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Turkish Journal of Orthodontics (Turk J Orthod) is an international, scientific, open access periodical published in accordance with independent, unbiased, and double-blinded peer-review principles. The journal is the official publication of Turkish Orthodontic Society and it is published quarterly on March, June, September and December.

Turkish Journal of Orthodontics publishes clinical and experimental studies on on all aspects of orthodontics including craniofacial development and growth, reviews on current topics, case reports, editorial comments and letters to the editor that are prepared in accordance with the ethical guidelines. The journal's publication language is English and the Editorial Board encourages submissions from international authors.

Journal's target audience includes academicians, specialists, residents, and general practitioners working in the fields of orthodontics, dentistry, medicine and other related fields.

Turkish Journal of Orthodontics is currently indexed in PubMed Central, Web of Science-Emerging Sources Citation Index and TÜBİTAK ULAKBİM TR Index. The journal has been recently accepted for inclusion in Scopus.

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TYPE OF MANUSCRIPT	WORD LIMIT	ABSTRACT WORD LIMIT	REFERENCE LIMIT	TABLE LIMIT	FIGURE LIMIT
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REVIEW ARTICLE	5000	250	50	6	10 or total of 20 images
CASE REPORT	1000	200	15	No tables	10 or total of 20 images
LETTER TO THE EDITOR	500	No abstract	5	No tables	No media

Tables

Tables should be included in the main document, presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations used in the tables should be defined below the tables by footnotes (even if they are defined within the main text). Tables should be created using the "insert table" command of the word processing software and they should be arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should be supporting the main text.

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Figures, graphics, and photographs should be submitted as separate files (in TIFF or JPEG format) through the submission system. The files should not be embedded in a Word document or the main document. When there are figure subunits, the subunits should not be merged to form a single image. Each subunit should be submitted separately through the submission system. Images should not be labeled (a, b, c, etc.) to indicate figure subunits. Thick and thin arrows, arrowheads, stars, asterisks, and similar marks can be used on the images to support figure legends. Like the rest of the submission, the figures too should be blind. Any information within the images that may indicate an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. To prevent delays in the evaluation process, all submitted figures should be clear in resolution and large in size (minimum dimensions: 100 × 100 mm). Figure legends should be listed at the end of the main document.

Where necessary, authors should Identify teeth using the full name of the tooth or the FDI annotation.

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Books with a Single Author: Sweetman SC. Martindale the Complete Drug Reference. 34th ed. London: Pharmaceutical Press; 2005.

Editor(s) as Author: Huizing EH, de Groot JAM, editors. Functional reconstructive nasal surgery. Stuttgart-New York: Thieme; 2003.

Conference Proceedings: Bengisson S. Sothemin BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, editors. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sept 6-10; Geneva, Switzerland. Amsterdam: North-Holland; 1992. pp.1561-5.

Scientific or Technical Report: Cusick M, Chew EY, Hoogwerf B, Agrón E, Wu L, Lindley A, et al. Early Treatment Diabetic Retinopathy Study Research Group. Risk factors for renal replacement therapy in the Early Treatment Diabetic Retinopathy Study (ETDRS), Early Treatment Diabetic Retinopathy Study Kidney Int: 2004. Report No: 26.

Thesis: Yılmaz B. Ankara Üniversitesindeki Öğrencilerin Beslenme Durumları, Fiziksel Aktiviteleri ve Beden Kitle İndeksleri Kan Lipidleri Arasındaki Ilişkiler. H.Ü. Sağlık Bilimleri Enstitüsü, Doktora Tezi. 2007.

Manuscripts Accepted for Publication, Not Published Yet: Slots J. The microflora of black stain on human primary teeth. Scand J Dent Res. 1974.

Epub Ahead of Print Articles: Cai L, Yeh BM, Westphalen AC, Roberts JP, Wang ZJ. Adult living donor liver imaging. Diagn Interv Radiol. 2016 Feb 24. doi: 10.5152/dir.2016.15323. [Epub ahead of print].

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TURKISH JOURNAL of ORTHODONTICS

Contents

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ORIGINAL ARTICLE

Peer Assessment Rating (PAR) Index as an Alternative for Orthodontic Treatment Need Decision in Relation to Angle Classification

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ABSTRACT

Objective: This study aimed to determine cut-off points for the Peer Assessment Rating (PAR) index in relation with Angle classification to use as an alternative index for the treatment need assessment.

Methods: This study included 607 orthodontic patients aged between 9 and 18 years. Angle classification, PAR, and dental aesthetic index (DAI) scores were determined. The DAI was used as the gold standard to evaluate the subjects for treatment need. The receiver operating characteristics (ROC) analysis was used to evaluate the PAR index in relation to treatment need assessed by DAI.

Results: The mean PAR scores for Class I, II, and III malocclusions and total sample were 17.54, 14.27, 18.7, and 20.04, respectively. The areas under the ROC of PAR scores in relation to the DAI assessment were found as 68.3% for the total sample, 66.6% Class I, 59.2% Class II, and 71.3% Class III malocclusions. For the total sample, the optimum cut-off PAR score was 14 in relation to DAI assessment. The cut-off scores for Class I, II, and III malocclusions were 13, 11, and 16, respectively, but considering psychosocial aspects, the recommended score is 14 for Class III.

Conclusion: The PAR index can be considered to have an acceptable level of validity for the assessment of orthodontic treatment need regarding Angle classification.

Keywords: Angle classification, DAI, orthodontic treatment need, PAR index, ROC curve

INTRODUCTION

Because of the increasing awareness of acceptable and attractive physical appearance, there is a growing interest to dental aesthetics (1, 2). Hence, the request for orthodontic treatment has increased. In the countries where the cost of orthodontic treatment is being covered by the public dental services for children up to limited ages, an overcrowding in orthodontic clinics and delay in treatment are observed (3). Accordingly, researchers underline the significance of developing treatment priority indices that may allocate limited health resources and decrease the waiting period and overcrowding in orthodontic clinics (3). Based on this premise, several orthodontic indices have been designed to evaluate the orthodontic treatment need by means of malocclusion severity (4-12).

The widely used indices, the index of orthodontic treatment need (IOTN) (5, 6), index of complexity outcome and need (ICON) (8, 9), and dental aesthetic index (DAI) (10-12), were validated to assess an individual's need of orthodontic treatment that incorporated a measure of the psychosocial impact of malocclusion as well (the aesthetic component). However, some authors claimed that the aesthetic component alone might be insufficient to determine the orthodontic treatment need (13). Additionally, index scores differ in certain cases,

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and orthodontic treatment need may be identified differently according to each index. Thereby selection of the patients depends on the index used due to the inherent differences in how certain occlusal features are scored (6, 11, 12, 14, 15). In support, a recent study reported 20% of disagreement in treatment need determination for the same individuals in accordance to DAI and ICON (16). DAI may not be sensitive to the specific occlusal problems and treatment requirements of some patients. DAI does not consider the amount of overbite that may strongly influence the determination of treatment need of patients with Class II, Division 2 malocclusion. In addition, DAI scores neglect the edge-to-edge incisor relationships (14, 17). The other index ICON neglects midline diastema, mandibular spacing and crowding, and the amount of overjet.

The Peer Assessment Rating (PAR) index evaluates the dento-occlusal changes in an accurate and rapid way, and it can be used as a treatment need index by both evaluating aesthetic and occlusal features (18-21). The PAR index measures crowding and spacing in both maxillary and mandibular dental arches, buccal segment occlusion (anteroposterior, vertical, and transverse), overjet (including anterior crossbite), overbite, edge-to-edge relationship and openbite, midline discrepancies, and impaction of teeth.

Due to inherent differences in how certain occlusal features are scored between the indices, these factors bring a priority for concise decision of treatment to orthodontists. Considering all these, usage of alternative indices instead of only one index for orthodontic cases in evaluation of the treatment need would be logical and more reliable.

In literature, studies evaluate PAR index as an alternative index to decide orthodontic treatment need (18, 19). The PAR index was developed without recommended cut-off points, and it could not be used in orthodontic treatment need assessment, but as a method of measuring malocclusion and efficacy of treatment. Considering this, in those studies, the cut-off points were calculated and reported between 10 and 22 in maximum accuracy (18, 19). Firestone et al. (18) concluded that the PAR index could be used in the assessment of treatment need by using a PAR score of 17 as the optimal cut-off point in the UK and the US. Recently, Soh et al. (19) reported the PAR cut-off scores as 17 and 20 in relation to dental health component (DHC) and the aesthetic component (EC) of the index of orthodontic need assessment in Asian men.

In a recent study, it was emphasized that the determination of orthodontic treatment need should be performed in conjunction with Angle classification due to the prominent differences in scoring certain occlusal features of the indices (16). Therefore, assessment by the PAR index with Angle classification can be recommended for a more precise and alternative decision system to verify the treatment need. To our knowledge, no study in literature has determined the cut-off points of PAR index according to Angle classification. This study aimed to calculate the cut-off points and to determine the PAR index as an IOTN according to Angle classification.

METHODS

This study included 607 consecutive patients (227 males, 380 females), aged 9-18 years old, randomly selected among those admitted to the Department of Orthodontics. Patients with large restorations/crowns, serial extractions or cleft lip and palate, having previous orthodontic and/or prosthetic treatment were excluded from the study.

The study was approved by the Ethical Committee of the Gazi University (2018-65).

The data on demographic characteristics, Angle classification and DAI, and PAR scores were recorded by two specialists. Two examiners discussed diagnostic criteria of malocclusion. The inter-examiner reliability was assessed. Additionally, dental casts were obtained from the patients after clinical examination to assess any variations in the data of the PAR index originating from cast or clinical scores. To ascertain the reliability of the casts and clinical examination, statistical analysis was performed. The intra-rater correlation coefficient (ICC) for the measurements was found as 0.95 indicating high reliability.

Patients were considered according to Angle classification as Class I, II, and III (22). The DAI and PAR scores were determined for each patient. DAI was used to evaluate the subjects for treatment need. According to treatment need, malocclusions were divided into two groups (23): no treatment need [DAI ≤ 25 (grade 1)] and treatment need [DAI > 25 (grades 2-4)] to compare with PAR scores and find the cut-off points for the PAR index with regard to Angle classification of malocclusions.

Statistical Analysis

Statistical analysis was performed with Statistical Package for Social Sciences version 15.0 (SPSS Inc.; Chicago, IL, USA). Intra-examiner reliability of the data obtained two weeks later was evaluated by the ICC, and the inter-examiner agreement was determined by the Kappa statistics. Descriptive statistics were used to report the PAR scores among the types of Angle malocclusions (Table 1). The receiver operating characteristic (ROC) analysis was used to calculate an optimized cut-off score for the PAR index in relation to treatment need. The specificity, sensitivity, and positive and negative predictive values were calculated. Sensitivity is the percentage of cases with treatment need, and specificity is the percentage of cases without treatment need as identified by the index. The negative and positive predictive values represent the percentages of patients that are correctly determined as not needing (negative) or needing (positive) treatment (24).

RESULTS

For this study, the sample size of 64 subjects per group at $\alpha=0.05$ yields a statistical power of 80%.

The ICC for repeated measurements for each examiner was close to 1.0, indicating high reliability. Inter-examiner agreement was found to be 0.87, which is within acceptable limits.

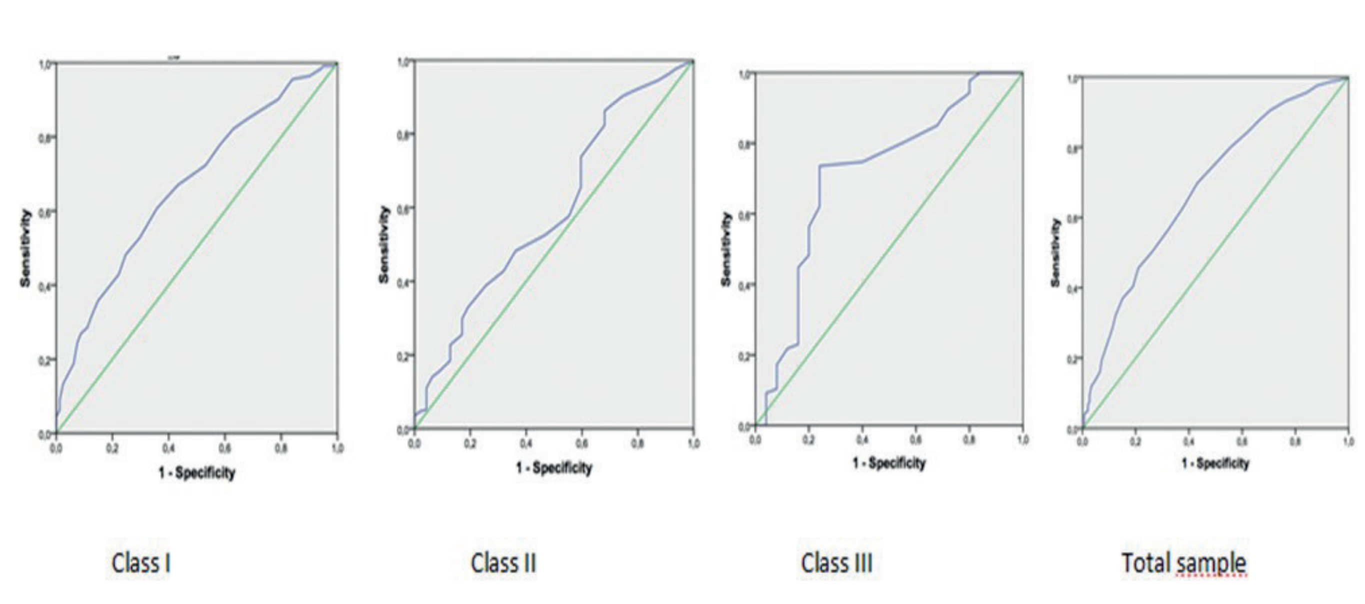

Figure 1. The ROC curves of PAR scores in relation to DAI assessment for total sample, Class I, Class II, and Class III malocclusions

Table 1. The PAR scores in accordance with Angle classification

Angle Classification	Mean	SD	Median (Min-Max)	p
Class I (n=193)	14.27	6.52	14 (2-38)	
Class II (n=302)	18.70	7.35	18 (2-43)	
Class III (n=112)	20.04	8.74	18 (5-52)	<0.001
Total (n=607)	17.54	7.72	17 (2-52)	

Table 2. The areas under curve, optimum cut-off, positive and negative predictive values of PAR scores in relation to the DAI assessment

	DAI									
	AUC	p	Cut-off score	Sensitivity (95% CI)	Specificity (95% CI)	PPV (Ratio)	NPV (Ratio)	False negative (n)	False positive (n)	Total correct prediction (%)
Total sample	0.683	<0.001**	14	70 (65-74)	57 (49-64)	0.83	0.39	30	43	67
Class I	0.666	<0.001**	13	61 (51-70)	64 (53-74)	0.70	0.54	39	36	62
Class II	0.592	<0.05*	11	86 (81-90)	32 (20-46)	0.87	0.30	14	68	78
Class III	0.713	<0.001**	16	74 (63-82)	76 (56-88)	0.91	0.45	26	24	74

AUC: Area under curve, PPV: Positive predictive value, NPV: negative predictive value, *p<0.05, **p<0.001

The mean PAR scores for Class I, II, and III malocclusions and the total sample were 14.27, 18.7, 20.04, 17.54, respectively (Table 1).

The areas under the ROC of PAR scores in relation to the DAI assessment were 68% for the total sample, 66.6% for Class I, 59.2% for Class II, and 71.3% for Class III malocclusions as shown in Figure 1.

For the total sample, the optimum cut-off PAR score for DAI was found to be 14 (sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 69.82, 56.86, 82.8, 38.8, respectively) (Table 2).

In accordance to Angle classification, the cut-off PAR scores were found to be 13 for Class I, 11 for Class II, and 16 for Class III malocclusions.

DISCUSSION

The generally used indices' scores differ in certain cases, and orthodontic treatment need may vary according to each index on which selection of a patient depends. Supporting this, 20% overall disagreement between the DAI and ICON indices was reported in quantifying orthodontic treatment need in a recent study (16). Each index has its own limitations; therefore, the decision of orthodontic treatment depending on the diversity of scores can be conflicting. The usage of alternative indices instead of only one index for orthodontic cases in evaluation of the treatment need to certify the decision would be more reliable. Therefore, in this study, it was aimed to calculate the cut-off points for PAR index in accordance to Angle classification by DAI.

Given that the DAI is recognized by the World Health Organization Oral Health Survey as a cross-cultural international orthodontic index for treatment need assessment (10) and as significant positive correlations were found between PAR and DAI scores for Angle classifications in the previous study (16), DAI was used as the gold standard in this study.

The ROC curve is a graph of sensitivity (y-axis) vs. 1 - specificity (x-axis). The area under an ROC curve defines the capability of the test to distinguish the subjects with and without the disease. In other words, the area is related to the ability of a test to correctly detect normal versus abnormal. An ideal diagnostic test could have a 100% area under the ROC curve (24). The goal of the ROC curve is to determine an optimized cut-off point defining the patient's treatment need. It is the point nearest to the left upper corner of the ROC curve graph (24).

In previous studies, the PAR index was defined to be a proper method to determine orthodontic treatment need in the US, UK, and Asian populations (18, 19). Soh et al. (19) reported that the areas under the ROC curves for PAR index were 84% and 94% for the DHC and EC assessments, respectively. Firestone et al. (18) defined this as 97%. The results of these studies indicated the high validity of the PAR index. The results of our study can be considered as compatible with those in other studies (18, 19). In this study, the areas under the ROC curves for PAR index were 68.3% for the DAI assessments. These percentages were lower than the Soh et al.'s (19) results due to the preference of different indices as gold standard.

Previously, Firestone et al. (18) had defined a PAR cut-off score of 17. Whereas, in another study, Soh et al. (19) reported cut-off scores as 17 and 20 in relation to DHC and the EC of the IOTN, respectively. Although a direct comparison could not be made between those studies and ours, the optimum cut-off PAR score was found to be 14 in relation to the DAI assessment. Differences in the cut-off points to determine the treatment need among the studies may be the result of methodological variations. The gold standard in the study of Firestone et al. (18) was the expert opinion of 15 orthodontists; and in the study performed by Soh et al. (19), two different indices were considered. In this study, the DAI was used as a gold standard in determining the cut-off points of PAR in this study, whereas orthodontic specialist's decisions or other indices might have been used as the gold standard to evaluate the treatment need of the patients. This was the limitation of this study.

Hamdan and Rock (20) reported that occlusal features vary in importance in different classes of malocclusion. In association with guidance for subtle verification of features, it would be more valid if each class of malocclusion were assessed separately. In consequence, with this concept, when the cut-off scores were determined regarding the Angle classification in this study, it was seen that the cut-off PAR scores varied. It was 13 for Class I ($p<0.001$), 11 for Class II ($p=0.045$) and 16 for Class III ($p=0.001$) malocclusions in relation to the DAI assessment. In this study, the p-values for each Angle classification were adequate to define that the PAR index can actually diagnose the orthodontic treatment need. If the p-value is small, then it is possible to conclude that the index actually distinguishes the patients who need treatment.

As the cut-off score for the total sample was 14, which is greater than that of the value of Class I and II malocclusions and lower than Class III in this study. Decisions about using either the total cut-off point or a specific cut-off score for each malocclusion are subject to discussion. To determine a particular value as a cut-off point, the costs and benefits should be considered. The important factors in choosing the cut-off point are the economic, risks of missing the treatment need (false negative) that leads to the delay of orthodontic treatment for patients with severe malocclusion and the increase in waiting times in countries where the cost is covered by the public services or incorrectly identifying the treatment need (false positive) that enables allocation of restricted health resources in regard to treatment priority (18, 24).

Considering these, it would be beneficial to use the cut-off score in accordance to each Angle Class I and II malocclusions to precise the actual treatment need. If you choose the lower cut-off score, you would correctly identify the patients who need treatment, but you would also diagnose the treatment need in more cases that do not need treatment (18).

Almost all Class III patients need orthodontic treatment; clinicians may prefer using the lower cut-off score of 14 instead of 16 for Class III malocclusions. If the score 16 is chosen as the cut-off value, there is a risk of missing some of the patients who would need treatment. If the lower threshold is preferred, almost all of the patients with treatment need will be identified. Besides, negative psychosocial effects of having a malocclusion, missing the opportunity to benefit from growth modification and the costs of supplementary treatments such as orthognathic surgery will be minimized.

Each index has its own limitations and restrictions in identifying orthodontic malocclusions. Angle classifications support the international communication worldwide; and as observed from our results in differing cut-off scores, they should be taken into consideration. The PAR index as an alternative to verify the orthodontic treatment need will provide a light on confirming conflicting or varying decisions in clinical evaluations.

CONCLUSION

The results of this study indicated that the PAR index could be used as an alternative index in evaluation of the treatment need in conjunction with Angle classification. For the total sample, the optimum cut-off PAR score was approved to be 14 in relation to DAI assessment. In the decision of treatment need, the usage of specific cut-off scores of 13 and 11 for Angle Class I and II, respectively, and a total score of 14 for Class III malocclusion are recommended.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Gazi University (2018-65).

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

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ORIGINAL ARTICLE

Evaluation of Airway Measurements in Class II Patients Following Functional Treatment

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ABSTRACT

Objective: This study aimed to evaluate the effect of fixed and removable functional treatment on pharyngeal airway measurements in class II patients.

Methods: In this study, patients treated with fixed (Forsus Fatigue Resistant Device-FRD) and removable (twin-block-TWB) appliances were included (n=15, eight females, seven males in each group). These groups were compared with untreated individuals as the control group (n=10). The mean age of individuals was 13.22±2.39 years. Initial and post-treatment cephalometric radiographs were digitized, and the sagittal pharyngeal airway changes were evaluated. The pharyngeal airway was divided into the nasopharynx, oropharynx, and hypopharynx. The one-way ANOVA, Kruskal-Wallis test, and paired samples t-test were used for statistical analyses.

Results: At the initial values, no statistically significant difference was observed between the groups. Only the ANB values differed between the groups ($p<0.05$). Although the skeletal effects of removable and fixed treatment were not exactly the same, the changes of the airway dimensions were similar.

Conclusion: The TWB and FRD appliances lead to an increase in nasopharynx, oropharynx, and hypopharynx sagittal dimensions. However, in terms of the effect on airway sagittal dimensions, there was no significant difference between treatment groups and the control group.

Keywords: Functional treatment, airway, cephalometrics, twin-block, Forsus

INTRODUCTION

Class II division 1 anomalies result from mandibular inadequacy rather than from excess of maxillary development. Mc Namara Jr. reported that mandibular retrusion is the most common characteristic of this anomaly (1). In that case, treatment focuses on using mandibular advancement appliances. The functional treatments used for this purpose target the positioning of the mandible in the anterior and the correction of the retrognathic mandible with the adaptation of the chin to this position.

As class II malocclusions generally occur because of the tongue being positioned at the back and restricting the cervical region, respiratory function is interrupted in the larynx region; and therefore, abnormal swallowing and mouth breathing occur (2). Considering its effects on airway dimensions, correction of class II malocclusions is not only important in terms of aesthetics and function, but also in terms of increasing patient comfort.

There are studies investigating the changes in the airways because of functional orthopedic treatment of class II malocclusions. Lin et al. (3) asserted that functional orthopedic treatment did not result in any changes in the anteroposterior dimensions of the pharyngeal airway, whereas Özbek et al. (4) reported a significant increase in pharyngeal airway dimensions. Hanggi et al. (5) mentioned the positive effects of activator-headgear combination treatment on pharyngeal airway dimensions, whereas Ghodke et al. (6) detected that twin-block (TWB)

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increased the dimensions of the pharyngeal airways but did not change the posterior pharyngeal wall thickness. Based on this ambiguity in the literature, it was determined that there are no studies that together evaluate the most frequently used two functional treatment types in clinical practice, that is, TWB and Forsus Fatigue Resistant Device (FRD), and making comparisons with a control group to assess the possible changes in airway dimensions because of the use of these appliances independently from growth.

This study aimed to investigate possible airway alterations caused by skeletal changes that may occur during functional treatments.

METHODS

This retrospective study was approved by the Ethics Committee of Gaziantep University (20/18.01.2018). The power analysis sample size determination revealed that for the ANOVA on three groups with an effect size of 0.66 for the ANB angle, an alpha level of 0.05, and a power of 0.9, a minimum of 12 subjects in each group was required.

The following points were considered in patient selection criteria:

- Being systemically healthy
- Having a skeletal class II division 1 malocclusion (ANB>4º)
- Having sufficient maxillary development and insufficient mandibular development
- Having no or slight crowding
- Having an overjet of more than 5 mm

This study included individuals undergoing treatment for TWB (15 patients) and FRD (15 patients) in the Orthodontics Department, Faculty of Dentistry at Gaziantep University, and individuals who did not receive any treatment (10 patients). The cephalometric radiographs of these individuals taken at different times were included in the study.

Appliances that can be attached to the teeth via Adams and ball clasps and that are separately applied to the mandible and maxilla were used in the TWB group. Pre-treatment radiographs taken before insertion (T1) and after the removal of the appliance upon obtaining the desired class I relationship (T2) were analyzed.

