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infection in patients with cystic fibrosis. *Drugs* 2013; [Epub ahead of print] Available from: <http://link.springer.com/article/10.1007%2Fs40265-013-0141-0>

Book

3. Mueller HJ, Freeman D. FT-IR spectrometry in materiography. 2nd Ed., Ohio: American Society for Metal 1994, p.51-56.

Chapter in a book

4. Alexander RG. Considerations in creating a beautiful smile. In: Romano R, editor. *The art of the smile*. London: Quintessence Publishing, 2005, p.187-210.
5. Hudson FB, Hawcroft J. Duration of treatment in phenylketonuria. In: Seakins J, Saunders R, editors. *Treatment of inborn errors of metabolism*. London: Churchill Livingstone, 1973, p.51-56.

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Figure 1. Panoramic radiograph of the patient taken 6 months after surgery, note irregular borders of the lesion.

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Prevalence of ectopic eruption of first permanent molars in a Turkish population

Yeliz Güven

Purpose

The aim of this study was to investigate the prevalence and characteristics of ectopically erupting first permanent molars (FPMs) in children attending the clinics of the Pediatric Dentistry Department at Istanbul University.

Materials and methods

This retrospective study was performed using panoramic radiographs of 7,649 patients (3,506 females and 4,143 males) aged from 5 to 11 years. The age and gender of the subjects, the number and location of the ectopic molars, bilateral versus unilateral occurrence, the degree of resorption of the roots of the primary molars, and other associated dental anomalies were assessed. Ectopic eruption was categorized according to a grading system based on the resorption rates of the primary molars.

Results

Of the 7,649 reviewed subjects, 203 (118 males and 85 females) were diagnosed with ectopic eruption of the FPMs, resulting in a frequency of 2.65%. The mean age of the subjects with ectopic FPMs was 6.82 ± 1.25 (range: 5–11) years. Of the 273 ectopic FPMs, 157 (57.5%) were detected in the maxilla and 116 (42.5%) in the mandible. Severe and very severe degrees of ectopic eruption were found to be more common in the maxilla than in the mandible, whereas a moderate degree of ectopic eruption was more prevalent in the mandible ($p=0.251$).

Conclusion

To our knowledge, this is the first study in a Turkish population reporting the prevalence of ectopic eruption of FPMs. Although the difference between the right and the left sides was not significant, the severity of ectopic eruption was different between the maxilla and the mandible.

Keywords: Ectopic eruption, prevalence, resorption of primary second molar, panoramic radiography, pedodontics

Introduction

Ectopic eruption of the first permanent molar (FPM) is a local eruption disturbance characterized by the abnormal eruptive pathway of FPM causing the permanent tooth to be locked under the distal undercut of the second primary molar and failure to erupt into normal occlusal plane (Figure 1) (1-3). The prevalence of ectopic eruption of FPMs varies from 0.75% to 6% in different populations worldwide (1, 4, 5). The differences in these rates are attributed to the group size, age range of the population and caries status (6). Ectopic eruption of FPMs can be associated with other dental anomalies such as infraocclusion of primary molars (7, 8), agenesis of the second premolars (7, 9), supernumerary teeth (9) and reduced size of maxillary lateral incisors (7). Additionally, ectopic eruption of the permanent canines has been associated with the ectopic eruption of the first permanent molars (8). Although the etiology of the ectopic

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Figure 1. Intraoral view and panoramic radiograph of a 10-year-old girl with ectopically erupted maxillary first permanent molars.

FPMs is not well known, it is considered to be multifactorial, including a genetic component and local factors. The increased prevalence in siblings suggests a hereditary component (10). Possible etiologic factors of this anomaly are insufficient intercusp and anteroposterior growth of the jaws, asynchronization between eruption of the FPMs and bone growth at the tuberosity region, smaller maxilla, posterior position of the maxilla in relation to the cranial base, abnormal eruption angle or delayed calcification of the FPM, and abnormal crown morphology of the second primary molars (1, 3, 9).

Early diagnosis of this anomaly can be made during a routine radiographic examination before the eruption of FPMs, usually between five and seven years of age. The earliest radiographic sign of ectopic eruption is the superiorly and mesially directed FPMs. Clinician should also have a suspicion for ectopic eruption if there is a delay (more than 6 months) or abnormal eruption position of one or more FPM compared with the other FPMs (2, 11).

To date, there have been no studies relating to prevalence of ectopic eruption of FPM in Turkish population. Therefore, the aim of the present study was to investigate the prevalence and characteristics of ectopically erupting FPM in Turkish population.

Materials and methods

Study sample

This project has been reviewed and approved by the Ethical Committee of İstanbul University, Faculty of Dentistry (2016/54). Informed consent was waived due to the retrospective design. The present study was performed using panoramic radiographs of 7649 patients (3506 females, 4143 males) ranging in age from 5 to 11 (mean age; 8.15 ± 1.649) subjected to Pediatric Dentistry Department at İstanbul University between the years 2010 and 2013. Children were included in the study if their permanent molars were present at the time of evaluation. Children suffering from any syndrome or craniofacial malformations were excluded from the study. The age and gender of the subject, the number and location of the ectopic molars, bilateral versus unilateral occurrence, the degree of resorption on the roots of the primary molars and the other associated dental anomalies were assessed by a single investigator (pediatric dentist).

Panoramic imaging

Panoramic radiographs were taken with the Kodak 8000 Digital Panoramic Machine (Kodak Dental Systems, Carestream Health, Inc., Rochester, NY, USA) using the parameters as 65-68 kVp, 2-3.2 mA for infants and 5-6.5 mA for adolescents.

Image assessment

Ectopic eruption was categorized according to a grading system proposed by Barberia-Leache *et al.* (11), which is based on the resorption rates of the primary molars. Although the original classification has four grades of resorption (mild, moderate, severe and very severe), the present study classified the resorption rates using a three-grade system (moderate, severe and very severe) (Figure 2). Mild cases were not included in the current study in order to eliminate the errors which may result from the diagnostic difficulty in differentiating a mild form ectopic eruption from a non-ectopic teeth. The distribution and frequency of ectopic FPMs were calculated with respect to dentition type (maxilla/mandible, left/right side), ectopic eruption type and associated dental anomalies including tooth agenesis, supernumerary teeth, macrodontia/microdontia and infraocclusion.

Statistical analysis

Statistical tests were carried out using SPSS software (version 21.0; IBM, Armonk, NY, USA). Statistical analysis included descriptive statistics, frequencies, and cross-tabs with chi-square analysis. Confidence level was set to 95% and p values less than 0.05 were considered significant.

Results

Of the 7649 reviewed cases, 203 subjects (118 males and 85 females) were diagnosed with ectopic eruption of the FPMs, giving a frequency of 2.65%. Ages of the subjects with ectopic FPMs ranged between 5 and 11 years with a mean age of 6.82 ± 1.25 years. Distribution of ectopic eruption according to gender shows that there was a slightly higher prevalence in males (2.85%) than in females (2.42%) with no statistically significant differences ($\chi^2=1.320$, $p=0.251$) (Table 1). 133 children had one ectopically erupted tooth whereas 70 children had two ectopically erupted teeth. The distribution and the type



Figure 2. a-c. Representation of the grades: (a) moderate, (b) severe, (c) very severe degree of resorption of the second deciduous molar (modified from the classification of Barberia-Leache et al. (11)).

Table 1. Distribution of ectopically erupted first permanent molars according to gender (n=7649)

		Ectopically erupted n (%)	Normal n (%)	Total n (%)	p
Gender	Female	85 (2.42)	3421 (97.58)	3506 (100)	0.251 $\chi^2=1.320$
	Male	118 (2.85)	4025 (97.15)	4143 (100)	
Total		203 (2.65)	7446 (97.35)	7649 (100)	

Table 2. Distribution of the type of ectopically erupted first permanent molars (FPM) stratified by the severity of ectopic eruption

		Quadrant of the ectopic FPM					Total n (%)
		Maxillary		Mandibular			
		Right FPM n (%)	Left FPM n (%)	Left FPM n (%)	Right FPM n (%)		
The severity of ectopic eruption	Moderate	n (%)	36 (13.19%)	38 (13.92%)	40 (14.65%)	53 (19.41%)	167 (61.17%)
	Severe	n (%)	30 (10.99%)	25 (9.16%)	13 (4.76%)	6 (2.2%)	74 (27.11%)
	Very severe	n (%)	17 (6.23%)	11 (4.03%)	3 (1.1%)	1 (0.37%)	32 (11.72%)
Total		n (%)	83 (30.4%)	74 (27.11%)	56 (20.51%)	60 (21.98%)	273 (100%)

Table 3. Distribution of the associated dental anomalies according to the subjects with ectopically erupted and nonectopically erupted molars

		Ectopically erupted n (%)	Normal n (%)	Total n (%)	p
Infraocclusion	Yes	2 (0.99)	76 (1.02)	78 (1.02)	1.00
	No	201 (99.01)	7370 (98.98)	7571 (98.98)	
Tooth agenesis	Yes	10 (4.93)	398 (5.35)	408 (5.33)	0.793
	No	193 (95.07)	7048 (94.65)	7241 (94.67)	
Supernumerary teeth	Yes	4 (1.97)	178 (2.39)	182 (2.38)	1.00
	No	199 (98.03)	7268 (97.61)	7467 (97.62)	
Macrodonia	Yes	1 (0.49)	1 (0.01)	2 (0.03)	0.052
	No	202 (99.51)	7455 (99.99)	7647 (99.97)	
Total		203 (100)	7456 (100)	7649 (100)	

of ectopic eruption recorded for these 273 teeth are presented in Table 2. The most commonly affected tooth was found to be maxillary right FPM followed by maxillary left FPM, and then mandibular left FPM and mandibular right FPM.

The anomaly occurred unilaterally in 144 affected patients (70.9%) and bilaterally in 59 patients (29.1%). Right-sided unilateral ectopic eruption was more common than left sided unilateral ectopic eruption. 157 out of 273 ectopic FPMs (57.5%) were detected in the maxilla and 116 (42.5%) in the mandible. Chi-square test revealed a significant association between the severity of ectopic eruption and the affected

jaw (maxilla or mandible) ($\chi^2=32.245$, $p<0.001$). Severe and very severe degree of ectopic eruption were found to be more common in maxilla than in mandible while moderate degree of ectopic eruption was more prevalent in mandible. No significant association was found between ectopic eruption and the presence of other dental anomalies ($p>0.05$). Seventeen subjects (8.37%) with ectopic FPMs exhibited other dental anomalies including tooth agenesis (4.93%), supernumerary teeth (1.97%), infraocclusion (0.99%) and macrodonia (0.49%). The most common associated anomaly was tooth agenesis and was only seen in 10 subjects (Table 3).

Discussion

The prevalence rate of ectopic eruption of FPMs has been reported to be between 0.75–6%. Higher incidence rates have been noted in subjects with cleft lip and palate (12–15). Kuroi and Bjerklin (10) reported that the prevalence in siblings was 19.8% whereas the general population showed a prevalence of 4.3%. The increased prevalence in siblings may also suggest a hereditary component of this anomaly. The largest study, carried out by Salbach *et al.* (16), found ectopic eruption of FPM in 1.3% of a sample of 8041 kindergarten and school children aged 5–9 years. To the best of our knowledge, the present study is the second largest prevalence study in ectopic eruption after the study of Salbach *et al.* (16). This is also the first prevalence study carried out in Turkish population. Although the sample size and age of the children investigated in the present study are similar to those of Salbach *et al.* (16), their results on the prevalence was lower than that of the present study. This can be due to the fact that the current study was performed in a university hospital set up not in the general population as in the study of Salbach *et al.* No relationship was found between the presence of ectopic eruption and gender in the present investigation. This is in agreement with the most of the previous studies (1, 4, 5, 11, 16). No significant difference was found between the right and left side and this result is consistent with those of previous studies (2, 4, 11, 16, 17). Contrary to the findings of most previous studies and the present study, Barberia-Leache *et al.* (11) reported that ectopic eruption on the right side is more frequent and of a greater severity than in the left side. In the present study, the prevalence of ectopic eruption of FPMs in the maxilla was similar to that in mandible. This result is in agreement with the findings of study by Chintakanon and Boonpinon (1), whereas this is contrary to the findings of most previous studies (2, 4, 16) who found that ectopic eruptions were more frequent in the maxilla than in the mandible.

The severity of ectopic eruption of FPM and the resorption degree of the second primary molar roots were greater in the maxilla than in the mandible. Similar results were reported by Chintakanon and Boonpinon (1) and they proposed that this is related to where ectopic molar crown impacts the second primary molar. In mandible, ectopic molar crown impacts mostly at the crown which is composed of enamel and therefore resorption is slight. On the other hand, in maxilla, ectopic molar crown impacts under the cemento-enamel junction thus the chance for resorption is greater (1).

In the present study, a total of 17 (8.37%) patients with ectopic eruption were also found to have radiographic evidence of one or more dental anomalies involving mostly tooth agenesis (4.9%) and supernumerary teeth (1.97%). Contrary to our finding, Mooney *et al.* (2) reported that 60.7% of the examined patients with ectopic molar eruption had at least one other dental anomaly: primary molar infraocclusion being the most common (n=9; 32.1%) followed by hypodontia (n=8; 28.6%), cleft lip and/or palate (n=7; 25%) and supernumerary teeth (n=5; 17.9%). The conflicting results are probably related to the differences in sample size and inclusion criteria of the subjects, as the study by Mooney *et al.* (2) was performed in 28 subjects and included the subjects with a cleft lip and/or palate while the present study was conducted in 203 subjects

and patients with cleft lip and/or palate were not included. Evidence suggests that individuals with cleft lip and/or palate had a higher incidence of dental anomalies so the inclusion of cleft patients may have been resulted in greater prevalence of dental anomalies in ectopic molar patients.

Early diagnosis of ectopic eruption is essential for the delivery of appropriate treatment. If the resorption degree is slight or moderate, no treatment is required and spontaneous self-correction can be expected. However, if the resorption degree is severe or very severe, the majority of the cases do not self-correct and treatment is needed (11). If appropriate treatment cannot be provided, this may result in premature loss of the second primary molar, resultant space closure in the area and potential impaction of the second premolar (2, 5).

Conclusion

The present study, which investigated the prevalence of ectopically erupted first permanent molar in 7649 Turkish subjects, is the first to describe the prevalence of ectopic eruption in Turkish population. No statistically significant differences were observed by gender. The incidence of ectopic eruption did not differ between the right and left side or maxilla and mandible. The severity of ectopic eruption of FPM and the resorption degree of the second primary molar roots were greater in the maxilla than in the mandible.

Ethics Committee Approval: This project has been reviewed and approved by the Ethical Committee of Istanbul University, Faculty of Dentistry (2016/54).

Informed Consent: Informed consent was waived due to the retrospective design of this study.

Peer-review: Externally peer-reviewed.

Author Contributions: YG designed the study, generated and gathered the data, wrote and approved the final version of the study.

Conflict of Interest: Authors have no conflicts of interest to declare.

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

Türkçe öz: Türk populasyonunda sürekli birinci büyük azı dişlerinin ectopik sürme prevalansı ve dağılımı. Amaç: Bu çalışmanın amacı İstanbul Üniversitesi Pedodonti Anabilim Dalı'na başvuran çocuklarda ectopik sürmüş sürekli birinci büyük azıların prevalansının ve karakteristik özelliklerinin araştırılmasıdır. Gereç ve Yöntem: Çalışmada yaşları 5-11 arasında değişen 7649 hastanın (3506 kız, 4143 erkek) panoramik röntgenleri retrospektif olarak incelenmiştir. Hastanın yaşı ve cinsiyeti, ectopik birinci büyük azıların sayısı ve lokasyonları, bilateral ya da unilateral oluşları, ikinci süt azılarının köklerindeki rezorpsiyon dereceleri ve gözlenen diğer anomaliler çalışma kapsamında değerlendirilmiştir. Ectopik sürme şiddeti süt azıların köklerindeki rezorpsiyonun derecesine göre sınıflandırılmıştır. Bulgular: İncelenen 7649 hastadan 203'ünde (118 erkek, 85 kız) ectopik birinci molar gözlenmiştir (%2,65). Yaşları 5-11 arasında değişen olguların ortalama yaşları ise $6,82 \pm 1,25$ olarak bulunmuştur. Toplam 273 ectopik olarak sürmüş birinci büyük azı dişinden 157'si (%57,5) üst çenede, 116'sı ise (%42,5) alt çenede gözlenmiştir. Şiddetli ve çok şiddetli derecelerdeki ectopik birinci büyük azılar üst çenede alt çeneye göre daha sık gözlenirken, orta derecedeki ectopik birinci büyük azılar alt çenede sıklıkla gözlenmiştir ($p=0,251$). Sonuç: Bu çalışma Türk toplumunda ectopik birinci büyük azı görülme sıklığını belirleyen ilk çalışmadır. Sağ ve sol taraflarda farklılık

olmamasına rağmen, ektojik sürme şiddeti alt ve üst çeneler arasında farklılık göstermektedir. Anahtar kelimeler: Ektojik sürme, prevalans, süt ikinci azılarının rezorpsiyonu, panoramik radyografi, pedodonti

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Oral health behavior differences between dental students in graduate and doctoral programs

Purpose

This study aimed to compare oral health behavior between dental students in graduate programs and those in doctoral programs (PhD students) and determine the effects of parental education and occupation on these behaviors.

Materials and Methods

A questionnaire on oral health behaviors was distributed in a faculty of dentistry in Ankara, Turkey. A total of 629 questionnaires were distributed, and 528 dental graduate and 101 PhD students responded. Parental education and occupation were also recorded, and data were statistically analyzed.

Results

Statistically significant differences were found between the two groups with respect to the frequency of replacing toothbrush ($p=0.001$), use of electric toothbrush ($p<0.001$), frequency of brushing ($p<0.001$), amount of water used to rinse mouth ($p<0.001$), toothpaste selection criteria ($p<0.001$), use of dental floss ($p<0.001$), amount of toothpaste used for brushing ($p=0.018$), frequency of professional care ($p<0.001$), and sugar consumption ($p<0.001$). The PhD group showed more favorable outcomes for these behaviors except for toothpaste selection. Parental education and occupation were correlated with higher frequencies of flossing and mouth rinsing.

Conclusion

The outcomes of this study show that the self-reported quality of overall oral health behavior is more pronounced in PhD students than in graduate students, with the exceptions of behaviors regarding the duration of brushing, toothpaste selection criteria, and use of mouth rinse. The current dental curriculum in the universities should be revisited with respect to oral health attitudes. This study also implies that educational and occupational status of parents had little effect on oral health behavior of the students, including the use of dental floss and mouth rinse.

Keywords: Oral health, toothbrushing, education, professional, parents

Introduction

Dental students, the future leaders in oral health care, have an important role in educating and promoting public oral health (1-3). Dental students in general have been found to have a positive attitude towards oral health (4, 5). Oral health behavior of dental students must be improved if they are to serve as positive models for their patients, families and friends (6-9).

There are several studies about oral health attitudes and behavior of dental students (10-25). Most of these studies have been carried out using the Hiroshima University Dental Behavioral Inventory (HU-DBI) questionnaire developed by Kawamura (10-12, 14, 15, 17-21, 25). Some participants in the surveys were from all academic years (10, 12, 15, 17-20, 25)

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and others were from only final years of university (13, 14, 16). Yildiz and Dogan (25) and Peker *et al.* (19) compared the oral health attitudes and behavior of preclinical students to clinical students. Tseveenjav *et al.* (24) evaluated cross-sectional and longitudinal comparison among clinical dental students. Rong *et al.* (22) administered the HU-DBI questionnaire to medical and dental students when they were in years 1 and 5 of their university.

There has been a lack of information about oral health attitudes and behavior of dental students in doctoral (PhD) programs. Most research about oral health attitudes and behavior of dental students in Turkey has been done by administering the HU-DBI questionnaire (12, 18, 19, 25). HU-DBI questionnaire was developed to understand patients' perceptions of oral health (26), a structured questionnaire containing more specific questions related to oral health behaviors was developed for this study. The study aimed to compare the effects of educational level on oral health behaviors of dental and PhD students. Also, possible effects of educational level and occupational status of parents on these behaviors were investigated. Main null hypothesis tested in this study was that there is no difference in any of the study questionnaire items between dental and PhD students.

Materials and methods

Study sample and administration of the questionnaires

A 17-item questionnaire was prepared regarding oral health behaviors. Before conducting a full-scale survey in the Ankara University in the city of Ankara, Turkey, the questionnaire was pretested with 35 subjects who were representative of the study sample. After testing accuracy and comprehension of the questions, the self-administered questionnaire was delivered to a larger population. This study had exemption from institutional ethics review board of the university. Graduate level dental school education in

Turkey takes 5 years. PhD programs including Endodontics, Periodontology, Oral and Maxillofacial Surgery, Dento-Maxillofacial Radiology, Orthodontics, Pedodontics, Prosthodontics take about 4 years. The questionnaire was carried on 528 volunteer dental students in graduate level and 101 volunteer students in PhD programs. The survey was completed anonymously. Questionnaire items are shown in Table 1. Age, gender, academic year data, educational and occupational status of parents were also recorded. ISCED 2011 (International Standard Classification of Education) was used for the educational status and ISCO-08 (International Standard Classification of Occupations) for the classification of the occupational status of the parents. Oral health behaviors of dental students and students in PhD programs were compared. The correlation between the educational/occupational status of parents and the behaviors of both dental and PhD students were examined.

Statistical analysis

The collected data from both groups were imported to Statistical Package for Social Sciences (SPSS) for Windows software, version 10.0 (SPSS Inc.; Chicago, IL, USA). The standard descriptive methods such as the mean, standard deviation, median, frequency, minimum and maximum were applied to determine the characteristics of the sample. Pearson's chi-square test was used to compare the categorical demographic variables among the groups. Because the distribution of the data did not meet the requirements for normality and homogeneity of variances assumptions. The confidence interval was set to 95% and p values less than 0.05 was considered statistically significant.

Results

Of the 528 participants, 417 were female and 212 were male. Frequency distribution of number of the students according to their academic year were as follows: 150 in the first year (28%), 109 in the second year (21%), 107 in the third year (20%), 83 in the fourth year (16%), 79 in the fifth year (15%).

The PhD students reported higher frequencies of flossing (60.40% PhD, 37.31% dental, Figure 1) and use of pea sized toothpaste during brushing (73.27% PhD, 61.36% dental) compared to the dental students. Seventytwo percent of the PhD students and 51.70% of the dental students reported that they replace their toothbrushes every 3 months (Figure 2). The PhD students visited professional dental care more frequently (every 6 months) than the dental students (39.60% PhD, 20.64% dental, Figure 3). Sugar consumption less than once per day was reported by 57.43% of the PhD and 38.45% of the dental students. The majority of participants (69%) brushed twice daily (87.13% PhD, 65.72% dental) (Figure 4). Most subjects (41.18%) reported rinsing with 2 handfuls of water after brushing. Two percent of all students brushed their teeth for less than 1 minute, 17.65% 1 minute, 30.84% 1-2 minutes, 24.32% 2 minutes, 23.53% more than 2 minutes and 1.59% more than 3 minutes.

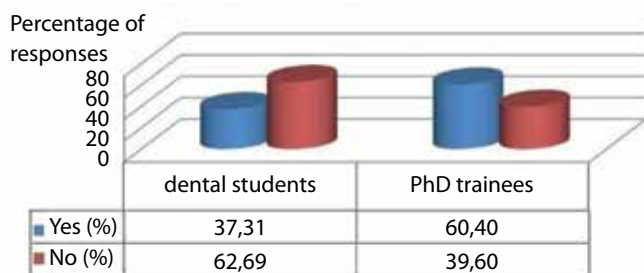


Figure 1. Frequencies of flossing in dental students and PhD trainees.

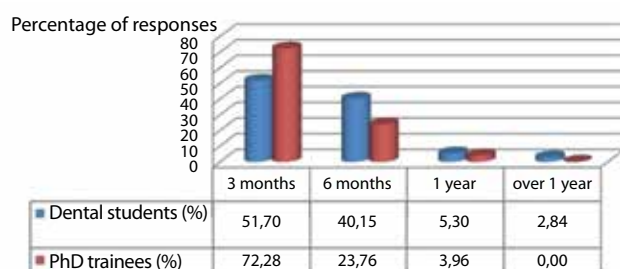
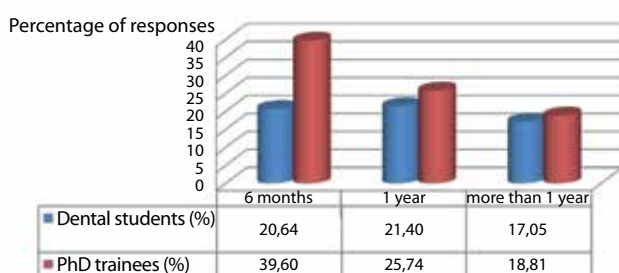


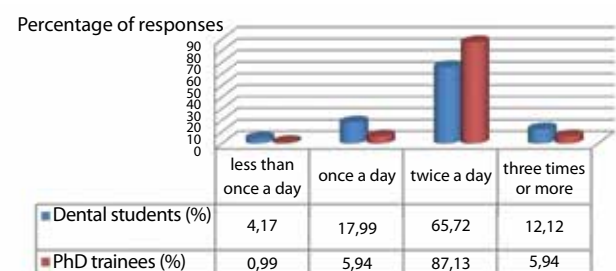
Figure 2. Frequencies of replacing toothbrush in study groups.

