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Assessment of Root Parallelism Following Orthodontic Treatment in Adolescent Vs Adult Patients Treated with Maxillary First Premolar Extraction: Observational-Analytical Study

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Abstract

Introduction: Achieving proper acceptable root parallelism in the extraction clinical cases is a challenge that may face any orthodontist. Although the age factor was investigated at several previous studies, there is scarce data regarding the correlation between the age of the patients and its expected relation to difficulty in attaining root parallelism as well as associated root resorption.

Aim: The aim of this study was to assess the root parallelism between maxillary canines and second premolars in adolescents versus adults group of patients requiring maxillary first premolar extraction during the orthodontic treatment (Primary outcome), and to indicate the incidence of root resorption after orthodontic treatment in both groups (Secondary outcome).

Methodology: The sample of this study was taken from panoramic radiographs of finished orthodontic cases where treatment plan included extraction of maxillary first premolars, from the record archives of the outpatient clinic of the Orthodontic Department, Cairo university. The sample enrolled in this study after fulfilling the eligibility criteria was divided into two groups, 96 Adult Patients (mean age 23.7 years old ± 6.7), and 84 Adolescent patients (mean age 14.3 years old ± 3.9). All included radiographs were digitized, the long axes of canines and second premolars were traced digitally. The angulation between the long axes of canines and 2nd premolars in the same quadrant was measured. Subsequently, the measured angulations of each quadrant were allocated as good, acceptable, poor and over-treated parallelism. Furthermore, mesiodistal angulation of canines and 2nd premolars were calculated in relation to a true horizontal reference plane passing through infraorbital rim. Moreover, root resorption was evaluated on panoramic radiograph using digital software program by calculating the difference of the tooth length between the pre- and post-treatment panoramic images after being calibrated. Besides, radiographs were assessed by two expert orthodontic clinicians using cut of point > 2 mm guided by Lavender and Malmgren grading.

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Results: the frequency of good root parallelism was statistically higher in adolescent group (60.11%) than the adult group (41.6%). The amount of root resorption in adult group was significantly higher than adolescent group (P < 0.05). 65.7% of the lateral incisors in the adult group showed root resorption which was opposed by 58.8% in the adolescent group. The highest mean of root resorption in adolescent group was in left lateral incisor (1.14 ± 0.26), while in adult group the highest mean of root resorption was in right lateral incisor (1.5 ± 0.3).

Conclusion: Adolescent group of patients showed higher frequency of Good root parallelism compared to the adult group. Incidence of root resorption was statistically higher in adult group of patients in comparison to the adolescent group.

Keywords: Root parallelism; Root Resorption; Adolescents and Adults

Introduction

One of the ways to achieve harmony during orthodontic treatment planning is by extraction of some permanent teeth in the dental arch, especially in the presence of arch length deficiency. The orthodontist may face some challenges in the extraction cases. One of them is to achieve proper acceptable root parallelism after extraction space closure. Additionally, mechanics used may be causative factor to apical root resorption, and the interdental bone level could be affected as well. Nowadays, the necessity of a "good parallelism" between the roots of teeth is a widely accepted concept. However, root resorption is an unpredictable disappointing side effect sometimes precipitated by the application of orthodontic forces.

The goal of any orthodontic treatment is to obtain the best possible esthetic and functional occlusion for the patient. Proffit., *et al.* stated that ""effectiveness and efficiency" involves correction of the underlying malocclusion in the shortest duration possible with minimal patient discomfort which has thus become the main target of orthodontists worldwide" [1]. To ensure ideal orthodontic outcome with reasonable stability and maintenance of the achieved results, the finishing stage should include: obtaining parallel roots, adjusting the position of individual teeth to correct mesiodistal and buccolingual inclinations, and leveling marginal ridges by correction of bracket positions.

Panoramic radiography is frequently used to visualize root parallelism and mesiodistal tooth angulation, so that orthodontists can critically evaluate crown and root position before, during, and after orthodontic treatment in the pursuit of excellence of the occlusal result. This is necessary to maintain the corrected occlusal relationships which amends distribution of the occlusal forces. Concurrently, the American Board of Orthodontics (ABO) Objective Grading System represent the current standard of care to which all patients should be treated. There are seven criteria that are graded for cases presented by candidates for Board Diplomate Status in the ABO, including root angulation and interproximal contacts [2].

Moreover, root parallelism has the added advantage of eliminating any additional trauma to the periodontium; by reducing the reopening of closed contact points between adjacent teeth leading to enhanced periodontal prognosis. Additionally, it has been observed from a restorative point of view that tight contacts between teeth prevent food impaction and subsequent trauma to gingival tissue.

On the other hand, the most unfavorable side effect to orthodontic treatment is external apical root resorption (EARR) which can be diagnosed by radiological examinations. The literature suggests that the dentoalveolar support is reduced after orthodontic treatment as a result of root resorption, proximal bone loss, and in teeth adjacent to closed extraction sites. Multiple risk factors have been correlated to the incidence of the external apical root resorption, among which the age of the patient at the start of orthodontic treatment. It has been noticed that the greatest orthodontic resorption takes place in adults when more orthodontic treatments are made and the apeces are already closed. Accordingly, adult patients require different treatment approaches from adolescents due to various age related considerations (lack of growth potential, aging of tissues, vulnerability to root resorption and vulnerability to TMD).

