal. 9 J of total dose delivery and 320 J/cm2 of energy density.

Group CUR: The root canals were filled with CUR (500 mg/l) and kept in the dark for 5 min before irradiation. For the activation of curcumin, a fiber optic tip with a diameter of 300 µm and a blue LED light (λ 480 nm, Valo Cordless; Ultradent, South Jordan, UT, USA) were applied to the root canals with helical movements at 1000 mW/cm^2 standard power for 60 s.[13]

Group TBO: The root canals were filled with TBO (100 mg/l) and kept in the dark for 5 min before irradiation. The diode laser (660 nm, SiroLaser Advance Plus) was applied

to the dentin surface with a fiber optic tip of 320 µm at a power of 220 mW for 60 s in continuous mode with helical movements in the apical-cervical direction.[20] Total energy dose of 13.2J was given to each canal.

Group DS: No disinfection protocol was used.

The fiber optic tip was introduced into root canals to 2 mm short of the working length for all photosensitizers during the activating process. All photosensitizers were agitated for 1 min using an ultrasonic tip coupled to an ultrasonic unit (EMS, Nyon, Switzerland) avoiding contact with the root canal walls. All photosensitizers were withdrawn from the root canal with a syringe and the root canals were washed with distilled water after the disinfection process. The root canals were dried with paper points.

The grooves were prepared on the buccal and lingual surfaces of the prepared teeth, parallel to the long axis of the tooth, without touching the root canals. The roots were divided into two parts by means of a cement spatula placed in these grooves. The root canal dentin microhardness was evaluated by the Vickers test method. Three measurements were made by applying 300 g of force for 15 seconds and the average was calculated. It was recorded as the Vickers hardness value.

The data were analyzed by using the SPSS program for Mac version 26 (IBM SPSS Inc, Chicago, IL) The Shapiro-Wilk test was used to determine the normality distribution of the data assessed. The values of the PBS were analyzed by one-way ANOVA and Dunnett's post hoc tests. All data was evaluated with 95% of confidence interval (α=0.05).

Results

The values of the root canal microhardness for each root canal disinfection method were represented in Figure 1. The highest root canal dentin microhardness among the groups was observed in the CUR group. In disinfection with PDT, different photosensitizers did not show a significant difference in terms of root canal dentin microhardness. However, NE group showed significantly lower microhardness values than DS, TBO, CUR and MB groups (p=0.026, 0.01, 0.002 and 0.001 respectively).

Discussion

The disinfection of root canals is essential for the recovery of periapical pathologies and to prevent recurrence of endodontic diseases. This study evaluated the effect of MB, CUR and TBO photosensitizers used in PDT on the microhardness of radicular dentin.[21] There was no difference among the photosensitizer groups. However, conventional irrigation method, NaOCl/EDTA indicated significantly lower microhardness value than the other groups. Therefore, the H0 hypotheses were rejected.

By analyzing the plastic and elastic deformation of a substrate, hardness is one of the mechanical characteristics that may be utilized to evaluate the mineral changes in dentin.[22] The Vickers indenter method was employed in earlier research to evaluate the dentin's hardness.[23,24] Microhardness measurements have been shown to offer indirect evidence of mineral loss or growth in the tooth hard tissues.[24] Although the Knoop hardness test was employed for surface changes of dental hard tissues in some research, previous investigations have demonstrated the applicability and feasibility of the Vicker's microhardness test for evaluating surface changes of dental hard tissues treated with chemical agents.[1] In this research, it was shown that the Vicker's microhardness test identifies surface alterations following treatment with PDT and conventional disinfection methods.

The combination of NaOCl and EDTA is routinely used to dissolve inorganic and organic components in the smear layer of the radicular dentin.[18,25,26] The proteolytic NaOCl had a negative effect on the collagen structure of radicular dentin, correspondingly dentin microhardness.[1,27] It has been shown that EDTA binds calcium, leading to the dissolution of root dentin mineral components, and inactivation of alkaline phosphatases, which play an important role in the formation of mineralized tissue.[28] Also, it was known that the exposure time of EDTA in root canal decreased the microhardness of dentin.[1] Although the sequential use of these solutions may produce satisfying results for revealing dentin tubules and able to ease adhesion of root canal sealer,[29] it had detrimental influence dentin hardness.[30,31] The present the study was in parallel with those above studies.

PDT using with MB, CUR and TBO photosensitizers was approved antibacterial activity in the disinfection of root canals and has the ability to effectively destroy gram-negative and gram-positive bacteria.[8,12,32] Therefore, the present study investigated the effect of PDT disinfection using these photosensitizers on the radicular dentin microhardness. Regarding the limitation of PDT, the photosensitizer may remain on the dentin structure and act as a diffuse chemical layer into dentinal tubules.[33] Therefore, in this study, inorganic precipitates formed after PDT might have contributed to dentin hardness.

In addition, methylene and toluidine blue, which are cationic, may bind to anionic molecules such as phosphate in hydroxyapatite, thereby affecting the calcium/phosphate ratio.[19] This may have provided a higher hardness value than the control group. Hydrophilic materials exhibit high wettability and low contact angle for dentin substrate.[34] However, there was no difference between hydrophobic CUR and hydrophilic MB and TBO groups. This may be due to the use of curcumin in higher concentrations than other photosensitizers.

In a study examining the effects of different concentrations of CUR and MB on radicular dentin hardness, there was no difference between the control group and the MB group, while both 500mg/L and 1000mg/L concentrations of CUR showed lower hardness values compared to the control group.[19] In another study investigating the effect of different concentrations of MB and light activation on root canal microhardness, no difference was found compared to the control group.[35] These results are not compatible with our study and can

be attributed to the use of different hardness measurement methods.

The current study presents some inherent limitations due to the *in vitro* design of the study. Evaluating the physical effects of natural and synthetic photosensitizers on the radicular dentin together with other mechanical tests such as fracture resistance, elastic modulus may be helpful in understanding the further effects of these photosensitizers. Although it has been tried to be limited by various methods, substrate homogeneity or standardization should be considered due to the changing characteristics of the natural teeth used in the study. Moreover, the lack of consensus for factors such as the concentrations, irradiation times and power density of photosensitizers used may be shown as the limiting aspect of the PDT. The strength of this study was first that it simultaneously evaluated the effect of most used photosensitizer types on radicular dentin hardness.

