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Research Report

Maxillary anterior root resorption in Class II/I malocclusion patients post fixed orthodontic treatment

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ABSTRACT

Background: *Previous studies on root resorption were reviewed by panoramic radiographs. Cone-beam computed tomography (CBCT) showed that 41.5% of teeth experienced resorption when panoramically examinated, while 68% of teeth experienced resorption when the examination method used was CBCT. Root resorption occurs in the maxillary central incisor (as much as 74%) and in the maxillary lateral incisor (as much as 82%). The maxillary canines have the most resorption, followed by the lateral maxillary incisors.* ***Purpose:*** *The aim of this study was to determine the differences of apical resorption in anterior maxillary teeth before and after orthodontic treatment in skeletal Class I/II cases of extraction.* ***Methods:*** *Samples from this study were the results of panoramic photographs of 50 patients treated by fixed orthodontic appliances at the Dental and Oral Hospital Airlangga University. These were selected according to the sample criteria. The evaluation method consists of measuring root and crown lengths with a digital application (RadiAnt DICOM Viewer). Subsequently, the measurements were evaluated using CBCT images.* ***Results:*** *The data were statistically analysed using normality tests with Shapiro–Wilk and Kolmogorov–Smirnov tests. Based on the results of paired sample tests, it was found that every treatment group had significant differences in the average length of the crowns and roots, with a result of p=0.000 (p<0.05).* ***Conclusion:*** *The use of CBCT is considered quite effective and accurate in evaluating root resorption compared to panoramic photographs.*

Keywords: *CBCT; Class II division I malocclusion; maxillary anterior; panoramic photographs; root resorption*

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INTRODUCTION

Malocclusion is a type of connection between the maxilla and mandible that deviates from the standard form, but is accepted as a normal form. Malocclusion can be caused by dentofacial balance. This dentofacial balance is not caused by one factor alone, but several factors that influence each other. These factors influence heredity, environment, growth and development, ethnicity, function and pathology.[1,2] Malocclusion can be treated using orthodontic appliances to obtain normal occlusion and a proportional facial profile.[2] The prevalence of malocclusion in Indonesia is still high (seen in around 80% of the population) and may increased dental and oral health problem[3]

Orthodontic treatment always uses mechanical force to move teeth. The mechanical force on the tooth that will be moved orthodontically will be transmitted to the entire tooth's supporting tissue, which starts a remodelling process to help the tooth move through the bone.[4]

Orthodontic treatment has a positive effect but can have undesirable secondary effects. During orthodontic treatment, the application of various procedures, tools and materials can cause side effects, both local and systemic. One of the side effects is root resorption, which is clinically difficult to identify when radiographs are made, especially in cases of orthodontic treatment.[5]

External Apical Root Resorption (EARR) is a state of permanent loss of the apex structure of the tooth. Cross-sectional studies show that EARR is a common iatrogenic consequence and minor problem for the average orthodontic patient, with the mean radiographic resorption being less than 2.5 mm.[6,7]

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One study found that the risk factors involved in root resorption were dental trauma, bone density, root morphology, age and length of treatment. Most of the research on root resorption has focused more on maxillary incisors because they are thought to be more prone to root resorption than other teeth. More specifically, root resorption often occurs in maxillary incisors and other teeth with an abnormal root shape; for example, those that are pipette-like, blunt or macerated. The maxillary lateral incisors were most frequently subjected to root resorption, followed by the maxillary central incisors.[4]

Root resorption occurs in the maxillary central incisor (up to 74%) and in the maxillary lateral incisor (as much as 82%). The maxillary canines have the most resorption, followed by the maxillary lateral incisors, which are measured using cone-beam computed tomography (CBCT).[8] Research shows that root resorption in maxillary first molars has a mean resorption of 53.3%-63.3%. This absorption occurs because the force applied to the molars is greater than that on the premolars. In addition, the resorption in the extraction case was 3.72 times greater than that in the non-extraction case.[7,8]

Several studies of root resorption and its relationship with orthodontic treatment have found that numerous factors influence root resorption: age, sex, nutrition, genetics, type of appliance, the amount of force used during treatment, extraction or non-extraction, length of treatment and distance of tooth movement. There is positive correlation between the strength of orthodontic style, length of treatment and increased resorption.[9,10]

Individuals with skeletal anterior open bite have a greater risk of resorption during orthodontic treatment compared to those with other types of malocclusion. Dental intrusions are four times more likely to cause EARR than extrusion movements.[4,11]