Table 1. Sample of the questionnaire used in the present study

Age:	Gender:	Academic year:
Father educational level:		Mother educational level:
Father's occupation:		Mother's occupation:
1. From where or whom did you receive your initial oral hygiene education? No instruction () From parents/family () From dentist () From advertisement, brochures () From university/classes () Other ()		
2. What is the frequency of replacing your toothbrush? 3 months () 6 months () 1 year () More than 1 year ()		
3. Do you use regular or electric toothbrush? Regular () Electric () Both regular and electric ()		
4. How many times do you brush your teeth daily? Less than once a day () Once a day () Twice a day () Three times a day ()		
5. How long do you brush your teeth? Half a minute or less () 1 minute () 1-2 minutes () 2 minutes () More than 2 minutes ()		
6. Do you rinse your mouth with water after? Never () Occasionally () Often () Always () Never considered ()		
7. How much water do you use for rinsing? A handful () 2 handfuls () Half a glass of water () A full glass of water ()		
8. What determines which toothpaste you use? Price () Taste () Advertisements () Uses what's at home () Do not know () Other () Toothpaste's ingredient ()		
9. How much toothpaste do you put on your toothbrush? Size of a pea () 1 cm () 2 cm () Never considered ()		
10. What is the effect of fluoride in toothpaste? Makes teeth whiter () Strengthens the teeth () Clean teeth () Makes your mouth fresh () Do not know ()		
11. Do you clean between your teeth? Yes () No ()		
12. Do you use interdental brush or dental floss on regular basis? Yes () No ()		
13. Do you use toothpick? Yes () No ()		
14. Do you use mouth rinse? Yes () No ()		
15. How often do you go to dentist for professional dental care? 6 months () 1 year () More than 1 year () Do not know ()		
16. Do you consume sugary products between meals? Less than once per day () More ()		
17. Do you smoke? Yes () No ()		

**Figure 3.** Frequencies of visiting dentist variable in study group stratified by interval.

The students whose fathers had the lowest educational status reported the lowest frequencies of flossing (28.28%) and using mouth rinse (5.05%). Likewise the students having

**Figure 4.** Frequencies of tooth brushing in study groups.

mothers with the lowest educational status reported the lowest rate of flossing (33.92%) and using mouth rinse (11.01%). Students with fathers having lowest occupation status also reported the lowest rate of flossing and using mouth rinse

(10%). Similar results were obtained for the students whose mother had the lowest occupational status with the lowest rate of flossing (34.49%) and using mouth rinse (12.41%). According to the results, parents of PhD students had significantly higher education level and higher skilled occupations than parents of dental students ($p < 0.001$).

Discussion

Professional dental education tends to have positive effects on dental students' oral health attitude and behavior as supported by several studies in different countries (19, 22-25, 27). To the best of our knowledge, this is the first study to examine oral health behaviors of PhD students in dentistry. This data might be useful to determine the effect of professional training on these behaviors.

According to the results of the present research, PhD students reported better behavioral responses for flossing, amount of toothpaste, sugar consumption, frequency of replacing toothbrush and visiting dentist variables. However, rates of other oral health behaviors were under 50% for both groups as indicated below. Most participants (41.18%) reported using 2 handfuls of water to rinse their mouth after brushing. Of the 17.17% who rinsed with 1 handful of water after brushing, 13.26% were dental and 37.62% were PhD students. Eighty three percent of all participants did not use mouth rinse (82.18% PhD, 83.14% dental). For the frequency of brushing, twice a day was the most common response (69%) and was reported by 87.13% of the PhD and 65.72% of the dental students. Only 12.12% of dental and 5.94% of PhD students reported brushing three times a day. The rate of choosing toothpaste according to the ingredient was higher in the dental student group (33.6% PhD, 41.29% dental). The ingredient was not a dominant factor in selection of toothpaste in both groups. Although the most frequent visit to the dentist (every 6 months) was higher in the PhD group, the rate of this response was only 39.60%. The duration of brushing was low for both groups. Most of the students brushed for 1-2 minutes (29.92% dental, 35.64% PhD). A further study should be performed to examine probable causes of these low results.

Theories of behavior may be used to search whether it is relevant to professional education or individual behavioral compliance. De Wandel *et al.* (28) used "attitude-social influence-self-efficacy model" to determine the predictors and determinants of noncompliance with hand hygiene prescriptions in intensive care unit nurses. They reported self-efficacy as a strong predictor whereas social influence and knowledge as noncontributing factors. According to Larson *et al.* (29), increase of one's knowledge should not be effective to improve one's attitude. Low correlation between knowledge/education and compliance to standard infection control precautions of healthcare practitioners was reported in the literature (30-32). Zadik *et al.* (33) found that oral self-care habits of dental practitioners were better but not perfect when compared to healthcare providers regarding toothbrushing, flossing and visiting the dentist. Maltby *et al.* (34) reported the relationship between how an individual perceives his/her brushing duration ranks relative to other people and the

duration for which they can clean their teeth. In the present study, individual comparisons within this social ranking system may have not promoted brushing duration. According to the results, 93% of all survey participants reported the use of regular toothbrush (95.64% dental, 79.21% PhD students). Not to use electric toothbrush may be due to financial factors which are not covered in this study.

The most frequent response for the origin of oral hygiene education was reported as "family" (42.57% of PhD, 39.58% of dental students). Oral health behaviors in contradiction to expected results may be related to the parental influence. A correlation was found between use of mouth rinse and both occupational and educational status of parents. There was no correlation between criteria for toothpaste selection and occupational/educational status of parents. The present results indicate that education and occupation of parents effect use of floss and mouth rinse of the participants. 51.67% of all participants' fathers graduated with a bachelor degree, 36.09% of mothers had primary education and 47.38% of fathers had occupations requiring professional skill, 64.07% of mothers had elementary occupations.

This study has been conducted with only one questionnaire, which is a serious limitation. To research the effect of education, cross-sectional and longitudinal comparisons would be more useful as personal differences between students may predominate over education. Clinical examinations besides the questionnaire would probably affirm the results. Another limitation of the study was that the sample population was limited to students of one university and had a small population of PhD students, which may have biased the results.

Conclusion

The outcomes of this study show that the self-reported quality of overall oral health behavior is more pronounced in PhD students than those in graduate programs, with the exceptions of behaviors regarding duration of brushing, criteria of choosing toothpaste and use of oral rinse. Present dental curriculum in the universities should be revisited with respect to oral health attitudes. This study also implied that educational and occupational status of parents had little effect on oral health behavior of the students including the use of dental floss and mouth rinse.

Ethics Committee Approval: This study had exemption from institutional ethics review board of the university.

Informed Consent: This study had exemption from institutional ethics review board of the university.

Peer-review: Externally peer-reviewed.

Author Contributions: NOC designed the study, generated, gathered and analyzed the data, wrote the majority of the original draft. SKN and SÜ generated, gathered the data. All authors approved the final version of paper.

Conflict of Interest: No conflict of interest was declared by the authors.

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Türkçe öz: Önlisans ve Doktora Programında Okuyan Diş Hekimliği Öğrencilerinin Kişisel Ağız Bakımları Arasındaki Farklılıklar. Amaç: Bu çalışmanın amacı, doktora (PhD) ve önlisans programlarında okuyan diş hekimliği öğrencilerinin ağız sağlığı davranışlarını karşılaştırmak, ebeveynlerin eğitim ve mesleklerinin bu davranışlar üzerindeki etkilerini belirlemektir. Gereç ve Yöntem: Ankara'daki (Türkiye) bir diş hekimliği fakültesinde ağız sağlığı davranışları ile ilgili bir anket yapılmıştır. Toplam 629 anket dağıtılmış, 528 diş hekimliği ve 101 doktora öğrencisinden cevap gelmiştir. Ayrıca ebeveynlerin eğitim ve meslekleri de kaydedilmiştir. Veriler istatistiksel olarak analiz edilmiştir. Bulgular: Diş fırçasını değiştirme sıklığı ($p=0,001$), elektrikli diş fırçası kullanımı ($p<0,001$), diş fırçalama sıklığı ($p<0,001$), ağız çalkalamak için kullanılan su miktarı ($p<0,001$), diş macunu seçme kriteri ($p<0,001$), diş ipi kullanımı ($p<0,001$), diş fırçalama sırasında kullanılan macun miktarı ($p<0,001$), profesyonel yardım alma sıklığı ($p<0,0001$) ve şeker tüketimi ($p<0,001$) açısından iki grup arasında istatistiksel olarak anlamlı farklar bulunmuştur. Sonuç: Bu çalışmanın sonuçları; diş fırçalama süresi, diş macunu seçme kriteri ve gargara kullanımı dışında belirtilen tüm ağız sağlığı davranışlarının üstünlüğünün PhD öğrencilerinde önlisans programındakilere göre daha belirgin olduğunu göstermektedir. Üniversitelerdeki mevcut diş hekimliği müfredatı ağız sağlığı davranışları açısından yeniden değerlendirilmelidir. Bu çalışma ayrıca, ebeveynlerin eğitim ve mesleki durumlarının diş ipi ve gargara kullanımını içermek üzere öğrencilerin ağız sağlığı davranışları üzerinde çok az etkisi olduğunu göstermiştir. Anahtar kelimeler: Ağız sağlığı, diş fırçalama, eğitim, profesyonel, ebeveynler

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Alkaline phosphatase levels of murine pre-osteoblastic cells on anodized and annealed titanium surfaces

Purpose

This study aimed to evaluate the initial adhesion morphology and alkaline phosphatase (ALP) activity of murine pre-osteoblastic MC3T3-E1 cells cultured on anatase/rutile mixed-phase TiO₂ thin films with photocatalytic activity with previously confirmed antibacterial properties.

Materials and methods

Anatase/rutile mixed-phase TiO₂ thin films fabricated by anodization and annealing of cpTi were used to culture MC3T3-E1 cells to evaluate the initial cellular adhesion morphology and ALP activity in vitro.

Results

Compared with MC3T3-E1 cells cultured on cpTi substrates and the control group, cells cultured on anatase/rutile mixed-phase TiO₂ thin films exhibited similar ALP levels after cell culture day 9.

Conclusion

Anodizing and annealing processes fabricate multifunctional surfaces on cpTi with improved osteogenic properties for implants.

Keywords: Titanium dioxide, surface roughness, crystal phase, alkaline phosphatase, pre-osteoblastic cell

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Introduction

Titanium and its alloys are widely used for dental implants due to their periimplant bone formation without tissue rejection. After the installation of an implant, implant surface comes in contact with the bone. Bone implant contact is surface dependent and sensitive to surface properties of the implant. The extent of incorporation of the implants is determined by the surface roughness, topography and chemical composition (1). Surface topography and chemistry were reported to influence osteoblast responses and the osseointegration between bone and implant (2). Greater surface roughness increased the total surface area, therefore creating more available surface sites for favorable cellular interactions as cellular adhesion, proliferation, spreading, motility, aggregation and maturation (3-5). Hence, surface modification techniques were deliberated to fabricate microscale to nanoscale structures on Ti surface to simulate the architecture of human bone surface and promote attachment of the osteoblasts (6). Surface chemistry is the other factor which affects the cellular response of the osteoblast cells. The thickness and crystalline structures of titanium dioxide (TiO₂) layers have been associated to influence the bioactive properties of the implant material (7). Since the proposition of photocatalytic oxidation by Fujishima and Honda (8), TiO₂ have gained great attention as a promising photocatalyst. The photocatalytic activity of TiO₂ is most significantly

influenced by crystalline structure (9). TiO_2 is usually used as a photocatalyst in two crystal structures: rutile and anatase. Considerable surface treatment and modification techniques were attempted to synthesize anatase/rutile mixed-phase TiO_2 such as sol-gel method (10), sputtering (11), chemical vapour deposition (12), atomic layer deposition (13), plasma immersion ion implantation (14), cathodic arc deposition (15), and anodization (16). Among these methods, anodization is an economic and efficient technique that allows controlled anatase/rutile mixed phase TiO_2 formation on the substrates that have been widely employed to biologically modify Ti implants.

Alkaline phosphatase (ALP) is a membrane-bound glycoprotein well known as an early osteogenic marker of bone formation and bone calcification, secreted by osteoblasts to provide a high phosphate concentration at the osteoblast cell surface during bone mineralization (17). Nano-surfaces (refers to the scale from 0.1 nm to 100 nm) could promote the proliferation of osteoblasts and increase the content of alkaline phosphatase after osteoblasts were cultured for 21 to 28 days (18). Non-selective actions of the highly oxidized species are expected to oxidize the cell membrane on the surface of the illuminated TiO_2 (19). However, dental implants are in contact with osteoblasts when they are placed into the bone and these modified surfaces need to be evaluated in terms of osteoblastic adhesion and ALP activity. In this way, a thorough understanding of the photocatalytic cell killing mechanisms at the periimplant osteogenic cells should be questioned in conjunction with their suggested killing effect on oral bacteria.

We suggested that anatase/rutile mixed-phase TiO_2 thin films, prepared by electrochemical anodization with potassium hydroxide and annealing treatment, would have significant effects on the initial adhesion morphology and ALP activity of murine pre-osteoblastic cells *in vitro*. To address this hypothesis, the aim of this study was to assess the cellular response of the murine pre-osteoblastic cells on anatase/rutile mixed-phase TiO_2 thin films which combined the nanoscale roughness characterization and photocatalytic activity by electrochemical anodization.

Materials and methods

Preparation of samples

This study was performed at the laboratories of New York University College of Dentistry and was supported by Istanbul University Fund of Scientific Research (BEK-2017-25356). Commercially pure titanium (cpTi) (ASTM B265-02) sheets in squares (10×10×1 mm) were used as substrates for the experiments as described previously by Yenyol *et al.* (9). The surfaces of the specimens were prepared by standard metallographical techniques. These sheets were ultrasonically cleaned in acetone, distilled water, and methanol, respectively. These untreated cpTi sheets were named as Group Ti. The electrochemical anodization was employed to form TiO_2 thin films on the cpTi sheets. Anodization voltage was performed under 40V and each Ti surface (anode) was electrochemically anodized in 0.1M KOH electrolyte for 3 minutes at 20°C. Stainless steel was used as the counter electrode. In order to convert the amorphous TiO_2 thin films into the crystallized TiO_2 thin films, sheets were annealed

at 550°C in air for 1 h after anodization treatment. These sheets containing mixed-phase TiO_2 thin films consisting of anatase and rutile were named as Group AR.

Surface characterization

The surface morphologies of the sheets were observed using a scanning electron microscope (SEM; JSM5410, JEOL, Tokyo, Japan) at a 20 kV acceleration voltage and a magnification of ×500.

The surface topologies of the sheets were investigated with the White Light Optical Profiling (WLOP) Wyko-NT1100 (Veeco Instruments Inc., Plainview, NY, USA) at VSI (Vertical Scanning Interferometer) mode, which is a noncontact optical profiling system that provides high vertical resolution. Two height descriptive parameters of roughness as $R\alpha$ and Rz were used to quantify the surface roughness (9).

The structure and phase of the Group Ti were monitored by utilizing a Philips PW 3710 grazing incidence x-ray diffractometer with a $\text{CuK}\alpha$ radiation (scan range 20° to 80°). A scan rate of 0.02°/sec was used with a grazing incidence of 0.5° for the Ti structure. The structure and phase of the Group AR were monitored by utilizing a Panalitical diffractometer (Phillips, Holland) using X-ray diffraction data collected in the reflection Bragg-Brentano geometry with a $\text{CuK}\alpha$ radiation under an applied voltage of 45 kV and a current of 40 mA. A scan rate of 0.03°/sec with a grazing incidence of 0.45° was used for the Ti and TiO_2 structure. The scanning data were recorded in the 2 θ range of 20–73°. The phase contents of rutile and anatase (% W_A) and rutile (% W_R) for the anatase/rutile mixed-phase TiO_2 thin films at Group AR were estimated by utilizing the obtained patterns to determine weight percentage of the anatase phase and rutile phase TiO_2 using the Spurr-Myers' equations (9).

Cell assay

In order to determine the impact of the electrochemical anodization and annealing on the biological properties of pre-osteoblasts, MC3T3-E1 were cultured on cpTi sheets submitted to the experimental conditions. Pre-osteoblastic MC3T3-E1 cells (ATCC, Rockville, MD, USA) were cultured in α -MEM (Gibco, California, CA, USA), supplemented with 10% fetal bovine serum (Hyclone, Utah, UT, USA), penicillin and streptomycin (Gibco, California, CA, USA) mixture employed as a cell culture medium. The cells were incubated at 37°C in a humidified atmosphere of 5 % CO_2 in air. The culture medium was changed every 2 d. Specimens were sterilized in 70% ethanol. Cells were seeded onto Group Ti sheets and Group AR sheets at a density of 10,000 cells/sheet in black 24-well polystyrene culture plates for non-UV based conditions. Polystyrene culture plate sheets in squares (10×10×1 mm) were used as positive controls (Control Group).

Cell morphology

Sheets were collected for SEM observation after 5 days to study cells' morphological changes during initial adhesion of MC3T3-E1 cells cultured on both experimental and control

surfaces. The samples were fixed with 2.5% glutaraldehyde. After washing three times in the 0.1M phosphate buffer, cells were postfixed with 1% OsO₄ for 1 h. After sheets were rinsed twice in the 0.1M phosphate buffer, they were dehydrated through a graded alcohol series (25–100%). Hexamethyldisilazane was applied twice. Sheets were subsequently critical-point dried; sputter coated with gold, and examined using a scanning electron microscope (SEM; Philips XL 30, Eindhoven, The Netherlands) at a 15 kV accelerating voltage and a x500 magnification.

Alkaline phosphatase activity

The differentiation of pre-osteoblast to osteoblast cells was evaluated as a function of alkaline phosphatase (ALP) activity for 5, 9, 12 and 21 days by ELISA method. Samples of various groups were transferred into a new black 24-well polystyrene culture plate and the cell layers were washed with PBS. Triton X-100 were added to each well to study lysis of the cells. The material was placed in an incubator for 30 min at 37°C. After 3 times freezing-thawing cycles, aliquots of cell lysis solution were collected for the analysis of the ALP activity. ALP activity was determined with conversion of p-nitrophenylphosphate to nitrophenol in an alkaline buffer. Reaction was initiated by adding of p-nitrophenylphosphate to the cell lysis solution. The reaction was stopped after 20 min by adding NaOH. Optical density (SpectraMax M5e Multi-Mode Microplate Reader; Molecular Devices, Sunnyvale, CA, USA) was measured at 405 nm to quantify the amount of p-nitrophenol produced.

Statistical analysis

All statistical analyses were performed using SPSS 22.0 (IBM SPSS Inc., Armonk, NY, USA). Data were expressed as the mean±standard deviation (n=12). Analysis of the baseline clinical data of ALP activity was performed by Chi-square statistics. We used the Kruskal – Wallis test for comparison of more than two independent groups, followed by the Mann – Whitney U test for comparisons between different groups, and the Friedman's test followed by the Wilcoxon Signed Ranks test for intra-individual comparisons. Differences were considered significant at p<0.05 (two tailed value).

Results

Surface characterization

Figure 1 shows surface SEM images of sheets of cpTi (Group Ti) and the mixed-phase TiO₂ thin film photocatalyst (Group AR). It is observed that cpTi surface has a flat texture and showed relatively a smooth appearance. The surface morphology of the photocatalyst was affected by the electrochemical anodization. Craters (2–5 μm) and protruding hills (10–50 μm) were observed in Group AR anodized in the KOH electrolyte, conferring a more pronounced increase of surface roughness compared to cpTi sheets in Group Ti (9).

Quantitative roughness parameters Ra and Rz obtained from WLOP analysis for 1x1.2 mm² areas for the Groups Ti

and AR are shown in Table 1. Three dimensional images of the surface topography of the Groups Ti and AR at x5.1 magnification are shown in Figure 2. Ra and Rz surface roughness parameters values obtained from the Group AR quantitatively presented higher height descriptive parameters of roughness (9).

The phase compositions of the obtained samples were characterized by XRD and the corresponding XRD patterns are shown in Figure 3. There were no anatase or rutile diffraction peaks observed in cpTi surfaces in Group Ti. After anodization treatment and annealing at 550°C for 1 h, the mixed-phase composition of the Group AR was confirmed by its XRD patterns in Figure 3, where two sharp peaks located at the 2θ values of 38.4° and 27.4°, which are attributed to the diffraction of the (004) crystal plane of anatase TiO₂ and the (110) crystal plane of rutile phase TiO₂, respectively, indicating the crystallinity of the structure. Other characteristic peaks of the different crystalline phases are also marked on the pattern (Ti: Titanium; A: Anatase; R: Rutile). Anatase and rutile contents (weight percentages) in each sample were confirmed by using Spurr–Myers' equations and the corresponding results of anatase and rutile were calculated as 54.6 wt% and 41.9 wt%, respectively (9).

Cell assay

Cell morphology was examined by using SEM analysis. It was found that cells were able to adhere to the Group Ti sheets and Control Group with similar cellular morphologies indicating healthy behavior and significantly longer configuration at day 5 (Figures 4b, c). Well-defined cytoplasmic cell extensions, namely filopodia and lamellipodia, of these flat cells were attached to the surface increasing the cell–material interaction as well as showing extracellular interaction with the neighboring cells.

In contrast to these findings, there were morphological change in cell morphology on the surface of the Group AR sheets (Figure 4a). SEM analysis showed that the electrochemically anodized and annealed surfaces exhibited bursted cell morphology. Cells were found separated from each other with no communication and no existence of filopodia or lamellipodia. The extracellular matrix in Group AR were improved and the network were found strong enough to cover the whole surface. In this present case, extracellular matrix was influenced by surface chemistry or the surface roughness.

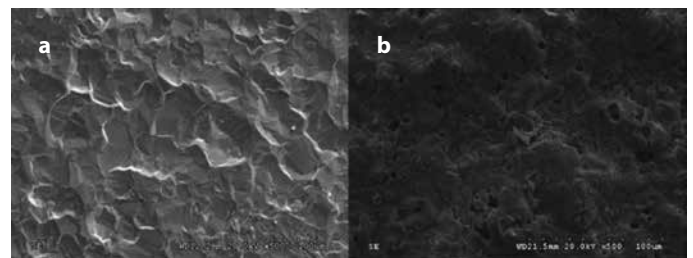


Figure 1. a, b. Representative top-view SEM micrographs of the (a) Group Ti, and (b) Group AR. (original magnification x500; bar=100 μm). SEM: scanning electron microscope; AR: Anatase/Rutile; Ti: Titanium; cpTi: commercially pure titanium.

Alkaline phosphatase activity

Figure 5 shows the ALP activity of murine pre-osteoblastic MC3T3-E1 cells on the different surfaces over the cell culture period. The ALP activity of the cells on Group AR

Table 1. R_a (arithmetical mean roughness) and R_z (ten-point mean roughness) of the Groups Ti and AR determined by WLOP for 736X480 μm^2 areas. Data are presented as the mean \pm SD (Standard Deviation). Values are in micrometers (μm) (9)

Groups	R_a (μm) \pm SD	R_z (μm) \pm SD
Ti	1.51 \pm 0.02	12.76 \pm 0.04
AR	4.08 \pm 0.02	42.40 \pm 0.27

was lower than that on Group Ti after 5 days ($p=0.002$). However, Group AR reached its highest ALP value at day 12, no significant differences were found between the three groups for the days 9, 12, and 21 ($p=0.0694$, $p=0.742$, and $p=0.849$, respectively).

Within the groups for time intervals, ALP levels of Group Ti significantly decreased at day 21 compared to the days 5, 9, and 12 ($p=0.006$, $p=0.019$, and $p=0.041$, respectively). ALP levels of Control Group significantly decreased at day 21 compared to the days 9 and 12 ($p=0.034$ and $p=0.041$, respectively) and ALP levels of Group AR significantly decreased at day 12 compared to the day 5 ($p=0.015$) revealing that ALP activity was surface roughness and crystalline structure dependent.

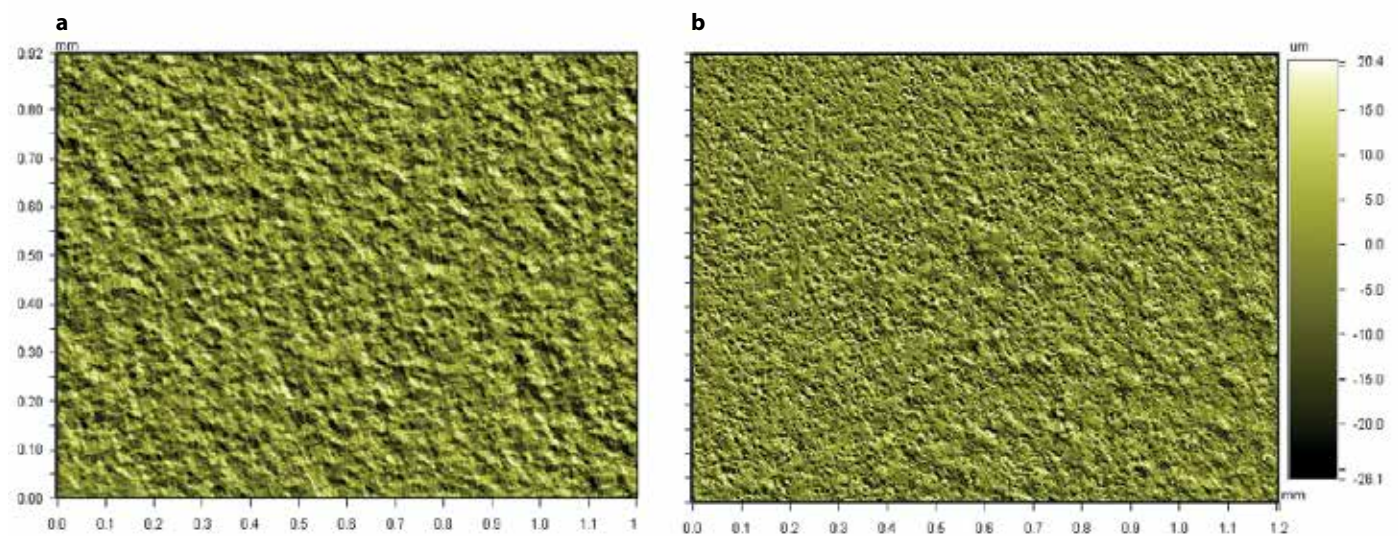


Figure 2. a, b. Representative WLOP images of (a) Group Ti, and (b) Group AR at $\times 5.1$ magnification for $1 \times 1.2 \text{ mm}^2$ of area (9).

