ORIGINAL ARTICLE

ROOT RESORPTION OF PERMANENT INCISORS DURING THREE MONTHS OF ACTIVE ORTHODONTIC TREATMENT

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Background: Root resorption is one of the most common and undesirable sequelea of orthodontic treatment. The aim of this study was to evaluate the amount of root resorption in permanent incisors during 3 month active period of fixed orthodontic appliance therapy using periapical radiographs. **Methods:** Periapical radiographs of a total of 138 permanent teeth (n=138, mandibular $n1$=52, maxillary $n2$=86) were evaluated for root resorption. All patients were treated with 3M MBT multi-bonded, pre-adjusted appliances with 0.022 inch slots. Initial levelling and alignment was achieved with 0.0175 inch co-axial wires. All four incisors (maxillary and mandibular) were measured for any change in root length. The change in root length between T_0 (pre-treatment) and T_1 (post-treatment) was measured in millimetres and expressed in terms of percentage of original root length. **Results:** The mean pre treatment (T_0) root length for the maxillary teeth ($n1$=62) was 19.27±2.86 mm and 20.01±2.57 mm for the mandibular teeth ($n2$=31). The post-treatment (T_1) root length for the maxillary teeth was 18.96±2.85 mm and 19.49±2.4 mm for the mandibular teeth showing a mean resorption of 0.31 mm and 0.52 mm for the maxillary and mandibular teeth respectively. **Conclusion:** Root resorption was strongly correlated with active orthodontic appliance therapy with maxillary and mandibular incisors being most susceptible. It was found that root resorption can be detected even in the early levelling and alignment stages of orthodontic treatment.

Keywords: Root resorption, incisor, orthodontics, dental radiography

INTRODUCTION

External Apical Root resorption (EARR) is one of the most common and undesirable sequel of orthodontic treatment.[1–3] It is an inflammatory process that leads to an ischemic necrosis localised in the periodontal ligament after the application of Orthodontic force.[4–7] While severe external apical root resorption can compromise otherwise successful orthodontic outcome most root loss resulting from orthodontic treatment does not decrease the longevity or the functional capacity of the involved teeth. The onset and progression of root resorption are associated with risk factors related to orthodontic treatment such as the duration of treatment,[8] the magnitude of the force applied,[9] the amount of tooth movement,[10] and the method of force application[11]. Patient-related risk factors are the individual susceptibility on a genetic basis,[12] some systemic diseases,[13,14] anomalies in root morphology[15,16] and previous endodontic treatment[17].

Orthodontically treated patients show loss of 1/3rd or ½ or even more of the root structure with maxillary incisors being the most susceptible.[18,19] Recent studies show frequency of root resorption in permanent incisors may increase up to 73% after orthodontic treatment.[20] Teeth with abnormal root form (long, narrow and deviated roots) are at an increased risk of resorption during early stages of treatment.[21] Therefore, lateral incisors show even greater degrees of root resorption as compared to the centrals.[22]

When root shortening exceeds a certain amount, the only way to diagnose it is by using roentogenic procedures,[23] such as peri-apical,[24] panoramic,[25] and cephalometric radiographs[26]. Peri-apical film exposure has less magnification and distortion but is more difficult for practitioner to obtain. When greatest accuracy is needed, peri-apical films are preferred.

A 3 month radiographic control has been recommended for incisors as they are at increased risk of root resorption (3% affected versus all other teeth).[27] As in most instances this phenomena is clinically asymptomatic, therefore, early radiographic evaluation during the treatment is necessary in order to detect the occurrence of root damages and quickly reassess the treatment goals.

The objective of this study was to evaluate the amount of root resorption in permanent incisors during 3 month active period of fixed orthodontic appliance therapy with light forces using a periapical radiograph and to compare the degree of resorption between maxillary and mandibular incisors.