Previous studies on root resorption were reviewed by panoramic radiographs and CBCT. It was found that 41.5% of teeth experienced resorption when panoramically examined, while 68% of teeth experienced resorption when the examination method used was CBCT.[9] An advantage of CBCT is its accuracy in measuring root resorption, but its disadvantage is that radiation levels are 1.5 to 33 times higher than levels in panoramic photographs; thus, careful consideration is needed when using CBCT.[9]

In this study, panoramic radiographs show some degree of distortion, which was caused by the lack of a three-dimensional image. CBCT imaging allows the three-dimensional evaluation of teeth and adjacent anatomical structures, which provides a more detailed visualisation of the tooth and surrounding structures and can diagnose EARR with accuracy.

Based on the above, the authors were interested in researching the evaluation of maxillary anterior tooth root resorption that occurred before and after orthodontic treatment in Class I/II malocclusion by using panoramic radiographs and CBCT. The aim of this study was to determine the differences of apical resorption in anterior maxillary teeth before and after orthodontic treatment in skeletal Class I/II cases of extraction and to help the operator prevent the occurrence of more severe root resorption when finding it on radiographs.

MATERIALS AND METHODS

This study is an observational analytic research. The sample of this study was made up of patients who had been treated by fixed orthodontic appliances at Dental and Oral Hospital Airlangga University from 2014 to 2018. They were selected according to the sample criteria: patients needed to have Class II division 1 skeletal patterns, have had both first maxillary premolars extracted. Ethical clearance was obtained from the health research ethics commission of the Faculty of Dental Medicine, Universitas Airlangga (number: 614/HRECC.FODM/IV/2019). The minimum sample size needed was 35 to avoid drop out. It is necessary to over-sample, so this study also used 50 samples from the data obtained at the Dental and Oral Hospital Airlangga University. These samples qualified according to the Lameshow formula.[7]

Panoramic Measurements: Methodology developed by Fontana et al.[11] demonstrates periapical radiographic measurements of central incisors with root lengths (reference teeth) taken before treatment and after treatment. The evaluation method involves measuring the length of the roots and crowns using a digital application (RadiAnt DICOM Viewer) (Figure 1). The root apex, incisal edge and cemento enamel junction (CEJ) of each tooth were

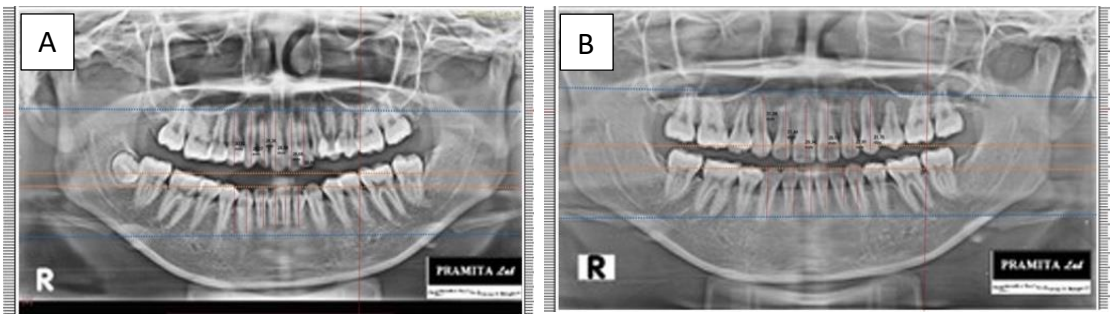

Figure 1. A) Before orthodontic treatment. B) After orthodontic treatment. An example of calculating tooth length before and after treatment using RadiAnt DICOM software.

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determined by making a point. The longitudinal axis of each tooth is projected from the tip point of the root to the edge of the incisal following the root canal. The perpendicular axis is then directed down the longitudinal axis from the mesial to the distal side of the CEJ. The value of the crown length is automatically calculated from the incisal edge to the CEJ projection and the root length from the CEJ projection to the apex of the root (Figure 2). The difference between the two measurements shows EARR.[11]

Measurements on CBCT: Then, the measurements were evaluated using the CBCT image. First, the CBCT image of the maxillary central incisor obtained after orthodontic treatment was aligned using the CEJ angle. Next, the amount of apical root resorption was calculated as the distance between the root apex before and after orthodontic treatment on the axis of the maxillary central incisor. The root resorption area was measured using a digital application (RadiAnt DICOM Viewer) and classified as labial and palatal after identifying tooth axes (Figure 3). The ratio of labial root resorption is defined as the ratio of the area of labial root resorption to the resorption area for all roots, and the ratio of palatal root resorption is defined as the ratio of the area of the palatal area to the area of resorption for all roots.