In the FRD group, after finalization of the leveling stage using 0.022 slot brackets, a spring was positioned between the distal lower canine and upper molar while 0.017×0.025 inch arch braces were in place. Radiographs taken right before FRD application (T1) and after the removal of the appliance upon obtaining the desired class I canine relationship (T2) were analyzed.

Patients included in the control group were selected from the archive of the Orthodontics Department, Faculty of Dentistry at Gaziantep University. Radiographs taken at the beginning (T1) and end (T2) of the 6-month patient follow-up period were analyzed.

Cephalometric Analysis

One investigator (DM) made the calibration, digital drawing, and measurements. The Dolphin software version 10.5 (Dolphin Imaging Systems, Chatsworth, CA) was used for drawings and measurements.

The airway measurements were horizontally divided into three: nasopharynx, oropharynx, and hypopharynx (Arnett-Gunson FAB Surgery Analysis) (7). Measurements of these areas in the horizontal direction were performed using a computer software.

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences Version 24 (IBM Corp.; Armonk, NY, USA) for Windows, and a p-value of <0.05 was accepted as statistically significant.

The normality of the distribution of continuous variables was tested using the Shapiro-Wilk test. When data were normally distributed, the one-way ANOVA and LSD test were used to compare variables between the groups; and when data were not normally distributed, the Kruskal-Wallis analysis was used. Data are expressed as mean±standard deviation. To determine the method, error 15 lateral cephalometric radiographs from the final records were randomly selected and retraced, and digitized at a 15-day interval by the same operator (DM). The intra-examiner reliability for the cephalometric variables was analyzed with the Pearson correlation test.

RESULTS

The mean age was 12.13±0.58 years in the TWB group, 14.47±0.62 years in the FRD group, and 13.00±0.58 years in the control group. The skeletal and airway measurements at T1 and T2 and p-values for all groups are shown in Table 1. According to the results, there was no statistical significance difference for the initial values between the groups (p>0.05). For SNB, ANB, and Wits value at T2, the meaningful differences were revealed. These differences were between the TWB and FRD groups for SNB (p=0.016), between the TWB and control groups for ANB (p=0.004), between the FRD and control groups for ANB (p=0.002), between the TWB and control groups for Wits (p=0.039), and between the FRD and control groups for Wits (p=0.001). However, the difference between the groups was not significant for pre-treatment and post-treatment airway measurements (p>0.05).

A statistical comparison of skeletal and airway intergroup measurements at different intervals is given in Table 1. The statistically different values in the TWB group were the SNA, ANB, Wits, oropharynx, and hypopharynx values, while in the FRD group, the ANB, Wits, nasopharynx, oropharynx, and hypopharynx values were statistically different. The oropharynx and hypopharynx values were statistically different in the control group (p<0.05).

Table 1. Means, standard deviations, and p-values for the measurements among groups

		Groups			p between groups			
		TWB	FRD	CONTROL	All Groups	TWB vs. FRD	TWB vs. Control	FRD vs. Control
SNA (°)†	T1	81.04±1.00	83.37±1.21	82.36±0.73	0.276			
	T2	79.06±1.16	82.35±0.91	82.33±1.15	0.051			
	pwithin groups	0.005*	0.087	0.963				
SNB (°)†	T1	75.62±1.15	78.05±0.78	75.75±0.95	0.146			
	T2	74.95±1.23	78.44±0.76	76.11±1.00	0.049*	0.016		
	pwithin groups	0.218	0.377	0.474				
ANB (°)†	T1	5.4±0.67	5.34±0.75	6.46±0.71	0.533			
	T2	4.11±0.51	3.91±0.49	6.53±0.62	0.004*		0.004	0.002
	pwithin groups	0.002*	0.005*	0.840				
Wits (°)†	T1	5.37±0.86	3.07±0.91	6.15±1.21	0.081			
	T2	2.79±0.77	0.47±0.89	5.87±1.36	0.003*		0.039	0.001
	pwithin groups	0.002*	0.009*	0.493				
Nasopharynx (mm)†	T1	13.39±0.34	14.46±0.48	14.65±0.48	0.095			
	T2	14.37±0.33	15.42±0.46	14.97±0.52	0.204			
	pwithin groups	<0.001*	0.001*	0.533				
Oropharynx (mm)†	T1	10.34±0.89	11.59±1.02	10.39±1.05	0.590			
	T2	11.35±0.84	12.99±0.95	12.04±0.96	0.418			
	pwithin groups	<0.001*	0.001*	0.001*				
Hypopharynx (mm)†	T1	11.09±0.79	12.49±0.64	9.91±0.89	0.085			
	T2	11.68±0.76	13.18±0.61	11.16±0.73	0.129			
	pwithin groups	0.009*	0.002*	0.009*				

†Mean±standard deviation; *Significant at 0.05 level

Table 2. Mean changes in each group and comparisons for the measurements among groups

				p			
	TWB (MC ± SD)	FRD (MC ± SD)	CONTROL (MC ± SD)	All Groups	TWB-C	FRD-C	TWB-FRD
Skeletal measurements							
SNA (°)	-2.13±0.56	-1.18±0.64	-0.03±0.62	0.083			
SNB (°)	-0.67±0.52	0.39±0.43	0.36±0.48	0.208			
ANB (°)	-1.29±0.33	-1.43±0.43	0.07±0.34	0.029*	0.023+	0.013+	
Wits (mm)	-2.57±0.67	-2.60±0.86	-0.28±0.39	0.075			
Airway measurements (mm)							
Nasopharynx	0.99±0.17	0.96±0.22	0.32±0.49	0.225			
Oropharynx	1.00±0.18	1.4±0.32	1.65±0.35	0.291			
Hypopharynx	0.59±0.19	0.69±0.18	1.25±0.38	0.254			

MC±SD indicates mean changes±standard deviation. C indicates control group. *p < 0.05 for one-way ANOVA test, †p < 0.05 for LSD test

The mean changes in all groups and the statistical significance are presented in Table 2. For the skeletal measurements, both treatment groups show a decrease in ANB angle with a consequent decrease in SNA in the TWB group (p<0.05), and a distinct but not significant increase in SNB angle in the FRD group. In terms of airway measurements, no statistically significant difference was found between any groups.

The correlation coefficient results were in the range of 0.89-0.99 for intra-examiner reliability, which shows high positive correlations and indicates the reliability of the measurements.

DISCUSSION

In this retrospective study, the effect of treatment type on airway problems experienced, especially in severe class II cases, was investigated. This study also analyzes pre-treatment and post-treatment cephalometric radiographs of individuals who received functional treatment. To eliminate the growth factor in the results, comparisons were made with the untreated control group from the archive. The increase in airway measurements was detected in proportion with growth both in individuals who received different treatments and in untreated individuals.

The average age of the patients included in the study was lower in the TWB group and higher in the FRD group. The important point here is the different indications of treatment types. Generally, fixed functional treatments are preferred to treat skeletal class II individuals who have arch crowding near the late growth-development period to prevent waste of time (8). This is why the average age was higher in this group. When designing this retrospective study, it was planned to analyze the effect of each treatment using pre-treatment and post-treatment radiographs to minimize the possibility of the average age of groups affecting the results. However, a limitation of this study is that growth difference between groups could not be completely eliminated.

Airway dimension is a variable parameter, especially in developing individuals. A dimension change in airway spaces may be expected with growth as seen in the entire body. Although there are conflicted findings in the literature regarding the effects of growth-development caused by different anatomic neighborhoods (9-11), craniofacial development deviates from its ideal line, and airway compensatory mechanism works in the existence of malocclusion (12). Therefore, 10 untreated control patients from clinical archive records were included in this study to evaluate the effects of growth and treatment type separately.

The study was conducted on the two-dimensional cephalometric radiographs, and this can be considered a limitation as it may cause errors because of superimpositions. However, because of disadvantages such as being an expensive method and the additional radiation dose received for tomographic imaging, lateral cephalometric radiograph analysis is a valuable and reliable method (13).

The difference between groups in the pre-treatment data was not statistically significant. This is important for the study results to reflect the efficacy of treatment. The homogenization between the individuals included in the study was one of the superior aspects of this study.

While ANB and Wits values showed a significant decrease after treatment, the control group did not exhibit a significant change. This result can be explained by both the movement of point B forward and point A backward with the application of mandibular advancement mechanism in the treatment groups. The difference between the pre-treatment and post-treatment values was not significant in the groups for SNB, while it was significant only in the TWB group for SNA. Therefore, it was thought that the decrease in ANB and Wits values was created with the effect of simultaneous movement at two points (A and B). The fact that the SNB difference value was positive in the FRD and control groups and negative in the TWB group can be interpreted as the FRD appliance causing point B to move forward further. However, the SNB value can also interact with vertical values. Clockwise rotation of the mandible can mask the amount of forward movement of point B (14). While removable functional appliances apply a forward force on the mandible, they apply an equal force on the maxilla in the opposite direction (6). Although it is only significant in the TWB group, the time-dependent decrease in SNA value in both treatment groups is compliant with this result.

The ANB value was significantly high in the control group. High ANB value in the control group can be explained by the mandibular retrognatism in untreated individuals in accordance with the comparison of T2 values. Lower SNA value in the TWB group implied that the skeletal force applied on the maxilla was more effective in the group receiving removable functional treatment.

While there was a significant increase in the oropharynx and hypopharynx values in all groups, the increase of nasopharynx values from T1 to T2 was only insignificant in the control group. This result in the nasopharynx is in line with the studies reporting that nasopharynx dimensions are independent from mandibular-sagittal change (15, 16). It has been reported that nasopharynx enlargement is obtained by sphenoid wing expansion and sliding of the palate forward (17). From this aspect, the oropharyngeal airway is expected to be most affected by mandibular advancement treatment. In the literature, the positive effect of functional treatments on oropharyngeal airway dimensions has been reported by several investigators (4, 16, 18). In our study, it was observed that functional treatments increased oropharyngeal and hypopharyngeal airway sagittal measurements in accordance with previous studies. However, this difference was not significant in the comparison of removable and fixed treatment groups with the control group. It is thought that this situation stems from the age differences between the groups. It is thought that the difference in the amount of airway growth in different age groups was compensated by the effect of the different treatment types.

Another limitation of the study was the failure to include the vertical measurements of individuals in the study. As airway space has a three-dimensional structure, it is not only affected by the change in sagittal relationship but also by the growth in vertical dimension. Considering the fact that growth occurs in the vertical direction rather than in the anteroposterior direction, this issue is significant (19). In the literature, there are studies that demonstrate the relationship between vertical change and airway dimensions (14, 20). It is thought that this issue could be clarified further in the future with extensive clinical studies conducted using other skeletal parameters as well.

CONCLUSION

While class II malocclusions can be effectively treated with FRD and TWB treatment, these functional orthopedic treatment appliances lead to an increase in nasopharynx, oropharynx, and hypopharynx sagittal dimensions. However, in terms of the effect on airway sagittal dimensions, there were no significant differences between treatment groups and the control group.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Gaziantep University (20/18.01.2018).

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Original Article

Evaluation of the Impact of Interdisciplinary Case-Based Courses in Dental Education on Smile Evaluation Skills of Undergraduate Students

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ABSTRACT

Objective: The purpose of the present study was to compare the perception of smile aesthetic between 3rd-, 4th-, and 5th-year dental students to identify if interdisciplinary courses have an impact on the attitudes of students.

Methods: A total of 118 dental students (3rd-, 4th-, and 5th-year; N=43, 43, and 32, respectively) assessed the aesthetic attractiveness of four smile photographs (normal, high, low, and asymmetric smile lines). To enhance the crown, length-to-width ratio and color Digital Smile Design (DSD) were applied to all photographs, and then scoring was performed by using the Visual Analog Scale (VAS).

Results: The VAS scores were all <60 regardless of the year of the student. The lowest scores were given for asymmetric smile line. Comparison of the scores of the different years showed statistically insignificant scores between 3rd- and 4th-year dental students ($p>0.05$), whereas statistical differences between 4th- and 5th-year dental students were found (Cases 1, 2, and 3: $p<0.05$ and Case 4: $p<0.01$).

Conclusion: All students were critical in the evaluation of smiles. Hence, the motivation for critical thinking based on multidisciplinary courses until 3rd year, the skepticism, and also the perception of the students were increased. The difference between 4th- and 5th-year student aesthetic perceptions showed the impact of interdisciplinary course on enhanced judgment competency of the students.

Keywords: Case-based learning, interprofessional education, undergraduate orthodontic education

INTRODUCTION

At the early 20th century, significant reforms were undertaken in dental medical education (1). Before this educational reform wave, the required cognitive skills for dental practice has been underestimated for years, and the fact that dental students have to be able to apply knowledge from different disciplines and to synthesize this information was overlooked (2). Recently, the American Dental Education Association formed a commission for changes and innovation in dental education and also stated the competencies for undergraduate dental students (3).

Dental students have to be motivated for data-gathering and multidisciplinary discussion of cases, alternative treatment plans, possible complications and treatment outcomes, and decision of one of the treatment plans during their education. Leading dental academies suggested dental educational models that direct the students to evidence-based approaches for clinical decision-making, which rests on critical thinking and integrative understanding of basic and clinical science (4). This competency to synthesize knowledge is approached by multi- and interdisciplinary case-based courses.

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To meet the requirements for this approach, several years ago, an interdisciplinary dental course was integrated into the final year dental educational program at Yeditepe University. In this case-based course, tutors of several dental science departments discuss the cases together with the students interactively to finally constitute the treatment plan, ensuring the most proper functional and aesthetic therapy outcomes. The main aim of the implementation of the interdisciplinary course into the curriculum was to help the students to connect their knowledge in dental science to clinical practice and, consequently, to gain interdisciplinary perspectives not only in functional but also in aesthetic basis.

The perception of aesthetics for smile is highly subjective and has a multifactorial background, such as race, gender, age, socioeconomic status, personal experience, social environment, and media, as well as education. The term "education" may be classified as "educational status" or "professional education" for this topic. By the term "educational status," the educational level, in other words, the graduation from primary, high school, and university, among others, was defined whereas "professional education" for smile means that the professional job of the individual is related with smile aesthetic, such as plastic surgeon and, of course, especially the dentist. In fact, Sadrhaghighi et al. (5) compared the smile elevation of orthodontist, general dentist, and dental students with artists and laypersons and determined that professional dental training affects aesthetic judgment. In the literature, although several studies evaluated the smile aesthetic perception of laypersons (6), dentists (7), and specialists (8), only few studies were conducted about dental students' perception (5,9,10). To the best of our knowledge, no study was performed among Yeditepe University dental students. Moreover, in most dental undergraduate education programs, aesthetic courses are monitored intradisciplinary by several dental departments, such as prosthodontics, restorative, and orthodontic departments, to help the students to gain perspectives in aesthetic evaluations (1,2). Only few of dental schools addressed aesthetic concerns in multi- or interdisciplinary case-based courses (11).

Dental students gain experience during their education about smile evaluation, including smile arch, presence of buccal corridor space, relationship between facial and dental midlines, tooth color, and occlusal plane inclination, as well as smile line (12). The smile line, defined as the position of the upper lip relative to the upper incisors and gingiva during natural smile, is commonly used to categorize pleasant and unpleasant smiles. In average (normal), high, and low smile lines, 75%–100%, 100%, and <75% of clinical crown are displayed, respectively. In addition to the full crown high, >2 mm gingiva is visible in high smile line cases (13). An additional smile line type is also present in addition to the three main classifications of the smile line, the asymmetric smile line. Passia et al. (14), in their systemic review, assessed the smile line for being a valid parameter to evaluate smile. They concluded that the smile line is a valid tool for aesthetic perception evaluation and may be applied universally by clinicians.

The purpose of the present study was to compare the perception of smile aesthetic between 3rd-, 4th-, and 5th-year dental students to identify if multidisciplinary courses in dental educational curriculums have an impact on the attitudes of students or not.

METHODS

Record Collection

The study design was approved by the ethics research committee of Yeditepe University. Informed consent was obtained from patients whose photographs were used in the present study. The photographs were selected from the routinely collected initial records of patients treated in the department of orthodontic clinic at Yeditepe University between 2016 and 2017. The records of the patients with the following characteristics were selected from the archive (Figure 1): normal smile line, high smile line, asymmetric smile line, and low smile line.

The records of patients with craniofacial syndromes and photographs with low quality were excluded from the groups. Thereaf-

Figure 1. a-d. Visual assessment form. Normal (a); high (b); asymmetric (c); and low smile lines (d)

ter, the fifth patient on the alphabetic written patient list (N=125, 71, 48, and 25 for Cases 1, 2, 3, and 4, respectively) was selected randomly for the study.

A visual form was constructed with the frontal extraoral smile photographs at onset stage of the four patients. The photographs were also cropped so that only the chin and nose were included, and other variables were eliminated. In addition, modifications were performed on the frontal photographs for alteration of color and tooth crown length using Digital Smile Design (DSD). First, the interpupillary line was used to establish the horizontal plane. Second, the facial midline was designed according to facial features, such as the glabella, nose, and chin, to find the best facial position. Thereafter, complementary lines, such as gingival line and smile arch, crossing among gingival zenith and incisal edges and canine tip, respectively, were drawn. The relative length-to-width ratio for the central incisor was measured, and the midline was confirmed by measuring the distance between the upper cuspids. Once the central incisor width was determined, the golden ratio was applied again to determine the lateral incisor width (62% of the central incisor width) and canine width (62% of the lateral incisor width). After finishing the canine–canine arch production, modifications, such as crown lengthening and color, were performed and inserted to the frontal extraoral photograph (Figure 2).

Intervention

Several educational courses at the dental faculty of Yeditepe University were based on either intradisciplinary (one discipline) or multidisciplinary (multiple disciplines) approaches, except the intradisciplinary course at the onset of the 5th year. The aim of the course is to produce students who are competent in evaluating and analyzing the aesthetic and functional requirements of individual cases and synthesizing and harmonizing their knowledge among different disciplines. Moreover, the students are competent to serve interprofessional health care to patients in their future practice. Therefore, they will be able to serve care with a variety of health care practitioners together in a cooperative, collaborative and integrative manner. The interdisciplinary course content also involves aesthetic smile concerns and the introduction of DSD. A case-based assessment was performed after the course, and only 5th-year dental students who passed the assessment were enrolled into the present study.

The four-case visual form was presented to 118 students who were in the 3rd-, 4th-, and 5th-year educational program at Yeditepe University (N=43, 43, and 32, respectively). All students scored the smile aesthetic of the cases using the Visual Analog Scale (VAS), with a 100 mm length scale starting with "0" (very unattractive) and finishing with "100" (very attractive). Each student was asked to mark along the VAS to reflect the smile aes-

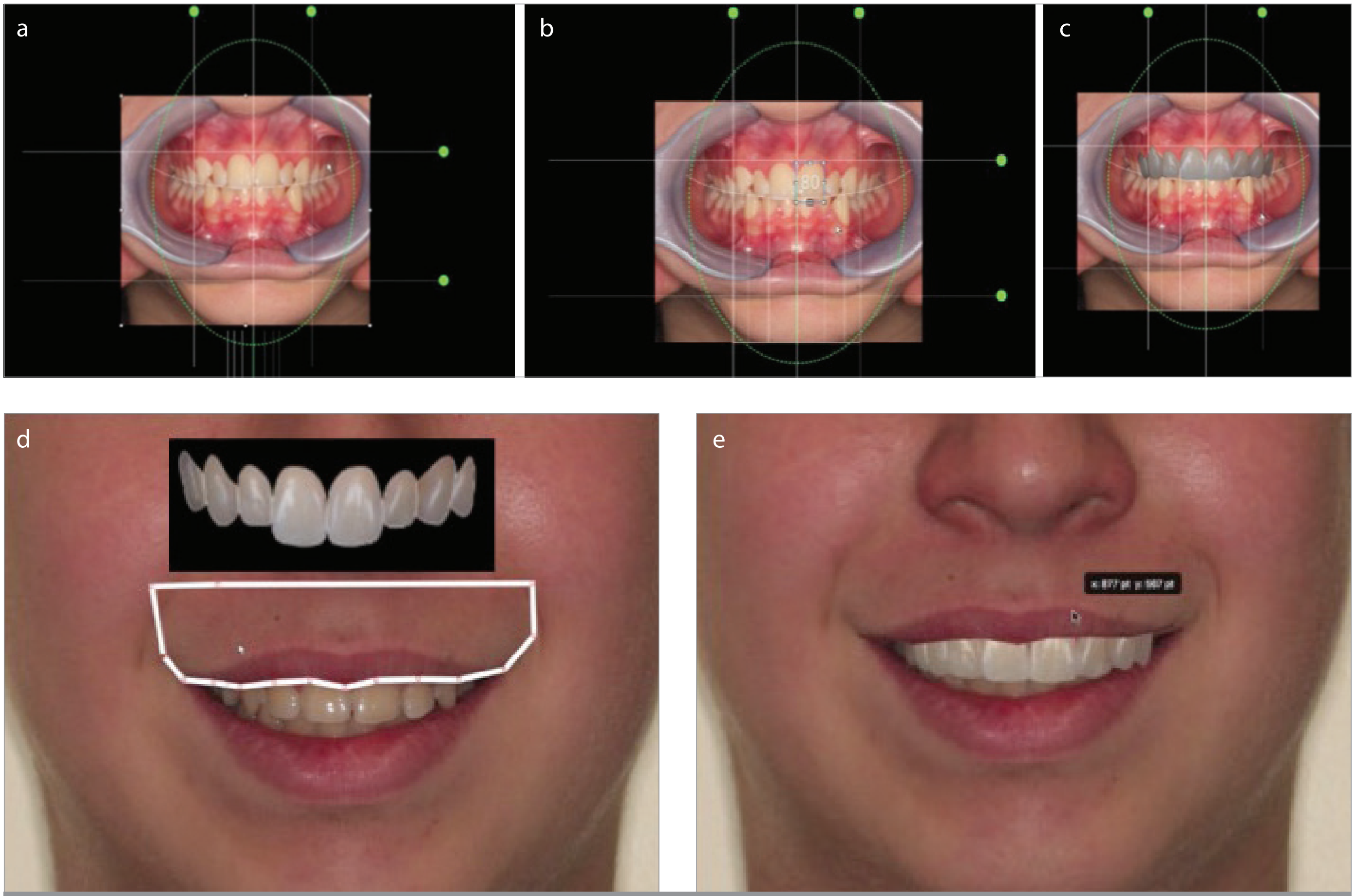

Figure 2. a-e. Modifications on frontal photographs using Digital Smile Design
Design of facial midline, gingival line, and smile arch (a); measurement of crown length-to-width ratio of central tooth (b); determination of lateral and canine according to golden ratio (c); insertion of the constructed canine-canine arch (d); final view (e)

Table 1. Comparison of case scores according to the educational year of students

	3rd year students N (43)		4th year students N (43)		5th year students N (32)		p N (116)
Cases	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
1	54.29	22.09	55.04	27.32	41.06	21.52	0.037(*)
2	45.44	18.28	47.44	20.68	39.35	21.79	0.023(*)
3	40.43	21.09	43.22	22.37	30.5	19.41	0.047(*)
4	47.79	22.71	45.47	26.93	39.79	23.51	0.006(**)

Descriptive statistics (mean and standart deviation (SD)) and Kruskal-Wallis test: p<0.05, (*) p<0.01, (**) p<0.001

thetic of each photograph. One week after the first evaluation, all students rescored the cases on the visual form to assess the intra-examiner reliability.

Statistical Analysis

Statistical analysis was performed using the Number Cruncher Statistical System (NCSS) 11 software (2016) (NCSS, LLC, Kaysville, UT, USA). Kolmogorov-Smirnov test was used to analyze descriptive statistical methods (mean value and standard deviation) and to determine the distribution of the sample. Kruskal-Wallis (one-way ANOVA) test was used to compare the groups. Intra-rater reliability was assessed by the Kuder and Richardson Formula 20 (KR-20: <0.7).

RESULTS

Comparing the first scores with the ones obtained a week later presented high internal reliability (KR-20: 0.801853). The 3rd-year students scored the normal smile line patient (Case 1) higher than the others (mean±SD: 52.09±22.09). On the other hand, the lowest scores were identified for the patient with asymmetric smile line (Case 3, mean±SD: 40.43±21.09). Although the high (Case 2) and low (Case 4) smile line patients were assessed with similar results, the former was rated as slightly more unattractive. The highest (Case 1) and lowest (Case 3) scores given by the 4th-year students were identical with the 3rd-year students. However, the scores for low and high smile lines were controversial. The 5th-year students also listed the cases in the same manner from the most attractive to the least attractive as Case 1, Case 4≅Case 2, and Case 3, respectively (Table 1).

Comparison of the 3rd-, 4th-, and 5th-year student scores for all four cases showed statistical differences (p<0.05). Although the scores of the 3rd- and 4th-year students were different, differences were found to be statistically insignificant (p>0.05). On the other hand, statistical differences between scores of 4th- and 5th-year students were found for Cases 1, 2, and 3 (p<0.05; p=0.019, 0.025, and 0.056, respectively) and Case 4 (p<0.01; p=0.005). Moreover, the 5th-year student scores were lower than the scores of the other two years.