Materials and Methods Material Study design

Observational cross sectional analytical study.

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Participants

The sample of this study was taken from panoramic radiograph of finished orthodontic cases with treatment plan included extraction of maxillary first premolar, from the records of the outpatient clinic of the Orthodontic Department, Faculty of Dentistry, Cairo University.

- Group 1 (Adolescents) = 84 participants.
- Group 2 (Adults) = 96 participants.

Eligibility criteria

The selected sample fulfilled the following eligibility criteria:

- Inclusion criteria:
 - 1. Panoramic radiographs for orthodontic patients older than 12 years old.
 - 2. Extraction of permanent maxillary first premolar.
 - 3. Same head position at scanning time by using the same machine settings.
 - Same machine: Orthopantomograph Planmeca Promax 2P (PM2002CC, Planmeca, Helsinki, Finland) with a kilovoltage of 55 to 85 and an exposure time of 15 seconds at a focal distance of 46 cm.
 - Same bracket prescription (Roth prescription, slot size #22).
 - 6. Full set of teeth (not necessarily including third molars).
- Exclusion criteria:
 - 1. Systematic diseases.
 - 2. Non extraction cases.
 - 3. Severe divergence or convergence between roots of maxillary canine and second premolar.
 - 4. Radiographic errors and artifacts.

Methods

Root parallelism measurements

First all included radiographs were digitized, the long axes of canines and second premolar were traced digitally using Digital software¹ (Figure 1). Followed by, Calibration of panoramic radio-

¹"IC Measure 2.0.0.161, the imaging source Europe GmbH, Bremen, Germany". graphs which was done before linear or angular measurements; to confirm that the radiographs were 1:1 scale.

Figure 1: IC Measure 2.0.0.161 digital software.

After tracing, the angulation between the long axes of canines and 2nd premolars in the same quadrant was measured and corrected to the nearest digits (Figure 2). Subsequently, according to the classification dictated by Mayoral [3], the measured angulations of each quadrant were allocated as good, acceptable, poor and over-treated parallelism.

In order to evaluate the mesiodistal angulation of canines and 2nd premolars, a true horizontal reference plane was constructed passing through infraorbital rim (Figure 3). This horizontal reference line was drawn through the lowest point of the orbital fossa on both sides following the method described by Mowafy and Zaher [4].

At the end, all data were inserted in a color coded table form.

Root resorption measurements

After screening the whole sample, patients who matched the selection criteria, were divided into 84 adolescent group of patients (mean age 14.3 years old \pm 3.9), and 96 adult group of patients (mean age 23.7 years old \pm 6.7). The drop out percentage did not exceed 13%.

Accordingly, root resorption was evaluated on panoramic radiograph using digital software program² (Figure 1). In addition to, taking the opinion of two expert orthodontic clinicians.

²"IC Measure 2.0.0.161, the imaging source Europe GmbH, Bremen, Germany".

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It should be noted that, several previous studies [5,6] have proven that maxillary central and lateral incisors were the most prone to dental injury and root resorption. So those were the only teeth evaluated.

Subsequently, the tooth length from the tooth apex to incisal edge or cusp tip was measured on the panoramic radiograph using the digital software (Figure 4). These measurements were performed on both pre- and post-treatment panoramic images after doing the calibration procedure.

Figure 4: Measuring the tooth length from the tooth apex to incisal edge.

At that moment, root resorption was calculated by the difference of the tooth length between the images. Besides, being reassessed using the opinion of two expert orthodontic clinicians using cut of point > 2 mm guided by Lavender and Malmgren grading [7].

Results

Root parallelism

Comparison of root parallelism between adults and adolescents according to Mayoral classification

Classification of root parallelism according to revealed that good is significantly higher percent in adolescent group (58.9, 73.4, 60.11) and in adult was (45.2, 43.7, 41.6) for right, left and both sides. On the other hand, Poor is the significantly lowest percent in adolescent group (4.1, 1.2, 2.3), while in adult group overtreatment revealed the significantly lowest percent (5.9, 7.2, 6.2) in right, left and both sides as presented in table 1 and figure 5.

Figure 2: Measuring the angle between the long axes of canine and 2nd premolar. (A) Denoting positive angulation.(B) Denoting negative angulation.

Figure 3: Measuring the angle between the long axes of canines in relation to a true horizontal reference plane passing through infraorbital rim.

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N		Right		Left		Both sides	
		%	N	%	N	%	
Adolescent	Good	43	58.9	58	73.4	101	60.11
	Acceptable	23	31.5	19	24.05	42	25
	Poor	3	4.1	1	1.2	4	2.3
	Over treatment	4	5.4	1	1.2	5	2.9
	P value	0.001*		0.001*		0.001*	
Adult	Good	38	45.2	42	43.7	80	41.6
	Acceptable	34	40.4	39	40.6	73	38
	Poor	7	8.3	8	8.3	15	7.8
	Over treatment	5	5.9	7	7.2	12	6.2
	P value	0.001*		0.001*		0.001*	

Table 1: Comparison of root parallelism between adults and adolescents according to Mayoral classification.N: Count; %: Percentages; *: Significant difference (P < 0.05).