The measurements of the lengths of the crowns and roots that were obtained were then tested using IBM SPSS 26 for Mac to determine the distribution of the data. The first data analysis that was performed focused on data normality. Analysing data is needed to determine the use of the next statistical test or whether parametric or non-parametric tests should be used next. If the data is normally distributed, parametric statistics can be used.[13] The normality tests used in the data analysis of this study were the Kolmogorov–Smirnov test and the Shapiro–Wilk test. These tests can be used on both research with small samples and research with large samples.[8]

RESULTS

Based on the measurements of the lengths of the crowns and roots using a digital application (RadiAnt DICOM Viewer), several results were obtained. The results of paired sample tests found that almost every treatment group had significant differences in their average lengths of crowns and roots, as p=0.000 (p<0.05) (Table 1). This significant difference indicates the presence of root resorption after orthodontic treatment.

As shown in this diagram (Figure 4), tooth 11 had an average root resorption of 0.98 mm, tooth 12 had an average of 1.17 mm, tooth 13 had an average of 0.86 mm, tooth 21 had an average of 0.93 mm, tooth 22 had an average of 1.13 mm and tooth 23 had an average of 0.87 mm. Based on the diagram above, the highest root resorption was in tooth 12 and the lowest was in tooth 13.

In this study, the authors included 10 participants who had completed orthodontic treatment and were then recalled

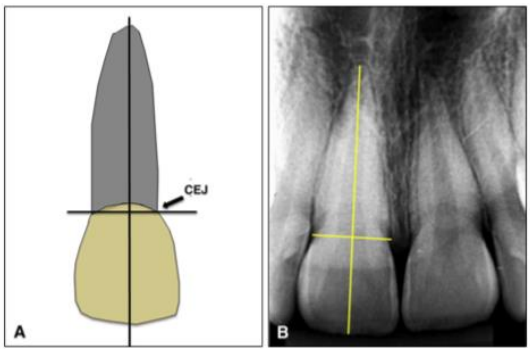

Figure 2. A) Anatomic landmarks for measuring EARR: cementoenamel junction (CEJ). B) A reference for measuring X-rays.[12]

Table 1. Mean and standard deviation of the calculations of crown and root lengths with panoramic measurements

Teeth	Mean ± SD		Delta (%)	p value
	Before treatment	After treatment		
11	29.34±3.48	28.46±3.25	-2.93	<0.0001
12	27.44±3.05	26.27±3.11	-3.11	
13	31.58±3.89	30.72±3.75	-2.83	
21	29.51±3.26	28.58±3.25	-2.98	
22	27.81±3.23	26.68±3.23	-3.08	
23	31.76±3.84	30.89±3.76	-2.89	

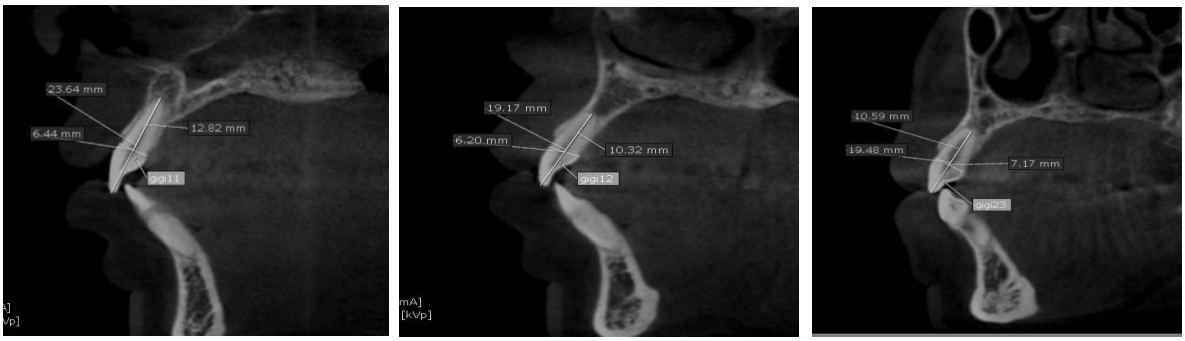

Figure 3. Measurement of the degree of absorption in CBCT with the use of RadiAnt DICOM software.