Conclusion

The present study conducted reveals the effect of PDT using with different photosensitizers on dentin microhardness. PDT had a positive effect on root canal dentin microhardness compared to the traditional disinfection method.

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Conflict of interest

The authors declared no conflict of interest regarding the publication of this article and any of the materials used in this study.

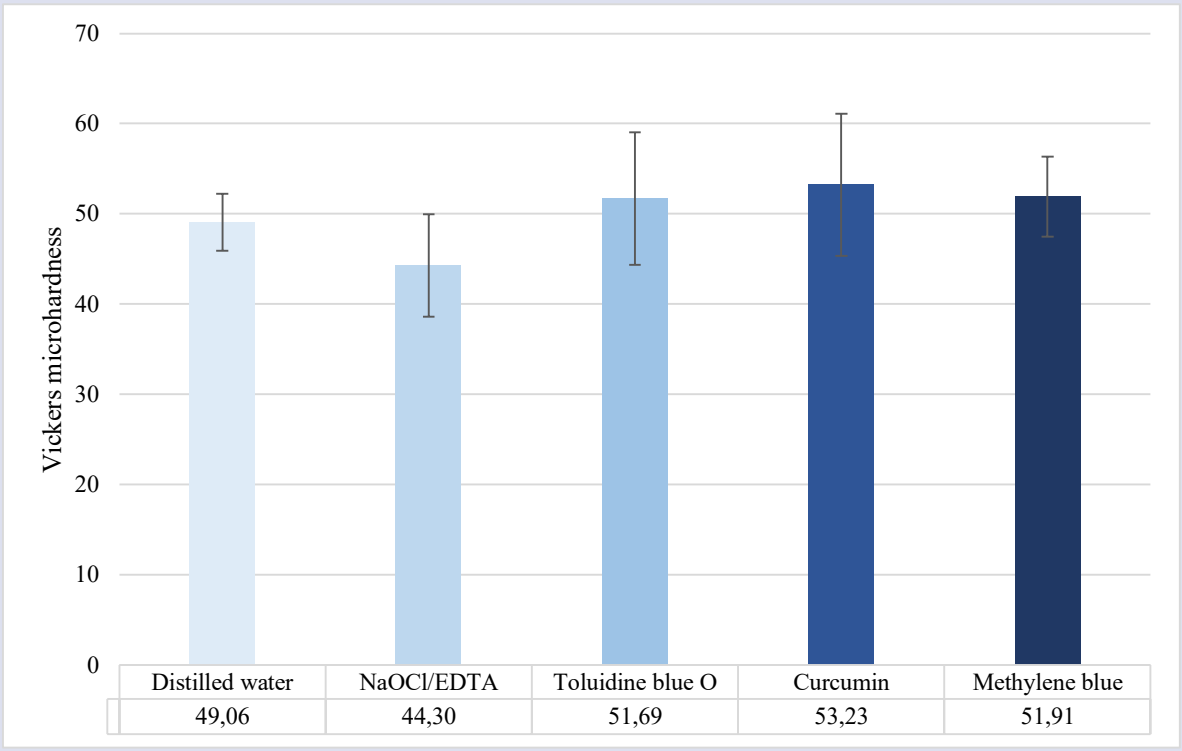

Figure 1. Vickers microhardness values of radicular dentin exposure to distilled water, NaOCl/EDTA, and PDT used with different photosensitizers

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New Dyestuff Production to Sensitively Determine the Sealing Capacity of the Implant Abutment Connection

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Research Article

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History

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ABSTRACT

Aim: In this study, it was aimed to synthesize a new dyestuff with fluorescent active properties, which can be easily produced and water-soluble, to be used in sealing tests.

Materials and Methods: In this study, oxo-titanium phthalocyanine compound, which has dyestuff properties and is soluble in water, was obtained as a result of the tetramerization reaction of substituted phthalonitrile derivative. The synthesis of the compound was carried out in closed glass tubes resistant to temperature and pressure under an argon atmosphere. The synthesized crude product was purified by washing from solubility differences and using column chromatography. The sealing capacities of the implant abutment connection of the dental implant systems manufactured by ESTAŞ were determined spectroscopically by UV-Vis spectrophotometer using the synthesized dyestuff in the first stage. Thanks to the fluorescent active property of the dyestuff, the emission spectra were measured with the fluorescent spectrometer, which is highly sensitive to changes, and the sealing capacities could be determined, depending on time. In addition, the gap between the implant and the abutment connection was determined using a Scanning Electron Microscope (SEM), and the sealing capacities were evaluated from a different perspective. In addition, sealing tests of the same implant systems were also performed with methylene blue dyestuff and the results were compared. The efficiency of our synthesized dyestuff was determined.

Results*:* The dyestuff to be used in the sealing tests of the implants was synthesized and characterized in a short time in our laboratory. The phthalocyanine compound from the porphyrin class was obtained as a result of the tetramerization reaction of the synthesized phthalonitrile derivative. The dyestuff, which can be synthesized in a short time like 10 minutes, was purified by taking advantage of the solubility difference and chromatographic methods. The obtained dyestuff was characterized by NMR, FTIR, UV-Vis, and MALDI-TOF MS. The results obtained are in harmony with the structure of the molecule. The produced dyestuff is water soluble and was especially used to determine the sealing capacity of the implant abutment connection of dental implant systems produced by ESTAŞ. The sealing properties of the implant were determined by spectroscopic methods such as UV-Vis and fluorescence. In addition, sealing capacities were evaluated with SEM. According to the results obtained, we can say that the synthesized dyestuff is a dye that can give spectroscopically more sensitive results than methylene blue.

Conclusions: Dental implants, which are artificially placed in the mouth to support dental prostheses, have changed dental treatment methods to a large extent and become the most preferred successful technique. However, infection risks may occur during the treatment due to the formation of a gap between the abutment cap and the implant resulting from both the production and adaptation of the abutment cap, which is a part of the implant. For this reason, it is important that the implants produced are routinely sensitively checked for sealing and put into use. In addition, sealing control will contribute to the control and shaping of the process from the manufacturing stage of the implant.