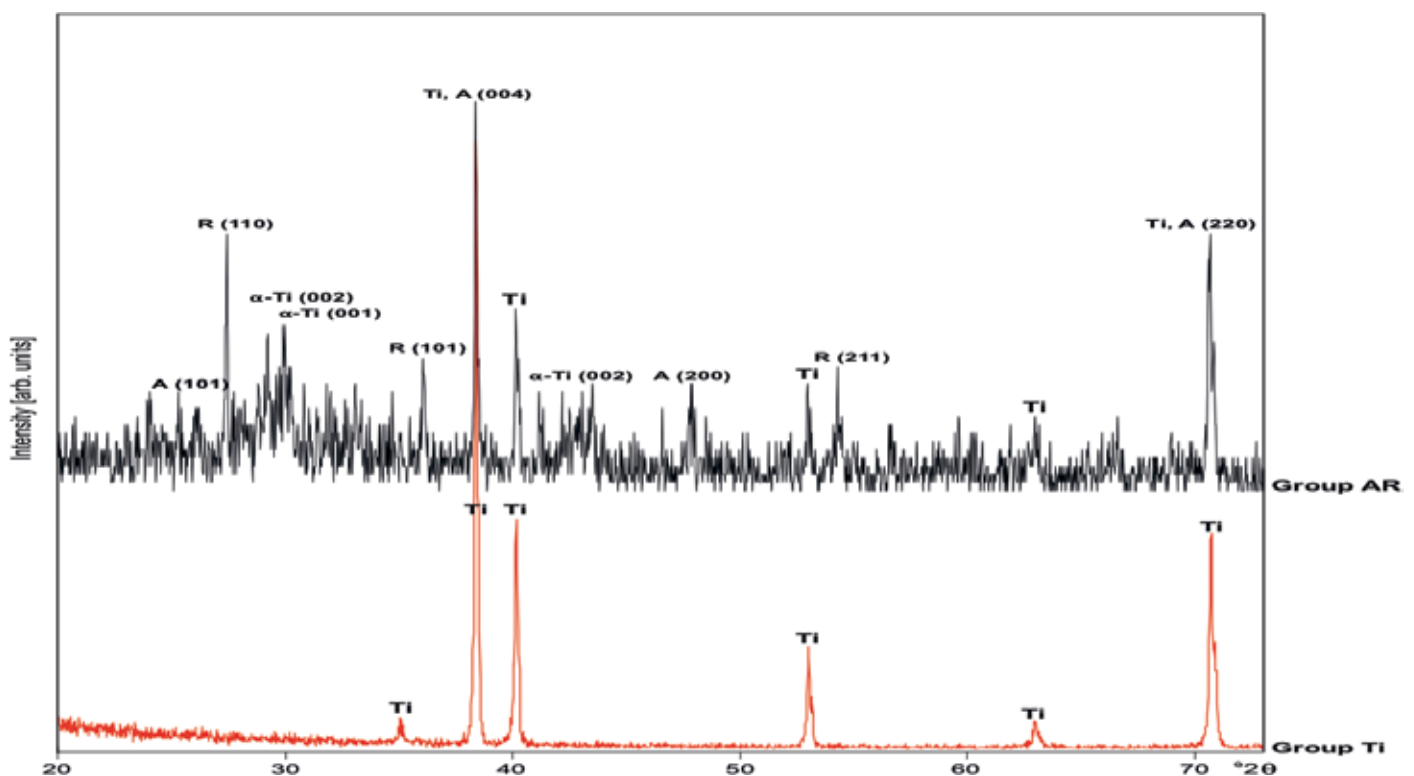


Figure 3. X-ray diffraction patterns of Group Ti: cpTi surface; Group AR: anatase/rutile mixed-phase TiO_2 thin film surface (Ti: titanium; A: anatase; R: rutile) (9).

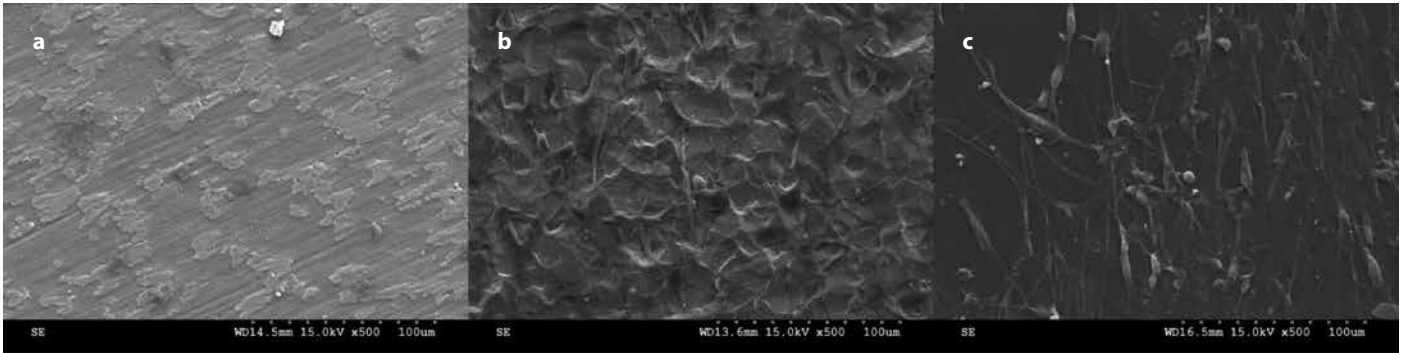


Figure 4. a-c. Representative SEM micrographs illustrating cell adhesion morphology on; (a) Group AR; (b) Group Ti; and (c) Control group (tissue culture polystyrene) (original magnification x500; bar=100 μ m).

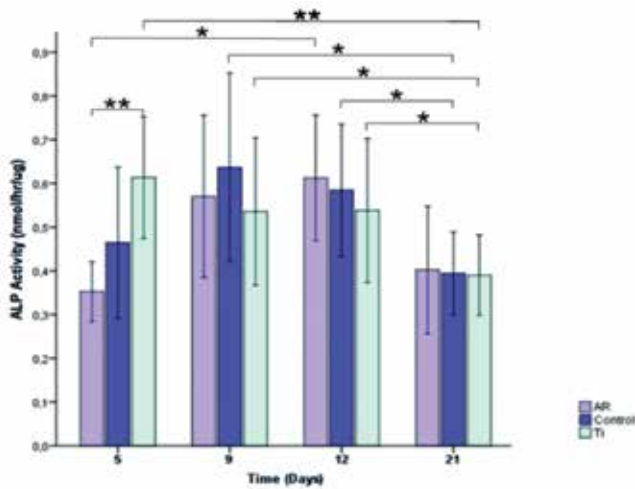


Figure 5. Histogram showing ALP activity of MC3T3-E1 pre-osteoblast cells at 5, 9, 12, and 21 days. Data are Means \pm SDs of absorbance values of the experimental and control groups (* p <0.05, and ** p <0.01).

Discussion

The aim of this study was to evaluate *in vitro* pre-osteoblastic initial cell adhesion morphology and ALP activity at the anatase/rutile mixed-phase TiO₂ thin film coated surfaces, prepared by electrochemical anodization with potassium hydroxide and annealing treatment.

Based on our previous study (9), by aiming to gain a better understanding of the surface roughness and crystalline structure of anatase and rutile, more active surface sites for reactions by higher photocatalytic reaction potential were created to be utilized for transmucosal components of dental implants to interpret the antibacterial clinical performance of these parts in relation to the intra oral usage sites. Anatase/rutile mixed-phase TiO₂ thin films were found to inhibit the adhesion of *A. actinomycetemcomitans* under UV light irradiation confirming enhanced photoactivity. This objective was achieved via electrochemical anodization by KOH and annealing of the cpTi substrates. This surface modification of the cpTi in Group AR specimens in the nano-scale regime, created craters (2–5 μ m) and protruding hills (10–50 μ m) conferring a more pronounced increase of surface roughness compared to cpTi specimens in GroupTi (Figure 1). Quantitative roughness parameters R_a and R_z , obtained from WLOP analysis, quantitatively presented higher height descriptive parameters of roughness for the anatase/rutile mixed-phase TiO₂ thin films in Group AR (Figure 2, Table 1) (9). SEM obser-

vations showed that the pre-osteoblast cells were well spread and attached onto both Group Ti and Control Group surfaces at day 5. In Figures 4b and 4c, the cells were oriented with filopodia and lamellipodia. In contrast to these findings, on the surface of the Group AR, bursted cell morphology as well as improved extracellular matrix formation were evident (Figure 4a). In consequence, surface topography was effective on the cellular response in the early phase of cellular proliferation.

Nanostructured alkali-metal titanates are utilized in applications including catalysis, photocatalysis, bioelectrocatalysis, hydrogen storage, lithium batteries, and solar cells (20). Sodium hydroxide and/or heat treatment, hydrogen peroxide treatment of Ti substrates have been widely used to enhance the biocompatibility and corrosion resistance of the implants in addition to their photocatalytic activities (21–24). When subjected to NaOH and KOH alkali and followed by heat treatment; formation of respective titanates as sodium titanate and potassium titanate on cpTi had been found superior owing to their mechanical properties and corrosion resistances. These bioactive surfaces were found to form a bone-like apatite layer on their surfaces when immersed in simulated body fluid providing earlier fixation of the implants (25). Tas and Bhaduri (26) were the first to soak Ti sheets in a 5 M KOH solution at 60°C for 24 h and 600°C heating for 1 h in air, followed by coating these alkali-modified surfaces with an apatitic calcium phosphate layer by using a supersaturated SBF. The microporous layer formed in the 5 M KOH solution were found to develop faster and thicker under anodization with superior to the analogous layer prepared in the 5 M NaOH solution by Tanaka *et al.* (27). Cai *et al.* (21) applied alkali treatment with immersion of cpTi discs into KOH solutions at concentrations of 4, 6, 8, and 10 M at 600°C for 24h followed by heat treatment at 600°C for 1h. This KOH alkali immersion treatment presented peaks attributed to anatase Ti and K₂Ti₄O₉, confirming anatase and potassium titanate formation on titanium substrate surfaces. KOH alkali treatment and heat treatment was found to increase corrosion resistance and induce the differentiation of murine mesenchymal stem cells into osteoblasts. In our study, anodic oxidation with 0.1 M KOH solution and annealing treatment were applied instead of immersion technique. In Group AR, corresponding results of anatase and rutile were calculated as 54.6wt% and 41.9wt%, respectively whereas Group Ti presented no anatase or rutile peaks, as previously described (Figure 3) (9). The chemical composition of the surfaces attribute to this result. Atomic structure of the substrate confined by its crystallographic orientations and its

interaction with the cell at nanoscale level must be controlled for the interface modeling between bone and the implant surface. Similar chemical compositions with different crystallographic textures can affect the biological responses of the cells (28).

Most works applying anodic oxidation and annealing on the preparation of titanium oxide thin films have reported on the formation of titanium oxide nanotubes, nanofibers, and nanowires (29-31). The effect of heat treatment on these structures was studied to form anatase titania having higher specific surface area compared to rutile which is important for the enhancement of photocatalytic property of the oxide (32).

The formation of self-organized TiO₂ nanotubes in fluoride containing electrolytes via electrochemical anodization is an attractive way with the ability to couple with other surface treatments such as thermal oxidation, coatings, nanotube doping, and drug-loading (1). The presence of nanophase surfaces and amorphous TiO₂ on Ti and Ti-alloys have been shown to render available sites for protein adsorption and cell-implant interaction (33). In our study, electrochemically anodized and annealed cpTi surfaces presented non-tubular TiO₂ thin film coated nanophase surfaces (Figure 1).

Alkaline phosphatase activity is used as an initial marker of cellular differentiation (34). These two groups of cpTi substrates having different surface roughness and crystallographic textures were used to assess the effects of surface roughness and crystal orientation on pre-osteoblast cell differentiation by measuring ALP activity in addition to its previous proven photocatalytic activity (9). In our experiment the ALP activity significantly decreased for that anatase/rutile mixed-phase TiO₂ thin films at Group AR at day 5 compared to the cpTi surfaces at Group Ti, whereas this difference became insignificant after the days 9, 12 and 21, which indicated that the osteogenetic activity of these cells was stable during this time (Figure 5).

The results of this present study show that anatase/rutile mixed-phase TiO₂ thin films fabricated by electrochemical anodization in KOH and annealing, which is responsible for the antibacterial properties, *per se* does not increase but it does not limit either pre-osteoblastic initial cell adhesion morphology and ALP activity at non-UV conditions *in vitro*. Anatase/rutile mixed-phase TiO₂ thin films fabricated by electrochemical anodization and annealing can be a promising option considered for the short-term antibacterial improvement applications for the implants.

Conclusion

Anatase/rutile mixed-phase TiO₂ thin films fabricated by electrochemical anodization in KOH and annealing showed slightly better differential response of pre-osteoblastic cells than cpTi during 21-days cell culture period, offering a choice to be a candidate for the surface of implant materials. However, for better understanding of photocatalytic mechanisms involved in the application of this material under UV-based conditions focused on cell-substrate interactions, experimental conditions should be tested under UV-based conditions to better understand the whole destructive effect of this surface

over cellular behaviors in further *in vitro* studies. It is difficult to simulate the real *in vivo* conditions, using murine pre-osteoblasts, as this study was carried out under laboratory conditions. Therefore, further *in vitro* and *in vivo* studies are warranted to demonstrate the influence of such anodization treatments on the cellular response of osteoblast cells. The findings, however, have to be verified in clinical settings.

Ethics Committee Approval: Not required.

Informed Consent: Not required.

Peer-review: Externally peer-reviewed.

Author Contributions: SY designed the study, generated, gathered and analyzed the data, wrote the majority of the original draft. JLR designed the study and generated the data. All authors approved the final version of paper.

Conflict of Interest: No conflict of interest was declared by the authors.

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Türkçe öz: Anodizasyon ve ısıtma işlemi maruz bırakılmış yüzeylere karşı pre-osteoblastik fare hücrelerinin alkalen fosfataz seviyeleri. Amaç: Bu çalışmanın amacı; daha önce antibakteriyel özelliği teyit edilen ve fotokatalitik olarak aktif olan anatase/rutil karışımı fazındaki TiO₂ ince film kaplamalara yönelik pre-osteoblastik fare MC3T3-E1 hücrelerinin başlangıç adezyon morfolojileri ile alkalen fosfataz seviyelerini (ALP) değerlendirmektir. Gereç ve Yöntem: Saf titanyumun anodizasyonu ve ısıtma işlemi maruz bırakılması ile elde edilen anatase/rutil karışımı fazındaki TiO₂ ince film kaplamalar MC3T3-E1 hücreleri ile kültüre edilerek hücrelerin başlangıç adezyon morfolojileri ve ALP aktiviteleri *in vitro* olarak değerlendirilmiştir. Bulgular: Anodize edilmiş ve ısıtma işlemi uygulanmış titanyum numuneler üzerinde kültüre edilen MC3T3-E1 hücreleri saf titanyum yüzeyler ve kontrol grubu ile karşılaştırıldığında hücre kültürünün 9. gününden sonra benzer ALP seviyeleri göstermektedir. Sonuç: Anodizasyon ve ısıtma işlem uygulamaları ile saf titanyum yüzeyler üzerinde implantlar için osteojenik özelliklerin geliştirildiği multifonksiyonel yüzeyler üretilebilmektedir. Anahtar kelimeler: Titanyum oksit, yüzey pürüzlülüğü, kristal fazı, alkalen fosfataz, pre-osteoblastik hücre

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Coloration of provisional restoration materials: a comparison of the effects of mouth rinses and green tea

Purpose

The present study aimed to evaluate the color stability of provisional restorative materials stored in different mouth rinses and green tea extract for 14 days.

Materials and methods

Forty cylinders of fixed provisional restoration material of 15-mm diameter and 2-mm thickness were prepared. The samples were separated into four storage solutions (three different mouth rinses and green tea) (n=10). The values of L*, a*, and b* were determined before and after storage in the solutions using a spectrophotometer, and the ΔE^* value was calculated. The effect of mouth rinses and green tea extract on the color change of provisional restoration materials was determined with one-way analyses of variance. The Tamhane multiple comparison analysis was used to determine the differences between the groups ($p < 0.05$).

Results

The color stability of the provisional restoration materials varies depending on the solution. Listerine mouth rinse showed more color change than Sensodyne or Colgate did. Minimal color change was found in the green tea solution.

Conclusion

The effect of mouth rinses on the color stability of fixed temporary restorative materials is remarkable. As green tea shows less color change, it can be suggested as an alternative to mouth rinses.

Keywords: Provisional dental materials, color stability, mouth rinses, green tea, spectrophotometer

Introduction

It is essential that provisional restoration should be used in order not only to protect the teeth having already been prepared while fixed restorations are being fabricated but also to provide the patient with comfort until the treatment ends. Provisional restorations should be able to withstand the chewing pressure for as long as they are used, apart from keeping the prepared teeth stable during any act of occlusal functioning. It is also necessary that provisional restorations should protect the dental pulp against thermal mechanic and bacterial interactions, and that they should protect the periodontium through edge matching. Finally, provisional restorations should also achieve aesthetic perfection (1-3).

In the fixed prosthetic treatment, provisional restorations are known to be good diagnostic tools because they are, in a sense, a kind of aesthetic and functional rehearsal for permanent restoration, which helps the dentist assess whether the prosthesis being planned will sufficiently meet aesthetic, biomechanical and physiological needs of the patient (4).

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While permanent restoration can be accomplished within two weeks in the prosthetic treatment, provisional ones can also be used for very long. It is necessary that long-term provisional restorations should be used in predicting treatment results of the patients who require changes in vertical dimension before the soft tissues in the anterior regions, where aesthetics is of great importance, can be shaped. They should also be used in treating temporomandibular joint disorders, and during the period when osseointegration is expected to take place after an implant treatment as well as in evaluating the prognosis of the teeth during a periodontal treatment (5, 6). Great care should be taken so that there are no big differences between good provisional and permanent restorations, because carelessly prepared provisional restorations are doomed to result in repetitions, waste of time, periodontal problems or a damaged oral mucosa (7).

Discoloration in the provisional restorations that have been used for very long in the anterior region, where aesthetics is of paramount importance, is known to adversely affect both quality of the restoration and patient satisfaction (8). Provisional restorative materials to be used should possess colour stability and resistance to discoloration in the oral cavity as far as diverse drinks and teeth-cleansing solutions are concerned (9, 10). Today, polyvinyl methacrylate, urethane dimethacrylate, polymethyl methacrylate, polyethylene methacrylate, Bis-acrylic resin and resin composites are used as temporary restorative materials. Polymerization of these materials is achieved either through chemical means or using light or employing both methods at the same time (11, 12). Acrylic resin restorations that are polymerised with heat are widely preferred due to their high resistance and durability merits (13). However, Bis-acrylic resins are increasingly used due to such properties as being practical, having minimal polymerization shrinkage and low exothermic reaction apart from providing remarkably satisfactory aesthetic results (10).

Gargling with mouthwash is an effective method for maintaining perfect plaque control and periodontal health. Depending on their ingredients, commercially available gargle preparations are used in treating gingivitis, preventing secondary infections following radiotherapy or chemotherapy, or supplementing an antibacterial treatment of inflammatory cases such as tonsillitis, sinusitis, pharyngitis, and laryngitis (14). Certain curative herbs like green tea are also used for oral rinse in addition to various conventional mouthwash solutions. We know of some studies that are working on a viable alternative substance to disinfecting dental materials (15, 16). Green tea is derived from the leaves of the *Camellia sinensis* and is processed in a different way than black tea. Green tea comes from ripe, fresh leaves, while black tea is derived from leaves oxidized in the sun. Green tea, which can have two or more phenol units, includes a larger number of antioxidants than all other drinks and helps remove free radicals. Several studies have reported that green tea helps prevent cancer, cardiovascular diseases and Alzheimer's disease apart from having neuroprotective and antimicrobial properties. Other studies have also proved that green tea helps reduce candida albicans involvement on dental materials (17, 18).

Teeth and restorations in the oral cavity tend to lose their colour stability due to internal and external factors. Today, when aesthetics is viewed as highly as oral hygiene, discoloration is undesirable not just for the dentist but also for the patient (14). Colour recognition of dental materials is achieved with digital colour measurement devices: spectrophotometer and colorimeter. These are known to be more reliable and constant than visual methods. The spectrophotometer measures the light reflected off the object in accordance with its wavelength, while the colorimeter measures the amount of blue, green and red colours reflected off the object. The amount of the three primaries used is known as the tristimulus values of the colour. Spectrophotometer and colorimeter numerically shows the tristimulus value that is present on the x, y, z level in recognition of colour. These values are calculated in accordance with Commission Internationale de l'Eclairage (CIE) and then $L^*a^*b^*$ values are obtained. According to CIE values, L^* indicates lightness while a^* and b^* indicate colour satisfaction. The value of a^* describes red-green measurement while b^* describes the measurement of the yellow-blue axis (19). The present study aims to evaluate the colour stability of three different mouthwash solutions and green tea extract upon provisional restoration with Bis-acrylic content that gets hardened via autopolymerisation. The null hypothesis tested in this study is that the mouthwash solutions and green tea extract do not affect the colour stability of provisional restorations.

Materials and Methods

Specimen preparation

In this study, 40 disc-shaped fixed provisional restoration material (Protemp) in diameter of 15 mm and in thickness of 2 mm (Protemp 4, Bis-acryl, 3M Espe, Seefeld Germany) were prepared using stainless steel mold between two glass plates in light of the suggestions made by the producing company according to definition number 27 by American Dental Association (ADA) (20). There is Bis-acryl resin containing microparticle-fillers (GMA, UDMA, TEGDMA, bis-EMA and 5nm silanized amorphous silica) in the composition of Protemp 4, which is a provisional restorative material. Once polymerization had finished, the samples taken out of the mold were inspected with the naked eye by the same researcher for air space, surface roughness, and presence of porosity. The samples with a defective surface were picked, so that 10 test samples were prepared for each of the groups. Since the samples had been prepared in glass plates, they had a smooth surface. For this reason, there was no need for a polishing process. The samples were stored in distilled water at $37^\circ\text{C}\pm 1^\circ\text{C}$ for twenty four hours prior to the test. A teabag of green tea was put in boiling water of 150 mL to prepare a standard tea solution and was used after ten minutes of storage. 150 mL was also used for mouthrinses. The solutions were renewed daily and stored for 14 days by being fully covered. After two weeks, the samples were washed and dried before they could be made ready for colour measurement. The solutions prepared for this study have been presented in Table 1.

Table 1. The solutions used in the present study

Brand name	Composition	Manufacturer
Listerine Total Care Zero	Aqua, Sorbitol, Propylene Glycol, Potassium Nitrate, Poloxamer 188, Benzoic acid, Aroma, Sodium Benzoate, Eucalyptol, Sodium saccharine, Sucralose, Sodium Fluoride, Methyl Salicylate, Thymol, Cocamidopropyl Betaine, Menthol, BHT, CI420 53	Johnson and Johnson, Istanbul, Turkey
Colgate Total	Aqua, Glycerin, Sorbitol, Propylene Glycol, Poloxamer 407, Polysorbate 20, Aroma, Cetylpyridinium Chloride, Potassium Sorbate, Sodium fluoride, Menthol, Sodium Saccharin, CI 17200, CI42051	Colgate-Palmolive Thailand
Sensodyne	Aqua, Glycerin, Sorbitol, Potassium Nitrate, PEG-60, Hydrogenated Castor Oil, Poloxamer 407, Sodium benzoate, Aroma Disodium phosphate, Methylparaben, Propylparaben, Sodium Phosphate, Sodium fluoride, Menthol, Sodium Saccharin, CI 19140, CI42090, Potassium nitrate, Sodium Fluoride	GlaxoSmithKline, Istanbul, Turkey
Green Tea	Green tea leaves	Natural food products, Akyurt, Ankara

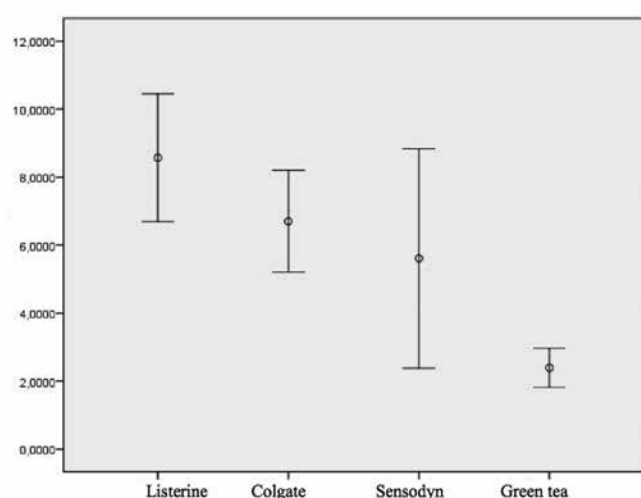


Figure 1. The relationship between the colour differences observed in the provisional restorative materials after being stored in the solutions *Values not overlapping horizontally are statistically different.

Colour assessment

The first colour measurements of the samples were made soon after they had been prepared, while the second measurements were made 14 days after they had been stored in the solutions. The measuring process was carried out with the aid of a digital spectrophotometer (VITA Easy shade Compact Advance 4.0, VITA Zahnfabrik H. Rauter GmbH & Co.KG), during which the suggestions by the producing company were taken into consideration. That is, the device was calibrated at regular intervals and measurements were made upon a white surface under D65 standard light conditions. The spectrophotometer used in this study is capable of measuring in colour values of vitapan classic and vitapan 3D-master, and has got a heat range of 15-40°C, apart from being a rechargeable device fitted with a White High Power LED light lamp. The measurements achieved upon the surface of every single sample were repeated three times before the mean values for L*, a* and b* could be recorded. The differences observed in the colour were calculated using the following formula (8, 14): $\Delta E = ((L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2)^{1/2}$ L1, a1 and b1 values stand for CIE L* a* b* values after the samples had been stored in the drinks, while



Figure 2. The provisional restorative materials evaluated in terms of colour change have been presented below from top to bottom: listerine, colgate, sensodyn and green tea samples, respectively.

L₀, a₀ and b₀ values stand for the CIE L* a* b* values that had been measured in the beginning.

Statistical analysis

The normality of the data was tested by the Shapiro-Wilk Test (p>0.05). The effects of mouthwash solutions upon the colour change observed in provisional restorative materials were determined by the one-way analysis of variance (ANOVA). The analysis of our study was evaluated using a statistic analysis software programme (SPSS 18.0 for Windows; IBM Corp, SPSS Inc, Chicago, IL, USA). Since the variance was not a homogenous, the difference between the average values had to be determined, for which we used the Tamhane multiple comparison test at the level 0.05 significance.