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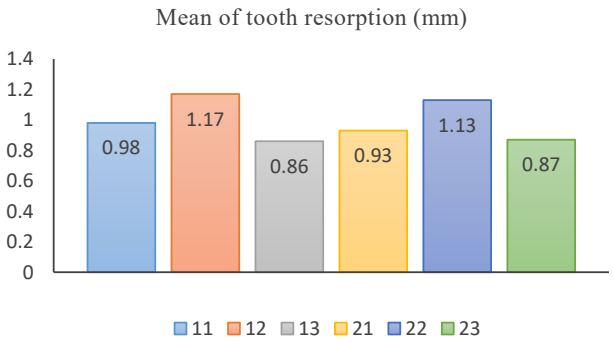

Figure 4. Diagram showing the mean of crown and root length calculations with panoramic measurements.

Table 2. Mean and standard deviation of the crown and root length calculations with CBCT

Teeth	Mean ± SD
11	29.82 ± 3.21
12	26.83 ± 3.13
13	34.02 ± 3.45
21	25.99 ± 3.11
22	25.01 ± 3.07
23	29.13 ± 3.14

for CBCT photos. The authors compared root resorption on panoramic radiographs after treatment with CBCT photographs (Table 2). The results obtained indicated that seven samples showed mild resorption by panoramic (an average of 1.2 mm) and three samples showed moderate resorption (around 2.5 mm). However, using CBCT revealed that eight samples showed moderate resorption and two samples showed mild resorption. This is consistent with Dudic's study in which 275 teeth were evaluated with panoramic radiographs and CBCT to measure apical root resorption.

DISCUSSION

In general, Class II malocclusion often occurs with tooth root resorption of mild to moderate severity.[14] Patients with Class II malocclusion have an increased frequency of tooth root resorption. Patients with Class I malocclusion had tooth root resorption with an average value of 1 mm, while patients with Class II malocclusion had an average of 2 mm. Maxillary central incisors had greater resorption values in Class II malocclusion patients.[15]

The classification of Class II malocclusion in this study was based on skeletal anteroposterior discrepancy. The antero-posterior relationship between the maxilla and mandible was evaluated through the A point, Nasion, B Point (ANB) angle, where the ANB size was significantly greater in skeletal Class II than in skeletal Class I.

In patients treated using bracketed MacLaughlin, Bennet and Trevisi (MBT), root resorption was 18.26%, while patients treated using edgewise brackets had a root resorption of 14.82%. Tooth root resorption in MBT patients was greater than in edgewise patients. This was due to the tooth root in MBT.

Torque with an increasing angle will affect the severity of tooth root resorption. The increase in torque angle and the duration of torque usage causes the apical tooth to have a hollow hyaline zone. The accumulation of this hollow hyaline zone will result in a short tooth root and will reduce the dimensional ratio between the root and crown of the tooth.[6]

Root absorption often occurs in the apical part of softer teeth and contains less of Sharpey's fibre. Another cause of this is the use of torque, as it presses the periodontal tissue at the apical part so that the tooth is more susceptible to root resorption.[6]

Significant differences were observed between the two methods and for all levels of resorption. One hundred and forty-five teeth evaluated panoramically showed no resorption, whereas, out of those evaluated by CBCT, only 80 teeth showed no resorption. Ninety-two teeth showed mild apical root resorption with panoramic evaluation, and this increased to 128 teeth with CBCT. Only 21 teeth had moderate panoramic resorption, but this increased to 48 teeth with CBCT. In addition, two teeth had severe resorption when assessed by CBCT.

CBCT imaging allows for a three-dimensional evaluation of teeth and their adjacent anatomical structures, resulting in a detailed visualisation of the tooth as well as its neighboring structures. Subsequently, the area of the tooth resorption can be detected easily. In contrast, the panoramic radiographic image is a two-dimensional radiographic image that experiences distortion. This results in difficult interpretation with minimal accuracy, which makes it less helpful in measuring root resorption.

In conclusion, this study has proven the existence of root resorption after orthodontic treatment in Class II/I malocclusion cases. The highest resorption (a value of more than 1 mm) was found in tooth 12 (1.13 mm) and the lowest was found in tooth 13 (0.86 mm). The use of CBCT is considered quite effective and accurate in evaluating root resorption compared to panoramic photos.

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