In line with all obtained data, it has been determined that the implant types produced by ESTAŞ have a sealing capacity below the acceptable limits. In addition, it was observed that our newly synthesized dyestuff spectroscopically gave sensitive results in the sealing tests of implant systems.

Keywords: Phthalocyanine, synthesis, sealing, spectroscopy, dental implant.

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Introduction

Dental implants, which are increasingly used for the treatment of tooth loss, are commercially produced materials from titanium alloys used to support dental prostheses.[1-3] Implants are produced by manufacturers with different standards and consist of a body and a changing head. Implants are produced by manufacturers with different standards and consist of a body and a changing head. During the production phase, it is important to ensure that the body and the abutment head are well interlocked. Because infection risks from dental implants may occur during the treatment. This is one of the most important problems

that reduces the sustainability of the process. For this reason, it is important to routinely check the sealing tests between the body and the abutment head of the dental implants produced before the treatment. In the literature, commercial dyestuffs such as methylene blue or toluidine blue are generally used in dental implant sealing tests and their sealing capacity is determined spectroscopically (UV-Vis).[1,4-7] The development of new dyestuffs with effective properties in performing dental implant sealing tests, which is important in the treatment process, will be interesting in terms of the sensitivity of the tests.

Phthalocyanines are aromatic macromolecules composed of isoindole groups bonded with nitrogen atoms. Phthalocyanine and its derivatives are widely used as colorants due to their blue and green colors. This macromolecule contains 18 delocalized π-electrons and can host transition metals in the core constituting metal complexes making them very useful in many applications. Phthalocyanine compounds were first synthesized by chance in 1907 by researchers named Braun and Tcherniac by heating o-cyanobenzamide at high temperature.[8] The structure of phthalocyanine was elucidated by X-ray diffraction analysis by Robertson in 1936.[9] In addition, phthalocyanines have high thermal stability and sublimate without melting, usually around 550°C. Unsubstituted derivatives of phthalocyanines, which are a versatile and stable compound class, are extremely poorly soluble in water and organic solvents. However, the solubility of phthalocyanines can be noticeably increased by attaching substituents to the ring. These fluorescence-active macromolecules can be used in many applications due to their superior spectroscopic, electronic and optical properties.[8, 10-14]

In this context, we propose that our newly synthesized water-soluble oxo-titanium phthalocyanine compound can produce spectroscopically sensitive results in the sealing control of dental implants. We propose that oxo-titanium phthalocyanine might be a promising candidate in promising candidate in terms of showing more effective dyestuff activity than the currently used methylene blue.

Materials and Methods

Materials

4- (2-Trimethylaminoethylsulfany) phthalonitrile iodide, which was used as the starting material in the synthesis reaction, was prepared according to previous reports.[15] All chemical reagents and solvents used in the study were purchased from Merck. The implants used in the study were produced by ESTAŞ and their properties are described in below.

Properties of implants

The implants produced by ESTAŞ were made from Ti6Al4V ELI (ASTM F136 Grade 23) material and Grade 23 was used to increase biocompatibility. The connection types of the products are explained below and shown schematically in Figure 1. The implant-healing head was inserted into the implant by screwing method. The products were mounted to each other in such a way that there was a forehead contact. The angular position within the implant was fixed with the implant-abutment hex region, and the implant was mounted with a 10° conical connection. The implant-abutment screw was mounted using the screw method. The abutment-abutment screw was mounted with a 45° conical connection. The carrying part-implant connection was mounted to each other in such a way that the products were in contact with the forehead. Flexible wings on the carrying part were placed inside the implant to fix the products. The implant-closure screw was inserted into the implant using the screwing method. The products were mounted to each other in such a way that there was a forehead contact.

Technical information on the implant parts produced by ESTAŞ and used in this study are given in Table 1.

Synthesis of Dyestuff

The synthesis procedure described below is schematized in Figure 2.

Tetrakis [(2-trimethylaminoethylsulfanyl) phthalocyaninato oxo-titanium(IV)] tetraiodide

A solid mixture of finely powdered 4-(2-trimethylaminoethylsulfany)phthalonitrile iodide (1.0 g, 2.69 mmol) and titanium(IV) butoxide (0.23 mg, 0.67 mmol) was heated at 300°C in the presence of DBU under nitrogen atmosphere. The mixture was then cooled and dissolved in DMF. The insoluble part was removed by filtration. The solvent of the solution was removed in the evaporator and the residue was dried in vacuum. The crude product was purified by column chromatography on alumina using $CHCl_3$:Methanol (4:1). The resulting dark green solid was soluble in water. Yield: 43%. M.p.: >300°C. ^{1}H-NMR (400 MHz, DMSO-d_6, 25°C) δ= 7.78-6.90 (Ar-H, 12H), 3.66 (t, S-CH_2, 8H), 3.50 (N-CH_2, 8H), 3.12 (N-CH_3, 36H). UV-Vis (DMSO) λ_{max}/nm (logε, $dm^3mol^{-1}cm^{-1}$): 687, 640, 345. IR (KBr pellet) υ (cm^{-1}): 2908-2800, 1605, 1463, 1305, 1100, 740. MS (MALDI-TOF) m/z: 1557 $[M+H]^+$.

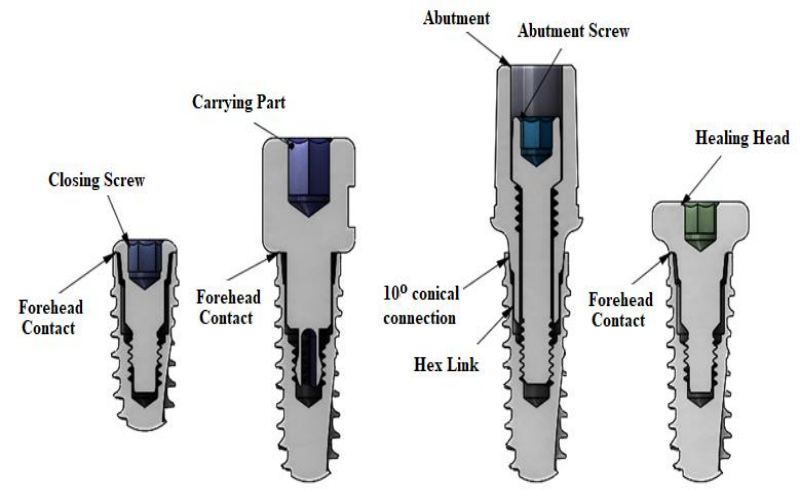

Figure 1. Connection types of implants manufactured by ESTAŞ.

