

Links Between Tooth Root Shape, Root Length, and Orthodontically Induced Root Apical Resorption

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ABSTRACT

Background: The risk factors associated with external apical root resorption can be broadly categorized into patient-related and orthodontic treatment-related factors. Patient-related factors contributing to external apical root resorption include genetic predisposition, systemic conditions, asthma, allergies, chronic alcoholism, the severity of malocclusion, the group of teeth affected by resorption, root shape, alveolar bone density, the proximity of the root to cortical bone, prior endodontic treatment, as well as the patient's age and gender. Orthodontic treatment-related factors encompass the duration of treatment, the magnitude and direction of the applied forces, the degree of apical displacement, and the method of force application. Numerous studies have investigated the potential association between the occurrence of root resorption during orthodontic treatment and abnormal dental morphologies, including agenesis, pipette-shaped, blunt, pointed, short, long, dilacerated, and narrow roots, as well as small and peg-shaped lateral incisors, dental invagination, and taurodontism.

Objectives: This study aimed to determine the potential relationship between orthodontic root resorption, abnormal dental root morphology, and root length. It was decided to detect normal, blunt, bent, pointed, pipette-shaped, and short roots from all resorbed teeth from 40 computed tomography (CT) images.

Methods: To fulfill the study's objective, patients from the research and control groups underwent cone-beam computed tomography (CBCT) examinations.

Results: A detailed analysis of the study groups reveals a significant correlation between root apical morphology in shortened, pointed, and bent root forms. High reliability was found concerning gender, with EAAR being identified predominantly in females.

Conclusions: The teeth most susceptible to external apical root resorption are those with shortened roots. Additionally, apical pointed and bent morphology exhibits a higher resorption risk than petite-shaped and long roots. In contrast, blunt roots demonstrate a high resistance to EAAR.

Keywords: Cone beam computed tomography (CBCT); external apical root resorption (EAAR); orthodontic tooth movement (OTM); root shape.

BACKGROUND

External root resorption is a significant complication associated with orthodontic treatment. It can affect both the apical and cervical regions of the roots subjected to orthodontic forces, potentially endangering the long-term viability of the affected teeth. External apical root resorption has a multifactorial etiology, often influenced by individual biological characteristics.

When orthodontic forces exceed the pressure of the periodontal capillaries, ischemic necrosis of the periodontal ligament occurs, leading to the collapse and localized disruption of the blood supply. This process results in the degradation of the outer protective layers of the tooth, forming a hyalinized zone. Subsequently, clastic cells are activated due to the loss of the cementum and its formative cementoblast layer, initiating root resorption during the active removal of the hyalinized necrotic tissue. If the reparative capacity of the cementum is exceeded, dentin becomes exposed, and odontoclast activity results in the irreversible loss of root structure.¹

The risk factors associated with external apical root resorption can be broadly categorized into patient-related and orthodontic treatment-related factors. Patient-related factors

contributing to external apical root resorption include genetic predisposition, systemic conditions, asthma, allergies, chronic alcoholism, the severity of malocclusion, the group of teeth affected by resorption, root shape, alveolar bone density, the proximity of the root to cortical bone, prior endodontic treatment, as well as the patient's age and gender. Orthodontic treatment-related factors encompass the duration of treatment, the magnitude and direction of the applied forces, the degree of apical displacement, and the method of force application.²⁻⁶

Numerous studies have investigated the potential association between the occurrence of root resorption during orthodontic treatment and abnormal dental morphologies, including agenesis, pipette-shaped, blunt, pointed, short, long, dilacerated, and narrow roots, as well as small and peg-shaped lateral incisors, dental invagination, and taurodontism.⁷

This study aimed to determine the potential relationship between orthodontic root resorption, abnormal dental root morphology, and root length. It was decided to detect normal, blunt, bent, pointed, pipette-shaped, and short roots from all resorbed teeth from 40 computed tomography (CT) images.



METHODS

A systematic search was conducted within the patient archives of the previous study, which was conducted at the Grigol Robakidze University Dental Center "Gruniverse." A trained professional team collected the required information using the center's database and record-keeping system. The search was conducted according to specific criteria, including the study timeframe, which commenced in June 2022.

