

# Factors related to apical root resorption of maxillary incisors in orthodontic patients

*Kirsten Nigul, Triin Jagomagi*

## SUMMARY

The Main Objective of the study was to determine the extent of external apical root resorption at the end of orthodontic treatment and to identify the possible pre-treatment and treatment factors that would allow to predict the possible incidence of root resorption before the start of treatment.

**Patients and Methods:** Panoramic radiographs of 75 patients that had been treated with full fixed appliances were used to assess apical root resorption in maxillary incisors. The degree of root resorption was measured in millimetres and the scale of Shape was used.

**Results:** The results showed that the resorption in the maxillary incisors is on the average 1.5 mm, the severe resorption was seen in 2.6% of patients. The worst resorption was seen in teeth with abnormal root shape. There were no differences in the severity of root resorption when comparing males and females as well as children and adults. Increased overjet, overbite and extraction therapy were not associated with greater root resorption. Duration of treatment and length of treatment time with rectangular wires were associated with greater root resorption. Patients wearing composite brackets with a metal slot had more resorption than patients wearing metal brackets.

**Conclusion:** Pre-treatment risk indicator for root resorption was abnormal root shape. Risk indicators for root resorption that were related to treatment procedures included length of treatment time with rectangular wires, duration of treatment and treatment with composite brackets with a metal slot.

**Key words:** Root Resorption; Orthodontic Treatment; Risk Factors.

## INTRODUCTION

Orthodontically induced inflammatory root resorption is a pathologic consequence of orthodontic treatment (1). Its occurrence may be of little significance when mild, fortunately severe root resorption is relatively rare (1-5%) (2,3,4).

The principal difficulties in studying root resorption are the infrequency of severe shortening and the many possible factors that can be associated with the condition. Several studies have been published about root resorption and possible etiological factors and a number of diagnostic and treatment factors have been implicated. Several investigators have suggested that the longer the active treatment time the greater the chance of severe resorption (5,6,7). Several pre-treatment factors have been associated with root resorption – abnormal root shape (3,8,9) and allergy (9,10). Recent data suggests that resorption is principally moderated by genetic factors rather than being initiated by the orthodontist (11).

The present investigation had two purposes. The first objective was to determine the extent of external apical root resorption at the end of orthodontic treatment. The second objective was to investigate anamnestic, pre-treatment and treatment factors and new variables

(bracket material) that would allow the clinician to predict possible incidence of root resorption before start of treatment.

## MATERIAL AND METHODS

Panoramic radiographs of 75 patients that had been treated with full fixed appliances in 5 private practices were used to assess apical root resorption in maxillary incisors. Only incisors with closed apices were measured. The exclusion criterion was orthognathic surgery. Not all the teeth were measurable on all radiographs.

Different x-ray machines were used to obtain the panoramic radiographs; the position of the patient was not standardized.

Collected demographic information included gender, allergy and age at start of the treatment. The pre-treatment variables used in the analysis were: tooth length, root shape, overjet, overbite, 2-phase treatment, presence of previous endodontic treatment, and history of trauma. The treatment variables used were slot size, bracket material, extractions, treatment time with rectangular arch wires and elastics and total treatment time.

### *Analysis of radiographs*

Root forms were divided into 5 categories (normal, short, blunt, dilacerated, pipette-shaped) as suggested by Levander and Malmgren (3) (Figure 1).

Two methods were used to calculate the amount of root resorption. The first method measured the resorption by millimetres. Crown length was measured from

<sup>1</sup>CityMed Dental Clinic, Tallinn, Estonia

<sup>2</sup>Department of Stomatology, University of Tartu, Estonia

**Kirsten Nigul**<sup>1</sup> – D.D.S.

**Triin Jagomagi**<sup>2</sup> – D.D.S., MSc, MORh RCSEd, lecturer

Address correspondence to Kirsten Nigul, CityMed Dental Clinic, Kuhlbari 6-9, Tallinn 10128, Estonia.

E-mail: kirsten@citymed.ee

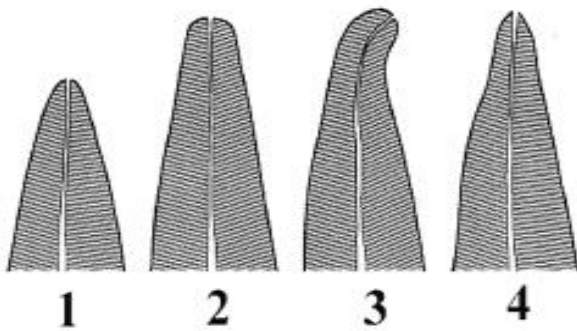


Fig. 1. Root forms (after Levander and Malmgren 1998).

1 – short root; 2 – blunt root; 3 – root with apical bend; 4 – root with apical pipette shape.

cementoenamel junction to the incisal edge. Total tooth length was measured from cementoenamel junction to the root apex. The method suggested by Linge and Linge (12) was used to correct the differences in enlargement and angulations.