Table 1. Technical characteristics of implant parts used in this study.

Parts of the product used in the study	Code
Dental Implant Ø3,3-13,0 mm	DNT-MTI-33130
Closing Screw, 0,5 mm	DNT-CS-3305
Implant Carrying Part AA2,0	DNT-İMT-20
Healing Head, Ø4,7x2,0 mm	DNT-HC-3320
Flat Abutment, Post 6,0 mm, Ø4,5-2,0 mm	DNT-ABST-4562
Abutment Screw, M1,6-6,0 mm	DNT-AS-1606

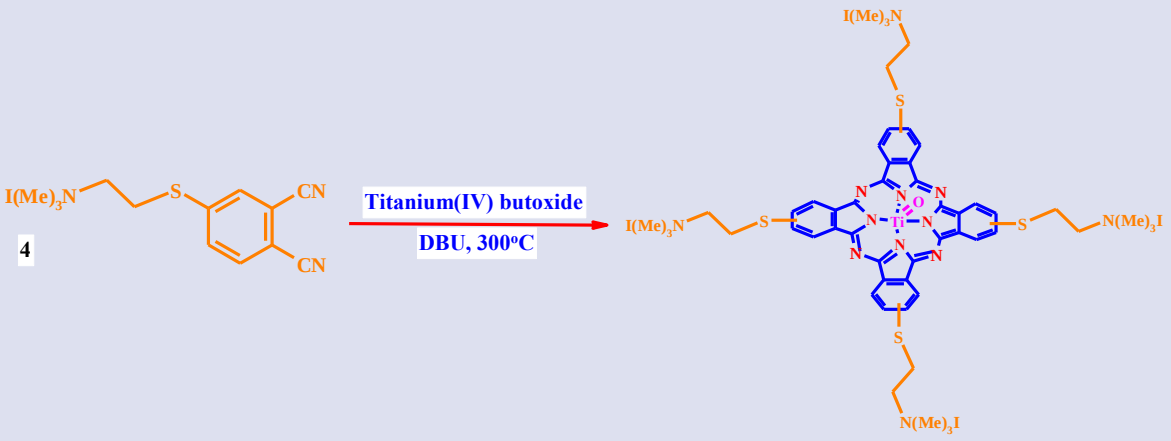

Figure 2. Synthesis of the dyestuff

Results and Discussion

The water-soluble oxo-titanium phthalocyanine compound was obtained by the tetramerization reaction of the quaternized phthalonitrile compound. The dyestuff was synthesized with high yields as a result of heating the solid mixture of phthalonitrile compound and metal salt in the presence of DBU in a short time like 10 minutes without using solvent. The synthesized oxo-titanium phthalocyanine compound was purified by washing from solubility differences and using column chromatography. The purified product was characterized by UV-Vis, FT-IR, ^{1}H-NMR and MALDI-TOF MS.

In the UV-vis spectrum of the water-soluble oxo-titanium phthalocyanine compound, typically a single absorption peak was observed between 600 and 700 nm in the Q-band region for metallophthalocyanines due to the D_{4h} symmetry. The Q-band absorptions of phthalocyanine compounds represent the $\pi \rightarrow \pi^*$ transition from the highest occupied molecular orbital (HOMO) to the lowest unoccupied molecular orbital (LUMO) of the ring. The B-band absorptions observed

between 300 and 350 nm indicate a transition from deeper π levels to the LUMO.[8, 16-19] In the UV-Vis spectrum of the synthesized dyestuff measured in DMSO, characteristic Q- and B-bands were observed at 687 nm and 345 nm, respectively. This result showed that the phthalocyanine compound was formed.

In the FT-IR spectrum of the synthesized phthalocyanine compound, it was observed that the -C≡N peak of the phthalonitrile derivative at 2240 cm^{-1}.[16, 20] disappeared. This result showed that the tetramerization reaction took place. Aliphatic C-H peaks of the phthalocyanine compound were also observed between 2908-2800 cm^{-1}. In addition, peaks in the FT-IR spectrum were observed for the stretching vibration of C=C and the substituted benzene ring at 1605 cm^{-1} and 740 cm^{-1}, respectively.[16, 20]

In the ^{1}H-NMR spectrum of the oxo-titanium phthalocyanine compound taken in DMSO-d_6 at room temperature, aromatic protons and aliphatic protons appeared in the range of 7.78-6.90 ppm and 3.66-3.12 ppm, respectively.[15, 21] It was observed that the integral ratios of the peaks in the spectrum were also compatible with the structure of the compound. This result confirms the structure of the compound we synthesized.

The MALDI-TOF MS result is also in agreement with the proposed structure of the compound.

All characterization results confirm that the oxo-titanium phthalocyanine compound shown in Figure 2 was successfully synthesized.

At the same time, the synthesized oxo-titanium phthalocyanine compound is a fluorescent active compound and gives a sharp and intense emission peak at 689 nm in DMSO. We investigated the usability in the sealing experiments of the implants by taking advantage of these superior spectroscopic properties of the water-soluble oxo-titanium phthalocyanine compound. Also, we can say that the synthesized compound also has a very intense dyestuff feature.

In this study, we aimed to evaluate the sealing capacity of the dental implant systems, especially the implant abutment connection, with the paint we produced. Dental implant systems were produced by the ESTAŞ manufacturer and their properties were defined in the experimental part.

In the literature, we see that methylene blue is generally used in sealing trials in implant systems. We performed the sealing tests on the same implant systems using both methylene blue and the dyestuff we synthesized. In this way, we were able to compare the activity of the dyestuff we produced with superior spectroscopic properties.