DISCUSSION

In the literature, although several studies evaluated smile aesthetic (6-8), only few studies were performed regarding dental students' perception (5,9,10). Only one study compared the smile perception of the students according to the educational year degree. Espana et al. (10) considered the student year as an independent variable and assessed several characteristics of smile separately. They concluded that the ability to determine smile aesthetic does not improve as the student continues his/her education in a higher student year. However, no information about the educational curriculum or system at their university was presented in their paper. Espana et al. (10) also emphasized that no study is applied with Spanish students. In the same way, no study was stated about Yeditepe University dental students. Therefore, the aim of the present study was to compare the perception of smile aesthetic between 3rd-, 4th-, and 5th-year dental students to identify if interdisciplinary courses in dental educational curriculums have an impact on the attitudes of students or not.

Smile line is a valid tool for aesthetic perception evaluation (14). Therefore, in the present study, the photographs that are to be evaluated by the students were selected according to the differential smile line groups. Main concerns, such as the tooth color and the crown length-to-width ratio, were improved using DSD to eliminate possible distractions. Hence, the skills of the students to synthesize their scientific knowledge by not focusing on one criterion were evaluated. Truly, none of the photographs indicate "a perfect smile," an average smile line but a narrow dental arch display, a high smile line with buccal corridors, an asymmetric smile line with tooth malinclinations, and a low smile line with incompatible dental midlines for Cases 1, 2, 3, and 4, respectively. The results showed that the scores of all students regardless of their grade were <60, this may be due to the detection of the other present unpleasant factors on smiles.

The results in the present study showed that all students perceive asymmetric smile as the most unattractive. Kokich et al. (15) evaluated the perception of asymmetric aesthetic alterations. Although they assessed the asymmetries related to teeth, they concluded that each type of asymmetries makes the elevation more unattractive. Similarly, Fernandes and Pinho (16) mentioned in their study about the aesthetic evaluation of dental and gingival asymmetries that in the horizontal plane, dental asymmetries are considered as more unattractive than gingival asymmetries. However, the opposite was recorded for evaluation of vertical asymmetries. In the present study, the prominent asymmetry of Case 3 was the gingival vertical asymmetries, and this might explain the lowest aesthetic scores. Additionally, the low and high smile line cases were scored <50 points. The only scores >50 were recorded for Case 1, yet these were not considered as high as well. Overall, the 5th-year students assessed the cases as more unattractive than the other year students.

As the dental educational year of the students increases, their knowledge and skill also increase. One of the main domains at our university also involving intradisciplinary courses is to teach students how they may develop critical thinking skills to facilitate their active argumentation and reasoning and thereby making knowledge-related value judgment. Although the 5th-year students' scores were significantly different from the 3rd- and 4th-year students' scores, there were no statistical differences of the scores between the 3rd- and 4th-year students' scores. Interestingly, the only difference between the end of the 4th and the onset of the 5th year of the students was the participation to the interdisciplinary course. It may be concluded that the interdisciplinary course enhances the judgment skills of the students by gathering interdisciplinary knowledge with regard to these statistical findings.

The present study was the first step to evaluate the outcomes of the integrated interdisciplinary course. However, the individual performance of each student could not be assessed. Therefore, longitudinal studies, in which each student is assessed on the 3rd year to the 5th year, are planned at our university.

CONCLUSION

All students scored asymmetric smile as the most unattractive, whereas symmetric with normal smile line case was listed as the most attractive. All students were critical in the evaluation of smiles (mean scores <60). However, the 5th-year students were more critical than the 3rd- and 4th-year students in smile evaluation. The motivation for critical thinking, as well as case-based problem-solving served on the onset of clinical practice (3rd-year educational program) by the educational academic staff, enhanced the skepticism and the reliance on the students to improve treatment outcomes. The impact of interdisciplinary aesthetic courses was present according to the results of the present study. Hence, the students may improve their competency to assess the cases from different dental disciplinary views.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Yeditepe University Clinical Research (Approval Date: December 6, 2017; Decision No: 1375).

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

Peer-review: Externally peer-reviewed.

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Original Article

Effect of Short-Term Placebo-Controlled Consumption of Probiotic Yoghurt and Indian Curd on the *Streptococcus mutans* Level in Children Undergoing Fixed Interceptive Orthodontic Therapy

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ABSTRACT

Objective: To examine the effect of short-term consumption of probiotic yoghurt, Indian curd, and ultra-heated yoghurt as placebo on the levels of salivary and plaque *Streptococcus mutans (S. mutans)* in children undergoing fixed interceptive orthodontic therapy.

Methods: A placebo-controlled double-blind study was carried out in a total of 30 children (8-15 years). The *S. mutans* level in the plaque and saliva were taken at the baseline and 2 weeks after the initiation of fixed orthodontic treatment by Dentocult SM kits. An equal number of participants randomized in three groups were asked to ingest 200 g of yoghurt containing *Lactobacillus acidophilus* La-1 and La-2 (>1×10^9 cfu/mL) once daily, Indian curd, or ultra-heated control yoghurt without viable bacteria and were followed for the *S. mutans* level after 2 weeks.

Results: A significant reduction in salivary *S. mutans* levels was recorded after probiotic yoghurt ingestion (p=0.001) in addition to a reduction in the plaque *S. mutans*, which was observed after Indian curd consumption (p=0.026).

Conclusion: Our findings suggest that short-term daily consumption of probiotic yoghurt along with Indian curd may help to reduce the levels of *S. mutans* in the saliva and plaque in children undergoing interceptive fixed orthodontic therapy.

Keywords: *Streptococcus mutans*, probiotics, yoghurt

INTRODUCTION

Insertion of fixed interceptive orthodontic devices with bands and brackets increases the caries risk, as such devices provide artificial niches for cariogenic microorganisms such as *Streptococcus mutans* (*S. mutans*) (1-3). The levels of cariogenic bacteria present in the plaque are higher in the cervical third of banded molars. A comprehensive management of dental caries involves the management of the disease as well as the lesion (4). There is now an intense focus on preventive strategies as minimal/noninvasive management. Considering the abovesaid, the use of probiotics is one of those strategies (5).

The current knowledge of the important role that the intestinal micro flora plays has promoted health by utilizing its microbial community. Therefore, preventive measures should concentrate on the change in oral ecology from pathogenic bacteria to ecofriendly bacteria in the oral cavity. This quest of low carcinogenicity has become focused recently on dairy products (6). The archetypical probiotic dairy products like yoghurt and Indian curd

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seem to be the most natural way to ingest probiotic bacteria (7). Indian curd is used in homes every day and is traditionally considered to be a great source of probiotic bacteria.

The goal of the study is to examine the effect of short-term consumption of probiotic yoghurt, Indian curd, and ultra-heated yoghurt as control on the levels of salivary *S. mutans* in pediatric orthodontic patients, which make a specific high-caries risk group, and whether incorporating these products in routine dietary practice is helpful in preventing a tooth structure damage due to orthodontic therapy.

METHODS

The study was double blinded and randomized consisting of 30 children (8-15 years in mixed/permanent dentition) having fixed interceptive orthodontic therapy. Enrollment criteria were the following: patients undergoing bilateral single-arch fixed interceptive and/or space management orthodontic therapy who had a good oral hygiene. Children were given tooth-brushing instructions and told to follow them twice a day using a regular fluoride tooth paste. The children were told to avoid chewing gums, candies, and medicated mouthwashes or to report immediately any medications that they have to use.

Clinical Methods

After explaining the study protocol and obtaining a written consent, 30 subjects (14 females, 16 males) undergoing orthodontic treatment were recruited and divided into three groups, 10 subjects each. Subjects who did not have clinically detectable caries and did not use systemic antibiotics 6 weeks prior to study were included. Ethical clearance was granted by the institutional ethical committee. Data were collected at three consecutive time periods. In Period I, before the banding for orthodontic therapy, oral prophylaxis was done, and instructions were given regarding the oral hygiene maintenance at the baseline examination. Period II started 2 weeks following the initiation of orthodontic treatment, and the aim was to see the effect of orthodontic treatment on the *S. mutans* count with the maintenance of oral hygiene. Period 3, a run-in period, started after 2 weeks of giving a masked cup (200 mg/day) of

I) Group (Py): probiotic yoghurt (Nestle Actiplus containing *Lactobacillus acidophilus* cfu/gm 20×10^7, *Bifidobacteria* 5.4×10^7 total useful bacteria 200,000,000)

II) Group (I c): Indian curd *Vita Lactobacillus acidophilus* cfu/gm$\times10^6$, *S. thermophiles* 35×10^4; total useful bacteria 5,350,000

III) Group (UHy): Nestle Actiplus ultra-heated (control) yoghurt

Microbiological Methods

A total of three saliva and plaque samples were obtained. Prior to sampling, subjects were instructed not to eat, drink, or brush their teeth for 1-2 hours, as it could affect results. Therefore, samples were collected between 10:00 am to 2:00 pm. Same banded teeth were selected in every patient for gingival plaque sampling, and they were isolated with cotton rolls and dried. A sterile explorer was carefully applied to buccal sites (cervical area) of the two molars to be banded. Stimulated saliva samples were collected after chewing a paraffin pellet of standard weight and size provided by the manufacturer (Dentocult SM kits) for 1 minute. The subjects were then asked to put two-thirds of the rough surface of the round tipped strip in the mouth and turn it around 10 times on the dorsal surface of the tongue. The strip was then removed by pulling between lightly closed lips to remove the excess saliva. Both square-tipped and round-tipped strips were clipped together, with their smooth surfaces facing each other, placed in the respective culture vial. These vials were then incubated in an upright position at the 37° centigrade for 48 hours, with the cap of each vial one-quarter of a turn open. To make subjects comfortable and accustomed to the sampling procedure, a mock trial was already carried out with wooden and plastic spoons on previous visit. We assessed the plaque and salivary S. mutans scores with a commercially available kit (Strip Mutans, Orion Diagnostica, Espoo, Finland) in accordance with the manufacturer's instructions (Jensen B., Bratithall D, 1989) (8).

After the incubation at the 37° centigrade for 48 hours, the presence of S. mutans was evidenced by dark-blue to light-blue, raised colonies on the rough surface of the strip. Density of the colonies on the rough surface of the round-tipped strip was compared with the interpretation chart in the manufacturer's manual, and accordingly a score of 0-3 was assigned (0, less than 104 CFU/mL, 1, less than 105 CFU/mL, 2, 105-106 CFU/mL, and 3, more than 106 CFU/mL).

A 7-day diet diary of each subject was also recorded as subjects were advised to take regular meals only, and it was also assessed for a total number of sugar exposures.

Statistical Analysis

We used the mean, median, and standard deviation for all bacterial parameters. To estimate the association between time-related variables (bacterial scores at the baseline, after 2 weeks of orthodontic treatment, and after 2 weeks of milk product consumption), the Wilcoxon signed-rank test was used. To see relations between variables, Fishers' exact test was used. A p-value less than 0.05 was considered to be statistically significant.

RESULTS

The follow-up study population comprised of 27 subjects, with 3 subjects denied participation. The sample included 13 (48%) girls and 14 (52%) boys, with 12 (44%) aged 8-12 years and 15 (56%) aged 13-15 years (Table 1).

Table 1. Age distribution of subjects

	Subjects	
Age in Years	Number	Percentage
8 -12	12	44%
13-15	15	56%
Total	27	100%

Table 2. Salivary and plaque Streptococcus mutans scores at the baseline, after 2 weeks of orthodontic treatment and milk product ingestion after intake of Probiotic curd, Indian curd, and ultra-heated yoghurt. Probiotic yoghurt (Py), Indian curd (Ic), and ultra-heated yoghurt (Uhy) group; (A) baseline, (B) after 2 weeks of orthodontic treatment; (C) after milk product ingestion; Sal ms, salivary Streptococci mutans score; Pl ms, plaque *Streptococcus mutans* score
0, <104 CFU/mL; 1, <105 CFU/ml; 2, 105-106 CFU/mL; and 3, >106 CFU/mL

	Milk Product																	
	Probiotic yoghurt (Py) n						Indian curd (Ic) n						Ultra-heated yoghurt (Uti) n					
	A		B		C		A		B		C		A		B		C	
***Streptococcus mutans* score**	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms	Sal ms	Pl ms
0	2	-	-	-	5	2	3	-	-	-	3	3	-	-	-	-	-	1
1	2	-	2	1	4	-	2	3	1	1	1	2	1	1	-	-	-	-
2	4	2	3	4	-	7	3	2	4	6	3	4	3	6	5	8	5	6
3	1	1	4	-	-	-	1	-	4	-	2	-	5	-	3	-	3	-
4		6		4		-		4		2		-		2		-		1

Table 3a. Comparative evaluation (subject-wise) of salivary Streptococci mutans scores (As, at baseline; Bs, after 2 weeks of orthodontic treatment; Cs, 2 weeks after yoghurt consumption)

	MILK PRODUCT					
Streptococcus mutans	Probiotic yoghurt		Indian curd		Ultra-heated yoghurt	
score n=27	As-Cs	Cs-Bs	As-Cs	Cs-Bs	As-Cs	Cs-Bs
Decrease in score	7 p=0.0103*	9 p=0.001*	2	5	1	1
Increase in score	-	-	3	1	1	1
Same score	2	-	4	3	6	6

Table 3b. Comparative evaluation (subject-wise) of plaque Streptococus mutans scores (Ap, at the baseline; Bp, after 2 weeks of orthodontic treatment; Cp, 2 weeks after yoghurt consumption)

	MILK PRODUCT					
Streptococcus mutans	Probiotic yoghurt		Indian curd		Ultra-heated yoghurt	
score n=27	Ap-Cp	Cp-Bp	Ap-Cp	Cp-Bp	Ap-Cp	Cp-Bp
Increase in score	-	1	-	1	-	1
Same score	1	3	2	2	7	6

Salivary and plaque *S. mutans* scores were recorded in each subject from the probiotic yoghurt (Py), Indian curd (Ic), and ultra-heated yoghurt (UHy) groups at the baseline, after 2 weeks of orthodontic treatment and after 2 weeks of specified masked milk product ingestion. The baseline salivary *S. mutans* scores were recorded in children who were planned for orthodontic treatment prior to oral hygiene maintenance, after 2 weeks of orthodontic period, that is, during the wash out period, and during the run-in period of 2 weeks of milk product consumption (Table 2).

Salivary *S. mutans*

At the baseline, the maximum (10) number of subjects had the score of 2 followed by the score of 3 (7) and the scores of 0 and 1 (5 each). After 2 weeks of orthodontic treatment, the maximum (12) number of subjects had the score of 2, followed by the score 3 (11) and score 1 (3) (Table 2), which showed that during orthodontic treatment, there was an increase in the number of salivary S. mutans. Comparing the baseline values versus values after the intake of specified milk product in all the 3 groups, the maximum decrease in the S. mutans score was observed in subjects who consumed probiotic yoghurt, followed by the Indian curd and ultra-heated yoghurt groups (Table 3). Comparing the baseline versus the third reading (2 weeks after milk product consumption), only the probiotic yoghurt results were significant (p=0.014)*; whereas they were nonsignificant for the Indian curd (p=0.581) and ultra-heated yoghurt groups (p=1.000). It shows a significant effect of probiotic yoghurt to reduce the S. mutans count in the saliva, irrespective of low- or high-caries risk groups (Table 2).

When comparing the second (after 2 weeks of orthodontic treatment) and the third reading (2 weeks after milk product ingestion); it was found that probiotic yoghurt (Py) results were highly statistically significant (p=0.006)**; whereas they were nonsignificant in the Indian curd (p=0.068) and ultra-heated yoghurt groups (p=1.000). It shows a highly significant effect of probiotic yoghurt to reduce the S. mutans count in saliva of the high-caries risk group followed by Indian curd when compared with placebo ultra-heated yoghurt (Table 2, 3, 4).

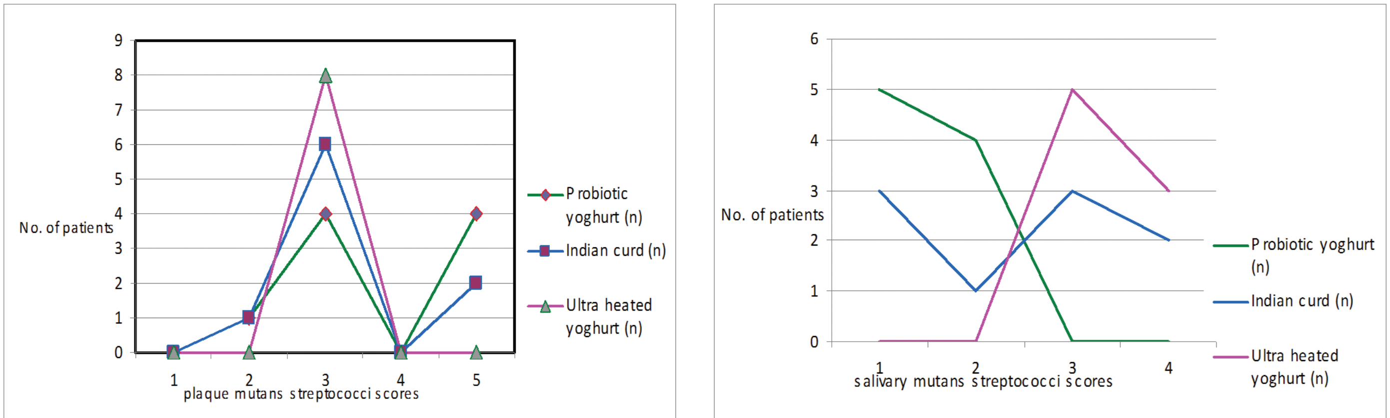

Figure 1. Graphic presentation of the salivary and plaque *Streptococccus mutans* count relation

Table 4. Wilcoxon-signed ranks test

Milk Product Group		2nd reading (Bp)-1st reading (Ap)	3rd reading (Cp)-1st reading (Ap)	3rd reading (Cp)- 2nd reading (Bp)
Indian curd	Z	-0.106[a]	-2.232[a]	-2.058[a]
	P value (2-tailed)	0.915	0.026*	0.040*
Probiotic yoghurt	Z	-1.604[a]	-2.636[a]	-2.049[a]
	P value (2-tailed)	0.109	0.008**	0.040*
Ultraheated yoghurt	Z	-1.414[a]	-1.000[a]	0.000[b]
	P value (2-tailed)	0.157	0.317	1.000

[a]: Based on positive ranks; [b]: The sum of negative ranks equals the sum of positive ranks; [c]: Wilcoxon signed-rank test

During orthodontic treatment, there was an increase in the number of banded tooth plaque associated salivary S. mutans. When comparing the baseline versus the third reading (2 weeks after milk product consumption), probiotic yoghurt showed a highly significant difference (p=0.008)** followed by Indian curd (p=0.026)* and ultra-heated yoghurt group (p=0.317). This shows a significant effect of probiotic yoghurt to reduce the plaque *S. mutans* count associated with banded teeth, irrespective of the low- or high-risk caries group (Figure 1).

Comparing of the second (after 2 weeks of orthodontic treatment) and third reading (after 2 weeks of milk product ingestion) indicated that both probiotic yoghurt and Indian curd groups showed a highly statistically significant difference (p=0.040)*, while the ultra-heated yoghurt group (p=1.00) was nonsignificant. This shows a significant effect of probiotic yoghurt in reducing the associated S. mutans banded tooth count in saliva of high-risk caries group followed by Indian curd when compared with placebo ultra-heated yoghurt (Table 2, 3, 4).

Correlation between the number of sugar exposures with salivary and plaque *S. mutans* scores

Out of 27 subjects, 3 subjects consumed snacks such as toffees, chocolates, Indian sweets (*Gajjak*) between the meals. It was observed that 2 subjects consumed toffees and chocolates once a week. One subject consumed toffees/Indian sweets once a day on all 7 days. The plaque and saliva samples for all these subjects were closely observed. Only one subject consumed sweets daily; even though the correlation between the salivary and plaque S. mutans counts 2 weeks of consuming of a specified milk product, and the number of sugar exposures was nonsignificant in our study.

DISCUSSION

All subjects showed an increase in the *S. mutans* count score after 2 weeks of orthodontic therapy, and half of them reached the highest scores both in the saliva and banded-tooth-associated plaque. This indicates that there is a rapid and definite increase in the caries risk in terms of the *S. mutans* count, even after 2 weeks of orthodontic therapy. Fixed orthodontic therapy should be considered as a definitive threat to oral health in terms of hard-tissue demineralization and caries because of an increased salivary S. mutans count (9). Milk products contain basic nutrients for the growing child; they are also safe for the teeth, with possible beneficial effects on the salivary microbial composition and inhibition of caries development due to their natural content of casein, calcium, and phosphorus (10). A dairy-based vehicle seems to be most promising because of its low cariogenic potential and a high buffer capacity (11). The archetypical probiotic food is yoghurt, and daily consumption of dairy products seems to be the most these are not consistent across species. The LAB abundance in curd increased rapidly at 12h of fermentation at room temperature and declined thereafter (10).

We used probiotic-containing milk products in the second part of our study in these orthodontic subjects with an increased caries risk. The effect of probiotic yoghurt consumption for 2 weeks on subjects undergoing fixed orthodontic therapy was found highly significant in terms of a decrease in the *S. mutans* scores. It shows that the ingestion of probiotic yoghurt can be a highly effective mean to decrease an increased caries risk in orthodontic subjects as far as the count of salivary *S. mutans* is concerned. Probiotic yoghurt shows a significant effect when used in these orthodontic subjects in terms of a decrease in the plaque *S. mutans* count. Reason behind the difference in the probiotic effectivity, that is, its better ability to reduce the salivary *S. mutans* count than the plaque *S. mutans* count, may be the localization of increased caries risk situation, as prophylaxis becomes highly compromised in these local areas adjacent to bands, and more aggressive and locally acting measures to reduce the *S. mutans* numbers will be required (12-14). In the plaque, a statistically significant difference was observed in probiotic yoghurt, when the baseline and third reading (after 2 weeks of milk product ingestion) was made. However, the comparison between the second and third reading revealed that both probiotic yoghurt and Indian curd were equally beneficial. Therefore, it can be concluded that probiotic yoghurt is an effective vehicle in decreasing the *S. mutans* numbers in orthodontic patients, but curd can also be considered beneficial in a developing country like India (15). It has been mentioned in the literature that the benefits of probiotics can be best exploited if started in early childhood, since the displacement of pathogenic bacteria by friendly bacteria can occur easily before a permanent establishment and colonization of microflora occurs (16, 17). The effect of probiotic is better in the oral cavity as it directly interacts with oral epithelium, thus reducing the incidence of caries, gingivitis, and malodor. While in the gut complex ecosystem exit; also, they depend on the colonization factors and resist the effect of peristalsis, which tends to flush out bacteria with food. Only those strains resistant to bile impart beneficial effects in the gut.

Observed changes in salivary microbiota provide evidence to clinicians for recommending probiotics to their patients in addition to "classical" oral hygiene practices and dietary counseling (18-20). Therefore, it can be concluded that the short-term consumption of probiotic-containing dairy products is highly effective in decreasing an increased *S. mutans* count in subjects undergoing fixed orthodontic therapy. Since, our study was a short-term study examining the effectivity of probiotics on the *S. mutans* level in subjects undergoing fixed orthodontic therapy, further long-term research is required to study beneficial effects of probiotics in groups with an increased risk.

CONCLUSION

- Probiotic yoghurt is significantly more effective in the reduction of *S. mutans* in the saliva than in the plaque in association with banded teeth of subjects undergoing orthodontic therapy.
- Indian curd decreases the *S. mutans* count in the plaque and saliva, but less effectively than probiotic yoghurt. Ultra-heated yoghurt does not impart any beneficial effects in reducing the *S. mutans* count in orthodontic patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Maharishi Markandeshwar deemed to be university**.**

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

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - S.G.; Design - S.G.; Supervision - S.G., M.S.; Data Collection and/or Processing - M.S., V.S.; Analysis and /or Interpretation - A.D.; Literature Search - N.J.; Writing Manuscript - M.S, S.G.; Critical Reviews - N.J., A.D.

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

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Original Article

Effects of High-Energy Curing Lights on Time-Dependent Temperature Changes of Pulp Space During Orthodontic Bonding

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ABSTRACT

Objective: The purpose of this study was to assess the temperature changes and cooling times during orthodontic bonding by a light-emitting diode (LED) and plasma arc lights (PAC) in different time and power modes with thermal imaging.

Methods: A total of 100 human permanent upper first premolar teeth were included in the study. Five groups were conducted, 20 teeth each, and different energy outputs of curing lights were used for adhesive polymerization with different exposure times. The temperature changes in the pulp space and cooldown times were measured by a thermal imaging system. A paired t-test, analysis of variance (ANOVA), and Student-Newman-Keuls multiple comparison tests were used for data analysis.

Results: A statistically significant temperature rise was detected with all curing lights ($p<0.05$). The greatest temperature changes were observed in the LED standard mode with 10 seconds of exposure time (6.66±1.98°C) and LED extra power mode with 6 seconds of exposure time (6.50±1.64°C) among groups, while using PAC for 3 seconds created the smallest temperature increase (1.81±0.99°C). An application of the LED extra power mode for 6 seconds exhibited the longest cooldown time (205.91±47.48 seconds), and the shortest cooldown time was detected as 71.30±43.15 seconds with the PAC 3-second application.