MATERIAL AND METHODS

In this prospective study 32 new patients, 10 males and 22 females (mean age at T_0=15.16 years) reporting to the orthodontic outpatient department between Apr 2008 and Dec 2008 were randomly selected after obtaining informed written consent from each patient and his/her guardian. Periapical radiographs of a total of 138 permanent teeth (n=138, mandibular n_1=52, maxillary n_2=86) were evaluated for root resorption. All permanent incisors (maxillary and mandibular)

without previous orthodontic treatment were included. Any impacted tooth, endodonticaly treated, presence of any morphologic dental anomaly *viz* mesiodens, taurodontism, dentinogenesis imperfecta, etc. and patients with craniofacial syndromes or systemic disease were excluded.

All patients were treated with 3m MBT multi-bonded, pre-adjusted appliances with 0.022 inch slots. Initial levelling and alignment was achieved with 0.0175 inch co-axial wires.

Standard periapical radiographs using long cone paralleling technique by the same operator were obtained before treatment (T_0) and approximately 03months (T_1) after placement of incisor (maxillary/ mandibular) brackets. All periapical radiographs of insufficient quality in which the roots were distorted or not clearly visible at either T_0 or T_1 were excluded. Thus, of the total of 138 incisors initially selected, 45 incisors were rejected and a final sample of 93 incisors was considered representative for the study population. All impressions of orthodontic patients were taken with fast setting alginate and poured with orthodontic plaster having a maximum expansion of 0.2%.

All four incisors (maxillary and mandibular) were measured for any change in root length. Three anatomic landmarks were identified for each incisor on each radiograph.

I: Tip of incisal edge
C: Centre of cementoenamel junction
A: Root apex

Following measurements were done on the selected radiographs at T_0 and T_1 using a digital caliper up to an accuracy of 0.01 mm.

Crown Length (CL)= From point I to point C
Root Length (RL)= From point C to point A

To counter any magnification errors in the radiographs, Young's formula was applied. For this purpose crown length was also measured on the corresponding study casts. The change in root length between T_o and T_1 was measured in millimetres and expressed in terms of percentage of original root length using the following formula:

$$\text{Change in root length (CRL)} = RL_{intital} - RL_{final} \times 100 / RL_{initial}$$

For intra-examiner reliability, measurements for 15 randomly selected radiographs were repeated after 1 month by the same examiner. Inter-examiner reliability was assessed by repeating the measurements for 15 randomly selected radiographs by an equally trained second examiner at least 2 weeks apart from the primary examiner.

All data were analysed using SPSS-16. Means and standard deviations for the root lengths at T_0 and T_1 were calculated. A paired *t*-test was used to assess intra examiner and inter examiner reliability and also to compare the root lengths at T_0 and T_1. Independent *t*-test was used to compare the change in root lengths between maxillary incisors and mandibular incisors. Analysis of variance was used to compare the change in root length between maxillary central incisors, maxillary lateral incisors and mandibular incisors.

RESULTS

Based on the inclusion and exclusion criteria, a final sample of 93 incisors (n=93) was obtained. Paired *t*-tests did not yield a significant result for intra examiner and inter examiner reliability. The mean pre treatment (T_0) root length for the maxillary teeth ($n1$=62) was 19.27±2.86 mm and 20.01±2.57 mm for the mandibular teeth ($n2$=31). The post treatment (T_1) root length for the maxillary teeth was 18.96±2.85 mm and 19.49±2.4 mm for the mandibular teeth showing a mean resorption of 0.31 mm and 0.52 mm for the maxillary and mandibular teeth respectively.

Table-1: Pre-treatment T_0 Means and SD

Group	Min (mm)	Max (mm)	Range (mm)	Mean (mm)	SD (mm)
Maxillary (n=62)	12.44	25.26	12.82	19.27	2.86
Mandibular (n=31)	14.07	24.69	10.62	20.01	2.57

Table-2: Post-treatment T_1 Means and SD

Group	Min (mm)	Max (mm)	Range (mm)	Mean (mm)	SD (mm)
Maxillary (n=62)	12.22	24.33	12.11	18.96	2.85
Mandibular (n=31)	13.61	23.74	10.13	19.49	2.40

The change in root length was also expressed in terms of percentages of the original root lengths to determine its clinical significance. The greatest percentage change in root length was observed for the mandibular incisors (2.60%) and least for the maxillary centrals (1.52%).