In these studies, each experiment was repeated three times in order to see the reproducibility of the experiments. In these studies, each experiment was repeated three times in order to see the reproducibility of the experiments. In the sealing experiments, solutions of the oxo-phthalocyanine compound in the first step were prepared at different concentrations in water. The absorption and emission intensities of these prepared solutions were separately measured by using UV-Vis and fluorescence spectrophotometers, respectively. Calibration curves giving peak intensity versus concentration were drawn with the obtained data. Afterwards, the volume of the cavity between the deepest part of the inner screw and its inner base was determined by using a micropipette with precision volume measurement. For implant systems produced by the manufacturer, this cavity volume was determined as 2 µL. Thanks to the very thin tips of the micropipettes, the dye solution we prepared in water at a concentration of 10^{-1}M was sensitively added into the implants and the implant heads were closed using torque under the same conditions. Each implant with closed caps was placed in the water-filled (the same volume) eppendorf tubes as seen in Figure 3. Spectrophotometric analyzes were performed with UV-Vis and fluorescence spectrophotometers for each sample at room temperature at incubation times of 1, 3, 6, 24, 48, 72, 96 and 144 hours. Concentrations corresponding to incubation times were determined with the help of measured spectroscopic data and standard curves. The same trials were performed on the same implants and under the same conditions, using methylene blue as a dye.

In implant systems, no color change was observed in the water in eppendorf until the 144-hour incubation period in the sealing tests with methylene blue, and no absorption/emission peak was observed in the spectroscopic measurements of the water. However, weak absorption/emission peaks were observed in the spectroscopic measurements of water after the incubation period of 96 hours in the experiments performed with the dyestuff we synthesized. No discernible change was observed in the color of the water in the Eppendorf. As a result of our experiments, it was determined that there was approximately 3% leakage in the implant systems after 96 hours of incubation period.

Figure 3. Solution of dyestuff in water (left) and symbolic representation of sealing experiments.

At the same time, the images of the implant systems, whose sealing tests were performed and whose heads were closed with torque, were taken with scanning electron microscopy (SEM). As seen in Figure 4, the cavity between the head and body of the implant is micron size and completely symmetrical. This SEM images are evidence why there is little to no spectroscopic sealing in implant systems.

In addition, we cut the implant systems with the bakelite method and examined their inner surfaces with SEM. We observed that the head and body parts of the implants were symmetrically connected to each other (Figure 5). The SEM images in Figure 5 are also evidence of impermeability in implant systems.

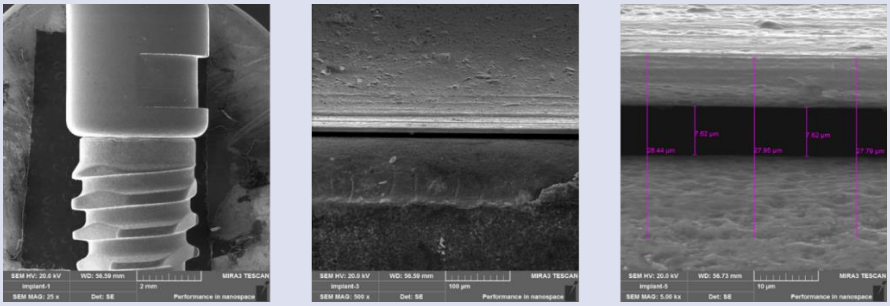

Figure 4. SEM image of the outer surface of the implant system.

Figure 5. Implants cut with bakelite method and their SEM images.

Conclusions

In this study, we synthesized a new oxo-titanium phthalocyanine compound as a result of the tetramerization reaction of the phthalonitrile derivative. This compound, which is a water-soluble and intense green colorant, was obtained in a very good yield in a short reaction time of 10 minutes. The newly synthesized dyestuff was characterized by UV-Vis, FT-IR, ^{1}H-NMR and MALDI-TOF MS and its molecular structure was confirmed. By using this obtained dyestuff, the sealing tests of the implant systems produced by the ESTAŞ manufacturer were carried out. The sealing capacities of the implants were examined by spectroscopic methods (UV-Vis, fluorescence) and SEM. It was determined that the produced implant systems had a sealing capacity below acceptable limits. At the same time, sealing tests were repeated with methylene blue dyestuff to see the activity of our synthesized dye in the same implant systems. As a result, it was determined that our synthesized dye was a spectroscopically more sensitive marker than methylene blue.

Conflicts of Interest Statement

There are no conflicts to declare.

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Examination of the Shear Force Resistance of Laminate Veneers Adhered with Different Resin Cements

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Research Article

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History

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ABSTRACT

Objectives: *This study investigated the mechanical properties of laminate veneers to determine their resistance to the shear force of three different types of cement used in the restorations.*

Materials and Methods: *Laminate veneers were prepared using standard tooth preparation methods for 30 extracted maxillary central incisors. To standardize the depth, guide burs were used to prepare a depth of 0.5 mm from the buccal angle. The samples were allocated into three randomized groups (n = 10): Group A (resin using the total etch method and Variolink Esthetic DC resin cement), Group B (resin using the PANAVIA F2.0 self-etch method), and Group C (self-adhesion bonded with Rely X U200 resin cement). The prepared specimens were stored in distilled water for one week before being thermal cycled for 500 cycles in 5°C and 55°C water. A shear test was used to determine the resistance of the veneers to the bonding. The obtained data were evaluated statistically.*

Results*: The values of the shear bond strength were statistically significant depending on the type of resin cement used ($p < 0.05$). The specimens that were cemented using the total-etch method had the lowest shear force value (18.79 ± 4.48 MPa). The obtained data were statistically evaluated using the Tukey multiple comparison test ($p > 0.05$).*

Conclusions: *The type of cement is a highly effective factor in the bonding between fixed prosthetic restorations and the abutment tooth, and the cement used must have sufficient resistance to shear forces.*

Keywords: *Laminate veneer, Shear strength, Resin cement.*

Değişik Rezin Simanlarla Yapıştırılan Laminate Veneerlerin Makaslama Kuvvetine Karşı Dirençlerin İncelenmesi

Bilgi

 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

Geliş: 12/10/2022
Kabul: 27/12/2022

ÖZ

Amaç: *Kullanılan simanların mekanik özelliklerinin bilinmesi restorasyonların başarısı için önemlidir. Bu çalışmanın amacı; laminate veneerlarde kullanılan simanların makaslama kuvvetine karşı dirençlerinin incelenmesidir.*