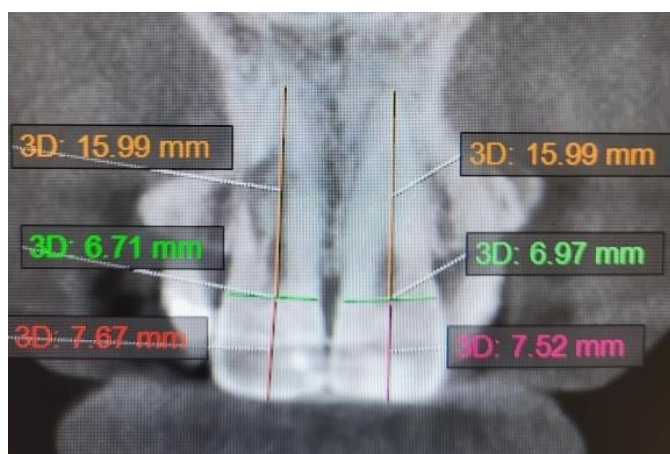
This study included 80 patients, comprising 40 individuals with fixed orthodontic appliances across different age groups: 20 patients from Group A (aged 12-17) and 20 patients from Group B (aged 18-35). Additionally, 40 patients with removable orthodontic appliances were included, divided into 20 patients from Group A1 (ages 12-17) and 20 from Group B1 (ages 18-35). In terms of gender distribution, Groups A and A1 each comprised 20 males and 20 females (50% male and 50% female), and a similar distribution was observed in Groups B and B1.

To fulfill the study's objective, patients from the research and control groups underwent cone-beam computed tomography (CBCT) examinations. Subsequently, statistical analysis and a comparative evaluation of the results were conducted. High-resolution CBCT (HR-CBCT) images were acquired using the KAVO Dental Excellence OP 3D device (Finland).

The median cemento-enamel junction (CEJ) point, defined as the midpoint between the mesial and distal points of the CEJ line, was used as the reference for each radiographic image. The root length was determined by measuring the distance from the median CEJ point to the root apex. The total tooth length was calculated as the distance from the apex to the incisal edge (Fig.1).

According to the research by Chipashvili et al., the data were considered to be the average length of the teeth.⁸

FIGURE 1. Tooth length measurement



Sample classification

Following the study objective, 46 roots exhibiting resorption due to orthodontic tooth movement (OTM) were classified based on apical morphology. The distribution was as follows:

Normal (N) (n = 15), Bent (Bt) (n = 15), Pointed (P) (n = 8), Pipette-shaped (P-sh) (n = 2), and Shortened (Sh) (n = 2).

RESULTS

First, the statistically significantly higher amount of tooth resorption in study groups A and B was analyzed. Then, the relative risk (RR) was calculated. The relative risk (RR), its standard error, and 95% confidence interval are calculated according to Altman (1991) (Altman DG, 1991).

As a result, there is a statistically significant difference between the study groups regarding the prevalence of tooth root resorption, which is influenced by the morphological peculiarities of the teeth and their roots, such as apical shape and root length.

The predictors and standard deviation for this segment were determined. The relationship between tooth root resorption and different tooth morphology in patients was assessed using the t-test.

988 teeth were examined using computed tomography in the research and control groups, specifically Groups A and A1, comprising 40 patients. The findings included 16 cases of partial eruption or agenesis of the mandibular second molar, 24 cases of partial eruption or agenesis of the maxillary second molar, 18 cases of secondary agenesis of the maxillary first molar, and 28 cases of secondary agenesis of the mandibular first molar. Additionally, 12 cases of retention or agenesis of the mandibular molars, 6 cases of primary agenesis of the maxillary lateral incisor, 28 cases of secondary agenesis of the mandibular first molar, 12 cases of retention or agenesis of the mandibular molars, and 6 cases of primary agenesis of the maxillary lateral incisor were identified. Furthermore, there were 10 cases of partial eruption or agenesis of the maxillary second molar, 6 cases of secondary agenesis of the maxillary second premolar, 4 cases of maxillary molar retention, 3 cases of primary agenesis of the mandibular second premolar, and 5 cases of secondary agenesis of the second premolar.