Results

As a result of the one-way statistical analysis, it was determined that there was a statistically significant difference between the effects of mouth rinse solutions upon the colour stability of the provisional restorative materials that had been stored in a solution for 14 days (p<0.05). On the other hand, less change was observed in the colour as far as the green tea extract was concerned (2.39±0.81). Differences between the materials have been presented in Figure 1. The mean colour change value (ΔE) observed with the provisional restorative materials being stored in different solutions has been

Table 2. ΔE ; mean and \pm standard deviation values of the provisional restorative material after being stored in the solutions. The mean values with different letters are different according to the ANOVA (One-way) test ($p < 0.05$)

	Mean \pm standard deviation values
Listerine	8.57 \pm 2.62 ^b
Colgate	6.70 \pm 2.09 ^b
Sensodyn	5.61 \pm 3.86 ^b
Green Tea	2.39 \pm 0.81 ^a

presented in Table 2. The change in colour was seen in the samples stored in Listerine (8.57 \pm 2.62), Colgate (6.70 \pm 2.09), Sensodyn (5.61 \pm 3.86), and green tea solutions (2.39 \pm 0.81), respectively. Figure 2 shows colouration photos of the samples after 14 days of storage.

Discussion

Several studies have used colouring solutions as diverse as water, coffee, tea, cola, oral rinse, red wine and food dyes for evaluating the colour stability of provisional restorations. Our study has evaluated the colour stability of green tea can serve as substitute alternatives to standard ones and different mouthrinses that. Green tea was found to cause less change in colour when compared to other mouth rinses.

Colour stability of dental materials are affected by liquid absorption, completion of material polymerization, the type of polymerization, the amount of residual monomer, the thickness of the material and the roughness of the surface (1). In the present study optimal polymerization was aimed in keeping with the suggestions made by the company that produces the provisional restorative material containing autopolymerized Bis-acryl. Polymerization was achieved between the glass plates with a view to reducing surface roughness. All the samples prepared consistently with those of others studies into the colour stability of provisional restorative materials were standardized in such a way that each would have a thickness of 2 mm (21).

It has been suggested that no full polymerization of the surface resin plate can be ensured if samples happen to get exposure to oxygen during the polymerization process (22). It has also been reported in the literature that smoothing and polishing are applied to remove the unpolymerized plate over the material so that harder, durable and aesthetic surfaces can be obtained (23, 24). This study used glass plates for preparing the study samples. However, it is still much better to smooth and polish the samples by wet sanding so that the top layer can be removed. Koroğlu *et al.* (9) emphasized that the surface roughness values of provisional restorative materials affect the stability of colour. Colour change is observed less frequently in the samples with a low roughness value; therefore, polishing the samples while they are being prepared on a glass surface will affect their surface roughness values. In order to obtain low colour change values, the samples to be studied should be as smooth as possible. Prottemp 4, fitted with a cartridge, is a Bis-acryl-based interim composite that is used with a gun. That it is fitted with a car-

tridge makes it better for miscibility and utility, which helps it gain increasing popularity (25). Bis-acryl-based Prottemp 4 has been shown in some studies investigating colour stability in provisional restorative materials to possess a lower colour stability than do PMMA and PEMA (26). Bis-acryl composite resins are known to be of a heterogeneous nature due to its organic polymer matrix and inorganic filler particles. However, presence of filler particles may prevent the surface of the material from being smoothed (27). Sen *et al.* (28) reported the fillers to cause protrusions to be formed over the surface of the material when they analysed the SEM images of Bis-acryl composite resins.

Discolouration of Bis-GMA is also affected by the polar OH-groups included in its monomer structure, which accounts for a larger amount of water absorption (29). Prottemp 4 is known to contain bis-GMA, UDMA, TEGDMA and bis-EMA. When the amount of TEGDMA in BisGMA rises from 0% to 1%, absorption of water also rises from 3% to 6%. As a result, discoloration increases in line with a rise in water absorption (30). Similar studies including different oral rinse agents have reported the biggest change in colour with the Listerine oral rinse (14, 31). This significant colour change was attributed to the high alcohol content of Listerine. Even though the Listerine used in our study was alcohol-free, the biggest colour change was observed with this mouthwash agent. As for the green tea, discoloration was observed due to the fact that it contained no chemical substances whatsoever. The provisional restorative materials were stored in different mouth rinses and green tea extract for 14 days, with the solutions being renewed every single day. Considering the fact that mouth rinses are used twice a day, a 24-hour storage period of the provisional restorative materials in the containers corresponds to a one-month storage period in the oral cavity. That is, a 14-day storage period equals to a 14-month aging period, which is one of the longest periods that can be used for restorative materials (31).

Studies into determining the colour of dental materials usually use the colorimeter and the spectrophotometer. The colorimeter determines the coordinates of the light reflected off the material according to the CIE system. While the colorimeter is capable of making one-dimensional measurement, the spectrophotometer can achieve a two-dimensional measurement. Because the spectrophotometer is able to measure all the spectral wavelengths reflecting off a material, it often achieves more precise and more systematic measurements. On the other hand, the colorimeter is capable of only measuring the amount of blue, red and green wavelengths (32, 33). Therefore, we used the spectrophotometer in our study for more precise results. In as much as using the ΔE value for the data obtained through the spectrophotometer is preferred more often than giving them separate values as L^* , a^* , b^* , we also used the ΔE value in evaluating the colour change in our restorative materials (34). If the ΔE value is 0 for the colour change being evaluated, it means there is no difference between colour changes. On the other hand, if this value varies between 0.5 and 1.5, it indicates perfect colour stability. If this value varies between 1 and 2, it means 'good' while a value between 2 and 3.5 is viewed as 'acceptable'. However, if the ΔE value is bigger than 3.5, it shows that discolouration of the

material cannot be accepted clinically (8, 21, 35). In our study, the sample groups showed a ΔE value over 3.5 with the exception of the green tea group.

The samples had been stored in distilled water for 24 hours at 37°C before they were transferred to the solutions was in order to imitate the oral medium. However, a wearing medium can be created for in-mouth dental materials. Depending on the person's dietary habits, the content of the food consumed, poor oral hygiene, smoking, and the makeup of the saliva can damage the chemical structure of the materials used for dental restorative materials (36). The resin matrix of dental composites has been shown to soften when exposed to organic acids and different food. The structure of the Bis-acryl composite, which we have used as provisional restorative materials in this study, bears similarity to that of dental composites. It can also be affected by oral fluids and chemical mediums induced by food (6).

One of the limitations of this study is that it is impossible to imitate the factors to be produced in the oral medium under the given experimental conditions. Another limitation is that the shape of the samples does not match those of eligible for clinical applications. The samples for this study were prepared over disc-shaped glass plates in such a way that they would have smooth surfaces. However, the provisional restorative materials used in the oral medium will have an indented surface just as natural teeth do. Unfortunately, it is not possible to apply polishing to all surfaces or to prepare between glass plates due to the uneven surface structures. Therefore, there arises a need for clinical studies that can help overcome this problem.

Conclusion

As a result of the 14-day aging process of the samples used in the study groups, where Listerine, Colgate, and Sensodyne mouthrinses were used, and within the limits of this in-vitro study, we determined the ΔE values above 5. As to the group using green tea extract, this value was 2.29, which seems to be clinically acceptable. We, therefore, concluded that green tea could be used as an alternative to the commercially available mouth rinses. However, the dentist should consider that the mouth rinses in question may fail to retain their colour stability, and devise a treatment schedule accordingly. We suggest that our results should be supported and confirmed by further studies although we are providing essential knowledge about discolouration in relation to mouth rinses and green tea.

Ethics Committee Approval: Not required.

Informed Consent: Not required.

Peer-review: Externally peer-reviewed.

Author Contributions: CA designed the study, generated, gathered and analyzed the data, wrote the majority of the original draft. MÇT designed the study, generated the data. MG generated the data. All authors approved the final version of paper.

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Türkçe özet: Ağız gargaraları ve yeşil çayın geçici restorasyon materyalinin renklenmesi üzerindeki etkilerinin karşılaştırılması. Amaç: Bu çalışmanın amacı 14 gün farklı ağız gargaraları ve yeşil çay ekstraktında bekletilen geçici restoratif materyallerinin renk stabilitelelerini değerlendirmektir. Gereç ve yöntem: Kırk adet silindirik şekilde 15 mm çapında 2 mm kalınlığında sabit geçici restorasyon materyali hazırlandı. Örnekler solüsyonlarda bekletilmek üzere 4 gruba ayrıldı (3 farklı ağız gargarası ve yeşil çay) (n=10). Hazırlanan örneklerin solüsyonlarda bekletilmeden önce ve sonra L*, a*, b* değerleri spektrofotometre kullanılarak tespit edildi, ΔE değeri hesaplandı. Ağız gargaralarının ve yeşil çay ekstraktının geçici restorasyon materyallerinin renk değişimi üzerindeki etkisi tek yönlü varyans analizi ile tespit edildi. Ortalamalar arasındaki farklılığın tespit edilmesi amacıyla Tamhane çoklu karşılaştırma analizi kullanıldı. (p<0,05) Bulgular: Geçici restorasyon materyallerinin renk stabilitesi kullanılan solüsyona göre değişmektedir. Listerine, Sensodyne ve Colgate ağız gargaralarından daha fazla renk değişimi göstermiştir. En az renk değişimi yeşil çay solüsyonunda bulunmuştur. Sonuç: Ağız gargaralarının sabit geçici restoratif materyallerin renk stabilitesi üzerine etkisi fazladır. Yeşil çay daha az renk değişimi gösterdiği için gargaraların yerine alternatif olarak hastalara önerilebilir. Anahtar kelimeler: Geçici restorasyon materyali, renk stabilitesi, ağız gargarası, yeşil çay, spektrofotometre

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Validity and reliability of a Turkish pediatric oral health-related quality of life measure

Purpose

This study aimed to develop Turkish measures for Pediatric Oral Health-related Quality of Life (POQL) and evaluate their reliability and validity for use in Turkish children aged 8–14 years (Child Self-Report measure; CSR) and their caregivers (Parent Report-on-Child measure; PRC).

Materials and methods

The English POQL was translated into Turkish, adapted for the Turkish culture, and tested in 149 children and their caregivers attending the Çukurova University Pediatric Dentistry clinics to assess the reliability, internal consistency, and discriminant and convergent validity of the Turkish version.

Results

The internal consistency of the Turkish POQL evaluated using Cronbach's alpha was 0.905 for CSR and 0.887 for PRC. To determine the test–retest reliability, the Turkish POQL was administered to a sub-sample (n=16) a second time 2 weeks after the first survey administration. Intraclass correlation coefficient values of the individual items were 0.895 for CSR and 0.992 for PRC. For total scores, there was a significant difference based on clinical caries status and perceived oral health in both CSR and PRC.

Conclusion

The Turkish POQL is a valid and reliable measure of the perceived impact of oral conditions on children's lives.

Keywords: Quality of life, oral health, children, validity and reliability, pediatric

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Introduction

The concept of need has a close relationship to the planning and organization of health care services (1). The drive for the use of patient-reported outcome measures, such as treatment need, has come from the modification of a biomedical perspective to a more comprehensive biopsychosocial model of health (2). Health related quality of life (HRQOL) measures refer specifically to an individual's perception of how their own health affects their activities of daily living and ability to function in society (3–5). The need to determine the significance and priority of oral health problems for children has led to the development of instruments for measuring oral health-related quality of life (6–9). Oral health-related quality of life (OHQL) assesses the subjective impacts of oral conditions on social and emotional well-being and daily functioning (10, 11). Quality of life reports in combination with clinical data may provide information for planning health actions and positive self-perceptions of oral health status may encourage children and individuals to adopt healthy behaviors (6, 12, 13).

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Oral health-related quality of life instruments for children include; The Child Oral Health Impact Profile (COHIP), The Early Childhood Oral Health Impact Scale (ECHOIS), The Child Oral Impacts on Daily Performance (Child-OIDP) and The Child Perception Questionnaire (CPQ) (1, 14-16). However, none of these instruments were developed with an emphasis on the experiences and views of children and parents from low-income populations. To address this need, Huntington *et al.* (17) developed POQL with a particular focus on input from parents and children from low income populations. This new instrument fulfils the need for measuring OHQL in Turkish children and their parents according to their socioeconomic condition, which may be shown by Gökalp *et al.* (18) by low rates of access to dental services, daily tooth brushing habits and dental appointment frequency.

To date, no oral-specific health-related quality of life instruments exists in the Turkish language for 8-14 year age groups. This is especially salient because dental caries is frequent among Turkish children, and there is an urgent need for community-based oral disease prevention programs. Thus, a brief self-report instrument in the form of a simple questionnaire may be helpful both in evaluating such programs as well as for assessing health status in individual children. The aim of this study is to evaluate the internal consistency, reliability and validity of a POQL developed for use on Turkish children between the ages of 8 and 14 years and their parents (caregivers).

Materials and methods

Study design

This is a cross-sectional study of the development and testing of a new oral health-related quality of life instrument developed to measure the impact of oral conditions on the daily lives of Turkish children and their parents. The study protocol and informed consent document was approved by the Çukurova University Ethical Committee, a subdivision of Turkish Ministry of Health, works full accordance with the World Medical Association Declaration of Helsinki (October 2, 2011, meeting number 5, decision number 5). The study started on 15th of March 2010 and ended on 7th of January 2013. Parents gave written consent for themselves and their children and the children verbally assented to their own participation.

Approach

In the first step, the English POQL instrument was translated into Turkish and adapted to Turkish culture. In the second step, we assessed the reliability, internal consistency, discriminant and convergent validity of the Turkish version of the POQL.

Study sample

For the cultural adaptation process, 23 children and their caregivers attending Çukurova University Pediatric dentistry clinics completed the draft Turkish POQL instruments. Initial linguistic corrections were done by individual interviews with

participants during this phase. After adaptation, the finalized Turkish POQL instruments were administered for testing of internal consistency, validity and reliability. A total of 196 children and their caregivers attending Çukurova University Pediatric dentistry clinics were asked to complete the Turkish POQL instruments. Of these, 149 completed the instruments in between 13 December 2011 and 22 May 2012. This convenience sample of 149 children, aged 8 to 14 years, and their caregivers, was used for the analyses described. A subset of 16 individuals from the sample completed the instrument again after two weeks in order to assess test-retest reliability.

Pediatric oral health-related quality of life instruments

The POQL is a 10-item instrument designed to measure oral health-related quality of life in children from both the child's and their caregiver's perspectives. Versions of the instrument for use in 8 to 14 year old children were created to capture two distinct perspectives: children's self-report (CSR) and caregiver's report on their child (PRC). POQL versions were also developed separately in English and Spanish for younger and older age groups of children and their caregivers (19). The original CSR and PRC that we used consisted of 4 domains: physical function (2 items), role function (2 items), social impact (3 items) and emotional impact (3 items). For each item, it was asked "how often the event occurred", with the response options of "all of the time", "some of the time", "once in a while" or "did not happen". It was also separately asked "how bothered the parent or child was by its occurrence", with response options of "very bothered", "somewhat bothered", "bothered a little bit", "never bothered" or "did not happen". A total POQL score was created by multiplying "how often" by "how bothered"; the sum of the multiplied scores from each survey were divided into the total sum of multiplied scores and multiplied by 100. POQL scores ranged between 0-100, with higher scores reflecting greater negative impacts of the child's oral conditions on their health-related quality of life.

The POQL was originally developed in English and validated in the Greater Boston Area (17). The process we used for developing the Turkish POQL versions followed internationally accepted guidelines for translation and cultural adaptation of self-report instruments (20-22). It consisted of: 1) two separate and independent translations from English to Turkish by two completely bi-lingual native speakers; 2) an initial meeting of an expert panel review committee consisting of 6 health professionals (native Turkish and English speakers, and bilingual speakers) to correct the translations and produce the first two independent Turkish versions; 3) back translations of the two Turkish versions independently by two bi-lingual speakers 4) committee review where the original English POQL and the two back translations were compared by English speakers; 5) corrections and reconciliation to achieve a single Turkish version; 6) pretesting the Turkish version with the target population using a convenience sample of 23 children their caregivers; 7) incorporate feedback from interviews with pre-test individuals; and creation of the final Turkish version (20-22). Face validity and content validity of the Turkish POQL instrument were examined at this stage of the study by the expert panel in order to assess the clarity of

the wording of the items prior to the main study. Table 1 and Table 2 show the Turkish translations of POQL Parent Report on Child and Child Self-Report.

Other data collection

In addition to the POQL, we administered a brief questionnaire to collect basic demographic data, as well as general health and dental information. Demographic data included "age" of child, "gender", caregiver (completed the PRC), "parent's education" (highest attained level of formal education of caregiver), "income" (self-perception of family's economic status as reported by the caregiver) and tobacco "smoking" status (whether caregiver smokes or not).

Each child was also asked to self-rate their global oral health status, and caregivers were separately asked to rate their

child's global oral health status. The CSR asked: "In general, how would you rate the health of your teeth and gums?" The PSR asked: "In general, how would you rate the health of your child's teeth and gums?" The response options for these questions were: 1=Excellent, 2=Very Good, 3=Good, 4=Fair and 5=Poor.

Clinical dental data collection

Participating children had a clinical dental examination, recording dmft and DMFT according to WHO criteria (7), and determination of treatment urgency as in the U.S. Association of State and Territorial Dental Directors Basic Screening Survey (ASTDD-BSS; 0=no obvious problems; 1=needs early treatment: caries without accompanying signs or symptoms or individuals with other health problems requiring care before

Table 1. Turkish translation of POQL Parent Report on Child (*questions for parents or caregivers)

Genel Sorular	Cevaplar
Genel olarak çocuğunuzun sağlığı nasıl?	Mükemmel/ çok iyi/ iyi/ orta/ kötü
Genel olarak çocuğunuzun ağız ve diş sağlığı nasıl?	Mükemmel/ çok iyi/ iyi/ orta/ kötü
Bir yıl öncesiyle karşılaştırdığınızda çocuğunuzun ağız ve diş sağlığı şimdi nasıl?	Çok daha iyi/ biraz daha iyi/ aynı/ biraz daha kötü/ çok daha kötü
Genel olarak ağız ve diş sağlığınız nasıl?*	Mükemmel/ çok iyi/ iyi/ orta/ kötü
Genel olarak diş hekimiyile deneyimleriniz nasıl?*	Mükemmel/ çok iyi/ iyi/ orta/ kötü
En son diş hekimine ne zaman gittiniz?*	Son 6 ayda/ 6 ile 12 ay arasında/ 1 yıldan fazla 2 yıldan az/ 2 ile 5 yıl önce/ 5 yıldan çok veya hiçbir zaman
En son diş hekimisi ziyaretinizin sebebi neydi?*	Düzenli kontrol ve diş taşı temizliği/ acil diş yaralanması/ acil diş ağrısı/ diş çekimi/ dolgu/ kanal tedavisi/ kaplama/ takma diş-protez/ diş teli- yer tutucu/ diğer
	Cevaplar
Ölçek Soruları	Hangi sıklıkla meydana geldi? Ne kadar rahatsızlık verdi?
Çocuğunuzun ağız veya diş bölgesinden kaynaklanan bir ağrısı oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden yemek yeme de güçlük çekti mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden okulda dikkat sorunu yaşad mı?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden okula devamsızlık yaptı mı?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuzun ağız ve diş problemlerinden dolayı başkalarının yanında gülümsemekten kaçındığı oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden diğer çocuklardan daha çirkin olduğunu düşünüp endişelendi mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden görünüşünden mutsuz oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden sinirli ve üzgün oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden endişelendi mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Çocuğunuz ağız ve diş problemleri yüzünden ağladı mı?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum

their next routine dental visit; 2=needs immediate treatment: signs and symptoms that include pain, infection or swelling) (23). Oral hygiene was recorded based on examination of the four maxillary anterior teeth, as 0=no plaque accumulation; 1=plaque on gingival 1/3rd of crown at least one tooth; 2=plaque on greater than 1/3rd of crown at least one tooth.

Two clinically experienced examiners were used. Training consisted of a PowerPoint presentation of written descriptions, pictures of caries lesions and soft tissue lesions. According to ASTDD-BSS protocol, examiners also assess treatment urgency and oral hygiene in addition to DMFT and dmft. The inter-examiner agreement obtained on the

Table 2. Turkish translation of POQL Child Self-report

Genel Sorular	Cevaplar	
Genel olarak sağlığın nasıl?	Mükemmel/ çok iyi/ iyi/ orta/ kötü	
Genel olarak ağız ve diş sağlığın nasıl?	Mükemmel/ çok iyi/ iyi/ orta/ kötü	
Bir yıl öncesiyle karşılaştığında ağız ve diş sağlığın nasıl?	Çok daha iyi/ biraz daha iyi/ aynı/ biraz daha kötü/ çok daha kötü	
Genel olarak diş hekimiyile deneyimlerin nasıl?	Mükemmel/ çok iyi/ iyi/ orta/ kötü	
En son diş hekimine ne zaman gittin?	Son 6 ayda/ 6 ile 12 ay arasında/ 1 yıldan fazla 2 yıldan az/ 2 ile 5 yıl önce/ 5 yıldan çok veya hiçbir zaman	
En son diş hekimi ziyaretinin sebebi neydi?	Düzenli kontrol ve diş taşı temizliği/ acil diş yaralanması/ acil diş ağrısı/ diş çekimi / dolgu/ kanal tedavisi/ kaplama/ takma diş-protez/ diş teli- yer tutucu/ diğer	
Ölçek Soruları	Cevaplar	
	Hangi sıklıkla meydana geldi?	Ne kadar rahatsızlık verdi?
Ağız ve diş problemlerin yüzünden ağrın oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız problemlerin yüzünden yemek yemede (sert/ sıcak/ soğuk) güçlük çektin mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemlerin yüzünden okula dikkatini vermekte güçlük çektin mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemlerin yüzünden okula devamsızlık yaptın mı?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemlerin yüzünden diğer insanların yanında gülmekten veya kahkaha atmaktan kaçındın mı?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Başkaları tarafından güzel görünmediğini düşündün mü?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemlerin yüzünden görünüşünden mutsuz oldun mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemlerin yüzünden sinirli ve üzgün oldun mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Ağız ve diş problemleri yüzünden endişelendin mi?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum
Diş sorunların yüzünden ağladığın oldu mu?	Her zaman/ bazen/ arada bir/ hiçbir zaman/ bilmiyorum	Çok rahatsız edici/ biraz rahatsız edici/ çok az rahatsız edici/ rahatsız edici değil/ hiçbir zaman/ bilmiyorum

Table 3. Internal consistency reliability (Cronbach's alpha) interscale correlation

	Role & Physical Function	Social Impact	Emotional Impact	Total POQL Score
CSR - Role & Physical Function	.862			
CSR - Social Impact	.615	.863		
CSR - Emotional Impact	.566	.553	.847	
CSR - Total Score	.887	.836	.815	.905
PRC - Role & Physical Function	.820			
PRC - Social Impact	.541	.789		
PRC - Emotional Impact	.550	.554	.853	
PRC - Total Score	.863	.827	.814	.887

Cronbach's alpha shown in bold

CSR: Child Self-Report measure; PRC: Parent Report-on-Child; POQL: Pediatric oral-health related quality of life

examination parameters such as treatment urgency, oral hygiene and DMFT on 25% of the children was 0.89 as measured by kappa statistic. Dental treatments of children with any treatment needs were completed in turn. This work was supported by Çukurova University Scientific Researches Projects Department with the project number DHF2010D3 and NIH/NIDCR grants U54 DE014264, U54 DE019275, K24 DE000419, and K24 DE018211.

Statistical analysis

All statistical analyses were performed using SPSS 16.0 software for Windows (SPSS, Inc.; Chicago, IL, USA). The final version of the Turkish POQL was assessed for internal consistency and test-retest reliability. Cronbach's alpha measured the internal consistency. Item-total correlations were calculated by Pearson correlation coefficient allowing us to determine the suitability of the domains of Turkish POQL identified in the factor analysis. Test-retest reliability was conducted in a subset of participants (n=16) two weeks after the initial POQL instrument administration and measured by intraclass correlation coefficient (ICC) (24). We assessed convergent validity by comparing the response on the POQL to responses to their self-rated overall oral health status, using the single-item global self-assessment of current oral health which ranged from "poor" to "excellent." In addition, discriminant validity was assessed by comparing scale scores and total scores for children with untreated car-

ies to children who were caries-free (25). The differences in POQL scores between the groups were assessed using the Mann-Whitney U-test.

Results

Turkish POQL adaptation process

After the interviews with the individual patients and parents, and the professional staff committee reviews, participants and committee members reported that all items were relevant in relation to children's oral health. The English, "don't want", in the 5th POQL question was replaced with the word "avoid" (kaçınmak) in the Turkish version. For the 6th POQL question instead of the word "worry", "think" (düşünmek) was used. With the exception of these changes the conceptual meaning was preserved as in the English version.

The demographic data of children and their caregivers who completed the surveys is; seventy-six (53.3%) children were male and 73 (46.7%) children were female of the total 149 participants. The age of children range were between 7 and 14 (mean±SD: 10.82±1.76). "Caregivers" were parents of the child who filled the survey while "Parent's education" was the highest grade or level of school that parent have completed. "Income" was a self-report of the economic status of the child's family and "Parent smoke" was current smoking situation.