Gereç ve Yöntemler: *Çalışmada 30 adet herhangi çürük ve restorasyon olmayan çekilmiş maksiller santral diş standart bir şekilde prepare edildikten sonra IPS e.max Press (Ivoclar) laminate veneerlar hazırlandı. Derinliği standardize etmek için bukkal açıdan 0,5 mm'lik bir derinlik hazırlamak için derinlik kılavuz frezi kullanıldı. Rasgele olacak şekilde dişler üç gruba ayrılarak (n=5); Grup A: Total etch yöntemi kullanılarak Variolink Esthetic DC (Ivoclar Vivadent) rezin, Grup B: Self etch yöntemi kullanılarak Panavia F2.0 (Kuraray) rezin, Grup C: Self adeziv RelyX U200 (3M ESPE) rezin simanla preparasyon yapılan dişlere simante edildi. Simantasyon işleminden sonra 1 hafta distile suda bekletip 5 ile 55 °C suda 500 döngü termal siklus işlemine tabi tutularak makaslama testi ile bağlanma dirençleri değerlendirildi. Elde edilen veriler Tukey çoklu karşılaştırma testi ile istatiksel olarak değerlendirildi.*

Bulgular: *Çalışmada kullanılan rezin simanların, makaslama kuvvetlerinin karşı dirençlerinin anlamlı farklılık ($p<0.05$) gösterdiği istatistiksel olarak saptandı. En düşük makaslama kuvveti değeri; Total-etch ile simante edilen örneklerde (18.79±4.48 MPa) elde edildi. Self-etch ve self adeziv yöntem ile restore edilen örneklerde anlamlı fark ($p>0.05$) görülmedi.*

Sonuçlar: *Sabit protetik restorasyonlar ve dayanak diş arasındaki bağlantıda siman son derece etkili bir faktör olup, kullanılan simanın makaslama kuvvetlerine karşı yeterli direnç göstermesi gerekir.*

Anahtar Kelimeler: *Laminate veneer, Makaslama kuvveti, Rezin siman.*

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Introduction

Advances in technology and research on new dental materials have provided a solution for the aesthetic and biological incompatibilities created by metal infrastructures.[1,2] These studies have improved the physical properties of the materials and their clinical success has enabled all-ceramic materials to play a significant role in standard restoration treatments.[3] Common dental problems include disturbances in tooth structure, misalignment of teeth, and discoloration or tooth loss. In recent years, there has been an increase in the use of aesthetic dentistry treatments in the anterior region of the mouth. Laminate veneers, which improve aesthetics with a conservative approach, have become very popular.[4] The main advantages of the laminate veneer technique are enhanced aesthetics, biological compatibility, minimal preparation requirements, and high bond strength. However, laminate veneers are fragile and difficult to repair, require technical skill, are expensive, and the porcelain can crack or break when chewing hard foods.[5,6]

In the laminate veneer technique, the lifespan of the restoration depends on the material used and the physical properties of the cement. The most important criterion for the long-term success of restorations is the connection it makes with the abutment tooth. Resin cements have become the preferred choice for cementing ceramic restorations due to their aesthetic appearance and superior bonding properties.[7]

In adhesive cementation applications, pre-treatment of dental tissue is required. Different cement application techniques can be used, including acid etching, primer and adhesive (total-etch method), or only primer and adhesive (self-etch method). Adhesive applications in the cementation stage complicate the application techniques of these cements, limiting their use.[8] In recent years, self-adhesive universal resin cements that do not require primer and adhesive applications, eliminating the acid etching process and reducing technical sensitivity, have been used for the convenience of the clinician.[9]

In dentistry, different methods are used to evaluate the effect of adhesives. While clinical trials are the most effective method, in vitro bond strength tests are often used because long-term follow-up in clinical trials is time-consuming and difficult to perform. Bond strength tests are used to measure the minimum force required to disrupt the bond between the adhesive and the adherent, causing failure.[10]

In this study, the resistance of laminate veneer specimens to the shear force of resin cements was examined to determine bonding strength. To do this, an appliance was prepared that applies an equal amount of force to the tooth surface and porcelain, opposite and parallel to each other.

The appliance is designed to prevent rotational force.[11]

The laminate veneer restorations prepared for this study were stored in distilled water after bonding with different resin cements, and their shear strength was examined. The null hypothesis of the study is: the restorations are formed in such a way that the shear force of the cement used does not affect them.

Materials and Methods

In the study, 30 maxillary central incisor teeth without caries or restorations were used. The G *Power package program (G *Power Ver. 3.0.10, Franz Faul, Universität Kiel, Germany) was used to determine the number of teeth needed for the study. It was determined that a total of 30 teeth should be used for 80% power at 25% effect size with $\alpha = 0.05$ type 1 error rates. The Atatürk University ethical committee gave its consent to use the extracted teeth. The mean incisocervical and mesiodistal lengths of all the selected teeth were 8 mm. After extraction, the teeth were kept in a 0.5% thymol solution until use. The teeth were stored in the same environment for similar periods of time.

Preparation of the Specimens

After removing all hard and soft tissue residues from the tartar on the teeth, markings were made 1 mm below the cervical line and wax was placed around this line to ensure that the enamel of the teeth was not dipped into the acrylic. The teeth were embedded in a silicone mold using a parallelometer (Kavo EWL, Type 990, Kavo Elektrotechnisches Werk GmbH, Leutkirch, Germany). The teeth were then vertically embedded in autopolymerizing acrylic resin (Imicryl SC, Imicryl, Konya, Turkiye) using a parallelometer. Acrylic resin was prepared according to the manufacturer's recommendations and poured into a silicone mold. After hardening, the teeth were removed from the mold and the acrylic resin was polished.

Preparation of the Teeth

To begin preparing the teeth, guide grooves were made. To standardize the depth, the depth was set to 0.5 mm from the buccal angle using guide burs. The grooves were then marked with a pencil to achieve a controlled groove depth. The preparation continued with a chamfer bur. The incisal edge was measured and marked with a 1 mm caliper (Figure 1) and prepared as a butt-joint. The marginal preparation was completed using a chamfer bur according to the shape of the bur. Proximal contact points were prepared to be palatal. Then, a polishing disc was used to make the teeth smoother.