The roots of 1,093 teeth from the study and control groups, specifically Group B and Group B1, comprising 40 patients, were analyzed using computed tomography. The findings revealed four cases of primary agenesis of the lateral incisor, five cases of primary agenesis of the mandibular first molar, seven cases of secondary agenesis of the mandibular first molar, and one case of secondary agenesis of the mandibular second molar. Additionally, 9 cases of secondary agenesis of the maxillary first molar and 1 case of secondary agenesis of the second premolar were identified.

Resorption was observed in 46 cases (roots) exclusively in the study groups, Group A and Group B, which involved patients with non-removable orthodontic appliances. Specifically, the findings included:

- In Group A, resorption was identified in 10 roots of anterior teeth among six patients out of the 431 teeth examined. This included 1 case of internal resorption and 9 cases of anterior teeth apical resorption, affecting five women and one man;

- In Group B, resorption was identified in 36 roots across 11 patients out of the 564 tooth roots examined. This included 19 cases of apical resorption in anterior teeth, affecting two men and nine women, and 17 cases in the posterior tooth roots, observed in four women and one man.

Among the 1,108 tooth roots examined in 40 patients with non-removable appliances, a total of 78 roots were identified as having a petite shape, with resorption observed in only 3 of them (3.8%). One hundred fourteen pointed roots were identified, of which only eight were resorbed (7%). It was revealed that 198 roots with bent morphology, of which only 15 underwent resorption (7.5%), and 65 had blunt, apical shape, of which none was resorbed (0- %). Among 58 short roots, apical resorption was detected in 5 of them (8.6%). The rest turned out to be as expected (n = 595). Nevertheless, 15 of them were resorbed (2.52%).

In Group A, among the ten resorbed anterior teeth, the observed apical morphologies were as follows: 3 roots exhibited a standard apical shape, 2 had a bent configuration, 1 presented a pointed form, three were short, and 1 displayed a pipette-shaped morphology.

In Group B, among 36 cases of EAAR, resorbed root morphology was observed across all upper and lower teeth groups. The distribution included 12 roots with a regular shape, 13 with a bent configuration, 7 with a pointed form, two short roots, and two pipette-shaped roots. Samples of root resorption are shown in Figure 2.

FIGURE 2. Resorption of pipette-shaped tooth #3.3 (A. Before treatment; B. After 6 months of treatment)

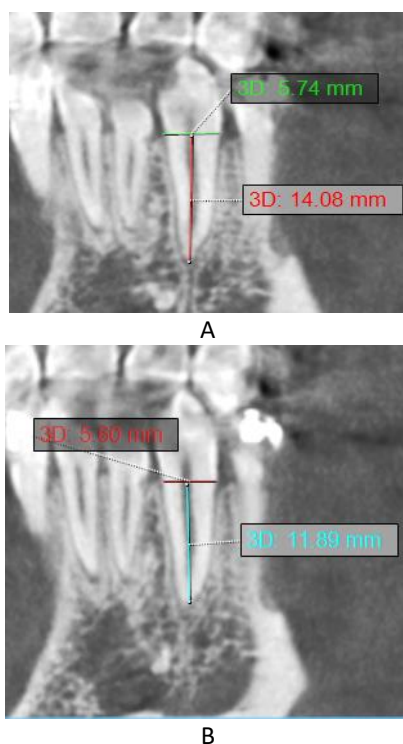


Table 1 presents the relationship between root resorption after orthodontic treatment and apical morphology and the reliability of the two root length measurements taken before and after treatment.