Table 4. Test-retest of child self report and parent report on child (n=16)

	Test1 Mean (sd)	Test2 Mean (sd)	Intraclass correlation coefficient		Paired T Test	
			ICC	p	T	p
CSR - Total Score	14.42 (14.31)	12.60 (10.38)	0.895	<.001	0.948	0.358
CSR - Role and Physical Function	13.28 (15.88)	11.84 (10.66)	0.852	<.001	0.590	0.564
CSR - Social Impact	14.58 (13.81)	12.15 (10.23)	0.853	<.001	1.005	0.282
CSR - Emotional Impact	15.79 (18.41)	13.88 (16.94)	0.911	<.001	0.754	0.462
PRC - Total Score	15.31 (13.74)	14.84 (12.35)	0.992	<.001	0.796	0.439
PRC - Role and Physical Function	15.49 (12.54)	14.84 (10.23)	0.967	<.001	0.639	0.533
PRC - Social Impact	20.31 (23.67)	19.79 (23.78)	0.989	<.001	0.417	0.682
PRC - Emotional Impact	10.06 (13.79)	9.8 (13.18)	0.996	<.001	0.436	0.669

CSR: Child Self-Report measure, PRC: Parent Report-on-Child, SD: standard deviation

Table 5. Pediatric oral health related quality of life scores by caries status and reported oral health of child and caregiver

SCORE	CARIES STATUS			OH1 – Child Self Report			OH1 – Parent Report on Child		
	Caries free	Caries	p	E, VG, G*	F, P*	p	E, VG, G*	F, P*	p
CSR – Total Score	15.0	26.2	<.001	13.6	35.2	<.001	13.2	34.1	<.001
CSR – Role & Physical Function	15.5	31.0	<.001	16.3	39.6	<.001	15.6	38.8	<.001
CSR – Social Impact	12.6	22.8	0.005	10.7	32.0	<.001	10.9	30.1	<.001
CSR – Emotional Impact	16.7	23.0	0.034	12.8	32.0	<.001	12.3	31.7	<.001
PRC – Total Score	14.4	24.1	0.001	15.4	28.8	<.001	11.9	35.1	<.001
PRC – Role & Physical Function	16.4	26.9	0.003	16.9	32.8	<.001	13.6	35.7	<.001
PRC – Social Impact	16.2	24.4	0.028	17.5	27.8	0.001	12.3	33.4	<.001
PRC – Emotional Impact	10.0	19.9	0.002	11.2	24.4	<.001	8.4	26.9	<.001

*E, VG, G: excellent, very good, good; *F, P: Fair, Poor; CSR: Child Self-Report measure; PRC: Parent Report-on-Child; SD: standard deviation

Factor Analysis

An exploratory iterated principal factor analysis on the 10 Turkish POQL items was conducted. Varimax rotation was used with the eigen value of 1. Turkish CSR and PCR data were separately rotated. Based on varimax rotation separately done for Turkish CSR and PCR, the variance was distributed across three factors and individual items clustered with a coherent theme to each factor: role and physical functioning, social functioning and emotional functioning. Factor loadings for "role and physical functioning" were .669, .679, .873 and .828 (pain, trouble eating, pay attention at school, miss school); "emotional impact" were .856, .820 and .789 (angry/upset, worry, cry); and "social impact" were .848, .836 and .731 on CSR. Factor loadings for "role and physical functioning" were .610, .785, .757 and .849 (pain, trouble eating, pay attention at school, miss school); "emotional impact" were .760, .873 and .782 (angry/upset, worry, cry); and "social impact" were .774, .805 and .697 on PRC. Thus, the Turkish version of POQL has 3 domains instead of the 4 domains in the English version. The English version includes Physical Functioning, Role Functioning, Social Impact and Emotional Impact. In contrast, the Role Function subscale in Turkish version includes both the Physical Impact and Role Function items of the original scale (17). For Turkish children and their caregivers the items "pain" and "difficulty while eating" are associated with the items "pay attention/school" and "miss school".

Reliability

The internal consistency was assessed using Cronbach's alpha coefficient. For the Turkish CSR Cronbach alpha was 0.905 and for the Turkish PCR it was 0.887. All the subscales show strong correlations with the total score ranging between 0.814 and 0.887. Cronbach's alpha coefficients did not increase by deleting any item. The item-total correlation coefficients ranged from 0.661 to 0.793 (Table 3).

The test-retest reliability of the Turkish POQL was examined through a sub-sample ($n=16$) completing the instrument a second time two weeks later the first survey application (Table 4). ICC values were 0.895 for the child self report and 0.992 for the parent report on child in Turkish version. ICC values of child report subgroups (role and physical function, social function and emotional function) ranged between 0.852 and 0.911. Parent report on child ICC values of subgroups ranged between 0.967 and 0.996. Discriminant validity of the scales and total scores was examined by comparing children with caries with children known to be caries free, and convergent validity by relating POQL scores with global perceptions of oral health status (the OH1) reported by child and caregiver separately. Table 5 shows the average scale and total scores by caries status and perceived oral health. For each scale and total score there was a significant difference by caries status and by child and parent-reported oral health.

Discussion

Studies in English speaking countries, evaluating dental impacts on the quality of life, have been conducted since 1980

(26). In order to use these instruments among other populations, instruments need to be translated, adapted and validated. The process of translation and cross cultural adaptation was done according to WHO criteria (20). The English and Turkish versions were conceptually equivalent except in regards two items, "don't want" and "worry"; resulting in modest differences in meaning from the English version before the initiating the testing process for reliability and validity.

Based on varimax rotation separately done for Turkish CSR and PCR, the variance was distributed across three factors. Distinctive from the four factor English version, role and physical functioning perception loadings for the Turkish version were on one factor defined as role plus physical functioning. This could be the result, for example, of a Turkish cultural perspective binding physical health to school success and attendance.

In relation to internal consistency, the item-total correlation values were higher than Streiner and Norman's (25) recommended level of 0.20. The Cronbach alpha of this analysis was satisfactory (between $r=0.661$ and $r=0.793$ in child report, between $r=0.664$ and $r=0.768$ in parent report on child). Cronbach alpha values and interscale correlations were close to those in the English version. The child self-report's Cronbach's α values were between 0.55 and 0.83 while the parent report on child values were between 0.54 and 0.86 (17).

Assessment instruments should be reproducible over time, the two week interval between the survey applications revealed high test-retest reliability. In general total and subscale scores of child and parent report showed ICC values $r>0.7$, indicating good reproducibility. Parent report on child test-retest correlation was better than for the child self-report. The ICC of the Turkish version were between 0.85 and 0.99, higher than those in the English version (0.49 and 0.88) (17). By comparison, ICC values of the Turkish PedsQL condition-specific version for arthritis were 0.79 to 0.91 for child self-reporting and 0.80 to 0.88 for parent report on child. Parent-child concordance was 0.42 to 0.92 for the PedsQL Turkish version. Similarly, the Spanish version of the POQL showed high values of Cronbach α , between 0.86 and 0.93, for item-domain and item-total (19). The Spanish version of the POQL's ICC values showed similar results with the present study.

Importantly, the Turkish POQL instrument is able to discriminate between children with and without dental caries. Children with untreated caries had higher average total and subscale scores than children without untreated caries ($p<0.05$). The English version of the POQL showed similar results regarding untreated caries; caries-free children as compared to children with untreated caries showed significant differences by total POQL score, and by physical and emotional function scores based on the child self-report instrument. On the other hand, the PRC instrument showed significant difference between the groups for total POQL, role, physical and emotional function scores (17). Both the Turkish and English POQL instruments also demonstrated strong associations between caries experience and POQL scores like the Spanish POQL instruments; significant differences between the groups by dental caries were seen ($p=0.4$) (19).

Convergent validity was performed by grouping the answers to the "global rating of oral health item" (OH1) dichot-

omized as excellent, very good, and good versus fair or poor. The differences between POQL scores in the "Excellent", "Very Good" and "Good" categories were statistically significantly different than in parents and children who rated the child's oral health as fair or poor. Turkish subscales and total POQL scores were worse in the OH1 groups rating their oral health as fair/poor. The differences in POQL scores among OH1 response groupings and caries experience groupings were also consistent.

To the best of our knowledge this is the first study among 8-14 year old children in Turkey on pediatric oral health-related quality of life. In order to enhance the assessment of oral health and more comprehensively evaluate the oral health needs of children in different age groups, pediatric oral-health related quality of life measurements should be implemented across multiple Turkish speaking populations. Further studies with larger sample sizes could add more information to the literature. Research using instruments like the POQL is needed to more accurately determine the oral health needs of children and the impacts of dental problems on their quality of life.

Conclusion

The Turkish POQL is a quantitative and objective means by which to measure the impact of oral health in Turkish children and their families. Our findings suggest that the Turkish version of the POQL is a valid and reliable measure of the impact of oral conditions on the day-to-day lives of 8-14 year old Turkish children.

Ethics Committee Approval: The study protocol and informed consent document was approved by the Çukurova University Ethical Committee, a subdivision of Turkish Ministry of Health, works full accordance with the World Medical Association Declaration of Helsinki (October 2, 2011, meeting number 5, decision number 5).

Informed Consent: Parents gave written consent for themselves and their children and the children verbally assented to their own participation.

Peer-review: Externally peer-reviewed.

Author Contributions: İY, JJ, SR and RIG designed the study. İY and CD generated the data. İY gathered the data. İY and CD analyzed the data. İY, SR and RIG wrote the majority of the original draft. All authors approved the final version of paper.

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Türkçe öz: *Türkçe Pediatrik Ağız Sağlığında Yaşam Kalitesi (POQL) Ölçeğinin Geçerlilik ve Güvenilirliğinin İncelenmesi. Amaç: Bu çalışmanın amacı Türkçe Pediatrik Ağız Sağlığında Yaşam Kalitesi (POQL) enstrümanının 8-14 yaş aralığındaki Türk çocukları ve ebeveynleri açısından geçerlilik ve güvenilirliğinin ölçülmesidir. Gereç ve Yöntem: İngilizce POQL Türkçeye çevrilmiş ve Türk kültürüne adapte edilmiştir. Çukurova Üniversitesi Çocuk Diş Hekimliği kliniğinde 149 çocuk ve onların ebeveynlerinin yaptığı anketlerle geçerliliği, iç tutarlılığı, ayırt edici tutarlılığı ve yakınsak geçerliliği ölçülmüştür. Bulgular: Türkçe POQL'in iç tutarlılığı Cronbach alfa ile ölçülmüştür ve çocuk anketi için 0,905, ebeveyn anketi içinse 0,887 sonuçları bulunmuştur. Test-retest geçerliliği için alt örneklem seçilmiş (n=16); bu grubun anketleri iki hafta sonunda yeniden yapması istenmiştir. Sınıf içi korelasyon katsayısının bireysel sonuçları çocuk anketi için 0,895 ve ebeveyn anketi için 0,992'dir. Toplam skorlar açısından ise anketler arasında klinik çürük durumu ve algılanan ağız sağlığı durumu açısından her iki anket için anlamlı fark bulunmaktadır. Sonuç: Türkçe POQL çocukların ağız sağlıkları ile ilgili algıladıkları etkiyi ölçmek açısından geçerli ve güvenilir bir ölçektir. Anahtar Kelimeler: Yaşam kalitesi, ağız sağlığı, çocuk, geçerlilik ve güvenilirlik, pediatrik*

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Quantification of volumetric, surface area and linear airway changes after orthognathic surgery: a preliminary study

Purpose

The aim of this study was to conduct a retrospective evaluation of the volumetric, cross-sectional surface area and the linear airway changes in healthy subjects undergoing orthognathic surgery.

Materials and methods

A total of 10 patients were included in this study and categorized into two groups. The first group consisted of five patients who underwent maxillary and mandibular advancements (MMA) with genioplasty. The remaining five patients who underwent maxillary advancement with mandibular setback (MAMS) comprised the second group. The changes in airway volume, surface area, and linear values obtained from defined hard and soft tissue parameters were evaluated using preoperative and postoperative cone-beam computed tomography. A paired t-test was used to explore the statistical significance.

Results

A statistically significant increase in the airway volume (34.3%) was observed in the MMA group. The changes in the MAMS group were not statistically significant, although an average volumetric decrease of 8.8% was observed. The minimal axial surface area measurements in the MMA group at the levels of the soft palate and the tongue were significantly increased (56.8% and 44.9%, respectively). However, MAMS resulted in no significant changes at these levels (11.2% and 9.1% decrease, respectively). Linear changes showed a statistically significant increase in the airway in the MMA group, whereas the same measurements failed to produce significant changes in the MAMS group.

Conclusion

As there were no significant changes in the measured parameters, surgeons can have greater confidence that MAMS does not have any negative influence on the airway.

Keywords: Volumetric, linear, surface area, airway changes, orthognathic surgery

Introduction

Utilization of the cone beam computed tomography (CBCT) has become an invaluable tool in the diagnosis and treatment planning in oral and maxillofacial surgery. Previous analysis of soft tissue and accompanying airway changes after skeletal movements of the maxilla and mandible were limited to two dimensions with the lateral cephalogram or increased radiation and cost using traditional CT scans. With the advent of CBCT imaging, practitioners are now able to accurately define and explore changes pre- and post-operatively in patients undergoing skeletal movements of the maxillofacial region (1).

Orthognathic surgery has been associated with both positive and negative changes in patient's airway function. The negative changes are con-

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troversial and have been implicated in the creation of obstructive sleep apnea syndrome (2, 3). Prior studies looking at airway changes after orthognathic surgery have been limited in quantifying the amount and location of changes in the airway before and after surgical intervention (4) The complexity of the changes in the airway include alterations in tongue position, hyoid positioning and pharyngeal wall changes that are affected by alteration of muscular and ligamentous attachments to the bone. Few studies have attempted to look at volumetric, surface area and linear changes in the same patient (4-7). By looking at these expanded parameters, it was aimed to help clinicians accurately predict and understand favorable and unfavorable airway changes that follow planned orthognathic movements.

The aim of this preliminary study was to explore volumetric, cross sectional surface area, and linear changes using pre- and post-op cone-beam computed tomography (CBCT) imaging in healthy patients undergoing orthognathic surgery. The null hypothesis tested in this study is that there is no difference between the pre- and post-operative volumetric, cross-sectional and linear measurement variables in patients undergoing orthognathic surgery.

Materials and methods

Study population

This study was approved by the Ethical Review Board of University Hospitals Case Medical Center, Cleveland OH,

Table 1. Patient demographics, average values for maxilla-mandibular movements

Average age	24.8	Range (17-54)
Average maxillary advancement	5.2 mm	Range (3-10)
Average mandibular advancement	5.4 mm	Range (3-10)
Average mandibular setback	3.3 mm	Range (2-5)
Average genioplasty (advancement)	7.8 mm	Range (6-11)

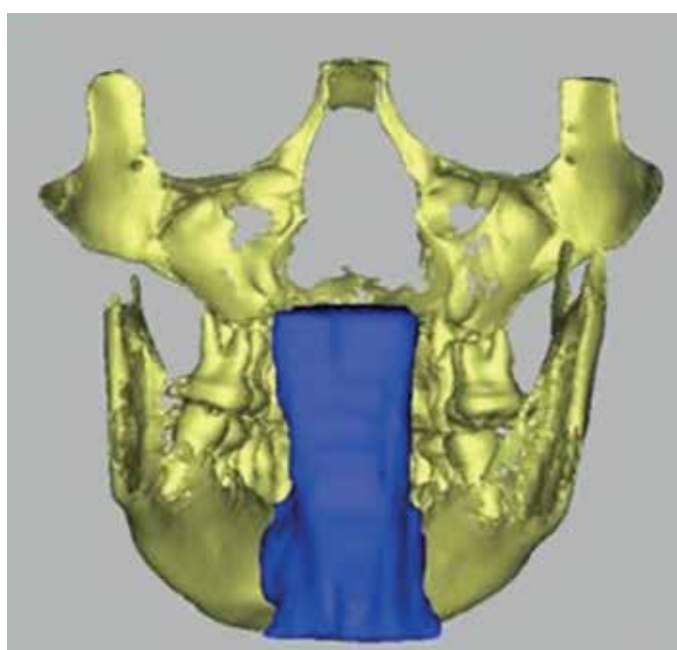


Figure 1. Reconstruction of the 3-D airway.

(Protocol Approval Number: 20110805). Written informed consent was obtained from patients who participated in this study. Patients included in the study were chosen randomly from a database of orthognathic surgeries performed by the above department. Exclusion criteria included previous orthognathic surgery, patients with craniofacial syndromes, midline shifts of greater than 3 mm, superior or inferior movements of more than 3mm, and any other previous hard or soft tissue surgery of the maxillofacial region including tonsillectomy and adenoidectomy. Ten patients, aged 17-54 years (average age of 24.8 years), 5 women and 5 men were divided into two groups. The first group included five patients that had maxillary and mandibular advancements with genioplasty. The second group included five patients that underwent maxillary advancement with mandibular setback. Mandibular surgery included bilateral sagittal split osteotomies. Maxillary surgery included Le Fort I osteotomies. All patients underwent rigid internal fixation of the maxilla and mandible. The average maxillary advancement was 5.2 mm (range of 3-10 mm) for both groups. Mandibular advancement averaged 5.4 mm (range of 3-10 mm). The mandibular setback averaged 3.3 mm (range 2-5 mm). The advancement genioplasty averaged 7.8 mm (range 6-11 mm) (Table 1).

Imaging procedures

Postoperative CBCT images were obtained approximately two months after surgery with the patient in natural head position, using the same machine and technique. Two attending surgeons and multiple surgical residents, at the same institution, completed all of the surgeries. Pre- and post-operative CBCT scans were acquired with CB Mercuray® (CB Mercuray; Hitachi Medical Corporation, Tokyo, Japan) and analyzed using Invivo 5.1 (Anatomage, San Jose, Ca) and Dolphin 3D software. Digital imaging files were imported to Invivo. The files were then reconstructed into volumetric, sagittal, and axial slices.

Linear and volumetric measurements

The changes in airway volume, surface area and linear values from defined hard and soft tissue parameters were recorded. To increase accuracy, each patient underwent three independent measurements for the above values. These values were averaged to yield the final linear, volumetric and surface area numbers to be analyzed. All measurements were performed and recorded by the same specialist experienced in craniofacial radiology and imaging. Imaging was completed using the same scanner and technician based on the equipment specifications to acquire needed reference points and areas.

Volumetric analysis of the airway was defined by a superior plane at the level of the hard palate (HP), from the anterior nasal spine (ANS), posterior nasal spine (PNS), posterior pharyngeal wall (PP) and an inferior plane ending at the level of the third cervical vertebrae (3CV). They were then reconstructed before and after surgery (Figures 1-3). Within these boundaries a minimal constricted axial surface area at the level of the soft palate and tongue was identified and measured.

In addition to the above-mentioned parameters, linear two-dimensional measurements were recorded from the sagittal view at the level of the hard palate (HP), third cervical vertebrae (3CV), soft palate (SP) and tongue (T) pre- and post-operatively. A fourth measurement of the linear distance included the change from the genial tubercles to the hyoid pre- and post-operatively. Finally, on the axial cross sections at the level of the minimal constricted areas, (SP and T) lateral and antero-posterior dimensions of the airway were measured. Results were evaluated by calculating percent change of 3-D, 2-D, and linear values.

Statistical analysis

The collected data from all groups were imported to Statistical Package for Social Sciences (SPSS) for Windows software, version 22.0 (IBM Corp.; Armonk, NY, USA). Descriptive analy-

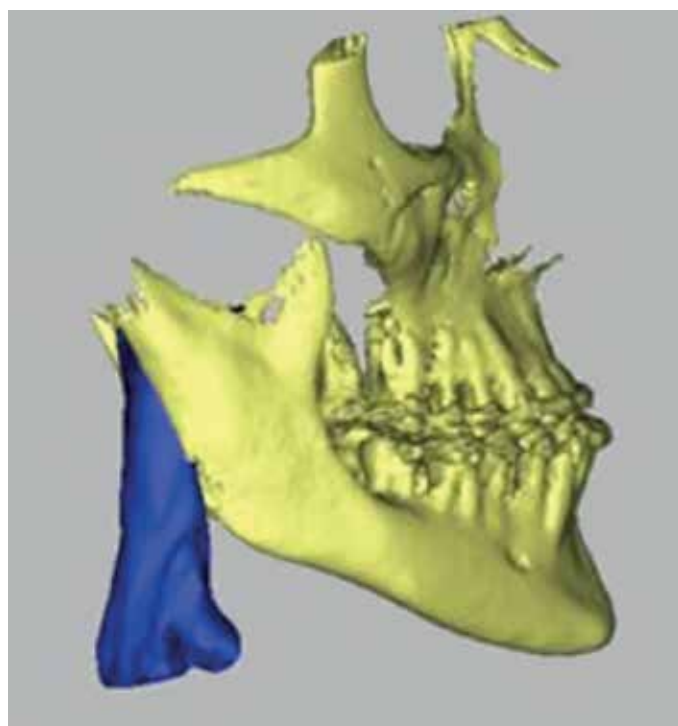


Figure 2. Sagittal view of the reconstructed 3-D airway.

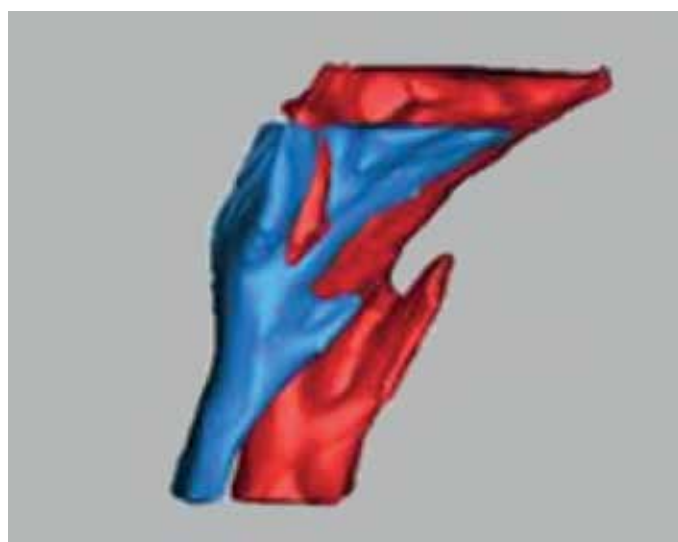


Figure 3. Pre- (blue) and post-operative (red) airway reconstruction for maxillary / mandibular advancement.

ses were performed to calculate the mean and standard error of variables in each group. An exploratory test (Kolmogorov–Smirnov) test revealed normal distribution of the data; therefore, a paired t-test was used to explore statistical significance pre- and post-operatively. Percent change for the groups was averaged for all measurements. The confidence interval was set to 95% and $p < 0.05$ was considered statistically significant.

Results

Ten patients met the inclusion criteria as outlined in the methods. In general, the results showed favorable airway changes in the maxillary and mandibular advancement group. Table 2 shows volumetric changes for the maxillary and mandibular advancement group. This group showed a statistically significant increase in airway volume of the defined

Table 2. 3-D Volumetric measurements for maxillary/mandibular advancement

Measurement	Volumetric		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Volume	10983(4450.8)	15528.8(5099.2)	Sig

Significant if $p < 0.05$, paired t-test, Sig: significant, measurements in mm^3

Table 3. 3-D Volumetric measurements for maxillary advancement/mandibular setback

Measurement	Volumetric		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Volume	21162(5855.7)	19373.6(5915.1)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm^3

Table 4. Surface area changes maxillary/mandibular advancement

Measurement	Surface Area		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Surface area of defined plane	5228.8(910)	5932(1312.2)	NS
Minimal axial (SP)	192.0 (151.8)	344.5 (137.6)	Sig
Minimal axial (T)	281.2 (233.3)	444.1 (193.0)	Sig

Significant if $p < 0.05$, paired t-test, values in mm^2

Table 5. Surface area measurements: maxillary advancement/mandibular setback

Measurement	Surface Area		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Surface area of defined plane	6800.6(1848.6)	6220.6(1755.4)	NS
Minimal constricted axial (SP)	555.67(209)	496.6(216.5)	NS
Minimal constricted axial (T)	467.3(304.8)	426.6(242.3)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm^2 . Min: minimal, SP: soft palate, T: tongue

area. The mean starting volume of 10,983 mm³ increased to 15,528 mm³. This corresponded to an average increase in airway volume of 34.3%. Table 3 shows the volumetric changes in the maxillary advancement and mandibular setback group. The results in this group were not found to be significant. The mean pre-operative and post-operative volumes were 21,162

Table 6. Linear measurements: maxillary/mandibular advancement

Measurement	Linear Measurements		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Hyoid-genial tubercle	28.3 (2.6)	37.8 (3.6)	Sig
Lateral dimension (min SP)	17.8 (3.8)	22.2 (4.3)	NS
A-P dimension (min SP)	5.7 (5.4)	8.9 (6.1)	NS
Lateral dimension (min T)	19.9 (7.5)	23.9 (4.9)	NS
A-P dimension (min T)	7.1 (5.1)	10.5 (4.0)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm
Min: minimal, SP: soft palate, T: tongue

Table 7. Linear measurements: maxillary advancement/mandibular setback

Measurement	Linear Measurements		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
Hyoid-genial tubercle	39.5 (6.6)	37.6 (7.1)	NS
Lateral dimension (min SP)	24.8 (7)	23.2 (5.3)	NS
A-P dimension (min SP)	12.0 (2.2)	11.8 (3.1)	NS
Lateral dimension (min T)	23.8 (6.8)	25.5 (3.9)	NS
A-P dimension (min T)	14.4 (7.5)	5.7 (3.5)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm
Min: minimal, SP: soft palate, T: tongue

Table 8. 2-D measurements for maxillary/mandibular advancement

Measurement	2-D measurements		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
HP sagittal	15.4 (4.4)	19.0 (3.03)	NS
SP sagittal	6.9 (6.1)	10.8 (6.4)	NS
T sagittal	7.2 (4.99)	10.7 (4.3)	NS
3 CV sagittal	10.3 (4.6)	11.7 (4.0)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm

Table 9. 2-D measurements for maxillary advancement/mandibular setback

Measurement	2-D measurements		Sig
	Pre-operative Mean +/-SD	Post-operative Mean +/-SD	
HP sagittal	21.0 (2.7)	22.3 (2.52)	
SP sagittal	12.3 (2.8)	12.6 (2.7)	NS
T sagittal	12.6 (2.7)	12.4 (4.4)	NS
3 CV sagittal	12.1 (4.4)	9.7 (2.0)	NS

Significant if $p < 0.05$, paired t-test, NS: not significant, measurements in mm

and 19,373 mm³, respectively. This was an average volumetric decrease of 8.8%.

The minimal axial surface area measurements in the maxillary and mandibular advancement at the level of the soft palate and tongue were found to be significant (Table 4). The values of the soft palate mean increased from 192 to 344.5 mm². Minimal axial surface area of the tongue increased from 281.2 to 444.1 mm². This represented a 56.8 and 44.9% increase. Once again, as in the volumetric analysis, the maxillary advancement and mandibular setback group did not produce significant changes in terms of axial cross sectional surface area (Table 5). The decrease in surface area at the soft palate and tongue was 11.2 and 9.1%, respectively.