Table-3: Change in root length

	Change in root length	
Group	**mm**	**%**
Maxillary central incisors	0.30	1.52
Maxillary lateral incisors	0.32	1.70
Mandibular incisors	0.52	2.60

Paired *t*-test showed a highly significant difference (p<0.001) between T_0 and T_1 root lengths for all three groups, i.e., maxillary central and lateral incisors and mandibular incisors.

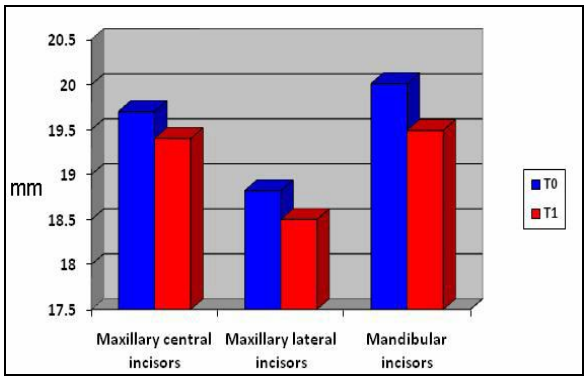

Figure-1: Pre-treatment (T_0) and post-treatment (T_1) root lengths

Table-4: Results of Paired *t*-test comparing T_0 and T_1 root lengths

Group	Mean root length (mm)		*p*-value
	T_0	T_1	
Maxillary central incisors (n=32)	19.7	19.4	0.000*
Maxillary lateral incisors (n=30)	18.82	18.50	0.000*
Mandibular incisors (n=31)	20.01	19.49	0.000*

*p<0.01 is highly significant

Independent *t*-test showed a significant difference between the change in root length for the maxillary and mandibular incisors. However one way analysis of variance ANOVA, used to compare the amount of root resorption between the maxillary central incisors, maxillary lateral incisors and mandibular incisors did not show a significant result.

DISCUSSION

Orthodontically induced root resorption starts by development of resorption lacunae adjacent to the hyalinized zones on the pressure side of root surfaces. These lacunae repair once the forces are alleviated. Root resorption is usually progressive during treatment in patients at high risk. Individual predisposition can be a major factor for the resorption observed.

In the present study, root length changes were evaluated using periapical radiographs made according to a standardized long cone paralleling technique. Though many authors have evaluated changes in root length from panoramic and cephalometric radiographs but these radiographs may overestimate the degree of root loss by 20%.[24] Furthermore, Young's Formula was applied to all the radiographs to eliminate magnification errors. Root length was measured from the midpoint between the mesial and distal Cementoenamel junction which is the most reliable reference point[28] to the tip of the root. A 3 month radiographic control was used in the study as orthodontic patients with detectable root resorption during the initial stages of active treatment are more likely to experience continued resorption during subsequent treatment with incisors being most susceptible.[29]

McFadden *et al*[30] studied the effect of light forces on root shortening in 1989. In contrast to our results they found a higher degree of root shortening in the maxilla than in the mandible.

Prevalence and severity of apical root resorption of maxillary anterior teeth in adult orthodontic patients was studied by Mirabella and Artun[10] in 1995. Sample means of averaged root resorption of all six anterior teeth and of the most severely resorbed tooth per patient were 0.94 mm and 2.39 mm, respectively.

A study by Baumrind *et al*[31] in 1996 analyzed the relationship between upper central incisor displacement measured on lateral cephalograms and apical root resorption measured on anterior periapical radiographic films. Mean apical resorption was found to be 1.36 mm.