$R = TL1 - TL2 \times CL1 / CL2$ , where

R – resorption;  
 TL1 – pre-treatment total tooth length;  
 TL2 – post-treatment total tooth length;  
 CL1 – pre-treatment crown length;  
 CL2 – post-treatment crown length.

The second method used the scale of Shape et al (13) (Figure 2):

0 = No apical root resorption;  
 1 = Slight blunting of the root apex;  
 2 = Moderate blunting of the root apex up to one-fourth of the root length;  
 3 = Excessive blunting of the root apex beyond one-fourth of the root length.

Pre- and post-treatment radiographs were measured parallel in order to minimize identification error. Measurements were made on the screen of a light box with electronic digital caliper. The same clinician measured all the radiographs. When the first method was used, all the measurements were duplicated and the mean values were used for statistical analyses. When the second method was used the measurements were made twice and in the case of differences the third measurement was also made. The interval between two measurements was at least 10 days.

#### Statistical data analysis

Group differences were analyzed by Student's t-test or Analysis of Variance. Correlation was studied by calculating Pearson's r.

## RESULTS

The total sample consisted of 281 teeth from 75 patients, aged 10.5–65.6 years at start of the treatment and they were treated for 4–38 months. From the 75 patients 56 were female and 23 were male; 46 were children (age at the beginning of treatment <16 years) and 29 were adults. The mean root resorption was 1.5 mm. The severe resorption (greater than one-quarter of the root length) was seen in 2.6 % of patients. No statistically significant differences were found between resorption in all incisors; therefore for most analysis all incisors were averaged. Root resorption measurements are given in Tables 1 and 2.

#### Root resorption in relation to demographic information (Table 3)

Adults, compared to children, had more root resorption, males, compared to females, had more resorption, but the differences were not significant. Allergic patients had more resorption than non-allergic patients when measured by millimetres, but the differences were not significant. Allergic patients had significantly more root resorption than non-allergic patients when the scale of Sharpe was used ( $p=0.01$ ). Comparison of dental practices was not done because of different sample sizes.

#### Root resorption in relation to pre-treatment variables

Pre-treatment tooth length, overjet and overbite at the beginning of treatment, 2-phase treatment, and history of pre-existing trauma were not significantly related to root resorption ( $p>0.05$ ).

Endodontically treated teeth had significantly less root resorption ( $p=0.04$ ), but the sample was too small (only 4 endodontically treated teeth) to make profound conclusions. Mean root resorption in endodontically treated teeth was 0.36 mm, in non-endodontically treated teeth 1.52 mm.

Incisors with small roots had significantly more root resorption than other root forms ( $p=0.00$ ) (Table 4). Blunt and normal roots had less root resorption than dilacerated and apically bent roots, but the differences were not significant.

#### Root resorption in relation to treatment variables (Table 5, 6)

Extraction treatment, slot size (018 vs. 022) and treatment time with elastics were not significantly related to root resorption. Patients wearing composite brackets with a metal slot (Spirit MB) had significantly more root re-



Fig. 2. Photographs illustrating categories of root resorption (Sharpe et al 1987):

A – Category 1 – slight blunting; B – Category 2 – moderate blunting; C – Category 3 – excessive blunting.

**Table 1.** Root resorption measured by millimetres

Tooth	Mean +/- SD mm
I2	1.57 +/- 1.2
D11	1.61 +/- 1.27
D21	1.48 +/- 1.05
D22	1.35 +/- 1.02

**Table 2.** Root resorption measured by the scale of Sharpe

Sharpe	D12	D11	D21	D22	%
0	11	11	9	9	12
1	46	37	46	48	64
2	11	18	15	11	14.6
3	3	2	2	2	2.6
Missing	4	7	3	5	6.6

**Table 3.** Root resorption in relation to demographic information

Demographic information	Mean root resorption (mm)	P value
Age		
Adults	1.61	0.22
Children	1.44	
Gender		
Males	1.62	0.25
Females	1.45	
Allergy		
Allergic patients	1.7	0.19
Non-allergic patients	1.46	

sorption than patients wearing metal brackets. The following variables were also of great importance for root resorption: total treatment time and the length of time with rectangular archwires.

## DISCUSSION

The decision to use panoramic radiographs for investigation was pragmatic – our orthodontists do them routinely before and after orthodontic treatment and there was no need for any additional radiographs. Although panoramic films are less accurate than periapical films because of greater magnification error, the magnification in maxillary incisors' area has been reported to be only 0.2 mm (14).

The examination focused on maxillary incisors because these teeth have been reported to be most severely affected. We decided to use two methods to calculate the root loss to find out the total loss of each tooth and the proportional loss of each root.

The root resorption of 1.5 mm in maxillary anterior area was in accordance with Sameshima and Sinclair findings (8), who used periapical films to measure root resorption in maxillary anterior area and found it to be 1.4 mm. 2.6 % of patients had severe root shortening - the finding is in accordance with Kaley and Phillips findings who reported the severe resorption in 3% of patients (4).