Table 6 demonstrates that linear changes in the maxillary and mandibular advancement group showed a statistical significance from the hyoid to genial tubercles. Linear changes in the maxillary advancement and mandibular setback group were not significant (Table 7). The percent change in the linear measurements in this group was minimal, a 5% decrease from hyoid to genial tubercles, a 7% decrease in the lateral dimension at the level of the soft palate and a less than 1% change in the A-P dimension at the level of the soft palate. The lateral dimension at the predefined level of the tongue showed an increase of 1%. The greatest percent change occurred in the A-P dimension at the tongue, with a decrease of 39%. Two-dimensional values for both groups failed to produce statistically significant changes (Tables 8, 9).

Discussion

The results of this study support previous findings of favorable airway changes after maxillary/mandibular advancement. The percent positive change in airway volume was significant with advancement of the maxilla and mandible. Volume was found to change less than linear or surface area values in this group. Of particular interest was the increase in the minimal axial surface area of the soft palate and tongue. This identification would not have been possible without using volumetric analysis to recreate the airway and identify areas of constriction. As expected, the increased linear distance from the hyoid to the genial tubercles followed a predicted pattern with mandibular advancement and genioplasty. Of interest to this study, a group with mandibular advancement without genioplasty would have led to further understanding of changes at this level, and provide data for statistical comparison.

The findings of the previous studies, which evaluate airway changes after mandibular setback surgeries, have so far remained controversial. Tselnik and Pogral (8) reported a reduction of the airway by 28% in distance and 12.8% in volume at retro-lingual level. Similar findings of decrease in the airway dimensions associated with mandibular setback surgeries have also been reported by Athanasiou *et al.* (9), Gu *et al.* (10) and Turnbull and Battagel (11) These studies commonly indicate postero-inferior displacement of the hyoid bone, decrease in inter-maxillary space and sequent posterior displacement of the tongue after the operation. In the present study however, the maxillary advancement/mandibular setback group failed to show significant changes after orthog-

nathic surgery. This was similar to Park *et al.* (6) who failed to show significant changes at the nasopharyngeal and oropharyngeal levels. Jakobsone *et al.* (7) also failed to show significant changes with maxillary advancement and mandibular setback. Lee *et al.* (12) demonstrated significant changes in linear values of the upper airway without significant changes in total airway volume. We believe that the complexity of the airway accounts for these differences. Each study, including the present one, used unique movements and positioning of the maxilla and mandible besides simple anterior or posterior repositioning. Superior movements, rotations, and asymmetric changes make uniform evaluation impossible and therefore can lead to different results.

The comparison of volumetric evaluation of changes with two-dimensional measurements has seldom been reported. Shaw *et al.* (13) have previously stated that two-dimensional measurements from conventional cephalometric lateral skull radiographs were comparable to those from CBCT images. Conversely, Burkhard *et al.* (14) reported limited comparability of linear and volumetric measurement of the pharyngeal airway space. In the present study, three-dimensional evaluations demonstrated statistically significant changes where two-dimensional values failed to identify statistically significant alterations. Although a limited number of subjects were included in this preliminary study, we find it safe to state that, three-dimensional evaluation has the potential to better determine the postsurgical morphological changes.

Several issues in the interpretation of the data need to be addressed. First, the total number of patients was limited. Larger numbers would strengthen statistical findings and future research may benefit to a great extent from the use of a larger sample size. Secondly, due to the retrospective nature of this study, no set timing of post-operative scanning existed. Multiple set post-operative images would allow the investigator to follow changes over time and lessen issues of post-operative edema, and compensation of soft tissue to new bony positions as previously reported by Becker *et al.* (15) and Sears *et al.* (16). It should also be taken into consideration that increased outcomes of volumetric airway changes may be achieved in cases of greater advancements. Future research may therefore consider the comparison of different levels of advancement to better understand the effects of orthognathic surgery on airway volume. Finally, the dynamic nature of the pharyngeal airway makes evaluation difficult. We believe that, future studies would benefit from standardization of the image recording techniques to a great extent.

Conclusion

Maxillary and mandibular advancement with genioplasty increased the volume of the pharyngeal airway. This increase in volume was greater than the increase in surface area and linear measurements. Mixed advancement of the maxilla and posterior movement of the mandible failed to produce significant changes, which can be interpreted as a positive result. Without significant changes in the measured parameters, surgeons can have greater confidence that this combination movement is not altering the airway in a negative way. Further studies with standardized movements and increased

number of patients will lead to more comprehensive understanding of airway changes after orthognathic surgery.

Ethics Committee Approval: This study was approved by the Ethical Review Board of University Hospitals Case Medical Center, Cleveland OH, (Protocol Approval Number: 20110805).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: FAQ, JTW and DAB designed the study. JTW and HAQ generated and gathered the data. MAA, FAQ, JTW and DAB analyzed the data. ÖÖ conducted literature review and helped with documentation of the study. MAA wrote the majority of the original draft. All authors approved the final version of paper.

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Türkçe öz: Ortognatik cerrahi girişim uygulanmış sağlıklı bireylerde havayolunda meydana gelen hacimsel, lineer ve kesit yüzey alanındaki değişimlerin incelenmesi. Amaç: Bu çalışmanın amacı, ortognatik cerrahi girişim uygulanmış sağlıklı bireylerde havayolunda meydana gelen hacimsel, lineer ve kesit yüzey alanındaki değişimlerin geriye dönük olarak incelenmesidir. Gereç ve Yöntem: Çalışmaya 10 hasta dâhil edilmiştir. İlk grupta maksiller ve mandibuler ilerletme (MMİ) ile birlikte genioplasti uygulanmış beş hasta yer almaktadır. İkinci grupta ise maksiller ilerletme ile birlikte mandibuler geriletme (MİMG) uygulanmış beş hasta yer almaktadır. Belirlenen sert ve yumuşak doku parametreleri kullanılarak, operasyon öncesi ve sonrasında konik-ışınli bilgisayarlı tomografi (KİBT) ile ölçülen havayolu hacmi, yüzey alanı ve lineer değerlerdeki değişimler incelenmiştir. Eşleştirilmiş t-testi kullanılarak istatistiksel değerlendirmeler gerçekleştirilmiştir. Bulgular: MMİ grubunda havayolu hacminde istatistiksel olarak anlamlı bir artış (%34,3) gözlenmiştir. MİMG grubunda, havayolu hacminde ortalama %8,8'lik bir azalma gözlenmesine rağmen, meydana gelen değişim istatistiksel olarak anlamlı bulunmamıştır. MMİ grubunda, yumuşak damak ve dil seviyesinde yapılan ölçümlerde minimal aksiyal yüzey alanında anlamlı artış gözlenmiştir (sırası ile %56,8 ve %44,9). MİMG grubunda bu seviyelerde yapılan ölçümlerde istatistiksel olarak anlamlı değişim gözlenmemiştir (sırası ile %11,2 ve %9,1 azalma). MMİ grubunda yapılan lineer ölçümlerde havayolunda istatistiksel olarak anlamlı bir artış gözlenirken, MİMG grubunda bu ölçümlerde anlamlı bir fark bulunmamıştır. Sonuç: Ölçülen parametrelerde anlamlı bir değişikliğe neden olmayışı ile havayolu üzerinde olumsuz bir etkisi olmadığı belirlenen MİMG cerrahisi güvenle uygulanabilir bir yaklaşımdır. Anahtar kelimeler: Hacimsel, lineer, yüzey alanı, havayolu değişikliği, ortognatik cerrahi

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Child perceptions questionnaire 11-14 in Turkish language in an orthodontic patient sample

Purpose

The Child Perceptions Questionnaire 11-14 (CPQ 11-14) is a generic tool that was developed to measure oral health-related quality of life in early adolescents. The aim of this study was to prepare a Turkish version of the CPQ 11-14 and to test its psychometric properties in an adolescent orthodontic patient sample.

Materials and Methods

The questionnaire was adapted to Turkish using a forward backward translation method, and it was found to be understandable in a pilot study (n=15). The Turkish version of the CPQ 11-14 was administered to 200 orthodontic consultation patients (aged 11–14 years). Retests were conducted in 50 patients 2 weeks after the first tests. The ICON index was used to determine the orthodontic treatment need. Decayed, missing, and filled teeth were also recorded with the DMFT index. Spearman correlations and t-tests were used to assess validity. Internal consistency was assessed using Cronbach's alpha coefficient, and intraclass correlation coefficients were calculated to assess test–retest reliability.

Results

Significant positive correlations were found between CPQ 11-14 scores and the global ratings of oral health ($r=0.381$), global ratings of well-being ($r=0.350$), ICON scores ($r=0.211$), and DMFT scores ($r=0.233$), supporting construct validity. Children who needed orthodontic treatment had a worse quality of life than those who did not need orthodontic treatment ($p=0.016$). Cronbach's alpha and intraclass correlation coefficients were calculated as 0.917 and 0.817, respectively, demonstrating good internal consistency and acceptable test–retest reliability.

Conclusion

The Turkish version of the CPQ 11-14 was found to be valid and reliable in 11–14-year-old orthodontic patients.

Keywords: Orthodontics, quality of life, child perceptions questionnaire, validation, Turkish

Introduction

WHO defined health as “the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” Since then biomedical health model evolved into the biopsychosocial health model and quality of life assessments have gained attention in medicine (1, 2). According to WHO, quality of life is defined as ‘an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment’ (3).

Oral health is also known to influence the quality of life. Although research

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on the oral health-related quality of life began in adult populations, more recently, adolescents' oral health-related quality of life assessments gained attention as well (4). This later growing interest was explained as a result of the inherent difficulties with the measurement of abstract concepts in growing individuals who are also developing regarding self-concept and cognitive capabilities (5). Therefore, further studies were carried out to provide quality of life assessment instruments for specific age groups (5–7). Child Perceptions Questionnaire 11-14 (CPQ 11-14) was developed to measure the oral health-related quality of life in 11-14 year olds with dental, oral and orofacial problems and became the most frequently used tool in the literature (5, 8).

Oral health-related quality of life assessments became increasingly popular in the field of orthodontics as well, mostly to determine treatment need or to assess treatment outcomes (9). Although CPQ 11-14 is increasingly being used in the orthodontic literature, there is no validated adaptation for Turkish culture and language. Therefore, the aim of this study was to adapt CPQ 11-14 to Turkish culture and language and to test its validity and reliability in 11-14 year old patients who had arranged for orthodontic consultations. The null hypothesis was stated as CPQ 11-14 Turkish version is not valid nor reliable to measure oral health-related quality of life in orthodontic patients.

Materials and Methods

Ethical approval

Ethical approval was granted by the Ethics Committee of Yüzüncü Yıl University, Faculty of Medicine (decision number 02; dated 18.04.2014). Informed consent was obtained from all of the participants included in the study.

Description of the questionnaire

CPQ 11-14 consists of 2 global questions addressing oral health and well-being and 37 questions on four different domains. These questions ask the frequency of events and feelings in the last three months about oral symptoms (6), functional limitations (9), emotional well-being (9) and social well-being (13). The questionnaire has a Likert scale structure and response options are; "0=Never", "1=Once/twice", "2=Sometimes", "3=Often" and "4=every day/almost every day". Higher scores indicate worse oral health-related quality of life (5).

Translation, adaptation and pretesting of the CPQ 11-14

Guidelines recommended in the literature for cross-cultural scale adaptations were followed during the preparation of the CPQ 11-14 Turkish questionnaire (10–12). In the first part of the study, CPQ 11-14 was forward translated into the Turkish language by two translators. Both translators were fluent in English and talked Turkish as their native language. While one of the translators had a medical background, the other did not have any knowledge about the CPQ 11-14 questionnaire or the concept of oral health-related quality of life. After

the synthesis of translated questionnaires, two other translators prepared two back translations. These two translators talked English as the native language, and both were fluent in Turkish. Neither of them had seen the original CPQ 11-14 questionnaire before. At last, the translators and the author of this paper gathered all four questionnaires together and evaluated CPQ 11-14 Turkish form regarding face and content validity.

Pilot testing of the questionnaire was performed on 15 volunteers who have applied to the Yüzüncü Yıl University, Faculty of Dentistry, and Department of Orthodontics for consultation. Each one of the volunteers was interviewed about his/her understanding for all of the explanations, questions and answer options in the questionnaire and, the questionnaire was found to be generally understandable. Turkish version of the questionnaire was shown in Table 1.

Application of the questionnaire

Two hundred children aged 11-14 who have applied for orthodontic consultation between 17.04.2014 and 27.12.2014 were included in the main study. Inclusion criteria were defined as the consent of the parent and the child, and the child's proficiency in Turkish reading and writing. Patients who had clefts of the lip or palate or any other syndromes were excluded. Parents were asked to stay in the waiting lounge to avoid interference in the responses. The questionnaires were collected and checked for missing responses before the children left the clinic. The participants were invited to answer any missing questions when existed. To assess test-retest reliability, 50 volunteers who had to take appointments for orthodontic record taking or reevaluation of oral hygiene problems were scheduled for two weeks apart and the CPQ 11-14 was applied again.

Clinical measures

During clinical examination, the numbers of decayed, missing and, filled teeth were recorded using DMFT index. Missing teeth related to congenital absence were not included. Orthodontic treatment need was determined using ICON (Index of Complexity, Outcome, and Need). Aesthetical assessment, crowding or spacing amount in the upper arch, cross bites, overbite-open bite and anteroposterior relation of the buccal segments are considered in orthodontic treatment need assessment using ICON index (13).

Statistical analysis

All analyses were performed with IBM SPSS Statistics software package ver. 24.0 (IBM Corp.; Armonk, NY, USA). Overall and subscale CPQ 11-14 scores were calculated for each respondent. Descriptive statistics (mean and standard deviation) for CPQ 11-14 overall and subscale scores were performed. Independent samples t-tests were used to compare CPQ 11-14 overall and subscale scores in patients according to orthodontic treatment need to assess discriminant validity. Spearman rank correlations were calculated between

CPQ 11-14 overall and subscale scores and global ratings of oral health, global ratings of overall well-being, DMFT scores, and ICON scores to test the hypotheses for construct and discriminant validity. Internal consistency was calculated with Cronbach's alpha coefficients and, test-retest reliability was assessed using intra-class correlation coefficients.

Results

Independent samples t-test results for the comparisons of CPQ 11-14 overall and subscale scores between patients according to their orthodontic treatment need status are shown in Table 2. Patients who had orthodontic treatment need ac-

Table 1. Turkish translation of the Child Perceptions Questionnaire 11-14 (CPQ 11-14) which was used in this study

Genel sorular

Sizce dişlerinizin, dudaklarınızın, çenelerinizin ve ağzınızın sağlığı nasıl?

Mükemmel/Çok iyi/İyi/Fena değil/Kötü

Dişlerinizin, dudaklarınızın, çenelerinizin veya ağzınızın durumu hayatınızı toplamda ne kadar etkiliyor?

Hiç/Çok az/Biraz/Fazla/Çok fazla

Ölçek soruları

SON ÜÇ AY İÇERİSİNDE NE SIKLIKLA...

1. Dişlerinizde, dudaklarınızda, çenelerinizde veya ağzınızda ağrı hissettiniz?

2. Dişetleriniz kanadı?

3. Ağzınızda yara oldu?

4. Nefesiniz kötü koktu?

5. Dişleriniz içine veya arasına yiyecekler takıldı?

6. Ağzınızın tavanına yiyecekler takıldı?

7. Ağızdan nefes aldınız?

8. Bir yemeği yemeniz diğer insanlardan daha uzun sürdü?

9. Uyumakta zorlandınız?

10. Elma, mısır veya biftek gibi yiyecekleri ısırma veya çiğnemekte zorlandınız?

11. Ağızınızı çok açmakta zorlandınız?

12. Herhangi bir kelimeyi söylemekte zorlandınız?

13. İsteddiğiniz yiyecekleri yemekte zorlandınız?

14. Pipetle birşey içmekte zorlandınız?

15. Sıcak veya soğuk gıdaları yemekte veya içmekte zorlandınız?

16. Sinirlendiniz veya hayal kırıklığına uğradınız?

17. Kendinizden emin olmadığınızı hissettiniz?

18. Utangaç veya mahcup hissettiniz?

19. Diğer insanların dişleriniz, dudaklarınız, çeneleriniz veya ağzınız hakkında düşüncelerinden endişelendiniz?

20. Diğer insanlar kadar iyi görünmediğinizden endişelendiniz?

21. Mutsuz oldunuz?

22. Endişelendiniz veya korktunuz?

23. Diğer insanlar kadar sağlıklı olmadığınızdan endişelendiniz?

24. Diğer insanlardan farklı olduğunuzdan endişelendiniz?

25. Ağrı, diş hekimi randevusu veya diş hekiminde yapılan işlem yüzünden okula gidemediniz?

26. Okulda dikkatinizi toplamakta zorlandınız?

27. Ev ödevinizi yapmada zorlandınız?

28. Sınıfta yüksek sesle konuşmak veya okuma yapmak istemediniz?

29. Spor, tiyatro, müzik veya okul gezisi gibi etkinliklere katılmak istemediniz?

30. Diğer çocuklarla konuşmak istemediniz?

31. Diğer çocuklarla birlikteyken gülmek veya kahkaha atmak istemediniz?

32. Flüt gibi bir müzik aleti çalmakta zorlandınız?

33. Diğer çocuklarla birlikte zaman geçirmek istemediniz?

34. Diğer çocuklarla veya ailenizle tartıştınız?

35. Diğer çocuklar sizinle dalga geçti veya size lakap taktı?

36. Diğer çocuklar tarafından dışlanmış hissettiniz?

37. Diğer çocuklar dişleriniz, dudaklarınız, çeneleriniz veya ağzınız hakkında sorular sordu?

Ölçek soruları için cevap seçenekleri Hiç/Bir-iki defa/Bazen/Sıklıkla/Hergün veya neredeyse hergün.

Table 2. Discriminant validity: Overall and subscale scores for children with and without orthodontic treatment need as determined by Index of Complexity, Outcome, and Need (ICON) (*Independent samples t-test)

	Orthodontic Treatment Need		p*
	Yes (n=140)	No (n=60)	
Total scale	41.40±20.67	34.03±17.14	0.016
Subscales			
Oral symptoms	7.99±3.46	7.33±3.49	0.220
Functional limitations	8.97±5.40	8.03±4.60	0.241
Emotional well-being	12.71±8.46	10.42±6.84	0.045
Social well-being	11.72±8.37	8.25±6.24	0.001

Table 3. Discriminant validity: Rank correlations between DMFT and ICON scores, and overall and subscale scores (*Spearman's correlation coefficient)

	DMFT		ICON	
	r*	p	r*	p
Total scale	0.233	0.001	0.211	0.003
Subscales				
Oral symptoms	0.145	0.041	0.019	0.787
Functional limitations	0.212	0.003	0.095	0.182
Emotional well-being	0.167	0.018	0.178	0.011
Social well-being	0.213	0.002	0.279	0.001

Table 4. Construct Validity: Rank correlations between global ratings of oral health and well-being, and overall and subscale scores (*Spearman's correlation coefficient)

	Global rating			
	Oral health		Overall well-being	
	r*	p	r*	p
Total scale	0.381	0.0001	0.350	0.0001
Subscales				
Oral symptoms	0.327	0.0001	0.167	0.018
Functional limitations	0.323	0.0001	0.161	0.022
Emotional well-being	0.325	0.0001	0.369	0.0001
Social well-being	0.301	0.0001	0.311	0.0001

Table 5. Reliability statistics for total scale and subscales (*One-way random effect model; p<0.001 for all values)

	Number of Items	Cronbach's Alpha (n:200)	intra-class Correlation Coefficient (%95 CI)* (n:50)
Total scale	39	0.917	0.817 (0.574-0.922)
Subscales			
Oral symptoms	6	0.726	0.885 (0.733-0.951)
Functional limitations	9	0.708	0.733 (0.379-0.886)
Emotional well-being	9	0.895	0.780 (0.488-0.906)
Social well-being	13	0.831	0.799 (0.532-0.914)

ording to ICON index had significantly greater CPQ 11-14 overall, emotional well-being and social well-being subscale scores when compared to patients who did not have orthodontic treatment need (p=0.045, p=0.001, p=0.016 respectively). There were no statistically significant differences in oral symptoms or functional limitations scores between groups (p>0.05).

Rank correlations between CPQ 11-14 overall and subscale scores and, ICON and DMFT index scores are shown in Table 3. There was a statistically significant positive correlation between ICON scores and CPQ 11-14 overall scores (r=0.211, p=0.003). Among the subscale scores emotional and social well-being were positively correlated with ICON scores (r=0.178, p=0.011, r=0.279, p=0.001 respectively). There were no statistically significant correlations between ICON scores and oral symptoms or functional limitations.

Significant positive correlations were observed between DMFT scores and CPQ 11-14 with all of its subscales (oral symptoms; r=0.145, p=0.041, functional limitations; r=0.212, p=0.003, emotional well-being; r=0.167, p=0.018, social well-being; r=0.213, p=0.002, total scale; r=0.233, p=0.001). There were significant positive correlations between global ratings of oral health, overall well-being, and CPQ 11-14 scores. Besides, all of the subscale scores were also significantly correlated with global ratings (Table 4). Reliability statistics for CPQ 11-14 are shown in Table 5. CPQ 11-14 total scale alpha coefficient was calculated as 0.917 and subscale alpha coefficients were between 0.708 and 0.895. Intra-class correlation coefficient was 0.817 for the total scale and varied between 0.733 and 0.885 for the subscales.

Discussion

It is important to use mutual measurement tools in the quality of life studies just as in clinical studies to conduct cross-cultural research, to collect global evidence together and to compare research results among different studies (14). CPQ 11-14 has been reported to be the most frequently used oral health-related quality of life questionnaire for early adolescents (8, 15). It has been proved to be valid and reliable in many adaptation studies (14–22). However, there is currently no study in the literature demonstrating CPQ 11-14 Turkish version's psychometric properties.

Construct validity is one of the prerequisites for health-related quality of life scales. Correlations between similar tests and comparison of test scores between patients with different clinical characteristics (known groups) can be utilized to test construct validity (23, 24). The null hypothesis was rejected. The results of this study have shown that there were significant correlations between CPQ 11-14 total and subscale scores and, both of the two global questions that were asked at the beginning of the questionnaire. This finding provides evidence that CPQ 11-14 Turkish version has construct validity, and it is similar to those of other studies which have validated CPQ 11-14 across several languages (5, 16, 17). Negative relations between the number of decayed, missing and filling teeth and oral health-related quality of life with all sub-dimensions were also observed (Table 3) which is in agreement with Canadian pedodontic patients (5) providing additional evidence for construct validity.

The results have shown a negative relation between malocclusion severity and oral health-related quality of life with emotional and social well-being domains (Table 3). When patients were compared according to their orthodontic treatment need status, significant differences were also observed in aforementioned dimensions (Table 2). This finding is also consistent with previous research (25–27). The reason why malocclusion severity is associated with emotional and social well-being but not oral symptoms or functional limitations can be explained by the fact that people often seek orthodontic treatment for aesthetic improvement (28) but not that much for physical reasons like pain or gingival bleeding or functional problems like chewing, mouth opening or speech.

Reliability of the CPQ 11-14 was evaluated with test-retest and internal consistency calculations. Retest reliability is the stability of the observed scores from a scale among different administrations. It is important to conduct retests within a reasonable period concerning the construct of interest. Longer retest time intervals may lead to decreases in reliability calculations since health is variable and patients may change their opinions about their health over time. Short retest intervals are also undesirable since patients may remember their old answers and some even think of the retest method as a memory test (29). Therefore, retest appointments were scheduled two weeks after the initial administrations with regard to similar studies (5, 14, 16). Intra-class correlation coefficients were calculated as 0.817 for total scale and 0.885, 0.733, 0.780 and 0.799 for subscales thus retest reliability coefficients were found to be acceptable (Table 5).

Cronbach's alpha coefficient examines the consistency between individual items and total scale or subscale scores (30). In this study, alpha coefficients were calculated as; 0.917 for total scale, 0.726 for Oral Symptoms, 0.708 for Functional Limitations, 0.895 for Emotional Well-Being and 0.831 for Social Well-Being subscales (Table 4). Alpha coefficients of the Turkish version are found to be similar to those observed in the original form (5). Internal consistency is considered ideal when alpha coefficients are between 0.70 and 0.95 (24).

Conclusion

CPQ 11-14 Turkish form is a valid instrument to measure oral health-related quality of life in orthodontic clinics. Hopefully, with the inclusion of the quality of life measurements in orthodontic clinical trials, those aspects of treatment that are important for patients would be evaluated as well as further information about the psychometric properties of the CPQ 11-14 Turkish form would be attained. Future studies would be appropriate to evaluate the performance of CPQ 11-14 Turkish version in general (non-orthodontic) samples.

Ethics Committee Approval: Ethical approval was granted by the Ethics Committee of Yüzüncü Yıl University, Faculty of Medicine (decision number 02; dated 18.04.2014).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: CA designed the study, analyzed the data and wrote the paper. CA, ACY, AA, DSS generated and gathered the data. All authors have approved the final version of this article.

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Türkçe öz: Ortodontik Hasta Örnekleminde Çocuk Algı Ölçeği 11-14 Türkçe Formunun Değerlendirilmesi. Amaç:Çocuk Algı Anketi 11-14 (CPQ 11-14), ergenlik döneminde ağızsağlığı ile ilgili yaşam kalitesini ölçmek için geliştirilen bir araçtır. Bu araştırmanın amacı CPQ 11-14'ün Türkçe uyarlamasını hazırlamak ve ortodontik bir hasta örnekleminde psikometrik özelliklerini test etmektir. Gereç ve Yöntem: Anket, çeviri geri çeviri yöntemiyle Türkçe'ye uyarlanmıştır. Anketin anlaşılabilirliği 15 kişinin katıldığı bir ön çalışma ile belirlenmiştir. CPQ 11-14 Türkçe formu, 200 ortodontik muayene hastasına (11-14 yaş) uygulanmıştır. İlk testlerden iki hafta sonra 50 hasta ile tekrar test uygulaması yapılmıştır. Ortodontik tedavi ihtiyacını ölçmek için ICON indeksi kullanılmıştır. Çürük, eksik ve dolgulu dişler DMFT indeksi ile kaydedilmiştir. Ölçeğin geçerliği, Spearman korelasyonları ve t-testleri kullanılarak değerlendirilmiştir. Ölçeğin iç tutarlık ve test-tekrar test güvenilirlikleri Cronbach alfa ve sınıf içi korelasyon katsayıları kullanılarak belirlenmiştir. Bulgular: CPQ 11-14 puanları ile ağız sağlığının geneldurumu ($r:0,381$), genel iyi oluş ($r:0,350$), ICON skorları ($r:0,211$) ve DMFT puanları ($r:0,233$) arasında anlamlı pozitif korelasyonların gözlenmesi ile ölçeğin yapısal geçerliğe sahip olduğu desteklenmiştir. Buna ek olarak, ortodontik tedaviye ihtiyaç duyan çocukların, ortodontik tedaviye ihtiyaç duymayan çocuklara göre daha kötü yaşam kalitesine sahip olduğunun gözlenmiştir ($p=0,016$). Cronbach alfa ve sınıf içi korelasyon katsayıları 0,917 ve 0,817 olarak hesaplanmış ve ölçeğinin derecede iç tutarlılık ve kabul edilebilir derecede tekrar test güvenilirliğine sahip olduğu bulunmuştur. Sonuç: CPQ 11-14 Türkçe uyarlaması, 11-14 yaş grubundaki ortodontik muayene hastalarında geçerli ve güvenilir bir ölçektir. Anahtar Kelimeler: Ortodonti, yaşam kalitesi, çocuk algı ölçeği, geçerlik, Türkçe

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The relationship between tooth color, skin and eye color

Purpose

Tooth color is one of the most important factors in dental and facial esthetics. The aim of this study was to determine the tooth color of the upper frontal teeth in subjects and to provide comparisons with different skin and eye colors.