Surface Preparation of the Restorations

After preparing the 30 maxillary central incisor teeth, lithium disilicate ceramic (MT E.max Press A2; Ivoclar Vivadent, Schaan, Liechtenstein) laminate veneers were applied. Laminate veneer specimens 0.5 mm thick were prepared separately for each tooth

(Figure 2). The thickness of each sample was checked with a digital caliper. After the laminate veneer samples were glazed, 9.5% hydrofluoric acid (Ultradent Porcelain Etch, Ultradent Products, Köln, Germany) was applied to the non-glazed surface for 20 seconds. The samples were then washed with air and water spray for 20 seconds and dried. The samples were treated with silane (Monobond Plus, Ivoclar Vivadent) for 60 seconds.

Cementation of the Restorations

After preparing the specimens, they were randomly allocated into three groups based on the cement type (n = 10) (Table 1) as follows:

Group A: The specimens in this group were cemented using the total-etch method. To do this, 37% phosphoric acid was applied for 30 seconds (K-Etchant, Kuraray Medical Co., Tokyo, Japan) and the specimens were air-washed using water spray. The prepared surface of the teeth was treated with an adhesive bonding agent (Adherse Universal bonding agent Ivoclar, Vivadent) for 20 seconds. The specimens were air-dried for 5 seconds and then light-cured for 10 seconds according to the manufacturer's instructions. Variolink Esthetic DC (VE-DC) resin cement (Ivoclar Vivadent) was applied homogeneously and the excess was cleaned. Cementation was completed by light-curing each surface for 10 seconds.

Group B: A 37% phosphoric acid gel was applied to the enamel and dentin of the self-etch-cemented specimens for 15 seconds, then they were washed and air-dried. PANAVIA F2.0 (PF) resin cement (Kuraray, Osaka, Japan) was mixed with one drop each of primer A and primer B, and then applied to the surface of each tooth and air-dried. The resin cement, produced as two fabricated tubes, was mixed in equal amounts and the restoration was bonded to each tooth. After removing the excess, each surface was polymerized by irradiation for 10 seconds.

Group C: The specimens in this group were cemented using Rely X U200 (RX) self-adhesive (3M ESPE Dental Products, St. Paul, MN) without any treatment to the teeth. After cleaning the excess, the surface of the teeth was light-cured for 10 seconds.

Shear Strength Value of the Restorations

After cementation, the laminate veneer samples were stored in distilled water for one week before being thermal cycled for 500 cycles in 5°C and 55°C water and using a shear test to measure the bond strengths. The test was applied in accordance with the requirement of the universal test (Instron) for shear testing. A knife-shaped metal tip was placed parallel to the interface between the restoration and the tooth (Figure 3). The maximum force value when the restorative material was separated from the tooth surface was measured in Newtons (N). A force of 500 N was applied at a speed of 0.5 mm/min.

Statistical Analysis

The Jamovi (Version 1.0.4) computer software application (https://www.jamovi.org) was used for statistical analysis. The Shapiro-Wilk test was used to determine whether the data were normally distributed. ANOVA was used to measure the variations in shear bond strength due to normal distribution. The Tukey's post-hoc test was used to analyze significant differences ($p = 0.05$).

Results

This study investigated the effect of different resin cements on laminate veneers. It was found that the applied composite resins had a statistically significant effect on the shear strength values ($p < 0.05$) (Table 2). When the average shear strength values of the specimens were examined, the lowest value was obtained in the specimens cemented with the total-etch (VE-DC) resin (18.79±4.48 MPa). No significant differences in the shear bond strength values were observed between the self-etch (PF) (26.57± 10.21 MPa) and self-adhesive (RX) (25.96 ± 8.08 MPa) resin cements ($p > 0.05$) (Figure 4). The specimens that were cemented using the self-etch method had the highest shear bond strength value.

Discussion

This study evaluated the mechanical properties of different resin cements used to restore laminate veneer restorations. While there was no statistically significant difference between the self-adhesive cement and self-etch cement among the types of cement used, the total-etch cement had a lower shear strength value. The study's null hypothesis was rejected.

Although it is questionable to use in vitro bond strength tests to determine the clinical effects of dental adhesives, they are used because clinical determination of the mechanical properties of these adhesives is difficult and time-consuming.[12] The shear test used in studies also provides information about the material. Although a shear test has some disadvantages, it also has advantages, such as an easy application procedure and minimal equipment requirement.[11] According to scientific documents from Ivoclar Vivadent, the shear strength of VE-DC resin cement in combination with Adhese Universal using UltraTester is around 20 MPa.[13-15] While this value is suitable for Variolink adhesive system shear strength tests, the results may differ when the analysis methods are different.16 In the present study, a shear strength value < 20 MPa was found. The results may not be the same as those reported in other studies due to differences in the methods applied. However, there is no standard method for testing shear strength in ceramic restorative materials.

Previous studies reported that strengthened porcelains provide a stronger bond with dentin by

cementation when new adhesive techniques and materials are used; thus, the fracture resistance of teeth increases significantly.[17,18] Lithium crystals in IPS-e.max porcelain significantly increase the resistance to breakage. They also provide resistance to the porcelain by preventing the cracks formed on the surface of the material from moving inward.[13,19] In the present study, IPS-e.max, which is mechanically more advantageous than other porcelains, had the highest shear strength value. One study compared a self-adhesive resin cement containing MDP (SpeedCEM Plus, Ivoclar Vivadent), VE-DC double-cured resin cement, and a primer containing phosphoric acid methacrylate and silane methacrylate, such as Monobond Plus. In bonding to conventional 3Y-TZP zirconia, VE-DC appeared to have a significantly higher bond strength value. In the present study, the VE-DC bond strength was found to be lower than the other two types of cement. This can be explained by the difference in the surface structure between zirconium and lithium disilicate glass ceramics.[20,21]