Conclusions: LED lights with an increased exposure time induced significant temperature rises, while no PAC light group exceeded the critical threshold value. The exposure time is more important than the energy output level of the light-curing system on temperature increments of the pulp chamber.

Keywords: Orthodontic bonding, dental curing lights, thermal imaging, pulp chamber, temperature change

INTRODUCTION

Light-cured adhesives have become more popular than self-curing resins in recent years for orthodontic bonding because they provide an increased bracket placement and positioning time (1), greater bond strength (1), and easier removal of excess material for some adhesives, also reducing the risk of contamination (2). Various types of curing-light units have been used for orthodontic purposes, such as Quartz tungsten halogen (QTH), light-emitting diode (LED), and plasma arc lights (PAC). The QTH lights have disadvantages, such as a prolonged radiation time and heat generation, and limited lifetime (3). PAC lights, and in particular LEDs, have recently gained popularity because of their shortened curing times.

The intra-pulpal temperature increase has been reported in the literature during composite resin polymerization for different light-curing units (2, 4-6). As the result of the study by Zach and Cohen who investigated the effects of temperature rise on the pulp tissue of primates (7), a 5.5°C temperature increase in the pulp was found to

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Table 1. Power intensity, wavelength, and exposure times of light sources provided by the manufacturer

Groups	n	Definition	Power Intensity (mW/cm²)	Wavelength (nm)	Exposure Time (s)
Group I	20	LED standard mode	1000 mW/cm²	390-480 nm	10
Group II	20	LED extra power mode	3200 mW/cm²	390-480 nm	3
Group III	20	LED extra power mode	3200 mW/cm²	390-480 nm	6
Group IV	20	PAC	1200-1500 mW/cm²	415-520 nm	3
Group V	20	PAC	1200-1500 mW/cm²	415-520 nm	6

LED: light-emitting diode; PAC: plasma arc curing

be the reason of irreversible pulp damage in 15% of the experimental animals. So, these 5.5°C of the intra-pulpal temperature increase were accepted as the threshold value for the irreversible pulp chamber damage in the literature (8).

Studies evaluating the effects of curing lights on temperature increase in the pulp chamber during bracket (1, 2) and buccal tube bonding (9) showed that no light source except QTH with high-light intensity (HQTH) (1) exceeded the critical value of 5.5°C. These studies used various types of thermocouple wires to measure the intra-pulpal temperature rise.

The temperature changes at the entire pulp space during bracket bonding can be also measured with optical thermal imaging systems. This system provides a gradual measurement of temperature changes on the whole pulp area for every second. A major advantage of thermal imaging during light curing is to give information about the cooling time of the pulp space to initial temperature values. Although several studies have evaluated the thermal effects of different curing lights (1, 2, 9), there was no study that revealed the time-dependent temperature changes in the pulp space, and no study existed that conducted the thermal measurements with thermal imaging during orthodontic bonding. Hereby, the purpose of this study was to assess the time-dependent temperature changes during bracket bonding by two recently popular high-energy light sources, LED and PAC, in the different time and power modes with thermal imaging

METHODS

The study was approved by the Ethics Committee of Erciyes University (approval number: 2017/472). The informed consent forms were signed by the patients or their legal guardians. The sample size was determined using a statistical power analysis (G*Power Ver 3.1.9.2, Universität Kiel, Germany), which revealed that 20 specimens in each group would give more than 90% power to detect significant differences (α error=0.05).

A total of non-carious, freshly extracted upper first premolar teeth with intact enamel (no cracks, hypoplastic areas, caries, restorations, or irregularities) were selected. Size, shape, and pulp space dimensions of teeth were examined on digital periapical radiographs using the grid superimposition method with image editing and graphic designing software (Adobe Photoshop CS3, Adobe Systems Inc, San Francisco, CA). According to the results of the radiographic assessment, teeth with abnormally shaped and/or sized pulp chambers were excluded from the study, and excluded teeth were replaced with others that did match the inclusion criteria.

The teeth were kept in thymol solution (0.1%) which was refreshed weekly for inhibition of microorganism growth. The teeth were sectioned into two halves (buccal and palatal) along the long axis. Remnant pulpal tissues were removed from the pulp cavity using a spoon excavator and NaOCl solution. Each buccal half of the tooth was embedded in acrylic resin while exposing 2-3 mm of the root from the cementoenamel junction and the crown. The buccal surfaces of the teeth were polished with non-fluoridated pumice and cleaned with water.

Bonding Procedure

Each tooth was etched with 37% phosphoric acid gel (Prime Dental Products, Chicago, Illinois, USA) for 30 seconds, rinsed for 30 seconds, and dried until the frosty white etched area was observed. Sealant (Transbond XT light cure adhesive primer, 3M Unitek, Monrovia, Calif., USA) was applied on the etched enamel and cured for 10 seconds with LED light (standard mode: 1000 mW/ cm², 390-480 nm, Valo ortho cordless curing light, South Jordan, USA). Subsequently, stainless steel brackets (American Orthodontics, 0.018 Roth Mini/Master Series, Sheboygan, USA) with Transbond XT adhesive composite (3M Unitek, Monrovia, Calif., USA) on the mesh base were fully seated into position using an intraoral gage to deliver a standardized force of 250 cN for 5 seconds.

Curing Procedure

Two different light resources, LED light (Valo ortho cordless curing light, South Jordan, USA) and plasma arc light (American Dental Technologies, Inc., San Carlos, California, USA), with various power and exposure times were investigated in this study (Table 1).

Group I: Twenty samples were cured with the LED light source (Valo ortho cordless curing light, South Jordan, USA) at the standard mode (SM), which has the power intensity of 1000 mW/cm² and a wavelength of 390-480 nm for 10 seconds.

Group II: Twenty samples were exposed to the same LED light source at the extra power mode (EPM), which has the power intensity of 3200 mW/cm² and a wavelength of 390-480 nm for 3 seconds.

Group III: Twenty samples were exposed to the same LED-EPM light (the power intensity of 3200 mW/cm² and a wavelength of 390-480 nm) for 6 seconds.

Figure 1. Thermal imaging of sample teeth from a 15 cm distance

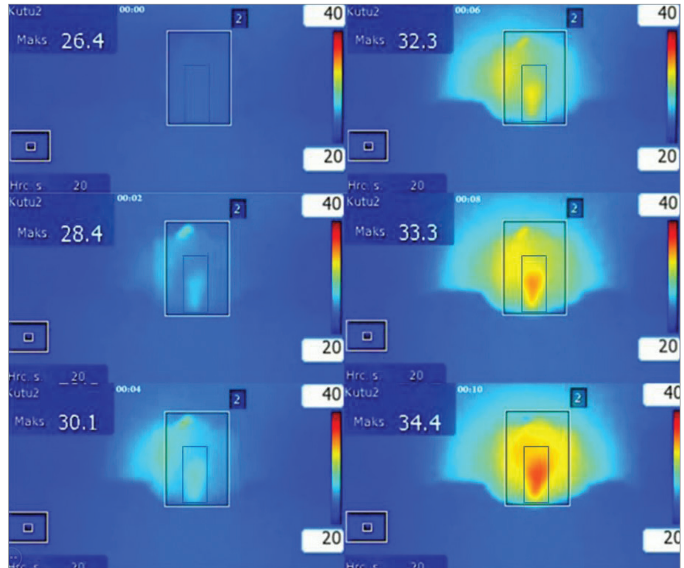

Figure 2. Thermal imaging of a sample tooth during polymerization. The temperature increased from 26.4°C to 34.4°C

Group IV: A PAC light source (American Dental Technologies, Inc., San Carlos, California, USA), which has the power intensity of 1200-1500 mW/cm^2 and a wavelength of 415-520 nm, was used for curing of 20 samples for 3 seconds.

Group V: The same PAC light source applied in Group IV was applied on 20 samples for 6 seconds.

The light outputs of the LED curing units were checked before the use by the manufacturer. The distance of the light-guiding tip to brackets was kept at the closest distance for all specimens, and the tip was angulated 90 degrees to the bracket on each tooth. So, the light beam direction was adjusted perpendicularly to the bracket surface.

Thermal Measurement

The temperature changes during and after bonding were recorded with a FLIR E60 thermal imaging camera (Extech Instruments Corporation, Waltham, MA) and its own software. The resolution of the camera was 320×240 pixels, and the field of view was 25°×19°. The camera was located 15 cm away from the sample blocks, which were fixed with handles (Figure 1) for the standardization of the thermal measurements and recordings.

The experiment was carried out in a special room with controlled environmental conditions (relative humidity, 44±5%; ambient temperature, 26±0.9°C; air flow, <0.5 m/s). Although the same distance between the camera and specimens was calibrated before all measurements, the focus of objective was checked manually for the best image. The temperature window was adjusted to 20°C minimally and 40°C maximally (Figure 2).

Recording was started 2 seconds before polymerization. Changes in the temperature of the pulp chamber during bonding and the duration for returning of the highest temperature values to the initial degrees were recorded, for all specimens. Temperature changes were calculated by subtracting the initial temperature from the highest temperature value. An additional 5.5°C to the initial temperature degrees was accepted as the critical temperature threshold value. The time needed for cooling of the pulp chamber to the critical temperature threshold (critical cooling time) and to the initial temperature degree (cooling time) was also calculated.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Science software (SPSS version 20.0, IBCM Corp.; Armonk, NY, USA). All parameters were found to be normally distributed after the Shapiro-Wilk test, and parametric tests were used for the temperature and time changes analyses. The mean and standard deviation of the temperature difference (TD), cooling time (CT), and critical cooling-time changes (CCT) were calculated. Temperature changes were assessed using a paired t-test. The analysis of variance (ANOVA) test and the Student-Newman-Keuls method were used for comparisons of all parameters between groups. A $p<0.05$ was considered statistically significant.

Method Error

All measurements were repeated for 10 samples of each group by the same investigator a month later. The reliability of measurements was calculated by the Cronbach alpha reliability test. Reliability coefficients were found to yield a sufficient reliability for both temperature (0.982-0.998) and time (0.919-0.956) measurements.

RESULTS

All photo-polymerization applications created significant temperature changes ($p<0.05$). All LED groups showed greater temperature increases than the PAC groups. The highest temperature changes were observed in LED-SM with a 10-second exposure time (6.66±1.98°C) and LED-EPM with a 6-second exposure time (6.50±1.64°C) among groups, while using PAC for 3 seconds created the lowest temperature rise (1.81±0.99°C, Table 2).

Table 2. Comparison of initial and final temperature changes with different light-curing sources

	T0		T1		T1-T0		
Groups	Mean	SD	Mean	SD	Mean	SD	p
LED 10 s	26.08	0.80	32.74	2.25	6.66	1.98	<0.05
LED 3 s	26.38	1.87	30.60	3.40	4.22	1.90	<0.05
LED 6 s	26.42	1.58	32.96	1.96	6.54	1.64	<0.05
PAC 3 s	26.65	1.12	28.46	2.11	1.81	0.99	<0.05
PAC 6 s	26.70	1.56	31.48	3.20	4.78	2.08	<0.05

LED: light-emitting diode; PAC: plasma arc curing; SD: standard deviation

Table 3. Comparison of temperature difference, time changes, and critical time changes between groups

	LED 10 s		LED 3 s		LED 6 s		PAC 3 s		PAC 6 s		
Groups	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p
TD	6.66[a]	1.98	4.22[b]	1.90	6.50[a]	1.64	1.81[c]	0.99	4.78[b]	2.08	<0.05
CT	196.80[x]	77.19	152.00[y]	38.14	205.91[x]	47.48	71.30[z]	43.15	165.67[x]	64.34	<0.05
CCT	28.67[α]	10.56	-	-	20.94[β]	11.46	-	-	18.67[β]	7.03	<0.05

TD: temperature difference; CT: cooling time; CCT: critical cooling time; SD: standard deviation
*Groups with different letters are significantly different from each other

LED-EPM with a 6-second exposure time (205.91±47.48 seconds) and LED-SM with a 10 seconds exposure time (196.80±77.19 seconds) displayed the longest CT to initial temperature, and parallel with the lowest temperature rise, the PAC group with 3 seconds of exposure time showed the shortest cooldown time (71.30±43.15 seconds) (Table 3).

Only 16 samples in Group I, 16 samples in Group III, and 6 samples in Group V exhibited a temperature rise of ≥5.5°C. Therefore, the CCT comparison was performed only among the Groups I, III, and V, which used high-exposure times for curing (Table 3). In the LE-SM group with a 10-second curing time, it took the longest to return to the critical threshold value (28.67±10.56 seconds), followed by LED-EPM and PAC groups with 6-second curing times (20.94±11.46 and 18.67±7.03 seconds, respectively).

DISCUSSION

The use of light-cured composites for orthodontic bracket bonding has increased in recent years. The QTH lights and HQTH have been widely used, but other technologies have come up with an even shorter irradiation duration (1). PAC and LED units are the most popular light resources nowadays, allowing for polymerization times as short as 3 seconds. Other advantages of LED lights compared to QTH, HQTH, and PAC lights are cordless, smaller, and lighter features; an increased lifetime; and no need for a noisy cooling fan (1). Although few studies exist in the literature about the thermal effects of curing lights on the pulp chamber during orthodontic bonding (1, 2, 9), to the best of our knowledge, no data have been presented yet on the temperature changes in the pulp space during curing of orthodontic adhesives with high-energy light sources.

Beside the importance of clarification of the thermal side effects of high-energy light curing, the cooldown duration of the teeth is also important to protect the teeth from possible heat-related damages during the orthodontic bonding. Therefore, evaluation of the time-dependent temperature changes during different curing procedures would provide valuable information in terms of reducing the possible harmful effects of consecutive dental application on the same tooth by giving information about an appropriate waiting time. As the result of a literature review, there were no data regarding time-dependent temperature changes during different bonding procedures. Thus, the purpose of this study was to evaluate the time-dependent thermal effects of popular LED and PAC curing lights with high-energy outputs in the pulp chamber.

A standardized 250 cN of force measured with an intraoral gage for 5 seconds was applied during the bracket placement to constitute a uniform adhesive thickness between the bracket base and the teeth in all samples. The effects of distance between the light-guiding tip and composite on the temperature rise were investigated, and a significant temperature decline was found when the distance of the light-guiding tip increased (10, 11). Therefore, the light-guiding tip was kept at the closest distance to brackets, not only to mimic the clinical conditions during bracket bonding, but also to measure the maximum heat changes transferred from the bracket surface to the pulpal site of the dentin effectively.

To the best of our knowledge, no accurate data exist in the literature that evaluated the possible harmful effects of heat-generating dental procedures on the tolerance limits of the human pulp tissue, so the maximum temperature without irreversible damage on the human pulp tissues is still unknown (12). Many studies have used the results by Zach and Cohen (7), derived from primate teeth as threshold values due to lack of such data. Zach and Cohen (7) investigated detrimental effects of heat on pulp tissues of primates and reported that a 5.5°C temperature increase in the pulp caused irreversible damage in 15% of macaque rhesus monkeys, an 11°C temperature increase led to irreversible alterations in the pulp of 60% of animals, and a 16.5°C temperature increase resulted in an irreversible necrotic response of the pulp tissue for all animals. Thus, a 5.5°C temperature rise in the pulp chamber has been accepted as a threshold value in terms of beginning of the pulp damage, in our study. Two groups, LED-SM with a 10-second exposure time and LED-EPM with a 6-second exposure time exceeded the critical 5.5°C threshold value, while 3 seconds of the LED-EPM application resulted in a 4.22±1.90°C temperature rise. However, both PAC groups did not exceed the critical value for pulpal injury. The PAC group with a 3-second exposure time showed the least temperature rise among the study groups, while using 6 seconds of PAC light increased the temperature for 4.78±2.08 °C.

The individual recovery capacity of the pulp is another important factor for the level of thermal injury (12). Kraut et al. (13) histologically found no pulpal inflammation or necrosis 2 weeks after debonding the ceramic brackets electrothermally, while Jost-Brinkmann et al. (14) showed a localized pulpal damage in several teeth with histological investigation of the human pulp *in vivo*, where more than one heating cycle was achieved following thermal debonding of ceramic brackets. The reduced recovery capacity of the pulp tissues due to depressed pulpal respiration after orthodontic force application was also reported (12, 15, 16). So, a temperature rise after orthodontic bonding with curing lights can threaten the vitality of the pulpal tissues (12).

Two factors are important for the temperature increment during polymerization of resin composites with light activation: absorbed energy as a result of irradiation and exothermic polymerization process (1). Thus, increased irradiation due to high-energy output lights was considered a risk factor for pulpal damage (1, 2, 17, 18). Hannig and Bott (5) investigated the temperature changes of pulp chamber in a Class II restorative cavity in a molar tooth, leaving a dentin layer 1 mm in thickness between the pulp chamber and the proximal cavity wall, and they found a greater temperature increase in curing units with a high-energy output (PAC) than in conventional or lower energy output lights. On the other hand, the importance of the exposure time rather than a high-energy output has also been presented in the orthodontic literature (1, 2, 9). The contrary findings between restorative and orthodontic studies evaluating the heat changes during light curing can be attributed to the differences in orthodontic and restorative bonding. In orthodontic bonding, brackets are placed onto the enamel without any connection to the dentine, but in restorative dentistry, the resins are commonly applied to dentine with a thin layer to pulpal tissues, and heat can be transferred to the pulpal area more easily (9). In addition, in restorative procedures, light energy is applied directly on the composite, and it can reach the required energy level rapidly in the resin region because it does not encounter an obstacle such as bracket. However, during orthodontic bonding, the bracket thickness must be passed by the light photons to reach to the resin. While some of the light energy is absorbed by the metal through the bracket thickness, the duration of curing may be getting importance to have enough energy accumulation for polymerization in the resin zone.

None of the previous orthodontic bonding studies, except a HQTH group (6.85±2.44°C) with 40 seconds of curing time in the study by Malkoç et al. (1), showed a temperature rise exceeding the critical value of 5.5°C. The studies showing the thermal changes during orthodontic bonding with LED lights used the power intensity values 400-1100 mW/cm^2 and PAC lights 1200-1850 mW/cm^2 (1,2,9). The power intensity values of the LED groups of this study (1000-3200 mW/cm^2) were higher than in previous studies in the literature, and the energy outputs of our PAC groups (1200-1500 mW/cm^2) were similar to other studies. Therefore, higher temperature changes were an expected result of higher energy output. The highest temperature rise (mean, 6.66±1.98 °C) was found in the LED group with 10 seconds of irradiation time in our study. Moreover, LED-EPM group with 3 seconds of exposure time and 3200 mW/cm^2 power intensity value showed 4.22±1.90°C temperature rise, but when the exposure time increased to 6 seconds, the 5.5°C of critical value was exceeded. Similar finding was also observed for the PAC groups: the exposure time and temperature rise showed a positive correlation, but no PAC group exceeded 5.5°C. On the other hand, Uzel et al. (2) found a significantly higher temperature increase when the tip of the light unit positioned at the surface of the teeth was more distant than 10 mm, and it showed higher heat changes in mandibular incisors than the premolar teeth. So, modifications of the light-guide tip distance and preference of short exposure duration during light curing on teeth that have thin enamel and dentin just like mandibular incisors may provide a smaller temperature increase in pulpal tissues.

The results of the literature review showed that there were no data regarding the cooling of teeth after orthodontic bonding. CT findings of our study revealed parallel findings with the exposure time-heating of the pulp chamber relationship. When the exposure time increased, CT and CCT also increased. Nearly 3 minutes were needed to cool down the initial temperature values in groups with an increased CT. Cummings et al. (12) showed a 16.2ºC temperature increase on the pulpal wall during the debonding of ceramic brackets and found that the temperature returned to normal values within 2-3 minutes. So, the authors recommended waiting for 5 minutes of the cooling period before the next heating application (12). The LED-SM group with a 10-second exposure time showed the highest CCT time (28.67±10.56 seconds), continued by 6 seconds of the LED-EPM and PAC groups (20.94±11.46 and 18.67±7.03 seconds, respectively). These results also showed that there was a relationship between the temperature change and CT. This outcome indicates not only the importance of curing time during the orthodontic bracket bonding (19), but also to achieve the light curing of teeth, without irradiating the neighboring teeth during bonding to give enough time to cooldown. The time-dependent temperature change results of this study may be also beneficial to establish a time-related bonding protocol.

As a limitation of our study, *in vitro* conditions cannot ideally reflect the *in vivo* environment. A lot of factors such as blood circulation of the pulp chamber, fluid flow of dentin tubules, age of the patient, periodontal tissues, and saliva can change or reduce the heat transfer to the pulpal area and CT of teeth (1,9,20). But histological human studies are needed both for evaluating the exact effects of heat changes to pulpal tissues and for determining the thermal thresholds of the human pulp.

CONCLUSION

- LED lights with an increased exposure time induced significant temperature rises, and they exceeded 5.5°C of the critical threshold value on the pulpal wall, while the critical threshold value was not exceeded in any of the PAC light groups.
- An increased exposure time during orthodontic bonding also increased the CT of the pulpal wall to both initial and critical threshold temperature values.
- Although no data exist with regard to thermal effects of curing lights on human pulpal tissues, the clinicians should be careful during the orthodontic bonding using curing lights that have increased exposure times, because of a decreased recovery capacity of pulpal tissues due to the orthodontic force.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Research Ethics Committee of Erciyes University (Approval Date: October 13, 2017; Decision No: 2017/472).

Informed Consent: Written informed consent was obtained from the patients or their legal guardians.

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Original Article

Comparison of the Shear Bond Strength of Metal Orthodontic Brackets Bonded to Long-term Water-aged and Fresh Porcelain and Composite Surfaces

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ABSTRACT

Objective: The aim of the present study was to compare the shear bond strength (SBS) of metal orthodontic brackets bonded to long-term water-aged and fresh porcelain and composite surfaces.

Methods: One porcelain (Vitadur Alpha (VA)) and three composite (Filtek Ultimate (FU), Tetric EvoCeram (TEC), and Gradia Direct Anterior (GDA)) materials were evaluated in the present study. First, 10 discs from each material were prepared and subjected to the aging procedure for 5 years. Then, for comparison, another 10 discs from each material were prepared as fresh surfaces and stored in distilled water for 24 h. Metal brackets were bonded to the prepared disc surfaces, and after being stored in water for 24 h, they were subjected to shear bond test using a universal testing machine. Adhesive remnant index (ARI) scores were obtained by examining the disc surfaces under a stereomicroscope at 10× magnification. Kruskal-Wallis test was used to compare the aged and fresh groups.

Results: Although the difference between the SBS between the aged and fresh groups with VA, FU, and TEC was not significant, the SBS was significantly higher in the fresh group with GDA. With regard to ARI scores, there was no significant difference between the aged and fresh groups with FU and GDA, whereas the ARI scores of the aged groups with VA and TEC were higher.

Conclusion: It was concluded that the aged restoration materials have a distinctive influence on the SBS of metal orthodontic brackets.

Keywords: Aging, porcelain, composite, bond strength, metal brackets

INTRODUCTION

The increase in the number of adult patients receiving orthodontic treatment presents new problems to the orthodontist (1). Inadequacy of the bond strength between the orthodontic attachments and teeth or restorations to withstand orthodontic forces will lead to low success rate with adverse consequences on the cost and duration of orthodontic treatment, efficiency of appliance, and patient comfort (2, 3). The presence of amalgam, composite, and porcelain restorations in the adult dentition causes difficulties in bonding of orthodontic attachments and in obtaining adequate bond strength (3, 4). Among these, porcelain and composite restorations are preferred more than amalgam due to their aesthetic appearance (4, 5).

While the porcelain materials, which have an inert structure, do not change very much in the oral environment, composite materials suffer degradation due to mechanical and chemical interactions (1, 5). The chemical bonding of a composite resin to another composite resin surface is enabled by the unreactive methacrylate groups, which are found in the oxygen-inhibited layer of the non-polymerized resin (4, 6). However, the reduction of these unreactive methacrylate groups with time and the intervention of instruments for polishing of composites

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reduce the bond strength between aged and fresh composite resins (6, 7). For this reason, the aging of restorations is very important with regard to orthodontic bonding.

The aging process is aimed to reproduce the hydrolytic degradation that occurs in the resin matrix and the silane-coated inorganic fillers formed under oral environment conditions (7). Although there is no standardized simulation method for aging, storage in liquid media, such as citric acid, ethanol, and water, immersion in boiling water, thermocycling, accelerated aging, and artificial saliva have been used (7, 8). In addition, studies evaluating the bond strength of aged restorations have reported that the duration of aging and the material itself are more important than the storage medium (9-11).

The aim of the present study was to compare the shear bond strength (SBS) of metal orthodontic brackets bonded to long-term water-aged and fresh porcelain and composite surfaces. To the best of our knowledge, there are no studies in the literature that have compared the SBS of metal orthodontic brackets bonded to aged and fresh porcelain and composite surfaces. The null hypothesis is that the aging processes of porcelain and composite surfaces have no effect on SBS of metal orthodontic brackets.