Material and methods

Tooth color was determined in 255 patients in the intercanine sector of the maxilla using an intraoral spectrophotometer Vita Easyshade® (Vita Zahnfabrik. H Rauter GmbH & Co. KG. Bad Sackingen. Germany). Skin and eye color was determined by visual perception. The shades of the Vita Tooth Guide 3D Master (Vita Zahnfabrik, H Rauter GmbH & Co, KG, Bad Sackingen, Germany) were registered by the spectrophotometer. Pearson's chi-squared test was used to examine the differences between tooth color and skin and eye color.

Results

The most frequent shade registered in the central incisors was 2M1 (62 subjects, 8.10%); in the lateral incisors, 1.5M1.5 (65 subjects, 8.50%); and in the canines, 2M3 (142 subjects, 18.56%). Pearson's chi-squared test results showed a statistically significant difference in the relations between skin and eye color and central incisor color ($p < 0.01$; $p < 0.001$), lateral incisor color ($p < 0.001$), and canine color ($p < 0.001$; $p = 0.001$). On the other hand, no significant difference was observed in the relation of the lateral incisors and canines with eye color.

Conclusion

Skin and eye color significantly correlate with tooth color; however, the color of lateral incisors and canines does not correlate significantly with eye color.

Keywords: Color determination, intraoral spectrophotometer, eye color, tooth color, skin color

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Introduction

The color of teeth is strongly determined by dentin with more translucent enamel playing a lesser role through scattering at wavelengths in the blue range (1). The tubules are the predominant cause of light scattering in dentin and in enamel the hydroxyapatite crystals contribute significantly to scattering (2). At the outermost incisal and proximal edges of teeth, the layer of enamel is backed only by its own curved surface; because of the interfacial reflection caused by the change in index of refraction, this surface acts as a condensing mirror focused on the dentin (3).

Many authors reported that color matching is difficult and the results are inadequate (4-8). The use of unsuitable shade guides for color selection adds to the problems making consistent color matching impossible (6, 9). Existing shade guides are unsuitable (10) as the shades do not conform to tooth color (8, 11) and there is a lack of any organized distribution of the samples (5, 6, 8). Also, they are constructed in different materials and the colors do not match the restorative material (6).

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Prosthodontists, in their daily routine have to harmonize tooth shade with facial appearance in fully edentulous patients or complete fixed appliances. Authors (12) suggest that the color of the teeth must harmonize with the surrounding environment such as skin, hair, eye color and age all with the aim of enhancing facial appearance. The color of the restorations is a significant factor affecting dental appearance of maxillary anterior teeth in patients and, therefore, the clinician has to be very careful in choosing the right one using reliable tools (13). The knowledge of human tooth color and its distribution are very important in aesthetic dentistry (14). Tooth color has an influence on aesthetics and it is important for social rehabilitation of denture wearers (15, 16). Sykora (17), concluded that the determination of the color of posterior teeth should be based on premolars and for anterior teeth on upper central incisors.

The denture aesthesis has been defined as "the cosmetic effect produced by a dental prosthesis which affects the desirable beauty, attractiveness, character and dignity of the individual (18). Based on Veeraganta (19), it can be concluded that tooth shade value is significantly influenced by age. Chi-square statistical test demonstrated that younger subjects have lighter tooth shade values. According to Richardson,

the illusion of greater contrast between skin color and tooth shade explains the visual perception that individuals with darker skin color have lighter shades of teeth (20). Lagouvardos *et al.* (21), concluded that teeth color was not related to eye color. The purpose of this study was therefore the determination of tooth shades of the upper frontal teeth in subjects and their comparison with different skin and eye color.

Materials and Methods

Study population

This study analyzed the tooth color, measured by a spectrophotometer in different skin and eye color and was realized in the University Dental Clinical Center of Kosovo (UDCCK). Before we started with this research, on 09th of November 2009, the Ethical Approval was issued from UDCCK. The statement for appropriation of the investigation was issued with no. 138/2009 and signed from members of Ethical Board in UDCCK. The measurements, which were conducted at the University Dental Clinical Center of Kosovo, were made in the intercanine sector of maxilla in 255 subjects of Kosovo Albanian population (130 females and 125 males). Based on visual perception, the skin tones were divided into 3 categories: light, medium and dark skin. The eye color was categorized into four groups: brown, green, blue, very dark brown eye color. The total of 765 left teeth from the midline of maxilla (central incisors, lateral incisors and canines) were analyzed. The subjects' teeth color measurements, were determined using an intraoral spectrophotometer Vita Easyshade® (Vita Zahnfabrik. H Rauter GmbH & Co, KG, Bad Sackingen, Germany), Figure 1.

Color assessment

The shades of Vita Tooth Guide 3D Master (Vita Zahnfabrik. H Rauter GmbH & Co, KG, Bad Sackingen, Germany) were registered from the spectrophotometer. The color of skin and eyes were determined by visual perception. In this study, only patients with natural teeth, without any fillings, stains and non-smokers were included. Before the color measurement, teeth were polished with tooth paste and brush. After that, Vita Easyshade was turned on and the lamp was warmed up. The Infection Control Shield was inserted to the probe tip, Figure 2. After the calibration, the normal measurement mode was used, which provides a possibility to measure the base shade of a tooth, with the selection of "Tooth Single" on the measurement style menu, Figure 3. The probe tip was holed at 90°, to the third middle segment of vestibular surface of the tooth. The 3D Master data shades were collected.

Statistical analysis

All statistical analysis were performed using the Statistical Program STATISTICA 7.1 (Stat. Soft, Inc.; Tulsa, OK, USA). To evaluate the relationship between tooth color, skin and eye color, Pearson's test was used. Chi square test of independence were selected to evaluate bivariate relationships among variables. Confidence level was set to 95% and p values less than 0.05 were considered as significant.



Figure 1. Intraoral spectrophotometer Vita Easyshade®.

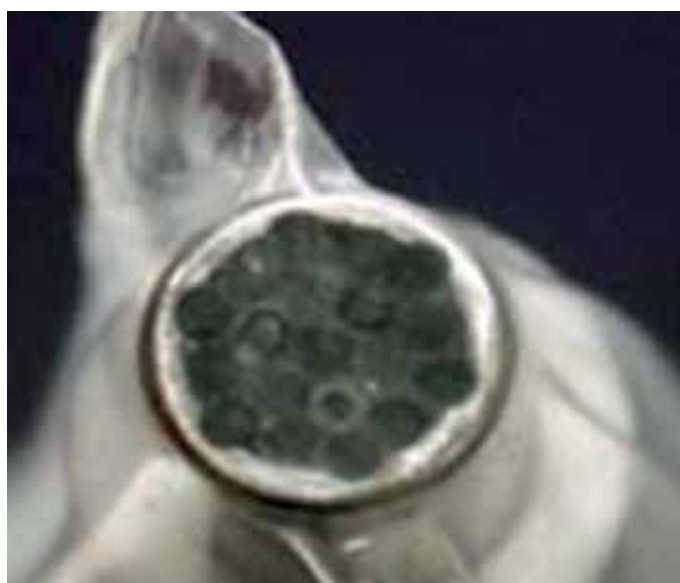


Figure 2. The Infection Control Shield was inserted to the probe tip of the spectrophotometer.

Results

In the central incisors the most frequently registered shade was 2M1 in 62 subjects (8.10%). The shades that were registered rarely were: 3.5M2.5 (0.13%), 4M1 (0.13%), 4M2.5 (0.13%), 1M1.5 (0.13%), 2.5M2 (0.13%), 3L2.5 (0.13%), and 2R2 (0.13%).

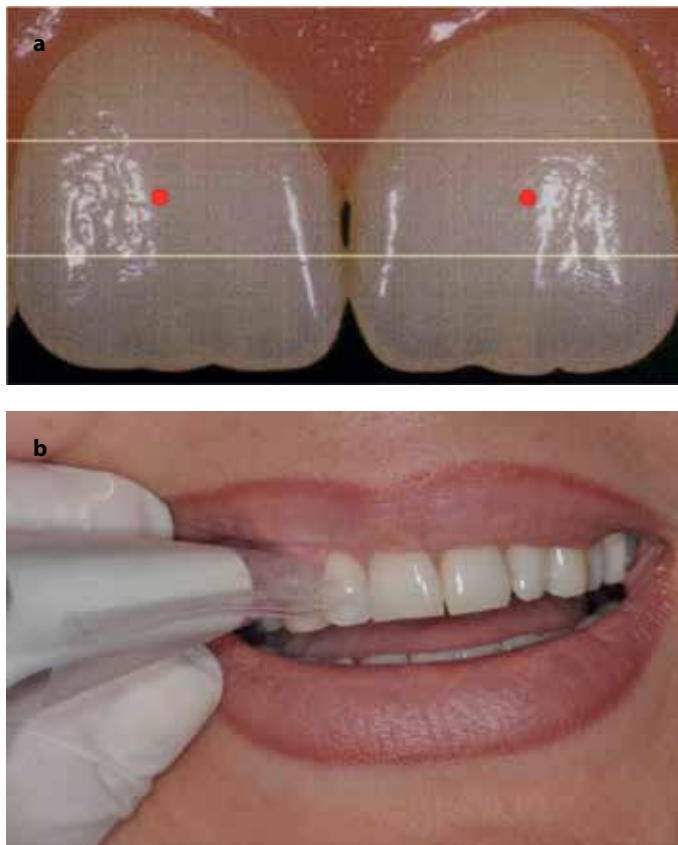


Figure 3. a, b. The tooth color measurement was made with program "Tooth Single" in the middle vestibular third.

In the lateral incisors the most frequent shade registered was 1.5M1.5 in 65 subjects (8.50%). The shades that were registered rarely were: 4M1 (0.13%), 3R2.5 (0.13%), 2.5M1.5 (0.13%), 2L1.5 (0.13%), and 2.5M2 (0.13%). In the canines the most frequent shade registered was 2M3, in 142 subjects (18.56%). The shades that were registered rarely were: 4M1 (0.13%), 2.5R2 (0.134%), 4M3 (0.13%), 4R1.5 (0.13%), and 3M2.5 (0.04%).

The relation between skin color and tooth shades in central incisors, lateral incisors and canines are presented in Table 1. From 765 analyzed teeth, in 189 teeth a light skin color was determined, in 501 teeth there was a relation with medium skin color, whereas 75 teeth were related to dark skin color.

There was a statistical significant difference observed in the distribution between skin color and tooth shades. The results for central incisors were $\chi^2=179.72$ and $p<0.001$ ($p=0.000$); for lateral incisors 179.43 , $df=82$, $p=.001$, and for canines 127.42 , $df=90$, $p=.006$. There was a statistical significant difference observed in the distribution between skin color and tooth shades. The relation between eye color and tooth shades is presented in Table 2. The results for relation between central incisors and eye color was $\chi^2=210.71$ and $p<0.001$ ($p=0.000$) which indicates a significant statistical difference in distribution.

The results for relation between lateral incisors and eye color were $\chi^2=137.53$ and $p>0.05$ ($p=0.18$) and this shows that in the distribution the difference was statistically insignificant. The relation between canines and eye color was $\chi^2=142.16$ and $p>0.05$ ($p=0.18$). In the shown distribution there was no statistically significant difference observed.

Discussion

The study was designed to explore the relationship between natural tooth shades, skin and eye color. The measurement of tooth color remains a challenge. Therefore, a thorough under-

Table 1. The tooth shades and distribution/Skin color

	Spectrophotometer	Skin color light	Skin color medium	Skin color dark	Total
Total	0.5M2-4M3 2L1.5-4L2 2R2-4R2.5	189	501	75	765
%	/	24.71%	65.49%	9.80%	

Pearson Chi-square: 179.72.d $f=82$. $p=.000$ / Central incisors

Pearson Chi-square: 179.43. $df=82$. $p=.001$ /Lateral incisors

Pearson Chi-square: 127.42. $df=90$. $p=.006$ / Canines

Table 2. The tooth shades and distribution/Eye color

	Spectrophotometer	Brown eyes	Blue eyes	Green eyes	Very dark brown	Total
Total	0.5M2-4M3 2L1.5-4L2 2R2-4R2.5	426	96	210	33	765
%	/	55.69%	12.55%	27.45%	4.31%	100%

Pearson Chi-square: 210.71. $df=123$. $p=.000$ / Central incisors

Pearson Chi-square: 137.53. $df=123$. $p=.18$ /Lateral incisors

Pearson Chi-square: 142.16. $df=135$. $p=.32$ / Canines

standing of appearance attributes of natural teeth is required along with new shade guides and shade taking instruments to maximize shade-matching results (22).

Spectrophotometers are amongst the most accurate, useful and flexible instruments for color matching in dentistry (23, 24). Compared with visual perceptions by the human eye, or conventional techniques, it was found that spectrophotometers offered a 33% increase in accuracy and a more objective match in 93.3% of cases (25). Vita Easyshade is a handheld spectrophotometer for tooth shade matching. The instrument consists of a handpiece and a base unit, which are connected by a monocoil fiber optic cable assembly. This device provides accurate shade determination for natural and bleached teeth and a variety of restorations. Easyshade displays its output on a touch-screen that is also used to make menu selections and enter data. It has the capability to measure the color in the vestibular thirds including cervical, middle and incisal area (26). From the 3D Master shade guide, results of Easyshade measurements for the central incisors showed that the most frequent shade was 2M1, in lateral incisors 1.5M1.5 and in canines 2M3.

Based on the literature it can be observed that a relation between ethnic background and tooth shade exists (27). Gómez-Polo *et al.* (28), concluded that the most frequent color among the Spanish population is 3M1. They also represented the most common color parameters according to the 3D Master System in the Spanish population and concluded as follows: lightness group was 2; the most frequent hue group was M and the most frequent chroma group was 1.5. Compared with the results of this study, it can be said that the Spanish and the Albanian population of Kosovo are part of the M group and this fact can be explained by the fact that the two population samples belong to the same neutral color, with different group of lightness and the same chrome intensity.

Veeraganta *et al.* (19) did not find any statistically significant differences according to tooth shade value, gender or skin color. Based on Goodkind and Schwabacher (29), women's teeth in general were lighter, less chromatic and less reddish-colored than men's; aging produced darker and more reddish teeth, whereas Dosumu and Dosumu (12), did not find any significant association between tooth shade and skin color nor between tooth shade and gender ($p < 0.05$). These findings do not correspond with the results of the present study. In the relation between central incisors and eyes color $p < 0.001$ ($p = 0.000$) there was a statistically significant difference. Also, between lateral incisors and skin color there was a significant statistical difference $p < 0.01$ observed. However, no significant association was found between tooth shade in lateral incisors and canines to eye color $p > 0.05$. Lagouvardos *et al.* (21), concluded that teeth color was not related to eye color, but persons with lighter teeth were found to be associated with lighter skins and redder lateral incisors to lighter hair. Darker facial skins or yellower forehead areas were also associated with darker hair and vice versa. Based on conclusions of Hassel *et al.* (30), teeth and eye color coordinates were not correlated. The other study (22), which investigated facial characteristics concluded that these characteristics are inter-correlated weakly to moderately, and for this reason predicting the color parameters of one facial characteristic by another would not be accurate, but helpful for a rough color selection as associations show.

The Saudi Arabian, East Asian, and Indian groups had positive linear correlation with the lightness value between tooth and skin color (31). A significant correlation was found between tooth and skin color. This study found an association between skin color and tooth shade. Based on statistical analysis and results of this study, it was found that there was significant correlation between light skin color and tooth shades with low lightness; between dark skin color and tooth shades with highest lightness and between medium skin color and tooth shades with medium lightness. These results are similar to the findings of Jahangiri *et al.* (15) who found inverse relationship between tooth shade and skin color in their study on multiracial population. From all analyzed subjects, as more representative skin color was medium, whereas eye color was brown. The tooth shades in the central incisors correlated with medium skin color and brown eye color showed that there is a significant statistical difference. The most frequent shade in the central incisors was 2M1. The tooth shades in the lateral incisor related with skin color with a significant statistical difference. The most frequent shade in the lateral incisors was 1.5M1.5. On the other hand, the correlation between eye color and lateral incisors did not show a significant statistical difference the tooth shades in the canines, in relation with skin color showed that there is a significant statistical difference. The most frequent shade in the lateral incisors was 2M3, whereas, the correlation between eye color and canine showed no statistically significant difference.

Conclusion

Teeth color of prosthodontic appliances, must harmonize with the factors such as skin and eye color. The shades obtained from the intercanine sector (2M1, 1.5M1.5 and 2M3), might be used as a guide for shade selection for prosthodontic appliances. The most frequent group from Hue was M, which indicates that during the teeth color determination we should be focused more on neutral shades from the Vitapan 3D-Master shade guide. The skin and eye color significantly correlate with the tooth color, except in the relation with lateral incisors and canines to eye color. Therefore, this fact will serve as a guidance to the appropriate selection of tooth color for prosthodontic appliances.

Ethics Committee Approval: Ethical Approval was issued from University Dental Clinical Center of Kosovo. The statement for appropriation of the investigation was issued with no. 138/2009.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: TPK, EX, NA, TB, LD and ZL designed the study. TPK, TB, LD and ZL generated the data. TPK, NA, TB, LD and ZL gathered the data. TPK analyzed the data and wrote the majority of the original draft. All authors approved the final version of paper.

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Türkçe öz: Diş rengi, cilt ve göz rengi arasındaki ilişki. Amaç: Diş tonları, diş estetiği ve yüz estetiğinde en önemli faktörlerden biridir. Bu çalışmanın amacı, deneklerdeki üst ön dişlerin diş tonlarını belirlemek ve farklı cilt tipi ve göz rengi ile karşılaştırmalar yapmaktır. Gereç ve yöntem: Deneklerin diş renk ölçümleri, intraoral spektrofotometre Vita Easyshade® (Vita Zahnfabrik, H Rauter GmbH & Co. KG, Bad Sackingen, Almanya) kullanılarak yapıldı. Ölçümler maksillerin kaninler arasında ve 255 hastada yapıldı. Cilt ve göz rengi görsel algı ile belirlendi. Vita Diş Rehberi 3D Master'ın (Vita Zahnfabrik, H Rauter GmbH & Co, KG, Bad Sackingen, Almanya) tonları spektrofotometre ile kaydedildi. Diş rengi ile cilt ve göz rengi arasındaki farkları incelemek için Pearson Chi-square testi kullanıldı. Bulgular: Orta kesici dişlerde en sık görülen ton 2M1 (%8,10) 2M1, yan kesicilerde 65 olguda (%8,50) 1.5M1.5 ve 142 olguda kanin dışında (%18,56) 2M3 idi. Pearson Chi-square testi sonuçları, santral dişlerin cilt ve göz rengi ile ilişkisinde istatistiksel olarak anlamlı bir farklılık olduğunu göstermiştir ($p<0,01$; $p<0,001$); lateral kesici dişlerde $p<0,001$, kaninlerde $p<0,001$ ($p=0,001$) olarak bulundu. Öte yandan, lateral kesici dişlerin uçlar ile kanin dişlerinin göz rengiyle ilişkisinde anlamlı bir fark gözlenmemiştir. Sonuç: Deri ve göz rengi, lateral ve kanin dişlerinin göz rengiyle ilişkisi dışında, diş rengiyle anlamlı şekilde korelasyon göstermektedir. Anahtar kelimeler: Renk tayini, İntraoral spektrofotometre, göz rengi, diş rengi, ten rengi

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Removal of a supernumerary tooth displaced into the infratemporal fossa during extraction

Accidental displacement of an impacted tooth into the infratemporal fossa (ITF) is a rare but serious complication because of the vulnerability of the surrounding anatomical structures. Here we present the case of a 40-year-old man who reported pain on the right side of his face. Panoramic radiography and cone-beam computed tomography revealed an impacted third molar and a supernumerary tooth positioned immediately below it. Under local anesthesia, the third molar was easily extracted; however, the supernumerary tooth was inadvertently displaced into the ITF. The position of the tooth was confirmed by radiographic examination, and it was immediately removed intraorally by expanding the flap and carefully dissecting the soft tissues. Clinical aspects of this rare complication were evaluated, with special emphasis on the reliability of imaging modalities and surgical techniques.

Keywords: *Infratemporal fossa, supernumerary, cone beam computed tomography, accidental displacement, complication*

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Introduction

Removal of an impacted maxillary third molar or supernumerary tooth is a routine procedure in the daily clinical practice of oral and maxillofacial surgery. Maxillary tuberosity and root fracture, maxillary sinus perforation, prolapse of the buccal fat pad are common complications of this procedure (1, 2). However; displacement of an entire tooth into the anatomical spaces such as infratemporal fossa (ITF) is a serious but rarely reported occurrence (3).

Infratemporal fossa contains lateral and medial pterygoid muscles, the branches of the mandibular nerve, the otic ganglion, the chorda tympani, the maxillary artery, and the pterygoid venous plexus and it is also bounded in front by the posterior surface of the maxilla, behind by the styloid process, above by the infratemporal surface of the greater wing of the sphenoid, medially by the lateral pterygoid plate, and laterally by the ramus of the mandible (4). Because of the vulnerable nature of neighboring anatomical structures, patients are at risk of having a post-operative infection, limitation of mouth opening, prolonged pain and foreign-body reaction (1, 4-6). Even ligation of the internal maxillary artery and blood transfusion may become necessary in the case of abundant bleeding (1).

Radiographic examination is crucial to determine the exact location of displaced tooth. Diagnostic potential of conventional techniques such as occlusal, panoramic or occipitomenal radiographs are limited even when they are used simultaneously (7). The introduction of cone-beam computed tomography (CBCT) in the field of oral and maxillofacial surgery dramatically increased the quality of medical care in such conditions, as it is now possible to obtain high-resolution images of the relevant anatomy from multiple planar orientations. Analysis of CBCT images allows pin-

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pointing the location of the displaced tooth, in exchange for relatively low levels of ionizing radiation when compared to medical CT, which is also capable of providing similar diagnostic information (3).

The aim of this article is to report the displacement and immediate removal of a supernumerary maxillary tooth into ITF with special emphasis being on the surgical procedures and the reliability of imaging modalities.



Figure 1. Pre-operative panoramic radiograph showing impacted third molar and supernumerary teeth.



Figure 2. Pre-operative three dimensional reconstruction with volume rendering algorithm.



Figure 3. Panoramic radiograph of the displaced tooth taken during the surgery.

Case report

In May 2012, a 40-year-old male applied as a self-referred patient complaining of having persistent pain for the last three months at the right side of his face. His medical history was non-contributory. There was no visible swelling, tenderness or pus discharge. Skin color and temperature were normal. In the intraoral examination of the relevant region, oral hygiene level was good and oral mucosa was in normal color. The patient stated that his maxillary right first molar tooth had been extracted more than five years ago without any problem. The second molar was found to be in good condition, but no third molar could be observed.

Digital panoramic radiography (PANO) was selected as the initial radiographic modality (OP200D digital, Kavo Instrumentarium Dental, Charlotte, NC, USA) by using the following imaging parameters: 66-85 kVp, 10-16 mA, 14.1 exposure time. An impacted third molar tooth in the horizontal position was observed immediately below the level of alveolar crest, along with an impacted supernumerary tooth which was located more superiorly in the vertical orientation. To overcome the effects of superimposition on the diagnostic process, CBCT imaging was ordered as the advanced imaging modality. Newtom 5G CBCT device (QR, Verona, Italy) was used to acquire tomographic data with 0.25 mm isotropic voxel size setting. Images were displayed on 32 inches liquid crystal display screen with a resolution of 1280 × 1024 pixels and examined in the NNT viewer (Version 3.0, Verona, Italy) installed in a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA). Multiplanar reconstructions from the axial and coronal planes confirmed that the patient had an impacted third molar with curved roots and supernumerary tooth located superiorly to the third molar (Figure 1, 2).

Based on the findings of radiographic examination that corroborate clinical complaints, simultaneous surgical extraction of the impacted third molar and the supernumerary tooth was planned. Maxillary third molar was extracted without any problems under local anesthesia with 4% articaine with epinephrine 1:200.000 (Ultracain DS, Sanofi Aventis, İstanbul, Turkey) via the intraoral approach. The crown of the supernumerary tooth then became immediately visible. After removing some bone, a Bein elevator was used to move the tooth in the craniocaudal direction. Although the crown of the supernumerary tooth has emerged out of the crestal bone; it was not possible to keep a tight grip with the extraction forceps. Therefore, a hemostatic clamp was used to further move the tooth vertically. However, when the clamp was released to replace it with the extraction forceps, the tooth immediately disappeared deeper into the soft tissues. Visual inspection was not possible at that time because of the prolapsed buccal fat pad and hemorrhage. To determine the position of the tooth, another set of PANO (Figure 3) and CBCT imaging (Figure 4a, b) was obtained which clearly showed that the tooth has been displaced into the ITF and positioned medially to coronoid notch between the lateral wall of the maxillary sinus and the zygomatic arch (Figure 5).