Other studies examining shear force have reported that failures were predominantly due to mixed application procedures for PF adhesion material.[25,26] Self-etch primers produce a thin hybrid layer by partially removing the smear layer. Although the hybrid layer is important, its thickness and relationship to the adhesion bond are still unclear.[27] Amines have been reduced to prevent color change in self-etch resin cements. The bond strength of autopolymerizing resins may have decreased due to the reduction of amines, which causes a decrease in polymers at the bonding surface.[28] Zhang and Degrange[29] examined how the shear bond strengths of different restorative materials were impacted by total-etch (Variolink), self-etch (Multilink Automix), and self-adhesive (RelyX Unicem, Multilink Sprint, and Maxcem) resin cements. In that study, Maxcem cement had the lowest shear bond strength among the glass ceramic materials, while total-etch and self-etch adhesive resin cements had significantly higher bond strength than self-adhesive resin cement ($p < 0.05$). Unlike the present study, in Zhang and Degrange[29] the lowest value was seen in the samples cemented with VE-DC. This conclusion may have been reached due to the different type of cement used. The bond strength may depend on the different composition, solvent, initiator, viscosity, and wettability of the resin cements used. In a study comparing the bond strengths of PF self-etch and RX self-adhesive resin cements, no significant difference was observed, which is similar to our results.[30] Sokolowski et al.[31] investigated the state of stress through photoelastic analysis of resin cement, one of which was VE-DC and the other was RX, using aging in water. A study examining VE-DC resin cement has shown that it has high solubility due to its ability to absorb water. Similar to the present study, the results of that study were obtained using VE-DC, which has the lowest bond strength value.

The polymerization of the double polymerized resin cement is completed within one week after curing, according to previous studies.[32,33] Therefore, in the present study, bond strength tests were conducted one week after the specimens were prepared, presuming that the resin cement was completely polymerized and had reached its maximum bond strength.

The limitation of the study is that it does not completely mimic the oral environment. A clinical trial may reveal different data from the results of the current study. Therefore, a clinical study is recommended to analyze the effect of resin cements on the longevity of the restoration.

Conclusions

Considering the limitations of the study, the following conclusions can be made:

i. The fact that total-etch resin cement has a lower resistance to shear strength can be attributed to its high solubility in water.

ii. Monomers in self-etch resin cement and self-adhesive resin cement may be effective factors in the connection.

iii. Regardless of the method used in the clinic, cement is an effective factor in the connection between the restoration and the abutment tooth. Since the self-adhesive resin application procedure is easier than the self-etch or total-etch methods, it can be preferred in cementation.

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Conflicts of Interest Statement

The authors do not have any financial interest in the companies whose materials are included in this article.

Figure 1. 1 mm of reduction is measured using a Digital caliper.

Figure 2. According to the tooth surface, a laminate veneer was produced.

Figure 3. The interface shear bond strength between tooth and restoration was applied.

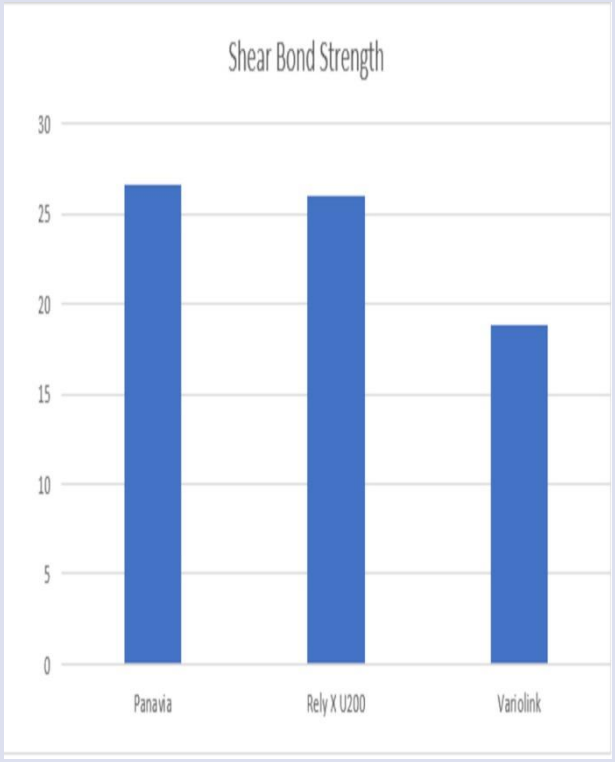

Figure 4. Shear bond strength

Table 1. Compositions of the Resin Cements Used in the Study

Resin cement	Manufacturer	Product batch*	Chemical composotion
Variolink Esthetic DC	Ivoclar Vivadent	Dual-cure (amine-free) adhesive luting composite	UDMA and furthermethacrylate monomers. Inorganic fillers: ytterbium trifluoride and spheroid mixed oxide. Particle size: 0.04-0.2µm (mean:0.1 µm). Volume of inorganic fillers:38%, 60-68 wt%. Ivocerin for initiator. Additional ingredients: Stabilizers and pigments.
RelyX U200	3M ESPE	Self-adhesive dual-cure (methacrylated aliphatic amine) composite cement	Bis-GMA, TEGDMA, methacrylate monomers containing phosphoric acid groups, stabilizer components rheologic additives, alkaline (basic) initiator components, pigments. Inorganic silanated fillers: 43 V%, 72 wt% Sodium p-toluensulfinate, cam-phorquinone for initiator.
Panavia F2.0	Kuraray Noritake	Dual-Cure Adhesive Resin cement	Silanated barium glass, silanated silica, surface-treated sodium fluoride, bis-phenol poly ethoxy dimethacrylate, MDP, Hydrophobic dimethacrylate, Hydrophilic dimethacrylate, benzoyl peroxide, sodium aromatic sulfinate, N, N-diethanol p-toludine, photo-initiator

UDMA= urethane dimethacrylate; Bis-GMA= bisphenol A glycol dimethacrylate; TEGDMA= triethylene glycol dimethacrylate; MDP= Methacrylol oxidecyl dihydrogen phosphate

*Information supplied by the manufacturers

Table 2. Shear Bond Strength Values According to Materials and Solution Type

Material	Solution	Shear Bond Strength
Panavia	Distilled water	26.57± 10.21 MPa[a]
Relyx U200	Distilled water	25.96 ± 8.08 MPa[a]
Vario. Link	Distilled water	18.79±4.48 MPa[b]

Different superscript letters(lowercase for vertical lines) indicate significant differences ($p<0.05$).

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