METHODS

Vitadur Alpha (VA) porcelain and nanofilled Filtek Ultimate (FU), nanohybrid Tetric EvoCeram (TEC), and microhybrid Gradia Direct Anterior (GDA) composites were evaluated in the present study. The details of the porcelain and composite materials used in the study are shown in Table 1. A stainless-steel metal mold with 2 mm long internal concavity with 1 cm diameter was used to prepare the porcelain and composite discs.

Porcelain disc preparation: VA porcelain discs were prepared by mixing 0.5 g of ceramic powder and 0.18 g of model liquid until a homogeneous slurry was obtained in accordance with the manufacturer's instructions. The obtained slurry was poured into the stainless-steel mold on a vibrator to avoid any residual air inside. Then, in the dental porcelain furnace (Centurion Q200; Ney, Yucaipa, CA, USA), the following baking cycle was performed: the slurry was dried at 600 °C for 1 min, heated to 960 °C with full vacuum at 60 °C/min, kept at 960 °C for 1 min, and then removed from the furnace and allowed to cool down at room temperature.

Composite disc preparation: The composite discs were prepared by putting the resin into the metal mold by placing the polyester matrix bands on the top and at the bottom and compressing between these two lamellae. Then, using an Elipar FreeLight S10 device (3M ESPE Dental Products, St. Paul, MN, USA), the resin was polymerized in a single direction for 20 s. After every five polymerization processes, the intensity of the light source was controlled by the intensity meter on the device. All porcelain and composite discs that were removed from the metal mold were subjected to surface treatment using 600, 800, 1000, and 1200 grit abrasive paper (Atlas, Kocaeli, Turkey), respectively.

At first, 10 discs were prepared from each material (n=40) and subjected to the aging procedure in distilled water for 5 years. Then, before initiating the study, 10 new discs were prepared from each material and stored in distilled water for 24 h for comparison.

Bracket Bonding Procedures

Porcelain disc surface preparation: The porcelain disc surfaces were conditioned with 9.6% hydrofluoric acid (Ultradent Products, South Jordan, UT, USA) for 60 s, then washed with water for 60 s, and dried with oil-free air spray (5).

Composite disc surface preparation: The composite disc surfaces were conditioned with 37% phosphoric acid (Condicionador Dental Gel; Dentsply, Rio de Janeiro, Brazil) for 30 s, then washed with water for 30 s, and dried with oil-free air spray (12).

Thereafter, 0.018-inch stainless steel lower incisor brackets (Gemini Roth System; 3M Unitek, Monrovia, CA, USA) were applied to the middle of the porcelain and composite disc surfaces using orthodontic primer and adhesive (Transbond XT; 3M Unitek). During bonding, to obtain a uniform adhesive thickness, each bracket was subjected to 300 g of force using a force gauge (Correx Co., Bern, Switzerland) for 10 s (13). A scaler was used to remove the excess resin overflow from the bracket base. Adhesives were polymerized using a LED light source (Elipar FreeLight 2; 3M ESPE) for a total of 40 s, with 10 s for each of the mesial, distal, occlusal, and gingival surfaces.

Table 1. Materials used in the present study

Materials	Manufacturer	Material group code	Organic matrix	Fillers
Vitadur Alpha	Vita Zahnfabric, Bad Säckingen, Germany	Feldispatic ceramic	-	-
Filtek Ultimate	3M ESPE, St. Paul, MN, USA	Nanofilled composite	Bis-GMA, UDMA, Bis-EMA, TEGDMA	20 nm silica filler, 4-11 nm zirconia filler, zirconia/silica cluster filler 78.5% weight or 63.3% volume
Tetric EvoCeram	Ivoclar Vivadent AG, Schaan, Liechtenstein	Nanohybrid composite	Bis-GMA, UDMA, Bis-EMA	Barium glass, ytterbium-trifluoride, mixed oxide, and copolymers 75%-76% weight or 53%-55% volume
Gradia Direct Anterior	GC Co., Tokyo, Japan	Microhybrid composite	UDMA, dimethacryate comonomers	Fumed silica, prepolymerized filler, silica and/or fluoroaluminosilicate glass, 73% weight

The discs were embedded into 20 mm×10 mm×10 mm polymethyl methacrylate blocks (Meliodent; Heraeus Kulzer, Hanau, Germany), with the bracket bases placed parallel to the ground. All specimens were stored in 37±2 °C distilled water for 24 h.

Bracket Debonding Procedures

The SBS was measured using a universal testing device (Autograph AGS-X, Shimadzu, Japan), where the value of the applied force is recorded to the electronic display of the device in Newtons (N). The crosshead speed of the device was set to 1 mm/min (14). The direction of the debonding force was applied to the ligature groove parallel to the bracket base (Figure 1). The force required to dislodge the bracket was recorded in N and converted to megapascals (MPa) using the following equation: Shear force (MPa)=Debonding force (N)/(W×H) (mm^2), where W is the width of the bracket base, and H is the height of the bracket base (1 Mpa=1 N/m^2). A digital caliper was used to determine the bracket base area, which was found to be 10 mm^2.

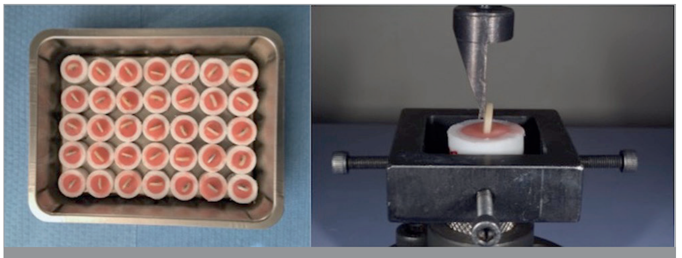

Figure 1. Shear bond testing of porcelain and composite discs embedded in polymethyl methacrylate blocks

Determination of Fracture Sites

After debonding, all disc surfaces were examined under a stereomicroscope at 10× magnification. The remaining residual adhesives on the disc surfaces were evaluated by the adhesive remnant index (ARI) defined by Artun and Bergland in 1984 (15). ARI scores range between 0 and 3, with 0 indicating no adhesive remains on the disc surfaces; 1 indicating <50% of adhesive remains on the disc surfaces; 2 indicating >50% of adhesive remains on the disc surfaces; and 3 indicating that the entire adhesive remains on the disc surfaces.

Statistical Analysis

Descriptive statistics for studied variables (characteristics) were presented as mean, standard deviation, median, minimum, and maximum values. Normality test was performed, and violation of the normality assumption was detected. Kruskal-Wallis test was used to compare the aged and fresh groups with regard to SBS. Dunn's multiple comparison test was used to determine different groups. Chi-square or Fisher's exact tests were used to compare the aged and fresh groups with regard to ARI scores. The significance level was set to 5%. Statistical Package for Social Sciences program version 13 (SPSS Inc.; Chicago, IL, USA) was used for all statistical computations.

RESULTS

Comparisons of SBSs in porcelain discs: The mean SBS values of metal orthodontic brackets in the aged and fresh VA porcelain

Table 2. Shear bond strength of metal orthodontic brackets bonded to aged and fresh porcelain and composite disc surfaces

		Sample size (n)	Median	Mean±SD	Minimum	Maximum
Vitadur Alpha	Aging	10	5.18	6.37±2.84d*	4.00	12.05
	Fresh	10	6.04	8.06±4.72d	3.67	16.79
Filtek Ultimate	Aging	10	10.06	9.88±2.46c	5.55	13.34
	Fresh	10	8.89	10.85±3.11c	6.24	14.55
Tetric EvoCeram	Aging	10	15.11	13.63±5.55bc	4.14	21.66
	Fresh	10	17.70	17.02±4.15ab	10.31	24.46
Gradia Direct Anterior	Aging	10	14.95	15.01±3.67b	9.08	20.55
	Fresh	10	18.50	19.09±5.33a	10.38	26.92
Total		80	12.05	12.34±5.81	3.67	26.92

*Different letters in lower cases represent statistically significant differences among the groups (p<0.05)

Table 3. Distribution of adhesive remnant index (ARI) scores among the aged and fresh groups

		ARI scores				
		0	1	2	3	p
Vitadur Alpha	Aged	4	6	0	0	0.001
	Fresh	10	0	0	0	
Filtek Ultimate	Aged	6	4	0	0	0.999
	Fresh	6	4	0	0	
Tetric EvoCeram	Aged	0	1	9	0	0.001
	Fresh	7	3	0	0	
Gradia Direct Anterior	Aged	5	5	0	0	0.361
	Fresh	7	3	0	0	

Chi-square or Fisher's exact tests (p<0.05) groups were 6.37±2.84 and 8.06±4.72 MPa, respectively. The difference between the aged and fresh groups was not statistically significant (Table 2).

Comparisons of SBSs in composite discs: The mean SBS values of metal orthodontic brackets in the aged and fresh groups were 9.18±2.46 and 10.35±3.11 MPa for FU composite, 13.63±5.55 and 17.02±4.15 MPa for TEC composite, and 15.01±3.67 and 19.09±5.33 MPa for GDA composite, respectively. Although the difference between the mean SBS of metal orthodontic brackets in the aged and fresh groups with FU and TEC composites was not statistically significant, the mean SBS of the fresh group with GDA composite was significantly higher. However, the differences between the mean SBS of metal orthodontic brackets with fresh GDA composite and fresh TEC composite and between the mean SBS of metal orthodontic brackets with aged GDA composite and aged and fresh TEC composites were not statistically significant (Table 2).

The results also show that the mean SBS of metal orthodontic brackets bonded to composite discs was higher than that of the porcelain discs.

ARI scores of porcelain discs: The ARI scores of VA porcelain were significantly higher in the aged group. Intergroup comparison showed that for VA porcelain, in the aged group, four samples had an ARI score of 0, and six samples had an ARI score of 1, and all samples in the fresh group had 0 (Table 3).

ARI scores of composite discs: No significant difference was found between the ARI scores of the aged and fresh groups with FU and GDA composites, whereas the ARI score of the aged group with Tetric EvoCeram composite was higher. Intergroup comparison showed that for FU composite, six samples in the aged group had an ARI score of 0, and four samples in the fresh group had an ARI score of 1. For Tetric EvoCeram composite, one sample had 1 and nine samples had 2 in the aged group, whereas seven samples had 0 and three samples had 1 in the fresh group. For GDA composite, five samples had 0 and five samples had 1 in the aged group, whereas seven samples had 0 and three samples had 1 in the fresh group (Table 3).

DISCUSSION

Dental restorations age in the long term due to the humid environment inside the mouth, since they become water-saturated and their free radical activity gradually dies off (1). The bond strengths of the aged materials decrease due to the hydrolytic degradation of the interface components and significant reduction in mechanical properties (16). In addition, the duration of aging and the material itself have a decisive effect on the decrease in bond strength (10, 11, 17). In this context, the aim of the present study was to compare the SBS of metal orthodontic brackets bonded to aged and fresh porcelain (feldspathic ceramic) and composite (nanofilled, nanohybrid, and microhybrid) surfaces.

In the present study, storage in distilled water, a commonly used aging technique, was used as water behaves similar to the liquids that usually exist in the mouth and constantly interact with the teeth and restorations (11, 16, 18). Furthermore, since the follow-up periods in prosthetic and restorative studies were between 3 and 22 years for composite restorations (19) and a minimum of 5 years for porcelain restorations (20), the duration of aging in our study was determined as the minimum follow-up period of 5 years.

To provide good adhesion and sustain the forces arising from mastication and orthodontic mechanotherapy, a minimum bond strength of 5-10 Mpa is recommended (21). In addition, extremely high bond strengths (40-50 MPa) should be avoided as they may harm the enamel due to the application of high debonding forces during or at the end of the treatment (22). It is assumed that the acceptable SBSs should be between 5 MPa and 50 MPa, even if the limits are within theoretical parameters. The results of the present study reveal that the mean SBS values of metal orthodontic brackets in the aged and fresh groups were between 6.37±2.84 and 19.09±5.33 MPa for porcelain and composite discs, respectively, and these values were within the acceptable limits. The results also show that the SBS of metal orthodontic brackets bonded to composite discs was higher than those of porcelain discs.

Owing to their high translucency, feldspathic porcelains are relatively aesthetic and are frequently used (23, 24). A number of studies have been published to evaluate the SBS of metal orthodontic brackets bonded to fresh feldspathic porcelain discs (Vitadur Alpha; Vita Zahnfabrik, Bad Säckingen, Germany) that were subjected to different surface treatments using Transbond XT primer and adhesive (Transbond XT). Of these studies, Türk et al. (24) reported that the mean SBS of metal orthodontic brackets bonded to 12 feldspathic porcelain discs that underwent surface treatment with 9.6% hydrofluoric acid (Porcelain Etch Gel; Pulpdent, Watertown, MA, USA) and silane agent (Bond Enhancer; Pulpdent) is 5.39±2.59 MPa. Yadav et al. (25) stated that the mean SBS of metal orthodontic brackets bonded to 20 feldspathic porcelain discs that underwent surface treatment with 9.5% hydrofluoric acid (Ultradent) and silane agent (Kuraray Co., Osaka, Japan) is 9.9±2.7 MPa. Abdelnaby (26) determined that the mean SBS of metal orthodontic brackets bonded to 25 feldspathic porcelain discs that were subjected to surface treatment with 9.6% hydrofluoric acid (Pulpdent) and resin-based primer (Embrace First-Coat) is 5.48±1.03 MPa. In addition, Buyuk et al. (5) indicated that the mean SBS of metal orthodontic brackets bonded to 10 feldspathic porcelain discs that were subjected to surface treatment with only 9.6% hydrofluoric acid (Ultradent) is 6.36±2.19 MPa. Consistent with these results, in our study, the mean SBS values of metal orthodontic brackets bonded to aged and fresh feldspathic porcelain discs were 6.37±2.84 and 8.06±4.72 MPa, respectively.

To our knowledge, no study in the literature has evaluated the SBS of metal orthodontic brackets bonded to aged feldspathic porcelain discs and compared the SBS of metal orthodontic brackets bonded to the aged and fresh groups. In the present study, no significant difference was found between the aged and fresh groups; therefore, the null hypothesis for porcelain surfaces was accepted.

Nanofilled composites have been produced as universal restorative materials, and their strength and aesthetic properties allow the clinicians to use it for both anterior and posterior restorations (17, 27). A limited number of studies evaluated the SBS of metal orthodontic brackets bonded to aged and fresh nanofilled composite discs (Filtek™ Supreme XT; 3M ESPE) on which Transbond XT primer and adhesive (Transbond XT) were applied. Among these, Bayram et al. (1) stated that the mean SBS of metal orthodontic brackets bonded to 15 nanofilled composite discs that were aged with an accelerated process involving surface treatment with 38% phosphoric acid (Pulpdent) is 3.71±1.22 MPa. Viwattanatipa et al. (27) reported that the mean SBS of metal orthodontic brackets bonded to 32 fresh composite discs that were subjected to surface treatment with 37% phosphoric acid (3M ESPE Dental Products) and plastic conditioner agent (Reliance Orthodontic Product Inc.) is 4.03±1.6 MPa. In another study, it was found that the mean SBS of upper molar tubes bonded to 31 composite discs stored in deionized water for 1 month and were subjected to surface treatment with 9.6% hydrofluoric acid, plastic conditioner agent (Reliance Orthodontic Product Inc.), and unite adhesive (3M Unitek) was 6.87±4.58 MPa (28). To the best of our knowledge, there are no studies in the literature that have compared the SBS of metal orthodontic brackets bonded to aged and fresh nanofilled composite discs. In the present study, the mean SBS of metal orthodontic brackets bonded to aged and fresh nanofilled composite discs were 9.18±2.46 and 10.35±3.11 MPa, respectively, and these values were higher than the results reported in the current studies on this subject. Furthermore, no significant difference was found between the aged and fresh groups.

Nanohybrid composites contain a range of macrofillers and microfillers in different sizes, which occupy the spaces between the larger particles and shorten the particle space (10). In studies evaluating the SBS of metal orthodontic brackets bonded to different nanohybrid composites, different results and different aging procedures were reported. Among these, Demirtas et al. (12) used thermocycling for aging and stated that the mean SBS of metal orthodontic brackets bonded to 40 nanohybrid composite discs (Filtek Z550; 3M ESPE) with a surface treatment of 37% phosphoric acid (Pulpdent) and Transbond XT primer and adhesive (Transbond XT) is 4.58±1.42 MPa. Hammad et al. (17) treated the labial surfaces of 20 incisor teeth with composite veneer restorations (Tetric EvoCeram; Ivoclar Vivadent AG, Schaan, Liechtenstein) and aged them in deionized water. Then, the mean SBS of metal orthodontic brackets bonded to these surfaces that were subjected to 38% phosphoric acid (3M ESPE) and no-mixed adhesive resin (Granitec®; Confi-Dental Products Co., Louisville, CO, USA) surface treatments was calculated as 5.14±0.03 MPa. Moreover, Eslamian et al. (29) calculated the mean SBS of metal orthodontic brackets bonded to labial surfaces of 15 premolar teeth restored with TEC composite and aged artificially and found that the mean SBS of metal orthodontic brackets is 12.85±5.20 MPa when 5% hydrofluoric acid (Ivoclar Vivadent AG) and no-mixed adhesive resin (Granitec®) were applied as surface treatments. To our knowledge, no study in the literature has evaluated the SBS of metal orthodontic brackets bonded to fresh nanohybrid composite discs and compared the aged and fresh groups. In our study, the mean SBS values of metal orthodontic brackets were 13.63±5.55 and 17.02±4.15 MPa in the aged and fresh groups, respectively, with no significant difference between the groups. Therefore, the null hypothesis for composite surfaces was rejected for nanofilled FU and nanohybrid TEC composites.

In our study, it was also observed that the mean SBS values of metal orthodontic brackets bonded to aged and fresh microhybrid GDA composite discs were 15.01±3.67 and 19.09±5.33, respectively, and the mean SBS of the fresh group was significantly higher. Therefore, the null hypothesis for composite surfaces was accepted for microhybrid GDA composite. Although a number of studies have been published to evaluate the SBS of metal orthodontic brackets bonded to different aged and fresh microhybrid composites with Transbond XT primer and adhesive surface treatments, to our knowledge, no study in the literature has evaluated the microhybrid GDA composite. Tayebi et al. (4) evaluated the cyclic aged microhybrid Filtek Z250 composite discs (3M ESPE) and concluded that the mean SBS values of metal orthodontic brackets bonded to these composite discs are 9.94±2.5 and 7.57±4.0 Mpa in the groups that underwent sandblasting and burring as surface treatments, respectively. In his study, Tse (6) used Filtek Z250 microhybrid composite in the restoration of Class V buccal cavities of 24 upper incisor teeth and aged these restorations in distilled water. Then, the mean SBS of metal orthodontic brackets bonded to these aged composites was calculated and found as 12.1±3.4 MPa. Moreover, Brunharo et al. (30) stated that the mean SBS of metal orthodontic brackets bonded to 10 fresh Charisma microhybrid composite discs (Heraeus Kulzer) that were subjected to 37% phosphoric acid surface treatment is 5.82±1.90 MPa.

In the present study, the ARI scores showed that bond failure predominantly occurred between the restoration and the adhesive as the majority of the adhesive remained on the bracket bases in all groups except for aged Tetric EvoCeram composite. These results were consistent with previous studies (1,6,24,26). However, in the aged TEC composite, most of the adhesive remained on the restoration surface, which was consistent with the results by Demirtas et al. (12) evaluating the aged nanohybrid composite discs (Filtek Z550; 3M ESPE).

Finally, we compared the SBS of metal orthodontic brackets in one porcelain material and three different composite materials that were subjected to a single surface treatment. Therefore, further studies using a greater number of porcelain and composite materials with different surface treatments are recommended.

CONCLUSION

- No significant difference was found between the aged and fresh groups with VA porcelain and FU and TEC composites with regard to the SBS of metal orthodontic brackets.
- The SBS of metal orthodontic brackets was significantly higher in the fresh group with GDA composite.
- No significant difference was found between the aged and fresh groups with FU and GDA composites with regard to ARI scores.
- ARI scores were significantly higher in the aged group with VA porcelain and TEC composite.

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Original Article

Assessment of Pain, Anxiety, and Cortisol Levels During the Initial Aligning Phase of Fixed Orthodontic Treatment

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ABSTRACT

Objective: We assessed pain and anxiety using psychological testing instruments (State-Trait Anxiety Inventory for Children, visual analog scale) and a physiological testing instrument (salivary cortisol hormone level) after the insertion of orthodontic appliances and during the initial alignment phase of orthodontic treatment.

Methods: The study group involved two groups matched according to age and gender. Group 1 used 0.016-, 0.016×0.016-, and 0.16×0.22-inch and Group 2 used 0.014-, 0.016-, and 0.016×0.016-inch superelastic nickel-titanium archwires in the initial alignment phase of treatment. Pain and anxiety instruments were applied, and saliva samples were collected from the patients before and after molar band insertions, and bracket and initial archwire placement, and 7 days after the initial bonding and archwire replacements.

Results: Cortisol levels and state anxiety scores revealed statistically significant differences within groups ($p<0.01$, $p<0.05$). No significant differences were found between Group 1 and Group 2 in cortisol hormone levels, anxiety scores, or pain measurements ($p>0.05$). Although not statistically significant, the most severe pain was measured in the posterior teeth after band insertion and in the anterior teeth after the first archwire insertion ($p>0.05$).

Conclusion: Orthodontic appliances and the initial alignment phase of orthodontic treatment affect patients' anxiety and cortisol hormone levels. Both archwires were equally effective with regard to perceived pain, anxiety, and stress hormone levels.

Keywords: Anxiety, cortisol, NiTi arcwires, orthodontic pain, visual analogue scale

INTRODUCTION

Orthodontic appliance-induced pain or discomfort is reported by up to 95% of patients, and it has been cited as a reason for discontinuation of treatment and may negatively affect patient cooperation (1-3). The level of pain varies according to the use of different appliance types. Fixed orthodontic appliances cause more pressure, discomfort, and pain than removable appliances (4). Nickel-titanium (NiTi) archwires are used during the initial phase of fixed orthodontic treatment for tooth alignment and leveling. These archwires produce light continuous forces with less patient discomfort and tissue trauma (5-7).

Litt (8) emphasized the effects of anxiety on pain sensation and reported that in clinical situations of acute pain, anxiety, and pain may be indistinguishable. Anxiety reduces the pain threshold and can cause the perception of "painless" stimuli as painful. Dental stimuli are also capable of provoking anxiety; Sergl et al. (9) reported that individual stress-related factors and anxiety influence the intensity of discomfort caused by orthodontic appliances. Pain measurements should be made with an assessment of the patient's anxiety level (10).

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Stress is commonly defined as the physiological and psychological reactions that mobilize an organism's defenses against external or internal stressors. The anxiety-induced stressor causes activation of the hypothalamus-pituitary-adrenal axis, with increased secretion of cortisol (11,12). Cortisol levels may be measured in saliva, which can be collected readily and safely in a stress-free and non-invasive manner (13).

The two most important aspects of pain and discomfort in orthodontic treatment are its intensity and duration. Understanding these has clinical implications to improve patient satisfaction and the quality of oral health (14). In light of the importance of this mostly overlooked issue, we aimed to assess pain and anxiety using psychological testing instruments (State-Trait Anxiety Inventory for Children [STAIC], visual analog scale [VAS]) and a physiological testing instrument (mid-morning salivary cortisol) after insertion of orthodontic appliances and during the initial alignment and leveling phase of orthodontic treatment

METHODS

Study Group and Clinical Management

The study group consisted of 20 patients (10 girls, 10 boys, mean age 12.83±0.71 years), who visited the Department of Orthodontics of Suleyman Demirel University for orthodontic treatment. The patients were informed about the fixed orthodontic treatment procedures, and informed consent to participate in this study was obtained from all patients. The study protocol was approved by the Research Ethics Committee of the Faculty of Medicine, University of Suleyman Demirel, Isparta (protocol number: B.30.2.SDU.0.01.00.14/219).

Patients were selected for this study based on the following inclusion criteria: (1) they required upper and lower fixed orthodontic treatment (without additional appliances, such as a quad helix, transpalatal arch, or headgear, which can cause additional discomfort); (2) they had mild crowding (1-4 mm) in the mandibular anterior teeth; (3) they had no previous active orthodontic treatment; (4) they had no history of medical problems, including diseases of the endocrine or metabolic systems or medications that could influence pain perception and cortisol levels; and (5) they agreed to participate in the study.

Exclusion criteria were the following: (1) the presence of a severe deep bite that could affect the bracket insertion at the initial bonding appointment; (2) malocclusion correction requiring treatment procedures other than continuous archwires and non-extraction protocols; (3) previous active orthodontic treatment; (4) medical problems/medications that could interfere with cortisol levels; and (5) regular use of analgesics for dental or orofacial pain.

Initial crowding was assessed using Little's irregularity index (15) with digital calipers to an accuracy of 0.01 mm. Patients were matched into groups according to age and gender. Group 1 (5 females, 5 males, mean age 12.6±0.65 years) used 0.016-, 0.016×0.016-, and 0.16×0.22-inch superelastic NiTi memory archwires (American Orthodontics, Sheboygan, WI, USA) in the initial alignment stage of orthodontic treatment. Group 2 (5 females, 5 males, mean age 13.06±0.72 years) used 0.014-, 0.016-, and 0.016×0.016-inch superelastic NiTi memory archwires (American Orthodontics) in the initial alignment stage of orthodontic treatment.