The patient was clearly informed about the situation and he approved to undergo surgical exploration under local anesthesia. The blood clot was removed and the incision was

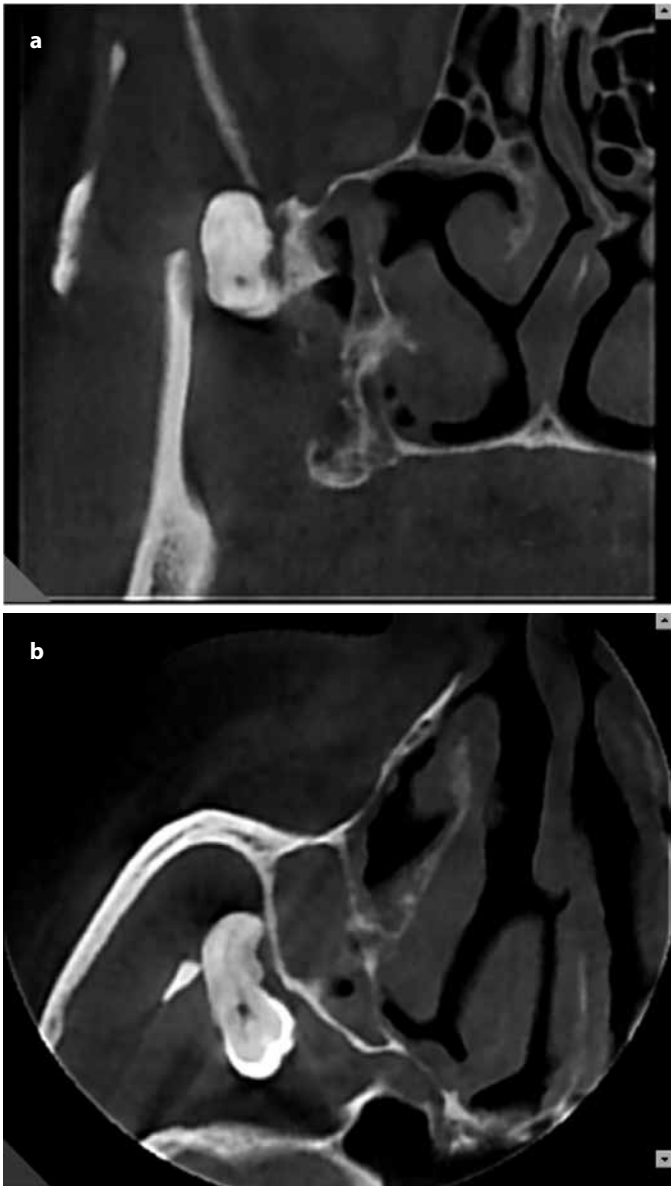


Figure 4. a, b. (a) Coronal view of displaced tooth in cone beam computed tomography. Note the displaced tooth between lateral superior wall of maxilla and coronoid process of mandible. (b) Axial view of displaced tooth in cone beam computed tomography.

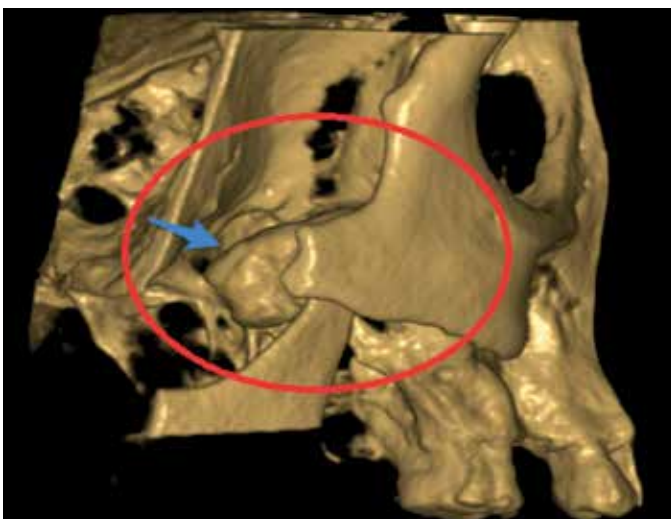


Figure 5. Three dimensional reconstruction by using volume rendering algorithm based on cone beam computed tomography data taken during the surgery. Blue arrow indicated the displaced tooth which was located medially to the coronoid notch of the mandible.



Figure 6. Panoramic radiography taken two years after the surgical removal of the displaced tooth.

extended to reveal the maxilla in the superior and posterior directions. A metal tongue depressor was used to protect and retract the buccal fat pad and muscles from the surgical site. Bone was removed from the maxillary tuberosity to increase visibility after carefully measuring the distance between the alveolar crest and the displaced tooth in CBCT. The crown of the supernumerary tooth was located and it was removed immediately. The surgical site was checked for signs of excessive hemorrhage, maxillary sinus perforation or any related complications. As none was found, oxidized regenerated cellulose was used as the hemostatic agent (Surgicel Nu-Knit, Johnson and Johnson Medical, Arlington, TX, USA) was inserted into the cavity. Primary wound closure was achieved by using a 3-0 vicryl polyglactin resorbable suture (Ethicon, Inc, Somerville, NJ, USA). 1000 mg amoxicillin combined with 250 mg clavulanate (Augmentin, GlaxoSmithKline, Brentford, UK) per oral twice daily for five days and 25 mg dextketoprofen-trometamol (Arveles, IEUlagay-Menarini Group, Italy) per oral twice daily for five days were prescribed for infection control and pain management, respectively. Healing was uneventful at one week control and the patient claimed that his initial symptoms have been resolved. Two years of the follow-up period was completed with no complication (Figure 6).

Discussion

Possible complications of maxillary impacted molar surgery include the displacement of the tooth into anatomical spaces (6) such as maxillary sinus, infratemporal fossa, buccal, lateral pharyngeal, and pterygomandibular spaces (7-14). The maxillary sinus is the most frequent space into which the maxillary third molars are dislocated but the displacement of a tooth into the ITF is a rare occurrence (4).

Displacement of maxillary teeth has been associated with lack of knowledge of the basic principles of surgical technique, lack of anatomical knowledge, inadequate flap design and decreased visibility during surgical extraction, incorrect extraction technique, distopalatal angulated tooth, tooth crown in the more superior level of the adjacent molar root apexes, limited bone volume distal to the teeth (7, 15). Applying excessive force when using the elevator may fracture the thin cortical layer of the buccal wall, thereby leading to the displacement of the tooth into the anatomical spaces. Consistently, Orr (16) reported that the right maxillary tooth has displaced into the infratemporal fossa because of the inattentive use of the elevator. Although excessive force

has not been applied in the present case, the supernumerary tooth was located superiorly to the right maxillary third molar and the root apices were angulated, which might have led the tooth to be stuck between muscular attachments and mucoperiosteal flap during extraction. Extracting the supernumerary tooth by using standard forceps proved to be very difficult in the present case, as the tip of the instrument was too short. Therefore, the hemostatic clamp was used because of its seemingly ergonomic design. However, although being long enough, a firm grip could not be established by using that clamp, probably because of its thin profile.

PANO is the standard imaging modality for the surgical extraction of impacted third molars (17, 18). However, angulation of the third molar and the position of the root relative to the maxillary sinus on panoramic radiographs can be difficult to diagnose because of the superimpositions of the anatomical structures. CBCT is capable of presenting high-quality cross-sectional images from different planes that provide more reliable diagnostic information regarding the position of the maxillary third molars (19). On the other hand, clinicians should remember that CBCT still uses higher ionizing radiation doses than PANO, therefore, benefit/cost ratio should be carefully evaluated to adhere to the As Low As Reasonably Achievable (ALARA) principles (20, 21). In the present case, CBCT was used for planning as well as emergency purposes, which shows the versatility of this imaging modality.

The timing for surgery is critical in the removal of displaced teeth, as potential risks may increase over time. The most notable risks of the delayed surgery include infection, limitation of mouth opening, pain, and foreign-body reaction (1, 4-6). Winkler *et al.* (22) reported a patient in whom swelling, pain, and mouth opening impairment developed almost 7 years after the displacement of the right maxillary third molar into the infratemporal fossa. In addition, external root resorption and pulp necrosis were observed in the removed teeth which may be considered as signs of an ongoing odontogenic infection (4, 15). On the other hand, some authors (7, 8) suggested postponing the removal procedure until the tooth is immobilized by fibrous tissue formation, as any attempt made before the formation of the fibrous capsule may dislodge the tooth deeper towards the base of the skull. It is important to note that, however, articles in which the authors suggest to delay the procedure have been mostly published before the year of 2000, a time when oral and maxillofacial surgeons had limited or no access to computed tomography. Accordingly, in the present case, immediate removal was performed based on the accurate information obtained from CBCT.

The ITF is a relatively large anatomical space with confined borders. Accordingly, a variety of surgical techniques has been proposed over the years to gain access to the ITF, such as Gillies's technique, Hemicoronal or coronal approaches and modifications of Caldwell-Luc procedure (2, 15). However, leaving the fragment in the displaced place could be another option (23). Additionally, the endoscopic approach may provide a direct view of the ITF for avoiding complications. Battisti *et al.* (24) suggested the use of endoscopic devices. Authors mentioned that, as only one hand will be free to use, endoscopy may be perceived as uncomfortable at first, however, this can be overcome with practice.

All of the techniques mentioned above offer good surgical visibility that eliminates the need for extensive temporal dissection. However, no aggressive approach was considered in the present case as the tooth has become accessible after extending the flap and carefully retracting the mucosal tissues and buccal fat pad. Therefore, it can be stated that the large volume of ITF has a significant effect on the severity of the surgery as the tooth can be displaced anywhere within this space.

Conclusion

Whether supernumerary or not, displacement of a tooth into the ITF is a rare but serious complication of the surgical extraction procedures performed in the maxilla. Early removal of the displaced tooth is essential to prevent major life-threatening complications which may occur due to subsequent odontogenic infection. The use of advanced imaging modalities such as CBCT is recommended to determine the localization of the displaced tooth in three dimensions to prevent the aggressive exploration of the soft tissues and to considerably shorten the time needed for surgery.

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Türkçe Öz: Çekim Sırasında Infratemporal Locaya Kaçan Bir Artı Dişin Çıkartılması. Gömülü bir dişin infratemporal locaya (ITL) kaçması nadir görülen, ancak bu alanı çevreleyen anatomik yapıların hassasiyeti nedeniyle ciddi bir komplikasyondur. Bu olgu bildirisinin amacı yüzünün sağ tarafında ağrı şikâyeti nedeniyle başvuran 40 yaşında bir erkek hastayı sunmaktır. Alınan panoramik radyografi ve konik ışıklı bilgisayarlı tomografide gömülü bir üçüncü büyük azı dişi ve bu dişin hemen üzerinde konumlanmış bir artı diş olduğu belirlenmiştir. Hasta lokal anestezi altında opere edilmiştir. Gömülü üçüncü büyük azı dişi kolayca çıkarılmış, ancak artı diş çekim sırasında ITL'nin içerisine doğru yer değiştirmiştir. Dişin konumu radyografik muayene ile tespit edildikten sonra, flep genişletilerek ve yumuşak dokuları dikkatle diseke edilerek dişe ulaşılmış ve diş aynı seansta ağız içinden çıkarılmıştır. Nadir görülen bu komplikasyonun klinik özellikleri görüntüleme yöntemlerinin güvenilirliği ve cerrahi teknikler üzerinde durularak incelenmiştir. Anahtar kelimeler: Infratemporal loca, artı diş, konik ışıklı bilgisayarlı tomografi, yer değiştirme, komplikasyon

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A case of multiple dental anomalies: a variant of Ekman-Westborg–Julin trait

Simultaneous occurrence of multiple dental anomalies is relatively common and has been reported particularly in cases with systemic alterations or syndromes. However, in 1974, Ekman-Westborg and Julin described a unique case of multiple macrodontia and multituberculism of posterior teeth accompanied by multiple dental malformations without other systemic anomalies. Here we report the case of a 20-year-old female patient who presented with macrodontia affecting her maxillary lateral teeth, mandibular incisors, and impacted multituberculated wisdom teeth accompanied by other dental anomalies that manifested itself as a variant of the Ekman-Westborg–Julin trait.

Keywords: *Multituberculism, macrodontia, dental anomaly, Ekman-Westborg–Julin, cone-beam computed tomography*

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Introduction

Dental anomalies have been known to be congenital, developmental or acquired. They may be associated with defects in chromosomes or environmental factors (1). The occurrence of multiple dental anomalies is relatively common and have been reported especially in cases with other systemic alterations or syndromes. However, in 1974, Ekman-Westborg and Julin (2) described a unique case of multiple macrodontia and multituberculism of posterior teeth accompanied by multiple dental malformations without other systemic anomalies. Similar cases and their variants have been since reported in the literature (3-8). This condition is referred to as “Ekman Westborg-Julin Syndrome”, “Ekman Westborg-Julin Trait”, or “multiple macrodontic multituberculism” (3-9). The aim of this case report is to describe a 20-year-old female patient with multiple dental anomalies which appears to manifest itself as a variant of Ekman-Westborg-Julin trait.

Case report

A 20-year-old female patient was referred to the Clinic of Oral and Dentomaxillofacial Radiology Department in İstanbul Aydın University, İstanbul, Turkey, with the chief complaint of swelling in the left posterior mandible. A panoramic radiography was taken in order to evaluate the involved area. Clinical and radiographical examinations led to the diagnosis of pericoronitis of the mandibular left third molar.

During clinical examination, macrodontic maxillary laterals and mandibular incisors, as well as shovel-shaped maxillary incisors were observed. Also, enamel opacity on the right and left maxillary lateral incisors, and enamel hypoplasia on the left maxillary lateral incisor were noted. Carabelli tubercles on the right and left maxillary first molars, and extra palatal tubercles

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on the right and left maxillary second molars were detected. The right and left maxillary second premolars had been extracted during previous orthodontic treatment (Figure 1a-c). Panoramic radiography showed macrodontic impacted third molars, root dilacerations on the right maxillary first premolar and left maxillary second molar (Figure 2a).

For further evaluation, informed consent was obtained from the patient and cone beam computed tomography (CBCT) (3D Accuitomo 170, J. Morita, Kyoto, Japan) was performed with 90 kV, 5 mA and 30.8 sec using 250 µm voxel size and 140x100 cm field of view (FOV). Axial, coronal, sagittal and cross-sectional images with 1 mm slice thickness and intervals were investigated by two oral and maxillofacial radiologists (GÇ, MAE). C-shaped large palatinal root canal in the right maxillary second molar, double palatinal rooted left maxillary second molar, pulp stone on the left maxillary lateral incisor, enameloma on the right and left maxillary second molars, dilaceration on the right maxillary first premolar and left maxillary second molar, macrodontic multituberculated impacted third molars were also detected during the investigation of the CBCT images (Figure 2b-f).

Her medical and family history were questioned in detail to find out the cause of these multiple dental anomalies. The medical history was non-contributory and the patient was mentally and physically healthy. She did not give permission to perform chromosomal analysis but she was the second child of healthy parents and no genetic disorders were found in her family history. She had been delivered by caesarean

section. Consanguinity was denied. Extra-oral examination did not show any abnormalities. Only a generalised birth mark in pink colour was detected extending from her first toe of the right foot to her right leg (Figure 1d-f).

The patient was referred to a medical physician in order to eliminate the possibility of systemic diseases. Biochemical tests, including complete blood count, thyroid hormone (triiodothyronine, free thyroxine, thyroid stimulating hormone), sex hormone (follicle stimulating hormone, luteinizing hormone, progesterone, prolactin) and growth hormone levels, diabetes tests (fasting blood sugar, oral glucose tolerance test) and routine blood tests were carried out and only folic acid and vitamin B₁₂ levels were found to be within the border limits.

Discussion

Ekman-Westborg and Julian (2) described multiple macrodontia and multituberculism affecting only the teeth with no other systemic anomalies. This condition has been referred to as Ekman Westborg-Julin Syndrome, Ekman-Westborg-Julin Trait and multiple macrodontic multituberculism in the literature (3-9). Because these multiple anomalies are unique to the teeth and it's not a syndrome, we preferred the term "Ekman-Westborg-Julin Trait" (6). So this case was considered to be a variant of the Ekman-Westborg-Julin Trait due to the presence of the dental morphological anomalies including macrodontia affecting maxillary laterals, mandibular incisors



Figure 1. a-f. Intra-oral views of patient; (a) note the macrodontic teeth #12, #22, #32, #42, #31, #41, shovel-shaped teeth #11, #21, enamel opacity on tooth #12, enamel hypoplasia on tooth #22, (b) extra palatinal tubercles on teeth #17, #27, Carabelli tubercles on teeth #16, #26 and (c) extracted macrodontic multituberculated tooth #38. Extra-oral views of patient; (d) showing no abnormality and (e, f) Pink birth mark extending from her first toe of the right foot to her right leg.

and impacted wisdom teeth with multituberculism accompanying other dental anomalies.

Macrodonia, as one of the characteristic findings of the Ekman-Westborg-Julin trait, is an uncommon developmental anomaly in which the teeth appear larger compared to their normal sizes. Macrodonia more commonly involves a group of teeth or a single tooth, however rarely the entire dentition may be involved (1). Macrodonism has been reported to affect mostly the mandibular premolars, molars and rarely; the incisors (6). In our case, macrodonia was detected on the impacted third molars, maxillary laterals and mandibular incisors. Macrodonia is classified into three subgroups such as: true generalized, relatively generalized, and localized macrodonia of a single tooth. True generalized macrodonia may occur due to the systemic disorders (insulin-resistant diabetes, pituitary gigan-

tism) or syndromes (otodontal syndrome, facial hemihyperplasia, 47,XXY syndrome, oculo-facio-cardio-dental syndrome and postaxial polydactyly-dental-vertebral syndrome) (4). In order to eliminate these disorders, biochemical and routine blood tests were carried out in the present case and the patient was found to be systemically healthy. The chromosomal analysis could not be performed but detailed family history of the patient showed no genetic disorders. Although macrodonism may occur as an enlargement of all tooth structures, it may also be associated with other morphologic anomalies like multituberculism, schizodontia, invaginations and evaginations, and supernumerary teeth (2). Detailed radiographic examination (panoramic radiography and cone beam computed tomography) in this case revealed that the impacted macrodontic wisdom teeth showed multituberculism.

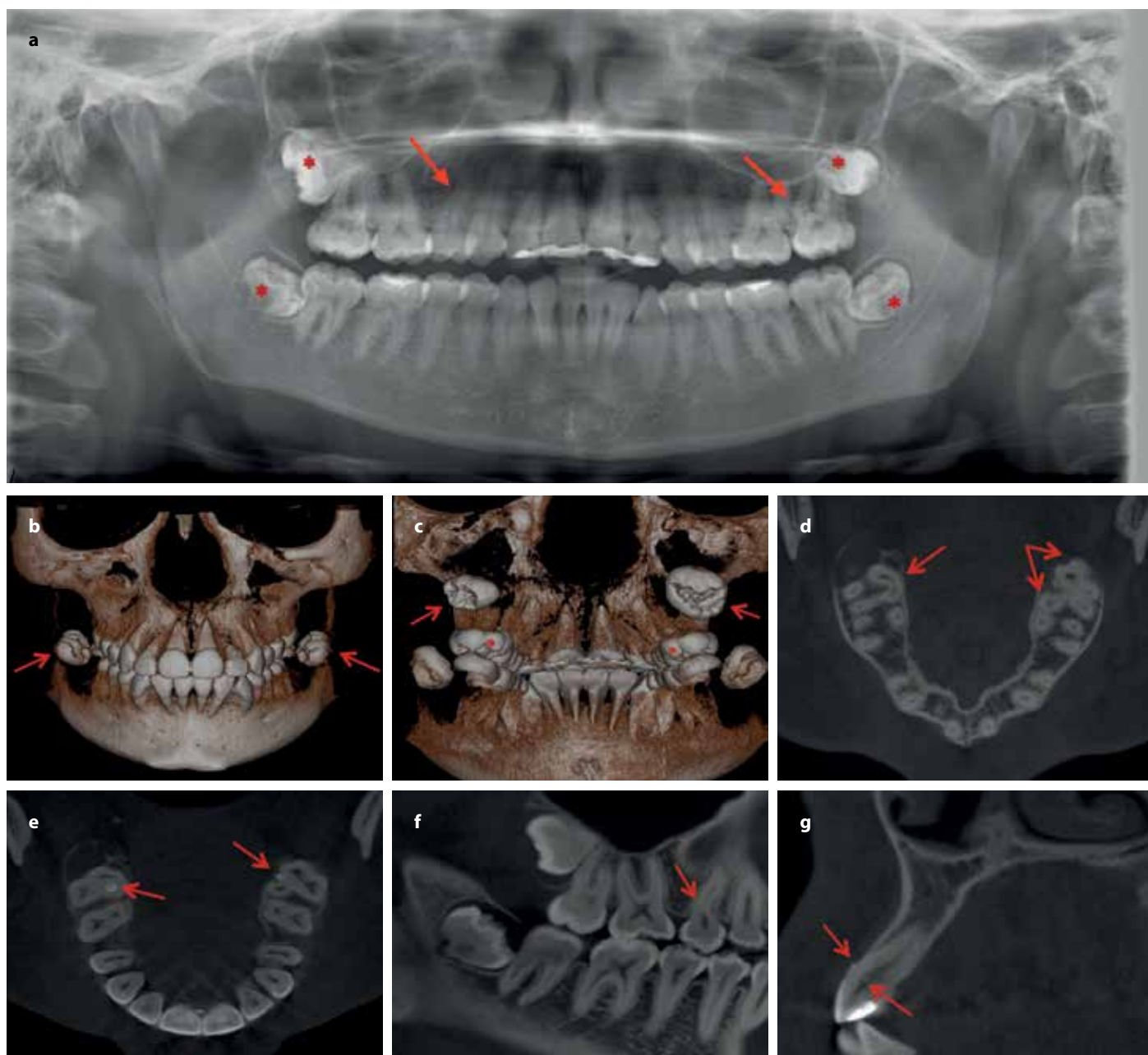


Figure 2. a-g. (a) Panoramic radiography showed macrodontic impacted third molars (red stars), root dilaceration on teeth #14, #27 (red arrows). CBCT images of the patient; 3D views of (b, c) Macrodonic multituberculated teeth #18, #28, #38, #48 (red arrows), (c) Extra palatal tubercles on teeth #17, #27 (red stars), Axial images showing (d) C-shaped large palatinal root canal of tooth #17, double palatinal rooted tooth #27, (e) Enameloma on teeth #17, #27 (red arrows), Sagittal images showing (f) Root dilaceration on tooth #14, (g) Dilaceration on cemento-enamel junction and pulp stone on tooth #22 (red arrows).

Malocclusion is a common finding in the reported cases related with Ekman-Westborg-Julian Syndrome (3-5, 7-9). The present case also had the history of orthodontic treatment and the right and left maxillary second premolars had been extracted according to the treatment plan.

The pathogenesis of this syndrome and the role of genetic factors (hereditary transmission) still remain unclear. Due to the limited number of cases reported it is not possible to elucidate the exact cause of this condition. Ekman-Westborg, Julian (2) predicted that the dental anomalies may be caused by a common pathogenetic factor during the early stage of tooth development, while the initiating factors remain obscure.

In the first reports of Ekman-Westborg-Julian Trait, there seemed to be a male predominance. Then, in 2003, Benjamin *et al.* (9) presented a 12-years-old female patient. Despite the limited number of cases, the male to female ratio is 7:5 which denotes almost no gender difference. Only in one case there was no information about gender (5).

In the literature, simultaneous occurrence of multiple dental anomalies in a single case without systemic disorders has also been reported apart from the cases which were thought to be Ekman-Westborg-Julian syndrome or a variant of this syndrome (10). The common feature of all these reports is that they present non-syndromic patients and/or those without non-systemic disorders with multiple dental anomalies. Besides, these patients are mostly young adults, as in the present case who is 20 years old. This may be related to the early recognition of dental and orthodontic problems.

Three dimensional imaging may be considered as a viable option for advanced imaging in cases with multiple dental anomalies. In the present case, CBCT was used to determine the exact morphology of macrodontic impacted third molar teeth. CBCT images revealed many other dental anomalies which were not mentioned in previous reports, such as pulp stones, enameloma, dilaceration and double rooted maxillary second molar accompanied with multituberculated macrodontic third molars. CBCT was first introduced in dentistry in the late 1990's and have been widely used in all fields of dentistry allowing the 3-dimensional and natural visualization of anatomical and pathological structures with the advantages of short acquisition time, low cost and especially low radiation dose compared with the computed tomography scanning (1).

Conclusion

Presence of multiple dental anomalies as a variant Ekman-Westborg and Julian trait is a rare occurrence. Definitive diagnosis and treatment procedures necessitate close cooperation among dental and medical professionals. Patients must be referred to medical physicians in order to exclude systemic and/or genetic disorders. CBCT can provide additional information that may be of clinical significance.

Ethics Committee Approval: Not required.

Informed Consent: Patient provided written informed consent.

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Author Contributions: GÇ, MK, IKB, and MAE designed the study. GÇ, IKB and EB generated the data. GÇ, MK and EB gathered the data. GÇ, MK and MAE analyzed the data. GÇ wrote the majority of the original draft. All authors approved the final version of paper.

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Türkçe öz: *Multiple Dental Anomaliler: Ekman-Westborg-Julian Trait'inin Varyasyonu. Multiple dental anomalinin bir arada görülmesi oldukça yaygındır ve özellikle sistemik hastalıklar ya da sendromlar ile birlikte rapor edilmiştir. Ancak 1974'te Ekman-Westborg ve Julian, sistemik bir anomalili olmaksızın birçok makrodonetik dişler ile multitüberküliizmlü posterior dişlere aynı anda başka dental malformasyonların eşlik ettiği bir olgu tanımlamışlardır. Bu makalede, 20 yaşındaki kadın hastada, makrodonetik maksiller lateral ve mandibular keser dişler ile multitüberküliizmlü gömülü yirmi yaş dişlerine diğer dental anomalilerin eşlik ettiği, Ekman-Westborg-Julian Trait'inin bir varyasyonu olduğu düşünülen bir olgu sunulmuştur. Anahtar kelimeler: Multitüberküliizm, makrodonetik, dental anomalili, ekman-westborg-julin, konik ışınli bilgisayarlı tomografi.*

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