Levander *et al*[29] in 1998 studied orthodontically-induced external apical root resorption of 92 maxillary incisors in vivo after 3 and 6 months treatment. After 3 months there was a higher degree of root resorption in teeth with blunt and pipette-shaped apices. They recommended a 3-month radiographic control in such teeth.

A cohort of 153 patients treated with comprehensive orthodontics was followed by Harris and co-workers[32] in 2001. They found no EARR at the start of treatment, but most (>80%) exhibited slight-to-moderate EARR by the end of treatment (i.e., a loss of 1–2 mm).

The relative change in root length in 456 upper and lower incisors was by Fritz *et al*[33] in 2003. They found the upper incisors presented with increased mean resorption rates ≤10%.

In 2005 Smale *et al*[34] studied root resorption in maxillary incisors using standardised periapical radiographs made before treatment (T1) and at a mean period of 6.4 months after placement of maxillary incisor brackets (T2) in 290 patients. The mean average root resorption for 4 incisors was 0.53 mm, whereas the sample mean of the most severely resorbed tooth per patient was 1.18 mm.

Armstrong *et al*[35] in 2006 used panoramic radiographs of 114 subjects to measure the pre- and post-treatment tooth lengths of the maxillary and mandibular incisors. Lower incisors were significantly shorter post-treatment which is in agreement with our results.

Nigul and Jagomagi[9] in 2006 assessed panoramic radiographs of 75 patients that had been treated with fixed full appliance to assess the apical root resorption in maxillary incisors. They found that the resorption in the maxillary incisors is on the average 1.5 mm, with severe resorption in 2.6% of the patients.

Mohandesan and Ravanmehr[22] measured the amount of EARR in maxillary incisors, during a 12-month active treatment period. The sample comprised of 151 maxillary incisor teeth in 40 patients. On average, the degree of EARR for the maxillary central incisors was 0.77±0.42 and 1.67±0.64 mm, respectively, during the 6- and 12-month follow-up (p<0.001). For the lateral incisors, the degree of EARR was 0.88±0.51 and 1.79±0.66 mm, respectively (p<0.001).

In 2007 Apajalahti and Peltola[36] studied the degree of apical root resorption in different tooth groups from pre- and post-treatment panoramic radiographs. Of the tooth groups, maxillary incisors showed apical root resorption most frequently, followed by the mandibular incisors. Root resorption

was significantly correlated with fixed appliance treatment ($p<0.001$).

The prevalence of various types of root resorption in different tooth groups in a Middle Eastern population was studied in 2008 by Tsesis and co-workers.[37] Orthodontic pressure resorption was detected in 14.6% of root resorption cases, mainly in maxillary incisors ($p<0.01$).

The results of this study are in agreement with the above mentioned studies in the fact that, root resorption is strongly correlated with active orthodontic appliance therapy. In the present study the root resorption was found to be 0.30 mm (1.52%) for the maxillary central incisors, 0.32 mm (1.70%) for the maxillary lateral incisors and 0.52 mm (2.60%) for the mandibular incisors in just 3 months of treatment with a 0.0175 inch coaxial wire. Although statistically highly significant ($p<0.01$) these values are clinically insignificant except for the mandibular incisors. There was a significant ($p<0.05$) difference in the change in root length between maxillary incisors and mandibular incisors. This may be attributed to the denser mandibular alveolar bone and finer root structure of the mandibular incisors. However there was no significant difference ($p>0.05$) between the resorption rates of the maxillary central incisors and maxillary lateral incisors reflecting that root resorption is probably more dependent on the density of the alveolar bone than the initial size of the roots.

It was found that root resorption can be detected even in the early levelling and alignment stages of orthodontic treatment. The susceptibility of incisors, particularly mandibular incisors, to root resorption was also confirmed. A limitation of our study was that root resorption was not evaluated qualitatively, which requires digital radiographs. Another limitation of the study was that root resorption was studied only over a short duration and long term follow up of the same patients was not done.

On the basis of results, a radiographic follow up for the assessment of root resorption of all patients undergoing orthodontic therapy even during initial stages is recommended.

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