On the first day of orthodontic treatment, molar bands were placed on the first permanent molars. On the next day, 0.018-inch-slot Roth brackets (Mini Master Series, American Orthodontics) were bonded to the buccal surfaces of the upper incisors, canines, and premolars of all patients. Then, a 0.016-inch pre-formed archwire was inserted into the slots of brackets in Group 1, and a 0.014-inch pre-formed archwire was used in Group 2, then fixed with 0.010-inch stainless-steel ligature wires. On the morning of the 7^{th} day, the control appointment was made. The patients were recalled at monthly intervals for 2 months during the stuhdy period, and archwire reinsertions were carried out each month for both groups. The progress of the study is shown in Figure 1.

Saliva Collection and Cortisol Assay

Saliva samples were collected from the patients before and after the molar band insertion (T0 and T1 time points), before and after the bracket and archwire insertion (T2 and T3 time points), 7 days after bracket bonding and initial archwire insertion (T4 time point), and before and after archwire reinsertions (T5, T6, T7, and T8 time points).

Patients were requested not to consume any food or drink an hour before saliva collection; only water was allowed. Saliva was collected into a polypropylene tube for 3 min while the patient was in a normal sitting position. Saliva samples were stored in the freezer at -80°C until the analysis. Cortisol levels in saliva were analyzed by an electrochemiluminescence immunoassay, using the Cobas cortisol kit (Roche Diagnostics, USA) on an Cobas e601 immunoassay system (Roche Diagnostics, Mannheim, Germany) (16).

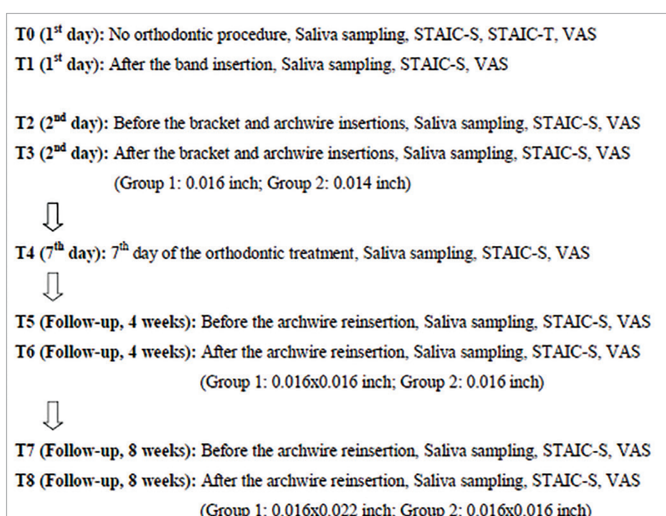

Figure 1. Flow chart demonstrating study design

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Assessment of Anxiety

The STAIC consists of two 20-item self-reported scales that were designed for children to measure state and trait anxiety levels. The STAIC state anxiety scale (range 20-60) was used in this study to measure transitory emotional state or a condition characterized by subjective, consciously perceived feelings of tension, apprehension, and worry that vary in intensity and fluctuate over time. The STAIC trait anxiety scale measures how children generally feel, as well as relatively stable individual differences in anxiety proneness (17). In this study, to measure anxiety, patients were asked to fill in the STAIC state anxiety scale at 9 time points (T0, T1, T2, T3, T4, T5, T6, T7, and T8) and the trait anxiety scale at 1 time point (T0).

Assessment of Pain

Pain perception was measured before and after orthodontic procedures using a VAS, which is a 100-mm-long horizontal line with defined end points. One end of the line was labeled "no pain" and the other as "worst pain possible" (18). The VAS is a valid, sensitive, and reliable scale for pain assessment (1, 5, 19). In this study, the patients were asked separately at 9 time points (T0, T1, T2, T3, T4, T5, T6, T7, and T8) whether they had pain and in which areas (anterior/posterior teeth) they perceived the pain. Each patient was asked to place a mark on the line nearest to his or her perceived pain. The mark was then measured from the left margin of the line to the nearest millimeter to quantify the pain, recorded as the VAS score in mm.

Statistical Analysis

All analyses were conducted using the Statistical Package for Social Sciences software version 22.0 (IBM Corp.; Armonk, NY, USA). The Mann-Whitney U test was used to compare differences between archwire groups (Group 1 vs. 2) and gender groups (female vs. male) at the same times of the study. Friedman's two-way analysis of variance for repeated measures was used to test for within-archwire group differences over time. The significance level was set at $p<0.05$.

RESULTS

Gender differences were not statistically significant in salivary cortisol levels, anxiety scores, or pain perception ($p>0.05$), so these findings were evaluated without gender discrimination.

Salivary Cortisol Values

The means and standard deviations (SDs) of the salivary cortisol values are listed in Table 1. Salivary cortisol values were similar and not statistically significant in Group 1 ($p>0.05$). Statistically significant differences were found in Group 2 ($p<0.01$), and the highest salivary cortisol values were found at the T3 time point in Group 2. No statistically significant differences were observed in mean salivary cortisol values between Groups 1 and 2 at any time point ($p>0.05$).

State-Trait Anxiety Values

The means and SDs of the state anxiety values are listed in Table 2. There were statistically significant differences in the state anxiety values for Groups 1 ($p<0.01$) and 2 ($p<0.05$). In Group 1, state anxiety values increased gradually and significantly after the first appointment. The T3 state anxiety values were significantly higher than at other time points (T0 and T8). In Group 2, the highest state anxiety values were determined between the T1 and T5 time points, and compared with the other time points, they increased significantly after the T0 time point. Table 3 lists the means and SDs of the trait anxiety values. No statistically significant difference was observed in trait anxiety levels between the groups ($p>0.05$).

VAS Values and Pain Regions

The means and SDs of the VAS scores are listed in Table 4. Statistically significant differences were found in Groups 1 and 2 ($p<0.001$). The peak for pain intensity was recorded at the T3 time point in both groups, and it started to decline after the T3 time point.

Table 1. Means and SDs of the salivary cortisol levels (µg/dL) at each time point

	Group 1			Group 2			
Time points	$\bar{X}\pm SD$	95% Confidence interval		$\bar{X}\pm SD$	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T0	0.39±0.03	0.31	0.47	0.41±0.04[b]	0.31	0.51	0.684
T1	0.51±0.04	0.41	0.61	0.52±0.06[ab]	0.38	0.66	0.853
T2	0.50±0.07	0.32	0.68	0.51±0.04[ab]	0.41	0.61	0.684
T3	0.57±0.07	0.40	0.74	0.59±0.03[a]	0.50	0.68	0.579
T4	0.46±0.03	0.38	0.55	0.44±0.03[b]	0.36	0.53	0.684
T5	0.44±0.03	0.35	0.52	0.42±0.05[b]	0.30	0.53	0.481
T6	0.45±0.05	0.33	0.57	0.42±0.03[b]	0.34	0.51	0.739
T7	0.38±0.03	0.31	0.45	0.38±0.03[b]	0.29	0.47	1.000
T8	0.41±0.02	0.35	0.48	0.40±0.02[b]	0.33	0.47	0.579
p	0.068			0.004**			

**p<0.01; superscript letters indicate the differences between the time points

Table 2. Means and SDs of the state anxiety scores at each time point

	Group 1			Group 2			
Time points	X̄±SD	95% Confidence interval		X̄±SD	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T0	37.00±1.74[a]	33.05	40.95	37.20±1.05[a]	34.82	39.58	0.579
T1	42.10±1.13[bc]	39.52	44.68	42.60±1.09[b]	40.12	45.08	0.579
T2	43.20±1.12[bc]	40.66	45.74	43.00±1.13[b]	40.43	45.57	0.971
T3	43.40±1.57[c]	39.84	46.96	42.90±1.75[b]	38.93	46.87	0.912
T4	42.40±1.46[bc]	39.07	45.72	42.20±1.01[b]	39.89	44.51	1.000
T5	42.50±1.15[bc]	39.88	45.12	41.90±1.36[b]	38.80	45.00	0.853
T6	41.30±1.13[bc]	38.73	43.87	40.90±0.93[ab]	38.78	43.02	1.000
T7	40.70±1.02[bc]	38.39	43.01	40.60±0.90[ab]	38.54	42.66	1.000
T8	38.80±1.27[ab]	35.92	41.68	39.50±0.83[ab]	37.61	41.38	0.529
p	0.005**			0.043*			

*p<0.05; **p<0.01; superscript letters indicate the differences between the time points

Table 3. Means and SDs of the trait anxiety scores at each time point

	Group 1			Group 2			
Time points	X̄±SD	95% Confidence interval		X̄±SD	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T0	33.10±1.17	30.43	35.76	34.10±1.42	30.87	37.32	0.631

Table 4. Means and SDs of the VAS scores at each time point

	Group 1			Group 2			
Time points	X̄±SD	95% Confidence interval		X̄±SD	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T1	28.50±4.94[ac]	17.31	39.69	25.50±6.60[ac]	10.57	40.43	0.853
T2	17.50±4.78[bcd]	6.67	28.33	19.00±5.46[bc]	6.63	31.37	0.912
T3	35.00±5.42[a]	22.72	47.27	38.00±4.16[a]	28.58	47.42	0.631
T4	14.75±3.30[bc]	7.28	22.22	16.00±3.63[bc]	7.77	24.23	0.796
T5	2.00±1.33[d]	-1.02	5.02	2.00±2.00[de]	-2.52	6.52	0.796
T6	8.00±2.90[bd]	1.43	14.57	13.00±4.72[bce]	2.31	23.69	0.579
T8	3.50±2.36[bd]	-1.84	8.84	4.00±2.21[bd]	-1.00	9.00	0.796
p	0.000***			0.000***			

***p<0.001; superscript letters indicate the differences between the time points

The means and SDs of the VAS scores in the anterior teeth are listed in Table 5. VAS scores in the anterior teeth showed statistically significant differences in Groups 1 and 2 (p<0.001). The T3 VAS scores were significantly greater than at other time points (T5 and T8) for both groups.

The means and SDs of the VAS scores in the posterior teeth are listed in Table 6. VAS scores in the posterior teeth showed statistically significant differences in Groups 1 and 2 (p<0.001). Severe pain was perceived in the posterior teeth at the T1 time point in both groups.

DISCUSSION

Many studies have investigated the degree of pain during the insertion of separators, bands, braces, and archwires (5, 7, 14, 20-23). However, to the best of our knowledge, no reports have documented the evaluation of pain, stress, and anxiety among preadolescent patients using psychometric and physiological methods after the insertion of orthodontic appliances and during the initial aligning phase of orthodontic treatment.

Sandhu and Sandhu (21) reported that orthodontic pain was affected significantly by the individual's age and gender. Biophysiological, psychosocial, and physical factors can contribute to the age and gender interactions and affect pain perception during adolescence. Pain perception among boys and girls changes after puberty, and girls tend to report more pain, due to fluctuations in hormone levels during the menstrual cycle (24). Considering the effects of these factors, the age group used in the present study represented early adolescence (11-14 years), according to the criteria of early adolescence of the American Academy of Pediatrics (25).

Table 5. Means and SDs of the VAS scores in the anterior teeth at each time point

	Group 1			Group 2			
Time points	X̄±SD	95% Confidence interval		X̄±SD	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T3	28.50±7.45[a]	11.63	45.36	40.00±5.05[a]	28.56	51.44	0.247
T4	28.00±7.85[a]	10.22	45.78	25.00±7.49[b]	8.05	41.94	0.684
T5	6.00±2.66[bc]	-0.03	12.03	11.00±4.33[bd]	1.20	20.80	0.529
T6	13.50±4.83[ac]	2.57	24.43	18.00±5.73[bd]	5.03	30.97	0.579
T8	5.50±2.83[bc]	-0.91	11.91	3.00±2.13[cd]	-1.83	7.83	0.684
p	0.000***			0.000***			

***p<0.001; superscript letters indicate the differences between the time points

Table 6. Means and SDs of the VAS scores in the posterior teeth at each time point

	Group 1			Group 2			
Time points	X̄±SD	95% Confidence interval		X̄±SD	95% Confidence interval		p
		Lower bound	Upper bound		Lower bound	Upper bound	
T1	30.50±5.39[a]	18.29	42.71	41.00±5.55[a]	28.43	53.57	0.105
T2	14.75±3.30[ac]	7.28	22.22	16.00±3.63[bc]	7.77	24.23	0.796
T3	18.50±6.23[ac]	4.39	32.61	22.25±5.35[b]	10.14	34.36	0.481
T4	12.00±4.42[bc]	1.99	22.00	16.00±5.46[bc]	3.63	28.37	0.684
T6	4.00±2.66[b]	-2.03	10.03	12.00±4.66[bc]	1.44	22.56	0.247
T8	1.00±1.00[b]	-1.26	3.26	4.00±2.21[c]	-1.00	9.00	0.436
p	0.000***			0.000***			

***p<0.001; superscript letters indicate the differences between the time points

In this study, saliva samples of each individual were taken at the same time in the morning, and a sample taken before the molar band placement with no application of any procedure served for each individual as his or her own control. Salivary cortisol values were generally higher after the molar band placement (T1) and bracket and archwire insertion (T3). Similarly, Gecgelen et al. (1) found that salivary cortisol levels were higher on the day the maxillary expansion appliance was cemented on the teeth. The difference could probably be due to these procedures creating anxiety and pain in patients. At later time points, cortisol values were similar to those in the control saliva samples; patients may have adapted to the appliances and orthodontic-induced pain.

Following the molar band placement, patients began to feel pain, and cortisol values and state anxiety scores increase. This was an expected result, in that anxiety/pain exhibited a parallel relationship with cortisol levels.

In this study, we found no statistically significant differences between salivary cortisol and gender. The present results were consistent with previous studies (1, 12, 13, 26), in that gender did not influence cortisol secretion.

State anxiety values increased gradually after the first orthodontic treatment appointment. It is clear from the existing literature that orthodontic procedures, such as band placement, archwire insertion, and activation, are stressful and anxiety-provoking procedures in orthodontics. Although patients were informed about their orthodontic treatment, their concerns about the treatment process, and dental anxiety and fear from the beginning of the treatment, caused a sense of discomfort. State anxiety values decreased from the 7th day of the orthodontic treatment to the end of study period. The patients may have adapted to orthodontic appliances over a period of time.

Although some studies reported higher levels of anxiety among females than males (27, 28), we observed no significant gender difference in the state or trait anxiety levels, consistent with other studies (1, 13). This may be because gender differences in anxiety and depression emerge after puberty.

Trait anxiety levels of patients were determined at the beginning of the treatment in this study. One limitation of this study was not assessing the trait anxiety scores at the end of the study period. We observed no difference between the groups in terms of trait anxiety values, and the pretreatment values were similar to pretreatment values reported in other studies (1, 29).

Following band insertion, the patients started to feel discomfort and pain. We found statistically significant differences between the pain perceived by those in whom different-sized archwires were inserted and different procedures were performed. However, we observed no statistically significant differences between the groups. The most severe pain was measured for the posterior teeth after the band insertion and for the anterior teeth after the first archwire insertion. Rakshan and Rakshan (14) reported that discomfort and pain caused in the initial stage of fixed orthodontic treatment can be moderate to severe and might last for more than 1 month. Generalized dentogingival discomfort is more prevalent than localized discomfort.

We found no significant difference between pain and gender, consistent with the findings of Cesur and Aksoy (2), Abdelrahman et al. (7), Sandhu and Sandhu (21), and Erdinç and Dinçer (23). We also found no statistically significant difference between the archwire groups for overall pain measurements. Erdinç and Dinçer (23) found no statistically significant difference in terms of perception of pain between the 0.014- and 0.016inch groups during the first week of initial alignment. Sandhu and Sandhu (5) found no statistically significant difference between 0.016-inch superelastic NiTi and 0.0175-inch multistranded stainless steel for overall pain experience. Similarly, Abdelrahman et al. (6) reported that the three forms of archwires used (0.014-inch superelastic NiTi, 0.014-inch thermoelastic NiTi, and 0.014-inch conventional NiTi) yielded similar pain intensities during the initial aligning stage of fixed orthodontic treatment. These findings are in accordance with our results.

This study was limited in some aspects. We used psychological and physiological testing instruments to assess pain and anxiety during the different stages of fixed orthodontic treatment with a limited sample size. Future studies should be conducted on larger sample sizes and should be determined by power calculations.

CONCLUSION

We assessed pain and anxiety after the insertion of orthodontic appliances and during the initial alignment and leveling phase of orthodontic treatment for mild crowding. Gender differences were not statistically significant in salivary cortisol levels, anxiety scores, and pain perception. Orthodontic appliances and the initial alignment phase of orthodontic treatment affect patients' anxiety and cortisol levels. Pain was perceived after the insertion of the bands and wires of different sizes used for initial alignment.

Ethics Committee Approval: Ethics committee approval was received for this study from the Research Ethics Committee of the University of Süleyman Demirel School of Medicine (Protocol Number: B.30.2.SDU.0.01.00.14/219).

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

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Original Article

Identification of Maxillofacial Problems in Extraoral Photographs by Panel Members: A Pilot Study

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ABSTRACT

Objective: The aim of this pilot study was to evaluate the effectiveness of the profile and frontal photographs in determining sagittal maxillofacial problems by the panel members created from different professional groups.

Methods: Frontal and profile photographs of four individuals with skeletal Class I, Class II Division 1, Class II Division 2, and Class III malocclusion were assessed by panel members. A total of 42 panel members from 7 different professions participated in the study. Panel members were asked to choose one of the frontal or profile photographs to be used in determining the maxillofacial problem. Mann-Whitney U test, Kruskal-Wallis test, and Fisher's exact test were applied to evaluate the difference between the panelists.

Results: Of the 42 panel members, 16% selected frontal photographs, and 84% selected profile photographs. There were no statistically significant differences between seven panels with regard to photography selection (p>0.05). When all panel members were compared with regard to gender, 17.9% of the frontal photographs and 82.1% of the profile photographs were selected by females, whereas 15.4% of the frontal photographs and 84.6% of the profile photographs were chosen by males. There was no statistically significant difference between males and females (p>0.05).

Conclusion: It was found that the profile photograph was more preferred and informative in determining the sagittal maxillofacial problem.

Keywords: Behavioral science, face, layout, malocclusion, perception, photography

INTRODUCTION

The most important factors affecting the facial appearance are the sagittal, vertical, and transversal relationships of the maxilla and mandible to the cranial base and/or to each other and the reflection of these skeletal structures to the soft tissue. In the past, orthodontists primarily aimed to align the teeth; today, they also intend to achieve a balanced facial aesthetics (1).

Consequently, pretreatment and posttreatment photographs, soft tissue appearance, and facial aesthetics have been progressively gaining importance. Achieving optimal facial aesthetics is primarily determined by the aesthetic perceptions and evaluations of the individual patients rather than by the ideal cephalometric values targeted by orthodontic treatment. Therefore, to fulfill the needs of patients, it is important to anticipate their expectations and to discuss their aesthetic perceptions, orientation, and motivation (2, 3). Owing to the reasons mentioned above, panel studies have been used to collect ideas about and to compare the aesthetic perceptions of dentists, dental specialists, and professionals from other related fields, such as maxillofacial surgeons and plastic reconstructive and aesthetic surgeons. Panels consist of individuals who evaluate the documentation, such as photographs and X-ray images, based on their own point of view and aesthetic perception (4). Variables, such as age, gender, and profession of the panel members, may affect their preferences. Previous studies have evaluated various anomalies (5), the pre-intervention and post-intervention

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Figure 1. Patient with Class I malocclusion

Figure 2. Patient with Class II Division 1 malocclusion

Figure 3. Patient with Class II Division 2 malocclusion

Figure 4. Patient with Class III malocclusion

results of extraction and non-extraction treatments, orthognathic surgeries (6-9), and smile aesthetics (10, 11).

To evaluate aesthetics, lateral cephalograms, profile silhouette images, frontal photographs, profile photographs, and 3/4 photographs are frequently used. Frontal photographs are usually used to determine facial proportions, asymmetries, and transversal evaluations (12). On the other hand, profile photographs are frequently used to assess the anteroposterior position of the maxilla and mandible, the soft tissue profile, and the vertical dimensions (12, 13). One panel study reported that simultaneous display of both profile and frontal photographs is more advantageous than displaying only one type of photographs (5). However, to the best of our knowledge, no study has reported on which types of photographs can be more useful in understanding sagittal maxillofacial problems.

The aim of the present study was to determine whether frontal or profile photographs would be more effective for evaluating sagittal maxillofacial problems. The null hypothesis assumed that there was no difference between the selection of photographs of various groups consisting of professionals with different ages.

METHODS

The samples were selected from the registry of Kırıkkale University, Faculty of Dentistry, Department of Orthodontics. The study was approved by the ethics committee of clinical investigations of Kırıkkale University.

Sample Selection

The frontal and profile photographs of four patients with skeletal Class I, Class II Division 1, Class II Division 2, and Class III malocclusion (according to the ANB angle) were used (14). The photographs were captured using a digital camera (Nikon D7100; Nikon Corporation, Tokyo, Japan). Inclusion criteria were photographs being standardized (similar light, Frankfurt horizontal plane parallel to the horizontal, and lips relaxed); no asymmetry, craniofacial anomaly, and syndrome; no previous orthodontic treatment, maxillofacial, or plastic surgery; no trauma related to the face and neck; no mustache, beard, acne, striking hairpin, jewelry, makeup, glasses, and scarf (Figures 1, 2, 3, 4).

The lateral cephalometric radiographs were analyzed using VistaDent 2.1 AT (GAC International Inc., Bohemia, NY, USA) software program. A four-slide presentation (Microsoft Office 2010, PowerPoint, Seattle, WA, USA) was prepared for evaluation of the samples. The frontal and profile photographs of Class I (17-year-old female, ANB: 3°, overjet: 2.5 mm), Class II Division 1 (14-year-old male, ANB: 6.3°, overjet: 7.3 mm), Class II Division 2 (16-year-old female, ANB: 6.5°, overjet: 4 mm), and Class III (14-year-old male, ANB: -2°, overjet: -1.5 mm) patients with malocclusion were presented (Table 1). In the photos, the patient's lips were relaxed, and their eyes were closed with black stripes. The presentation included frontal and profile photographs of each patient on a single slide, similar to the study by Philips et al. (5). Smile photographs were not included to avoid affecting panel members by any dental anomaly; thus, photographs with lips closed were preferred (15).

Panel Formation

Seven panels were assembled for selection of the photographs to be used in the determination of the maxillofacial problem. Panel members included first-year dental students, fifth-year dental students, orthodontists, oral and maxillofacial surgeons, plastic reconstructive and aesthetic surgeons, dentists, and parents of orthodontic patients. A total of 42 panelists were involved in the study, and each panel constituted of 6 members.

The age of the panel members was between 19 and 45 years. The median ages of the panel members were 20.5 years for first-year dental students, 23 years for fifth-year dental students, 29 years for orthodontists, 27.5 years for oral and maxillofacial surgeons, 30 years for plastic reconstructive and aesthetic surgeons, 41.5 years for dentists, and 40 years for the parents of the individuals (Table 2).

Following the question "which photographs should be used in determining the maxillofacial problem?," each slide was displayed for 5 s, and members were asked to choose one of the frontal or profile photographs.

Table 1. Cephalometric values of four patients

	Class I	Class II div 1	Class II div 2	Class III
ANB (°)	3°	6.3°	6.5°	-2°
Wits (mm)	0 mm	6 mm	6 mm	-3 mm
FMA (°)	20°	21°	21°	23°
SN-GoGn (°)	28.7°	31.1°	28°	34°
SN-OcP (°)	15.7°	23.9°	18.3°	15°
Mx1-SN (°)	103.4°	109.6°	90.5°	98°
U1-NA (mm)	7 mm	5 mm	9 mm	4 mm
U1-NA (°)	25.3°	29.3°	10.2°	20°
L1-NB (mm)	4 mm	3 mm	5 mm	5 mm
L1-NB (°)	24.4°	27.1°	22.5°	23°
IMPA (°)	100°	105°	100°	91°
Overjet (mm)	2.5 mm	7.3 mm	4 mm	-1.5 mm
Overbite (mm)	2.5 mm	4 mm	6.5 mm	3.5 mm
Lower lip E-line (mm)	-6 mm	0 mm	-1 mm	-6 mm
Upper lip E-line (mm)	-1 mm	0 mm	-2 mm	1 mm

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences version 15.0 (SPSS Inc.; Chicago, IL, USA) package program. Numerical variables were presented as median (minimum-maximum), and categorical variables were presented as frequency (percentage). Differences among the groups were determined by Mann-Whitney U test, Kruskal-Wallis test, and chi-square and Fisher's exact tests. A p value <0.05 was considered statistically significant.

RESULTS

As the answer of "which photographs should be used in determining the maxillofacial problem?" question, 16% of the panel members chose frontal photographs, and 84% chose profile photographs. No statistically significant difference was found among the decisions of seven different panels with regard to photography selection (Table 3).

