

ORIGINAL PAPER

Orthodontically induced root resorption correlated with morphological characteristics

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Abstract

Orthodontically induced root resorption is an irreversible process that can have medical, ethical and legal implications. *Aim:* The objective of this research was to identify morphological risk factors, in order to prevent it. *Material and Methods:* We realized a retrospective study on 50 patients and made correlation between the prevalence and gravity of radiological identified root resorption and multiple biological and anatomical features. *Results and Conclusions:* We found that, when removable orthodontic appliances were used, there were not found root resorption (0%), and in cases in which fixed appliances were used, the root resorption was found, and it generally presented a high prevalence (96%) and low severity. Prevalence of root resorption is influenced by the sex and age of the patients (is greater for males than for females and higher in older patients). Topographically, differences were found in prevalence of root resorption (79.33% in mandibullary frontal teeth and 74% in the maxillary ones). The highest prevalence of root resorption was found in the lower central incisor (86%). Prevalence of root resorption is higher when there are alterations of the normal anatomy (facial hypo- or hyperdivergence, Angle class II and III malocclusion, angulated roots). Some anatomical aspects may present a fact of prevision of the appearance of root resorption within the orthodontic treatment.

Keywords: root resorption, orthodontics, morphology, risk factor.

Introduction

External root resorption can be defined as the process in which hard tissue (cement and dentin) is lost from the root of a tooth. When it occurs in permanent teeth, it is considered a pathological process that can be correlated with trauma, ectopically erupted teeth, inflammatory infection of periapical tissues, tumors and others [1–3]. After orthodontic treatment, root resorption can be encountered, and usually in these cases it is seen as a biological response to forces action, a secondary effect or iatrogenic consequence. Some researchers consider that after orthodontic treatment its prevalence is 100%, which can be evidenced by microscopic analysis [1, 4]. Its presence can be a problem from the medical (treatment quality), ethical and legal point of view [5].

Usually the amount of orthodontically induced root resorption is very low and has almost no long-term implications, especially if we consider the benefits of the treatment for the dento-maxillary apparatus, for the patient's health and quality of life. Most frequently, it is found in the apical area of the roots, because orthodontical forces are concentrated there. Also, the

apical tooth structure present cellular cement, that is less mineralized, more friable and easy to be injured [6]. Morphopathological investigations show a hyalinization or aseptic necrosis of periodontal ligaments [7–9]. In the first stages appear some lacunas that give an irregular contour to the root apex on radiographs. In more advanced phases, it will come to a surrounding apical root resorption, accompanied by tooth shortening [2]. Severe root resorption (more than 1/4 of root length or more than 5 mm) is rare, with prevalence between 1–5% [10]. When this occurs, it has a negative effect on tooth implantation and it contributes to a bad long-term prognosis of the tooth.

Root resorption is an inconstant phenomenon, in which take part several biological factors (individual susceptibility, systemic and genetic factors, habits, anomalies of position, and number of the teeth, alveolar bone density etc.), and mechanical factors, correlated with the orthodontic appliances (type of the appliance, presence of tooth extraction, type of tooth movement, some orthodontic forces characteristics like size, continuity, direction, etc.) [6].

The objective of this research was to identify risk

factors for orthodontically induced root resorption. In order to do that, we made a retrospective study in which we wanted to see if there was any correlation between morphological features and root resorption. Some anatomical and biological factors were taken into consideration (age, sex, facial, occlusal and dental particularities), and they were analyzed in correlation with the type of orthodontic treatment (fixed or removable appliance). Taking into consideration that the best way of treating a disease is preventing it, we consider important to accurately evaluate the patient for the risk of root resorption before actually begin the orthodontic treatment.

Material and Methods

We realized a retrospective study in order to make correlations between the presence of orthodontically induced root resorption and some morphological features, supposed to be risk factors.

The study group consisted of 50 patients (10 males; 40 females; average age 12 years) orthodontically treated in the Department of Orthodontics, Faculty of Dental Medicine, “Carol Davila” University of Medicine and Pharmacy, Bucharest, between 2004–2008 (the average time of wearing the orthodontic appliance was 28 months). We included an equal number of individuals wearing removable (n = 25; eight men and 17 women; average age nine years), and fixed appliances (n = 25; two men and 23 women; average age 15 years).

The inclusion criteria were:

- both dental arches had to have an orthodontic appliance;
- the patient records had to include the initial situation (anamnesis, clinical examination, diagnostic photographs, cephalometric and panoramic radiography, study casts), treatment plan and everything what was done till the second radiograph was made;
- for each patient there had to be two panoramic radiographs, made at an interval of time larger than 12 months and at the same radiological clinic.

The exclusion criteria were:

- patients treated with both types of orthodontic appliances (fixed and removable);
- patients with orthognathic surgery;
- teeth which presented, between the two radiographs were made, some alteration that may have a role in the mechanism of root resorption (trauma, periapical infections, endodontic treatment, replantation, etc.).

For each group of patients (with fixed and removable appliances) there were registered the data presented in Figure 1.

- Gender
- Chronological age
- Angle class of malocclusion
- Facial divergence
- Severity of the anomaly
- Individual record for each frontal tooth

- Tooth topography
- The morphology of the root apex
- The severity of root resorption

Figure 1 – Data registered for each patient.

The data regarding the type of orthodontic appliance, gender and age were taken from the patients

records. Facial divergence was estimated by measuring the FMA angle on the cephalometric radiograph. For values less then 22, we considered the patient as hypodivergent, for values between 22 and 28 normo-divergent and for values greater than 28 hyperdivergent. Angle Class of malocclusion was evaluated after studying the initial study casts.