TABLE 1. Relationship between root resorption after orthodontic treatment, gender, and apical morphology

Root resorption (tooth #)	Total number of cases	Number of cases in Group A	Number of cases in Group B	Apical morphology	Initial root length (mm)	Root resorption (mm)	Gender		Standard Deviation (Average ± SD)	P value
							F	M		
1.1	7	1	6	2N 2Bt 2P 1Sh	12.9±6.7	1.8-2.4	7	-	1.98±1.0	<0.09
1.2	5	1	4	5N	12.2±1.9	1.9-2.02	4	1	1.99±0.8	<0.078
1.3	1	1	-	P	17.18	2.48	1	-	-	-
1.4	1	-	1	1N	15.31	1.79	1	-	-	-
1.5	1	-	1	Psh	14.24	1.32	1	-	-	-
1.6	3	-	3	3Bt (b/m)	11.8±4.8	0.8-1.3	3	-	1.78±1.0	<1.15
2.1	1	-	1	N	13.53	1.65	1	-	-	-
2.4	1	-	1	Bt	16.43	3.66	1	-	-	-
2.5	4	-	4	2Bt 2N	13.0±4.6	2.1-4.1	4	-	2.08±1.0	<0.074
2.6	4	-	4	3Bt (b/m) 1N	11.8±1.9	1.9-2.6	4	-	1.69±1.1	<0.088
3.1	8	4	4	1PtSh 5P 1Sh 1N	11.02±7.1	0.8-2.51	5	3	1.60±1.1	<1.16
3.2	6	3	3	1PSh 3N 2Sh	12.2±9.8	1.9-5.43	3	3	2.60±2.1	<1.08
3.3	1	-	1	1PSh	14.08	2.19	-	1	-	-
3.4	1	-	1	Bt	14.7	2.18	1	-	-	-
3.6	1	-	1	Sh-d	9.19	1.42	-	1	-	-
4.1	1	-	1	Bt-m	14.2	3.4	1	-	-	-

Explanations and abbreviations: Group A, 12-17 years old with non-removable appliances; Group B, 12-35 years old with non-removable appliances. Bt, bent; N, normal; P, pointed; Psh, pipette-shaped; Sh, shortened.

DISCUSSION

The latest studies have shown that the apical morphology influences root resorption; teeth with rounded and rectangular apical morphologies are more resistant to root resorption. Short and wide roots are less likely to undergo resorption than long and narrow ones.⁹

Weltman and coworkers have been unable to demonstrate an association between teeth with roots of unusual morphology and increased susceptibility to moderate and severe root resorption. Various studies have reported a relationship between tooth length and root resorption; however, results have been inconsistent. While some studies have revealed that EARR increases with shorter teeth,¹⁰ others have indicated that resorption increases with longer teeth.¹¹⁻¹³

Similarly, there is ongoing debate regarding which teeth are most susceptible to external apical root resorption (EARR). As a result, some studies have indicated that central incisors are at a higher risk.¹⁴ Conversely, other studies have suggested

lateral incisors are more prone to root resorption.¹⁵ According to Paetyangkul A et al., thin and irregular apices (e.g., long, curved) are at a greater risk of resorption, possibly due to decreased resistance of the apices to overcome the mechanical stimuli.¹⁶ Sameshima et al., have shown that upper and lower incisors appear more susceptible to EARR.¹⁷ Some authors have found that the maxillary lateral incisors, followed by the mandibular incisors, show the highest prevalence of resorption.¹⁸⁻²⁰

The findings of this study, which demonstrate the consistent influence of apical morphology on the increased occurrence of external apical root resorption following corrective orthodontic treatment, align with routine clinical observations and numerous published studies utilizing similar methodologies.

Our research findings align with Sameshima and Sinclair's, indicating that the upper and lower incisors are more susceptible to external apical root resorption (EAAR) due to orthodontic forces. Normal-shaped roots exhibit the least resorption among the apical morphologies, whereas bent and pointed roots are the most susceptible. Additionally, short roots present a higher risk of resorption than roots of average length.

CONCLUSIONS

A detailed analysis of the study groups reveals a significant correlation between root apical morphology in shortened, bent, and pointed root forms. High reliability was found concerning gender, with EAAR being identified predominantly in females.

According to our data, teeth with shortened roots are most susceptible to external apical root resorption. Additionally, apical pointed and bent morphology exhibits a higher resorption risk than petite-shaped and long roots. In contrast, blunt roots demonstrate a high resistance to EAAR.

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