Adults had more root resorption than children, but the findings were not statistically different. This finding is in agreement with other findings that found no differences between adults and children (8, 12, 15).

**Table 4.** Root form in relation to root resorption

Root form	Means mm	Std. dev.
Normal	1.37	1.03
Small	3.00	1.59
Blunt	1.34	1.32
Apically bent	1.52	1.03
Pipette shaped	1.85	1.13
All Groups	1.51	1.14

**Table 5.** Bracket material in relation to root resorption

Bracket material	Mean root resorption (mm)	P value
Spirit MB	1.38	0.009
Metal	1.75	

**Table 6.** Important treatment variables in relation to root resorption

Treatment variable	r value	P value
Total treatment time	0.13	0.02
Time with rectangular wires	0.14	0.01

Males, when compared to females, had more root resorption, but the differences were not statistically significant - this is in agreement with other reports (4, 8, 12). Some researchers have registered more root resorption in females (3).

Allergic patients had more resorption than non-allergic patients when measured by millimetres, but the differences were not significant. When the scale of Sharpe was used, the allergic patients had significantly more root resorption than non-allergic patients. This was the only variable with differences between millimetres and Sharpe scale. Owmann-Moll and Kurol (10) found also increased risk of root resorption in subjects with allergy, but this was not statistically significant. Nishioka et al found that allergy and asthma might be an etiological factor in excessive root resorption in the Japanese population (9).

Several authors have shown that roots with abnormal shape have a higher susceptibility of root resorption (3, 8). We found that small roots resorbed almost twice as much as all other root forms. The reason for that might be the previous resorption; there have been reports finding that the rate of previous root resorption doubles during orthodontic treatment (2). Dilacerated and pipette shaped roots have more root resorption than normal and blunt roots; the same finding has been confirmed in other studies (3, 8). In accordance with Sameshima and Sinclair (8) the least resorption was found in normal and blunt roots; one previous study found that the blunt roots were more susceptible to root resorption than normal roots (3).

The subgroup of patients with a presence of previous endodontic treatment was limited to only 4 teeth in our sample. In accordance with Mirabella and Artun (15) we also found that endodontically treated teeth were more resistant to apical root resorption than vital teeth. When the root canal filling was reached up to the apex, there was no root resorption, but in case of a shorter filling the part without the filling resorbed.

In contrast to other studies (8, 16), we found no correlation between initial tooth length and the amount of

root resorption. In agreement with other studies (4, 8, 16) we found no correlation between the amount of overbite present at the beginning of orthodontic treatment and the amount of root loss.

In extraction cases the remaining teeth are usually moved relatively greater distances, particularly when maxillary incisors are retracted to reduce a large overjet. We found that reduction of greater overjet does not correlate with greater root resorption, Sameshima and Sinclair (8) reported a weak correlation between these two variables. Our results also indicated that extraction treatment was not associated with excessive root resorption. The few other studies that examined this factor did not find it to be significant (4, 9, 17); one study found that patients who underwent 4 first premolar extraction therapies had greater resorption than those patients who were treated with nonextraction (6).

The study found no association between root resorption and history of previous trauma; this is in accordance with Nishioka et al (9). It has been widely accepted that traumatized teeth may undergo root resorption even if they do not undergo orthodontic treatment. Birnie (2) has stated that if traumatized teeth do not exhibit root resorption prior to orthodontic treatment they behave as normal teeth. Also no positive relationship between root resorption and 2-phase treatment was found. Mirabella and Artun (15) found that early treatment followed by phase II treatment served as a protective factor limiting root resorption.

The treatment variables related to root resorption were total treatment time, treatment time with rectangular archwires and treatment with composite brackets with a metal slot. A correlation between duration of treatment

and apical root resorption has been reported by others as well (5, 6, 7). Levander and Malmgren (5) also stated that long treatment time with elastics and rectangular archwires were related to greater root resorption. In meta-analysis (7) treatment related causes of root resorption appeared to be the total distance the apex had moved and the time it took. No significant relationship between treatment with inter-arch elastics and root resorption was found in present study - this is in accordance with Sameshima and Sinclair research (6). Wearing elastics depends on patient cooperation and the treatment time that is reported in papers may not always reflect the real wearing time.

Cases of treatment with composite brackets with a metal slot had significantly more root resorption than cases treated with metal brackets. The reason for that might be the longer treatment time because of higher debonds and failure rate. As we know, there has been no previous investigation about bracket material and root resorption.

In accordance with other studies we found no correlation between slot size and root resorption (6).

## CONCLUSIONS

Treatment planning for patients with abnormal root shape and history of allergy should take into consideration the higher risk of apical root resorption during orthodontic therapy. Caution should be exercised in patients who have been in treatment for longer than the usual period of time, especially with rectangular archwires and with composite brackets with a metal slot.

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