		Adolescent 84		A	P value	
		N	%	N	%	
Central	Right	4	11.7	6	15.7	0.7
	Left	4	11.7	5	13.15	0.9
	Total	8	23.5	11	28.9	0.9
Lateral	Right	11	32.5	12	31.5	0.5
	Left	9	26.4	13	34.2	0.8
	Total	20	58.8	25	65.7	0.6

Table 2: Comparison of root resorption (Binary) of both groups.N: Count; %; Percentages.



Figure 5: Classification of root parallelism.

Root resorption

Comparison between both groups (binary)

Chi square test was used to compare between adolescent and adult group and revealed that adult was significantly higher than adolescent in right, left and total of both central and lateral as presented in table 2 and figure 6.

Discussion

Nowadays, wide range of patients are seeking orthodontic treatment. This study sheded light on a topic that the literature failed to introduce a conclusive evidence about the correlation between the age factor of the patients and its expected relation to difficulty in attaining root parallelism as well as associated root resorption. Although, the literature recommends applying light forces when dealing with adult patients because they are more prone to complications that may accompany orthodontic treatment including root changes, and periodontal damage, there is scarce data regarding the correlation between the age of the patients and its expected relation to difficulty in achieving proper root parallelism.

Some studies tried to describe the bone condition histologically through aging. Melsen., *et al.* [8], claimed that adults did not have the same cellular pool of young people and that is why forces ap-

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plied to teeth through orthodontic treatment should be reduced. Additionally, cortical bone becomes denser and the spongy bone reduces with age according to the study conducted by Sebbar., *et al* [9]. Consequently, marginal bone loss is more common in adults, which leads to apical shifting of the center of resistance of the involved tooth resulting in increased tipping moment produced by the applied force.

The reliability of panoramic radiographs in assessment of root parallelism and evaluation of root resorption incidence is a controversial issue in the literature. Many studies investigated the suitability of the panoramic radiograph for the assessment of the mesiodistal angulation of teeth. The accuracy of panoramic radiographic systems in determining tooth angulations was detected by lucchesi., *et al* [10].

Mayoral [3] (1982) evaluated root parallelism of canines and 2nd premolars in fifty-three 1st premolars extraction cases treated with light continuous wire. In 67.4% of assessed maxillary quadrants and 46.2% of mandibular quadrants good root parallelism was obtained. Results of this study agree with the current study that the orthodontic treatment in the majority of patients finished with favorable parallelism between teeth adjacent to extraction sites. In this study, the frequency of good root parallelism in adolescent group was 60.11% which was higher than the adult group where the frequency of good root parallelism occurred in 41.6%.

Several difficulties were encountered whether during sample allocation or at the measuring stage. Screening was done for the collected sample and exclusion of panoramic radiographs that had errors or artifacts. The excluded radiographs included: distorted images from improper alignment of the tube or film, blurred images from movement of the patient during exposure, dark or light films, double exposure artifact and magnification error. However, digital processing of the collected sample solved many problems through adjusting brightness and contrast.

The correlation between the incidence of the EARR, and the age of the patient at the start of orthodontic treatment was carefully diagnosed. The greatest orthodontic root resorption was noticeable in adults where more orthodontic treatments are made and the apices are already closed. In the current study, amount of root resorption in adult group was significantly higher than adolescent group (P < 0.05) in right, left and total of both central and lateral incisors. As 65.7% of the lateral incisors showed root resorption in the adult group which was opposed by 58.8% in the adolescent group. While the central incisors showed less amount of root resorption in both groups compared to the laterals.

The results of the present study agreed with the study conducted by Sameshima and Sinclair [11], who described that radicular resorption increased with age, especially in the anterior segment, corresponding to the incisors. The results of their study showed that resorption occurs primarily in the maxillary anterior teeth, averaging over 1.4 mm. Besides, the worst resorption was seen in maxillary lateral incisors and in teeth with abnormal root shape (pipette, pointed, or dilacerated).

Conclusion

Based on the data from the current study, the following could be concluded:

- 1. Adolescent group of patients showed higher frequency of Good root parallelism compared to the adult group.
- For the adolescent patients, Class I crowding had the highest frequency of good root parallelism by 62.8% followed by Class II division 1 by 61.4% and Class I bimaxillary protrusion by 53.3%. While for the adult patients, the Class I bimaxillary protrusion malocclusion had the highest frequency of good root parallelism by 58% followed by Class I crowding by 40.6% and Class II division 1 by 31.1%.
- 3. Incidence of root resorption was statistically higher in adult group of patients in comparison to the adolescent group.
- 4. Moderate to severe EARR is more prevalent in lateral than in central maxillary incisors.
- 5. Significant associations exist between EARR and the duration of fixed-appliance treatment and the magnitude of overjet reduction.

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