In evaluating the photograph of the patient with Class I malocclusion (slide 1), 31% of the panel members chose frontal, and 69% chose profile photograph. For Class II Division 1 malocclusion patient (slide 2), 4.8% of the panel members selected frontal, and 95.2% selected profile photographs. For Class II Division 2 malocclusion (slide 3), 14.3% of the panel members chose frontal, and 85.7% chose profile photograph. For Class III malocclusion patient (slide 4), 16.7% of the panel members chose frontal, and 83.3% chose profile photograph (Table 2).

When the decisions of the panel members were compared with regard to their gender, 17.9% of the females selected frontal, and 82.1% selected profile photographs, whereas 15.4% of the males chose frontal, and 84.6% chose profile photographs. No statistically significant difference was found between the decisions of males and females.

Orthodontists preferred profile photographs for all malocclusions, and dentists preferred profile photographs for Class 2 and 3 malocclusions.

Table 2. Demographic data of panelists

Panel	n	Females	Males	Average age		
				Median	Minimum	Maximum
First-year dental students	6	3	3	20.5	19	21
Fifth-year dental students	6	3	3	23	23	25
Orthodontists	6	3	3	29	27	34
Oral surgeons	6	3	3	27.5	26	31
Plastic surgeons	6	3	3	30	27	40
Dentists	6	3	3	41.5	29	45
Parents of orthodontic patient	6	3	3	40	36	50

Table 3. Comparison among panelists

		First-year dental students		Fifth-year dental students		Orthodontists		Oral surgeons		Plastic surgeons		Dentists		Parents of orthodontic patients		
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	p*
Class I	Profile	4	66.7	4	66.7	6	100	3	50	4	66.7	4	66.7	4	66.7	0.671
	Frontal	2	33.3	2	33.3	0	0	3	50	2	33.3	2	33.3	2	33.3	
Class II Division 1	Profile	5	83.3	6	100	6	100	5	83.3	6	100	6	100	6	100	1
	Frontal	1	16.7	0	0	0	0	1	16.7	0	0	0	0	0	0	
Class II Division 2	Profile	4	66.7	5	83.3	6	100	6	100	5	83.3	6	100	4	66.7	0.549
	Frontal	2	33.3	1	16.7	0	0	0	0	1	16.7	0	0	2	33.3	
Class III	Profile	4	66.7	4	66.7	6	100	6	100	6	100	6	100	3	50	0.056
	Frontal	2	33.3	2	33.3	0	0	0	0	0	0	0	0	3	50	

*Fisher's exact test

DISCUSSION

Previous studies investigated different anomalies (5), pre- and posttreatment results of extraction and non-extraction orthodontic treatments, and orthognathic surgeries (6-9). In other studies, patients treated with orthognathic surgery and growth modification pre- and posttreatment results of functional appliance treatment (16) and smile aesthetics (10, 11) were evaluated using digital photographs. The investigations usually involved scoring of facial attractiveness and smile aesthetic using the visual analog scale. However, our pilot study aimed to question whether frontal or profile facial photographs would be more effective in the evaluation of sagittal maxillofacial problems based on the point of view of professionals from different fields.

Aesthetic evaluations are generally known to be based on profile and frontal photographs, as well as profile silhouette images obtained from cephalograms (5-11, 15, 16). Recently, three-dimensional images and video recordings have also been used; however, no statistically significant difference between photographs and video images has been reported in the literature (17, 18). Therefore, frontal and profile photographs were used in our study.

Some studies emphasized that the use of cephalograms and profile silhouettes would provide more accurate results than that of photographs because variables, such as skin color and texture, hair color and style, and facial expressions, could affect the specialists' decisions (19, 20). However, the face cannot be fully examined with these methods, particularly during frontal evaluation (19, 21). Therefore, frontal view evaluation was used in our study instead of silhouette images and cephalograms. To prevent the manipulation of the decisions of the members, mustache, beard, acne, herpes, striking hairpins, scarves, jewelry, and makeup were not present in the photographs of the patients included in the sample.

In some studies on aesthetic evaluations, panel members have been reported to be affected by their own appearance during the decision-making process (22, 23). The assessments of individuals dissatisfied with their own facial profile could result in more negative scores (24). Thus, it is necessary to include a larger number of panelists to minimize the impact that the subjectivity of the members' reflections has on their decisions in relation to the study results (16). However, it has also been reported that contrary to the perception that a fewer number of members would lead to less reliable results, too many panel members would result in considerable time loss (25). Howells and Shaw (26) stated that the reliability of the two-people panel is acceptable, but it would be better to increase the number of panel members. Thus, our study included a total of 42 individuals from 7 different occupational groups.

In the current body of literature, studies evaluating facial attractiveness reported that frontal photographs were more important than profile photographs (7, 8); however, in the assessment of skeletofacial morphology, it was proposed that lateral images, such as cephalometric radiographs, provide more information than frontal images (14, 27). These results might explain the high preference of profile photos in our study because the panel members were asked to select photographs to determine the sagittal maxillofacial problem rather than make an aesthetic evaluation.

Matoula and Pancherz (28) reported that when examining the effect of lateral skeletal morphology, differences in lateral skeletal morphology are less noticeable in the frontal images. Therefore, since profile observation in profile photographs of Class II Division 1, Class II Division 2, and Class III patients is more intense and striking, panel members might have preferred profile photographs rather than frontal photographs to evaluate these anomalies. The presence of an orthognathic profile in Class I anomalies could explain the close decision ratios of frontal and profile photographs in comparison with other anomalies. Furthermore, the fact that orthodontists only chose profile photographs for all anomalies could be explained by the use of cephalometric radiographs for lateral assessments in determining maxillofacial problems during orthodontic training.

Different malocclusions have been evaluated in the aesthetic perception studies (5-9, 11, 15, 29). In our study, the photographs of individuals with Class I, Class II Division 1, Class II Division 2, and Class III anomalies were used to assess whether changes in anomalies could be seen in the photographs selected by panel members when determining maxillofacial problems.

CONCLUSION

No difference was found in the perceptions of different occupational groups, different ages, and different genders in our study which looked for the answer of the question "Should I use frontal or profile photographs in determining sagittal maxillofacial problems?". Our findings have shown that profile photographs would be more preferable when evaluating maxillofacial problems.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Kırıkkale University.

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

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – Y.K., T.S.E., F.E.Ö.; Design - Y.K., T.S.E., F.E.Ö.; Supervision - Y.K., T.S.E., F.E.Ö.; Data Collection and/or Processing - Y.K., T.S.E., F.E.Ö.; Analysis and/or Interpretation - Y.K., T.S.E., F.E.Ö.; Literature Search - Y.K., T.S.E., F.E.Ö.; Writing Manuscript - Y.K., T.S.E., F.E.Ö.; Critical Review - Y.K., T.S.E., F.E.Ö.

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Review

Alternate Rapid Maxillary Expansion and Constriction (Alt-RAMEC) protocol: A Comprehensive Literature Review

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ABSTRACT

The aim of this comprehensive review is to introduce clinicians to the increasingly popularity Alt-RAMEC procedure, a method commonly used in the treatment of class III malocclusion in the last 15 years. Another application of the literature to enhance the skeletal effects of Class III treatment on the maxillae is the Alternative Rapid Maxillary Expansion and Constriction (Alt-RAMEC) procedure introduced by Liou, which improves the effectiveness of the maxillae relative to the surrounding sutures and the enhancement of the maxillae. In the Alt-RAMEC protocol, maxillae will be enlarged to be 1 mm per day, first enlarged to 7 mm, and then the 1 mm screw is closed. In other weeks, in this order the screw of the expansion device is turned on for one week and then closed for one week, completing the Alt-RAMEC protocol at the end of the 9-week process. In this review, we will discuss the advantages and disadvantages of the studies, which include successful treatments by applying this protocol, differences with other methods, its effect on the airway, and its advantages and disadvantages.

Keywords: Alt-RAMEC, Class III malocclusion, literature review

INTRODUCTION

For centuries, Class III malocclusions have attracted more attention than other problems in orthodontics (1). Even in Renaissance portraits and paintings, Class III malocclusions appear to be a significant feature (2). Today, patients are even more aware of the apparent effects on the external appearance, and therefore even less frequent than other malocclusions, due to their adverse effects on the psychosocial status of the patients. These malocclusions, which are primarily etiologically caused by genetics, involve mandibular prognathism, maxillary retrognathism, or a combination of these two conditions (2-3).

There are two approaches of the treatment of Class III anomalies according to patient status. Among these approaches, orthopedic treatments are used to treat patients in the growth-development period, and the other approach is camouflage treatment or orthognathic surgical treatment, which is preferred in adult individuals whose growth-development has been completed (4).

In cases of growth-development period, mandibular treatment is used to prevent and direct the development of mandibles in cases of mandibular origin with chin cap, and maxillary protraction treatments are performed with frequent face mask in cases of maxilla origin. In the literature, we found that there are some researchers who utilized the face mask application in combination with several methods in maxillary protraction (5).

The purpose of this method is to increase the efficiency of an appliance that requires patient cooperation, to perform more prototypes in a short period, and to reduce unwanted dentoalveolar effects and obtain more skel-

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etal effects. Studies have shown that increasing the skeletal effect can reduce post-treatment relapse, which is one of the most significant problems in orthodontic treatment (6-8). In light of this information, researchers have implemented face masks with the rapid maxillary expansion (RME) appliance (9-10), skeletal anchorage (11), and Alternate Rapid Maxillary Expansion and Constriction (Alt-RAMEC) protocol (12-13) to increase the skeletal efficacy in the procedure.

Alt-RAMEC Protocol

In 2005, the Alt-RAMEC protocol was introduced by Liou; it enables sutural mobilization with the opening and closing of the RME screw for 7-9 consecutive weeks without unnecessary expansion (14). Its rationale is similar to that of simple tooth extraction in which we repeatedly rock the tooth buccally and lingually until the tooth is "disarticulated" out of the alveolar socket (12).

First, RME performed prototyping by providing sutural activation with the device. Some researchers report that a 5 mm expanse is sufficient for sutural mobilization, whereas other researchers state that at least 12-15 mm expansions are needed. However, such an excessive expansion may cause clinical irritation of the palatal mucosa, as well as a marked discrepancy between the maxillary and the mandible in non-restrictive individuals (15).

In the Alt-RAMEC protocol, the maxilla is expanded by 7 mm on week 1 through an expansion device that expands 1 mm/day, and then the screw is closed at a rate of 1 mm/s on week 2. In the remaining weeks, the screw of the expansion device is turned on for 1 week and closed for 1 week, and the Alt-RAMEC protocol is completed at the end of the 9-week cycle. Following completion of this protocol, protraction force is applied to move the maxillae forward (12).

In his article introducing the Liou Alt-RAMEC protocol, Liou schematized the changes that occur in the maxillae with RME and Alt-RAMEC (Figure 1). With the hyrax-type RME, the center of rotation of the maxillae is opened at the point of the PNS, and the tuber maxillae move forward and backward as the A point is located at the same position according to the amount of resorption in the maxilla. With the Alt-RAMEC, the center of rotation of the maxillae is opened at the point of the PNS, and the tuber maxillae move forward more without any resorption in the maxilla. Owing to this protocol, there is much more mobilization in the sutures, and resistance structures (e.g., sphenoid) are weakened (12).

Comparison of Alt-RAMEC Protocol and RME

Face mask application after the 1-week RME and face mask therapy after the Alt-RAMEC protocol in different procedures were compared in the majority of studies involving the Alt-RAMEC

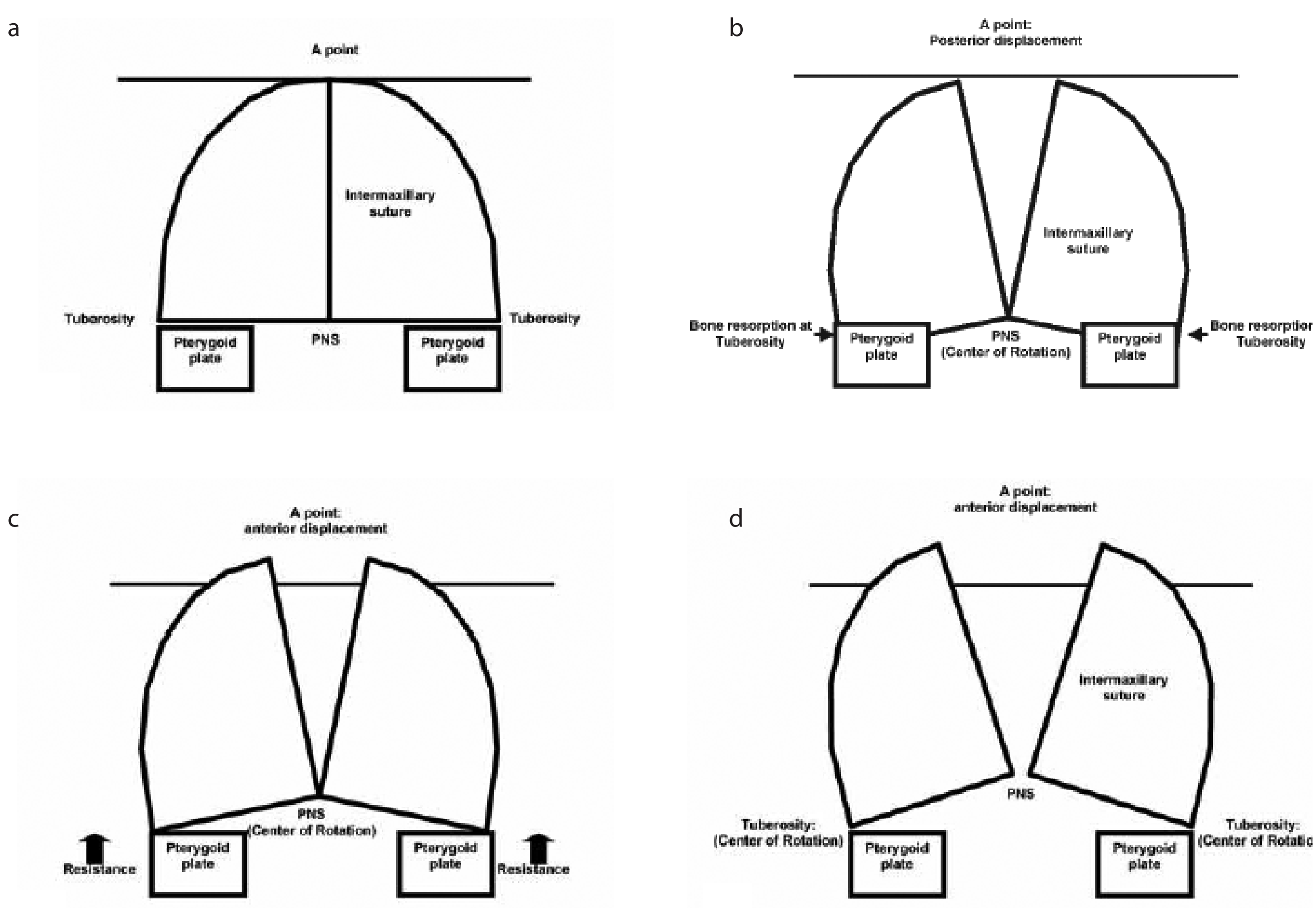

Figure 1. a-d. Schematic illustrations of the postulated maxillary displacement. (a) The maxillae before RME. (b) Posterior displacement of the maxillae after expansion by hyrax-type RME. (c) Anterior displacement of the maxillae after expansion by hyrax-type RME. (d) Anterior displacement of the maxillae after expansion by Alt-RAMEC (12)

		GROUP 1	GROUP 2	GROUP 3	PROTOCOL / PROTRACTION FORCE
LIU et al	2015 44 Patient 7-13 years	7 weeks Alt-RAMEC 3,04 mm (A') *	1-week RME 2,11 mm (A')		Daily 1 mm 400-500 g
MASUCCI et al	2014 31 Patient 7-9 years	4 weeks Alt-RAMEC 2,7 ° (SNA) *	1-week RME 1,5 ° (SNA)	Control Group -0,5 ° (SNA)	Daily 0,4 mm 400-500 g
ISCI et al	2010 30 Patient 11-13 years	4 weeks Alt-RAMEC 4,13 mm (A') *	1-week RME 2,33 mm (A')		Daily 0,4 mm 700 g
DO-DELATOUR et al	2009 18 Patient 8-10 years	7 weeks Alt-RAMEC 1,4 ° (SNA)	1-week RME 2,1 ° (SNA) *	Control Group -0,6 ° (SNA)	Daily 1 mm 380 g
VIERA et al	2009 20 Patient 10-12 years	7 weeks Alt-RAMEC 1,92 mm (A')	1-week RME 2,74 mm (A') *		Daily 1 mm 500 g
LIOU et al	2005 26 Patient 9-12 years	9 weeks Alt-RAMEC 5,8 mm (A') *	1-week RME 2,6 mm (A')		Daily 1 mm 400-500 g

Figure 2. Studies comparing Alt-RAMEC protocol and RME

protocol (Figure 2). More forward movement was detected twice at the A point and maxilla in the groups involving the Alt-RAMEC protocol, except in two studies, than in the Alt-RAMEC protocol applied to the group.

Liou and Tsai (14) distinguished two groups of 26 patients with unilateral lip palate, ranging in age from 9 to 12 years, to investigate whether there was a difference between maxillary protraction after the Alt-RAMEC protocol and RME. RME was applied to the first group with normal hyrax screws for 1 week, whereas the Alt-RAMEC protocol was applied to the second group for 9 weeks at 1 mm/day with a double-hinged expander (Figure 3). Following this procedure, the researchers performed maxillary advancement for 6 months with the intraoral maxillary protraction springs in both groups. At the end of the study, more protraction was obtained in the Alt-RAMEC group (A point, 5.8±2.3 mm) than in the RME group (A point, 2.6±1.5 mm).

Both studies by Viera et al. (16) and Do-delatour et al. (17) reported more forward movement in the maxilla in the RME-treated group than most other studies. Do-delatour et al. (17), in their retrospective study, reported 18 individuals treated with the Alt-RAMEC protocol. They indicated that the Alt-RAMEC protocol alone is not sufficient in the maxillary procedure, and that the amount of protraction is higher in the RME-treated group than in the Alt-RAMEC-treated group. Viera et al. (16), in a study of 20 patients with unilateral lip palate, reported that the application of RME and Alt-RAMEC protocol does not make any difference before maxillary protraction, and that the effects are similar.

In 2010, Isci et al. (18) compared the dentofacial effects of the 4-week Alt-RAMEC protocol with the 1-week RME application prior to face mask in Class III patients in the growth and development period, where maxillary protraction was needed. Two groups of 15 individuals each were included in the study. At the end of the study, it was reported that the amount of movement of A point (4.13 mm) in the Alt-RAMEC group was twice as much in the RME group (2.33 mm) (18).

Masucci et al. (19) performed face mask therapy with the 4-week Alt-RAMEC protocol for early treatment of Class III malocclusions and reported higher SNA and ANB angles and Wits values than face mask applied with normal RME.

In 2015, Liu et al. (20) compared face mask effects after the 7-week Alt-RAMEC protocol and RME. In the Alt-RAMEC group, there were more translations in the maxilla and less posterior rotation in the mandible.

Wilmes et al. (13) reported that face mask application with the Alt-RAMEC protocol is more effective in maxillary prolapse than conventional face mask therapy combined with normal RME as a result of implementing the 8-week Alt-RAMEC protocol with hyrax RME in two patients with Class III malocclusion.

Canturk et al. (21) compared the efficacy of using face mask during and after the 8-week Alt-RAMEC protocol for individuals with Class III malocclusion. The Alt-RAMEC protocol was not statistically different before or in combination with the face mask, but the maxillary showed significant prominence in both groups.

When experimental animal studies involving the Alt-RAMEC application were examined, Wang et al. (22), in a study in which they evaluated the opening of sutures on inbred cats in 2009, observed that the sagittal sutures are more open than with 1-week normal RME. It has also been reported that this protocol should be applied for >5 weeks for mobilization in coronal sutures of the maxilla.

Pithon et al. (23), in a systematic review, found that the Alt-RAMEC protocol is more effective than RME, that studies are inadequate with regard to relapse and recurrence, and that studies involving long-term outcomes are necessary.

Relationship Between Skeletal Anchorage and Alt-RAMEC

There are also studies in which two methods were used together to increase the skeletal effects of maxillary protraction. In 2011, Kaya et al. (24) used a face mask with miniplates placed on the lateral nasal wall of the maxillae following the 8-week Alt-RAMEC protocol, another method of increasing the skeletal effect of maxillary protraction in their studies. At the end of the study, they observed retraction in the mandibular incisors without movement in the maxillary incisor teeth, with a 2 mm maxillary advancement at an average of 9.9 months and a clockwise rotation of 0.8° in the maxillae.

Implementation of Different Protocols in the Alt-RAMEC Protocol

To the best of our knowledge, there is no study to date that indicates that Alt-RAMEC is a disadvantage or has a negative effect on tooth roots, alveolar bones, and periodontal tissues. RME has been the only method reported to promote root resorption in teeth as supported by some studies (25). It is important to determine the protocol that can provide the most effective protraction as soon as possible due to the risk of creating a jiggling effect (26), which occurs in recurring weeks with the Alt-RAMEC protocol.

There are a limited number of studies comparing different Alt-RAMEC protocols. Celikoglu et al. (27) examined skeletal and dentoalveolar changes after the 5-week and 9-week Alt-RAMEC protocols. The study has shown that the effects of the two protocols are similar.

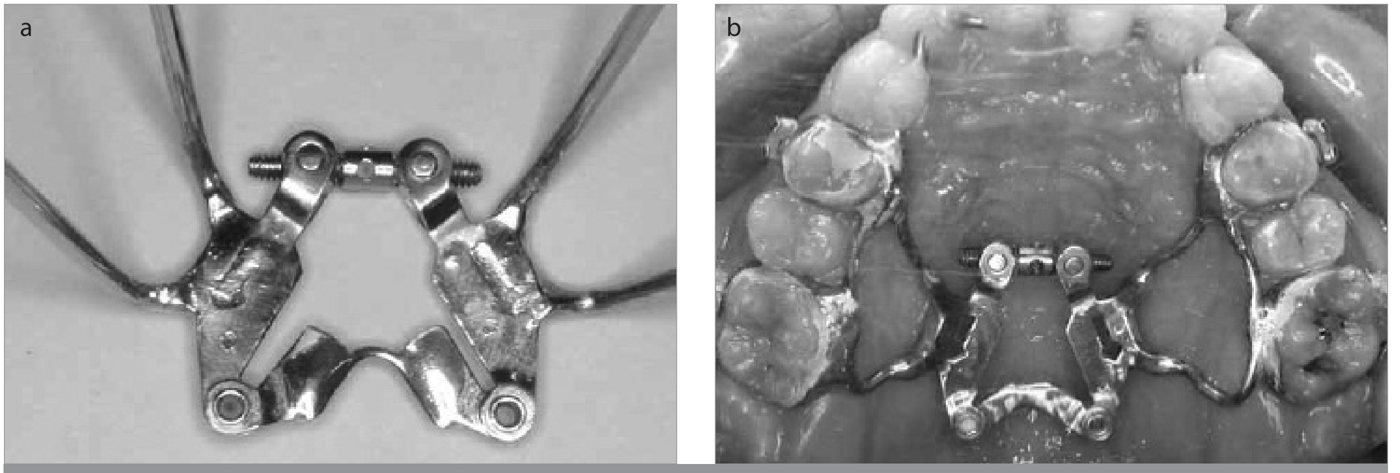

Figure 3. a, b. The configuration of a double-hinged rapid maxillary expander (12)

Effect of Screw Type on Protocol

When the Alt-RAMEC protocol was first introduced, it was applied with a double-hinged hyrax screw (Figure 3) as developed by Liou. In the studies conducted in the following years, this protocol was successfully applied with standard hyrax screws. However, to our knowledge, no study has investigated the effect of screw type on protocol or craniofacial and dentoalveolar construction.

However, in the study by Maino et al. (28) in 2018 with a different application, the hyrax screw was applied together with the hybrid anchorage. After applying 4 months of face masks, it was reported that dental effects were minimal.

Influence of the Alt-RAMEC protocol on the airway

Yılmaz et al. (29) evaluated airway measurements using cone beam computed tomography (CBCT) after 9 weeks of Alt-RAMEC protocol in an airway study. They reported that the A point moves forward, and that the upper airway and the nasal width increase.

Celikoglu et al. (30) examined the effect of maxillary protraction on the airway after different Alt-RAMEC protocols and reported that the effects of different protocols are similar.

In 2018, a study investigating the effect of the Alt-RAMEC protocol on the airway was also conducted using CBCT. The researchers compared individuals treated with RME and the Alt-RAMEC protocol in the study. They concluded in their study that the increase in nasal volume and nasopharyngeal volume was similar in both groups (31).

Long-term Results

The number of studies reporting the long-term results of the Alt-RAMEC protocol is rather limited. Although there are several studies on individuals with Class III malocclusion treated with maxillary protraction, to the best of our knowledge, there is no study that includes long-term results. The long-term studies performed on individuals with cleft lip and palate are both retrospective and relatively limited.

In 2018, 26 individuals with unilateral cleft lip and palate who had undergone the Alt-RAMEC protocol were subjected to 5-10-year long-term follow-ups. As a result of the present study, it was reported that long-term results were stabilized when applied at the best time by providing sufficient protraction with a double-hinged expander (32).

CONCLUSION

Based on the literature review, the following conclusions were made:

- The application of the Alt-RAMEC protocol before maxillary protraction is an effective method for early treatment of patients with Class III malocclusion.
- In most of the studies, the Alt-RAMEC protocol appears to be more effective than RME.
- Further long-term studies on the Alt-RAMEC protocol are needed.

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CASE REPORT

The Use of Mini-Plates for the Treatment of a High-Angle, Dual Bite, Class II Malocclusion

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ABSTRACT

To present a case report of an orthodontic treatment of a high-angle, dual bite, Class II malocclusion without extractions and with the use of mini-plates. Class II malocclusion treatment protocols vary according to the morphological component of the malocclusion and the magnitude and direction of craniofacial growth. It is generally agreed that the cooperation of the patient and careful planning of anchorage are the key determinants of successful treatment. Protrusion of the upper and lower lip and a retrognathic mandible were the patient's chief concerns. The patient had learned to project her mandible forward to disguise the overjet. The patient's parents elected to correct the malocclusion with the use of bilateral infrazygomatic mini-plates. Pre-treatment condylar stabilization with an orthotic established a stable centric relation position, followed by mounting of the models on a semi-adjustable Panadent articulator. This allowed diagnosis and treatment planning from a stable condylar position and eliminated possible misdiagnosis due to the dual bite. Distal retraction and vertical control of the upper teeth enabled correction of the Class II malocclusion with minimal patient cooperation. Mini-plate-assisted treatment corrected the excessive overbite and overjet. The patient completed treatment with a stable occlusion and no longer postured her jaw forward. The parents and patient were completely satisfied with the positive treatment outcome. A 2-year follow-up confirmed the clinical stability.

Keywords: Angle Class II malocclusion, skeletal anchorage, centric relation

INTRODUCTION

Centric relation (CR) has been a provocative subject in dentistry. The position and its definition have changed over the decades from a retruded, posterosuperior condylar position to an anterosuperior condylar position, centered transversely with the articular disc correctly interposed (1). Discrepancies between CR and maximum intercuspation (CR-MI), or centric occlusion, may be considered a controversial contributory factor to the development of temporomandibular disorder (2-6). The clinical concept of orthodontic treatment to achieve CR as a preventive measure to improve disk-to-condyle relationships is not supported (7). In any case, significant discrepancies (>2 mm in sagittal and vertical planes and/or >0.5 mm in transversal planes), clinically known as a dual bite, have relevance for orthodontic diagnosis and treatment plan (8).

CR-MI discrepancies can occur in any type of malocclusion, regardless of age and gender. However, special emphasis should be given to Angle's Class II and III cases before orthodontic treatment (9). In Class II malocclusion cases, the bigger the functional shift, the greater are the changes in increased overjet, decreased overbite, midline discrepancies, and severity of the Class II relation (9, 10). In addition, it has been demonstrated that CR-MI discrepancies can affect cephalometric measurements (11). Several methods have been used to evaluate CR-MI discrepancies, including direct clinical evaluation, imaging, and articulator mountings (3).

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The use of skeletal anchorage is an alternative for Class II malocclusions that allows for the application of force in various directions without the need for patient cooperation. The aim of this case report is to describe how an adolescent patient with a high-angle, dual bite, Class II malocclusion was treated with infrazygomatic mini-plates. The disadvantage of the use of mini-plates is their high value, and the procedure to install them is invasive.

CASE PRESENTATION

Diagnosis and Etiology

The patient was a 12-year-old female, whose menarche was reported 14 months previously. Her chief complaint was her retrognathic profile along with excessive overjet. She habitually projected her mandible forward in an attempt to camouflage the excessive overjet.

Facial analysis showed upper and lower lip protrusion (Ul-S line=2.8 mm, LI-S line=3.9 mm). The upper lip protruded upwards and the lower was everted. From the front, the face was symmetrical. Dental analysis revealed a complete Class II malocclusion of the molars and canines (Figure 1). The upper midline was to the right and the lower midline was to the left, in relation to the facial midline. There was mild crowding (3.5 mm) of the upper and lower anterior teeth (Figure 2). Initially, there were pain and discomfort of the masseter and temporalis muscles upon palpation. The manipulation of the mandible in CR revealed the existence of a CR-MI discrepancy of 4 mm on the left and 2.8 mm on the right, as measured by a condylar positioning indicator. The CR-MI discrepancy increased the divergence of facial planes, thus increasing the maxillomandibular discrepancy and making the profile convexity worse. Mounted models in CR revealed a more severe malocclusion and overjet than when evaluated in centric occlusion (Figure 3).

Figure 1. Pre-treatment facial and intraoral photographs

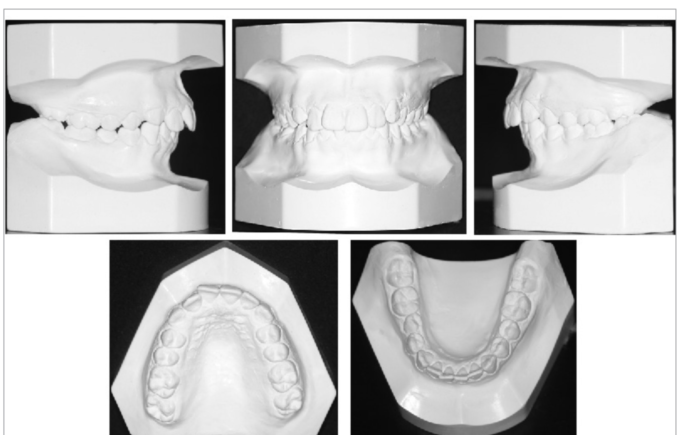

Figure 2. Pre-treatment dental casts

Good oral and periodontal health was confirmed by radiographic examination. The patient had previously reported chronic headaches. There was increased convexity of the maxilla (convexity angle=21.8°). The upper incisors were lingually inclined and retruded. The lower incisors were labially inclined. The maxillomandibular relationship was increased (ANB=10.9°) by the protrusion of the maxilla (89.1°) along with retrusion of the mandible (SNB=78.2°). The patient had a vertical facial pattern (SN.GoGn=34.7°) (Figure 4; Table 1).

Treatment Objectives

The treatment objectives for this patient were to relieve the crowding, establish a Class I canine relationship, correct the discrepancy between maximum intercuspation and centric relationship, correct the midline shift, create an ideal overbite and overjet, which was her chief complaint, and improve her facial profile.

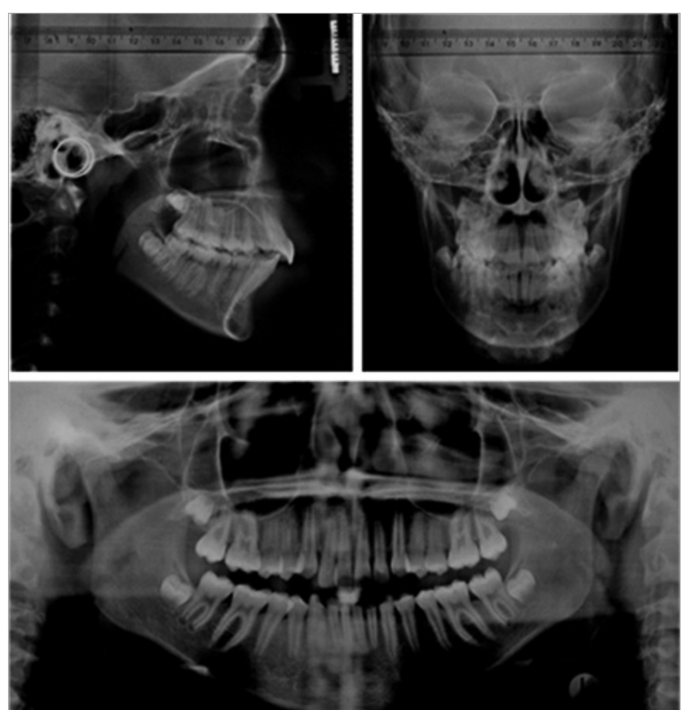

Figure 3. Pre-treatment lateral and posteroanterior cephalometric and panoramic radiographs

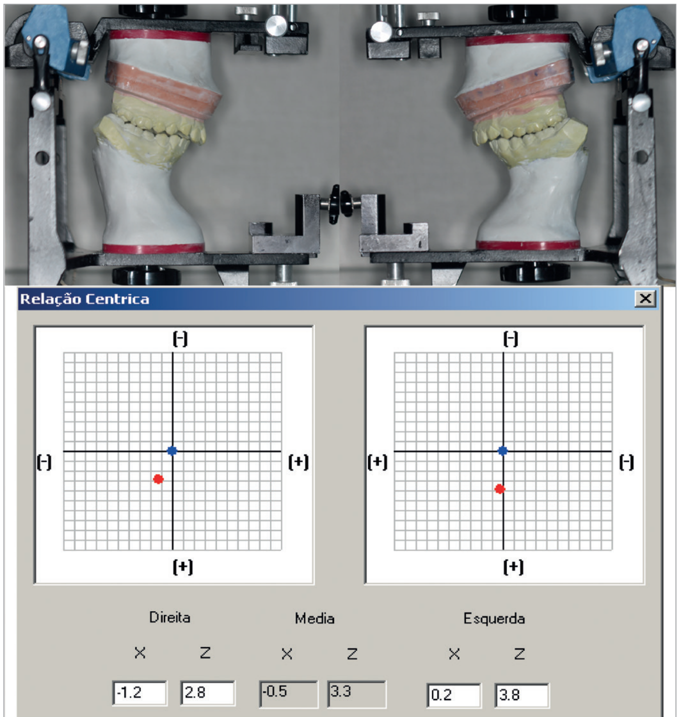

Figure 4. Mounted models on the articulator and pre-treatment CPI

Figure 5. Photographs of the treatment

Figure 6. Photographs of mini-plates force application on both sides

Figure 7. Post-treatment facial and intraoral photographs

Table 1. Descriptive statistics for bond strengths of orthodontic brackets in all groups

	Measures		Normal	A	B	A/B Dif.
Skeletal pattern	SNA	(Steiner)	82°	89.1°	85.0°	4.1°
	SNB	(Steiner)	80°	78.2°	77.9°	0.3°
	ANB	(Steiner)	2°	11.0°	7.01°	3.99°
	Convexityangle	(Downs)	0°	21.8°	14.1°	7.7°
	Y Axis	(Downs)	59°	60°	60°	0
	Facial Angle	(Downs)	87°	85.8°	86°	-0.2°
	SN-GoGn	(Steiner)	32°	34.7°	33.8°	0.9°
	FMA	(Tweed)	25°	29.8°	28.5°	1.3°
Dental Standard	IMPA	(Tweed)	90°	98.6°	100.1°	-1.5°
	1.NA	(Steiner)	22°	15.5°	23.6°	-8.1°
	1-NA	(Steiner)	4 mm	0.9 mm	1.7 mm	-0.8 mm
	1.NB	(Steiner)	25°	33.5°	33.3°	0.2°
	1-NB	(Steiner)	4 mm	7.9 mm	8.4 mm	-0.5 mm
	1.1-Interincisal	(Downs)	130°	120.1°	116.0°	4.1°
	1-Apo	(Ricketts)	1 mm	10.5 mm	10 mm	0.5 mm
Profile	Upper-Lip-S Line	(Steiner)	0 mm	2.8 mm	0.7 mm	2.1 mm
	Lower Lip- S Line	(Steiner)	0 mm	3.9 mm	0.0 mm	3.9 mm

Treatment Options

The patient had a vertical growth pattern and a retrusive mandibular projection. The maxilla was protrusive with a full Class II molar relationship. Treatment options to correct a Class II malocclusion include growth modification (orthopedic), orthodontic camouflage (compensatory), and an orthodontic surgical approach, with or without extraction. The viability of each therapeutic approach depends on the magnitude and direction of craniofacial growth, malocclusion severity, collaboration, and patient preference. Other factors such as airway obstruction and sleep apnea may influence a patient's treatment decision.[14] Several options were discussed with the parents during consultation, including extraction and headgear, upper extractions only, and non-extraction with mini-plates. The parents were adamant that they did not want the extraction of teeth, except the third molars, if necessary. They promptly refused orthognathic surgery when raised as a treatment option.

Figure 8. Post-treatment dental casts

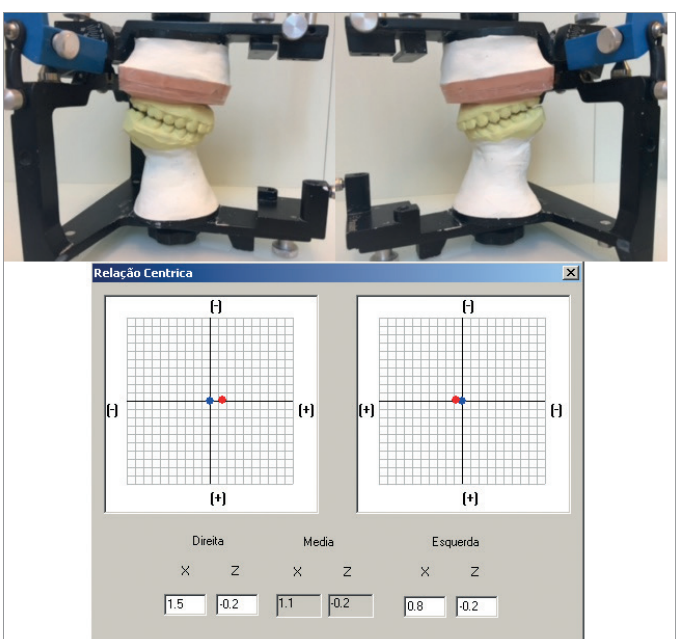

Figure 9. Mounted models on the articulator and post-treatment CPI

Treatment Plan

An acrylic splint was first recommended for the improvement of painful muscular and headache symptoms. It was worn full-time, with weekly adjustments in the first month and then adjusted once every 15 days for the final 4 months. The adjustments helped to re-establish proper canine and incisor guidance while allowing the condyles to seat properly in the fossa. Once the patient had been de-programmed and asymptomatic for 3 consecutive weeks with no perceived or painful symptoms, even on palpation, the models were mounted back on an articulator. The final articulator-mounted models were then evaluated and a diagnosis and treatment plan determined.

A self-ligating appliance (0.022×0.028-slot Roth prescription; In-Ovation R; Dentsply GAC International Inc., USA) was deliv-

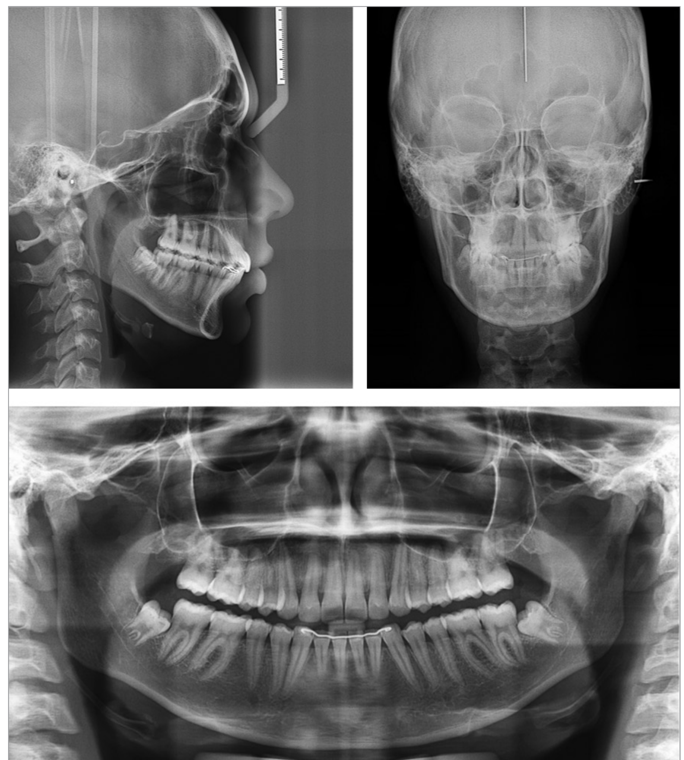

Figure 10. Post-treatment lateral and posteroanterior cephalometric and panoramic radiographs

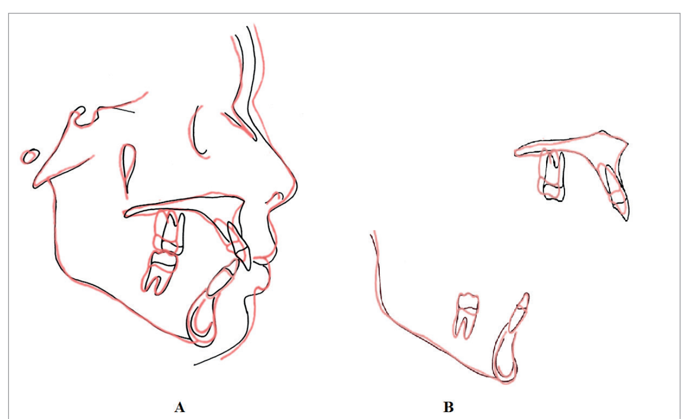

Figure 11. Superimposed tracings of the treatment (blackline) and post-treatment (red line) cephalometric radiographs. Full (A) and partial (B) overlap

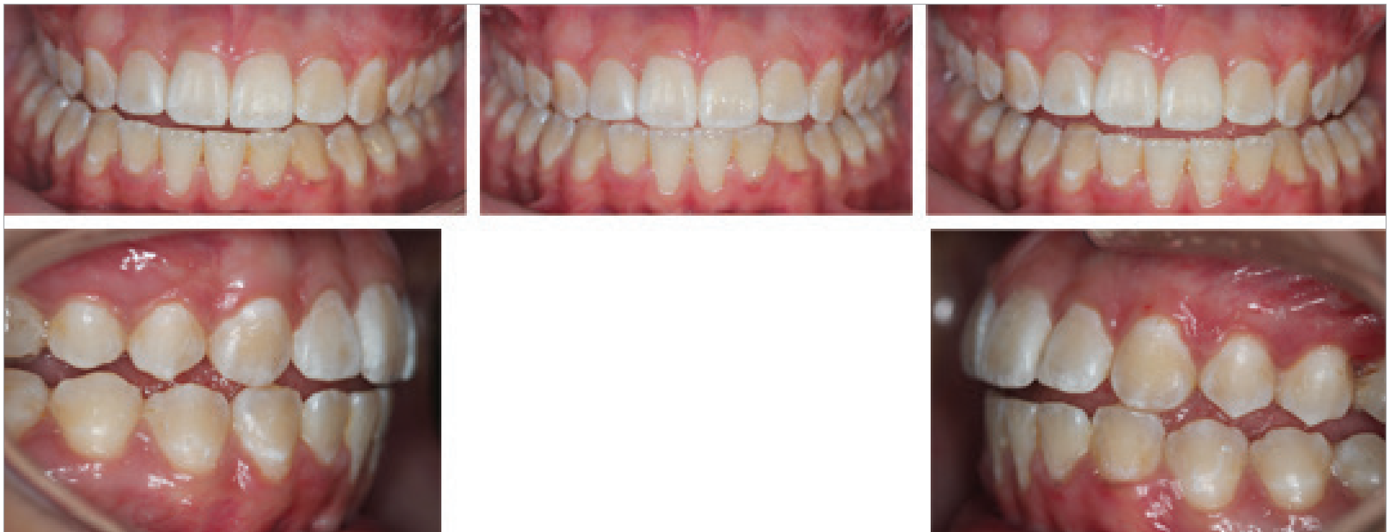

Figure 12. Anterior, right, and left canine guidance

Figure 13. Two-year post-treatment facial and intraoral photographs

ered to the upper and lower arch. Transpalatal bars were placed on the first and second molars for torque control, preventing the buccal inclination of the molars. Leveling and alignment were achieved with heat-activated NiTi archwires of the following sequence: 0.014", 0.018", 0.017×0.025". Final leveling was achieved by 0.019×0.025" stainless steel wires. After leveling, the patient was referred to an oral surgeon for the placement of bilateral maxillary zygomatic mini-plates (KLS Martin® L.P.-Jacksonville, FL, USA; ortho anchorage, faceplate, open loop, straight, three holes, 9-mm BRG, T=1.0 mm, CP titanium). The patient was allowed to heal for 15 days; then, 12-mm nickel-titanium springs of 147 cN or 5.29 oz were attached over the mini-plates and to the upper archwire between the first and second molars and mesial of the canines bilaterally.

Treatment Progress

A double 0.019×0.025" stainless steel key wire was installed for retraction of the upper incisors. A 4-mm interproximal strip was placed on the lower incisors with lingual torque to correct the crowding and excessive curve of Spee. During upper molar distalization, torques were applied to control the intermolar distance with transpalatal bars to avoid buccal proclination and crossing of the molars. After closing the spaces, study models were made for an evaluation of the maxillomandibular relationship and reassembly in the articulator. Twisted turbo 0.021×0.025" was installed intercuspally with 1/8" to intermaxillary elastics (medium strength) (Figure 5). With the orthodontic treatment accomplished, the correct relationship of the molars and canines was achieved, as well as the correct canine and incisor guides in excursive movements of the jaw, with appropriate horizontal and vertical overlap. The upper and lower fixed appliances were removed and replaced by 3×3 fixed retention of the lower arch. The patient was then referred for the removal of the mini-plates.

Treatment Results

Adequate intercuspation between the maxilla and mandible was achieved with treatment, achieving alignment between the central and maximum intercuspation relationship, as seen within the final CPI and models mounted on the articulator. A harmonious profile with significant lip improvement was observed. Correction of the relationship between the incisors provided support to the patient's lips. Correction of average midlines was achieved, achieving alignment between them. The positive treatment outcome satisfied the patient and parents, with the planned completion and treatment plan achieved (Figure 6-10; Table 1).

The final cephalometric measurements found no increases in FMA or SN-GoGn angles, indicating vertical control with mini-plates for the intrusion of the molars, observing no clockwise rotation of the mandible. Correction of the protrusion of the upper and lower lip with Class I canines and molars was achieved (Figure 9, 10; Table 1).

DISCUSSION

Several protocols are available to treat Class II malocclusion (12-15) These vary from functional appliances to orthognathic surgery, passing through molar distalization and premolar extraction. Normally, the compensatory treatment of a vertical Class II malocclusion requires two or four premolar extractions. However, the possibility of bone anchorage has expanded the range of options for the orthodontist because it is not collaboration dependent and allows for simultaneous distalization and vertical control in cases of vertical pattern (11, 14, 16, 17). Our case report reveals the challenges of these new approaches.

A comparison of intra-arch distalizers and bone anchorage has demonstrated unwanted side effects in terms of anchorage loosening, increased overjet, molar anchorage loss during retraction, and mandibular clockwise rotation with the use of a pendulum (11). In contrast, mini-plates are not dependent on patient cooperation and enable the application of force in different directions, i.e., in three planes (anteroposterior, vertical, and transversal), with absolute anchorage control. Complex treatments become simple and predictable. The mini-plates are set well above the apexes of the teeth, which allows the application of severe orthodontic forces and the movement toward several teeth; moreover, they do not interfere with tooth movement and allow the teeth to move in the area of the mini-plate (12-14, 16, 17).

A CR-MI discrepancy in the vertical or horizontal planes increases the severity of Class II malocclusion. It is difficult to correct and is considered a risk factor for masticatory muscle pain (18). This discrepancy is better detected by mounting on the articulator (18). Mounting models in CR changes the input data collected by the orthodontist and thereby affects the orthodontic diagnosis and treatment planning. The magnitude of occlusal discrepancy in the horizontal and vertical planes is more severe when the condyles are fully seated in a high percentage of patients (8). In CR, the overjet is increased and overbite decreased compared with MI, significantly changing the diagnosis and choice of treatment (19, 20).

The critical point in deciding on the use of mini-plates in our case was the refusal on the parents' behalf in relation to orthognathic surgery and the non-option of premolar extraction, as well as the high rates of success of treatments involving mini-plates (11-15, 19). Care must be taken to prevent anchorage loss of the distalized molars during retraction of the anterior teeth. Skeletal anchorage has emerged as an effective solution to many of these problems. Among the observations made on this patient was the control of anchorage loss and no unwanted side effects of distalizing, as observed by Ishida and colleagues (13). After distalization of the maxillary molars, the Class II molar relationship was successfully corrected in this patient, as observed by Nishimura et al (14).

The pre and post-treatment superimposed radiographs showed distalization and intrusion of the upper molars and a significant improvement in the facial profile, with intrusion and improved inclination of the upper incisors. There was considerable vertical control, using mini-plates for the distalization of molars, which also prevented clockwise jaw rotation. In contrast, there was a mild anti-clockwise rotation of the mandible, with an improved facial profile (12, 13, 16, 17).

CONCLUSION

This case report shows that mini-plates enable the correction of a vertical Class II malocclusion with considerable CR-MI discrepancy by the distal movement of the upper teeth without molar extrusion. This non-extraction treatment was performed with minimal patient collaboration.

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

Peer-review: Externally peer-reviewed.

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