The severity of malocclusion was evaluated using the *Index of Orthodontic Treatment Need (IOTN)* [11]. For each tooth, we registered the topography (maxillary or mandibullary central or lateral incisor and canine). Apical morphology was evaluated using the initial panoramic X-ray. For each tooth was identified one of the following shapes: normal, blunt, angulated, narrow. For establishing the presence and severity of root resorption two panoramic X-ray from the same patient were analyzed. The image of the teeth was analyzed using negatoscope and digital macrophotography (Figure 2).

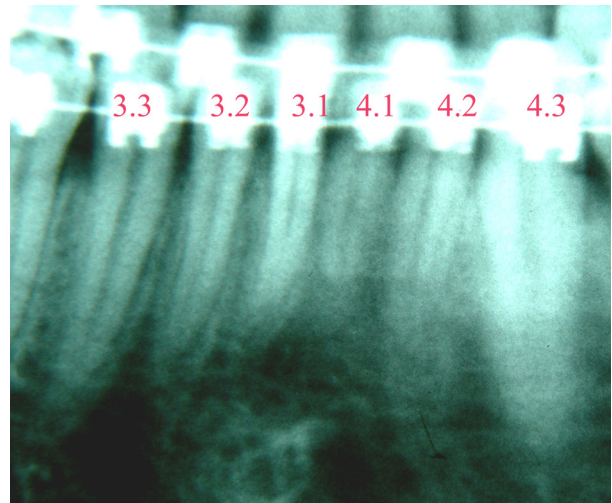


Figure 2 – Radiographic image of teeth presenting root resorption.

The investigated aspects were: changes in apical outline (irregular contour or flattened shape) and tooth shortening. For confirmation and quantitative evaluation of root resorption, measures on the panoramic radiographs were made, values being registered in [mm]. In order to correct the vertical deformations between the two X-rays the formula proposed by Linge and Linge was used (Figure 3) [10].

$$RRE = TL1 - TL2 \cdot (C1/C2)$$

RRE = resorption
 TL1 = pre-treatment total tooth length
 TL2 = post-treatment total tooth length
 C1 = pre-treatment crown length
 C2 = post-treatment crown length

Figure 3 – The formula proposed by Linge and Linge for quantitative evaluation of root resorption.

For the evaluation of the severity of root, resorption the Shape *et al.* index (1987) was used (Figure 4) [12].

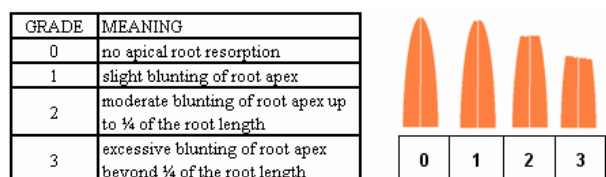


Figure 4 – Shape et al. Index (1987).

In order to use this scoring system we calculate the value of [RRE/(TL1-C1)]. To evaluate the severity of root resorption for each patient we used the system presented in Table 1.

Table 1 – The system used for scoring the severity of root resorption for each patient

Values of Shape <i>et al.</i> index for all patient's tooth	Severity of the case
0	0
0,1	1
0,1,2	2
0,1,2,3	3

All data were entered and processed in Microsoft Excel.

Results

Root resorption in different types of orthodontic appliances (fixed and removable)

Out of the 50 patients studied, at the 25 treated with removable appliances no root resorption was identified in any of the cases ($n=0$) and at any tooth ($n=0$). As for the 25 patients treated orthodontically with fixed appliances, root resorption was radiologically identified in 96% ($n=24$) of the cases. In the 300 tooth examined, root resorption was noticed at 76.7% ($n=230$) of them.

Due to these first results obtained, from this stage, only the data present at the patients treated with fixed orthodontic appliance was taken into consideration when root resorption was analyzed, considering general and anatomical aspects.

Differences according to the patient's age

The patients older than 12 ($n=23$) had root resorption with all degrees of severity. Fifty percents of the patients younger than 12 did not have root resorption, and the others had root resorption of less severity (1st grade).

Differences according to the gender

All male patients ($n=2$) had root resorption of 2nd degree. Female patients had root resorption at 95.65% ($n=22$) of the cases, this being of various severity (1st, 2nd and 3rd degree).

The severity of root resorption

Out of the 25 patients treated with fixed orthodontic appliances, root resorption was not identified radiologically only at a single patient (4%). The 2nd degree of severity was the most frequent. Out of the 300 teeth examined, the most frequent was root resorption 1st Shape degree (50%), and the rarest

3rd grade (1%) (Table 2).

Table 2 – The degree of severity of root resorption at the patients treated with fixed orthodontic appliances

Severity of root resorption	Patients presenting root resorption		Teeth presenting root resorption	
	N	%	N	%
0	1	4	70	23
1	3	12	150	50
2	18	72	77	26
3	3	12	3	1

Correlations between Angle classes and root resorption

After analyzing, the obtained data we realized that root resorption is present in all three Angle classes. The most severe root resorption, 3rd degree, was found only in patients of class II and III Angle. All the patients with Angle class III malocclusion had very high degree of seriousness (2nd and 3rd) of root resorption.

Correlations between facial divergences and root resorption

The prevalence of root resorption at the patients with normal facial divergence was lower (93.33%) than at those with modified facial divergence, meaning hypo- and hyperdivergent (100%). All the hypo- and hyperdivergent patients had high degrees of root resorption (2nd and 3rd) unlike those normal divergent, where 3rd degree was not found at all and 2nd degree at a rate of 33.34% (Table 3).

Table 3 – Root resorption and facial divergences

Root resorption	Patients					
	Normodivergent		Hypodivergent		Hyperdivergent	
	N	%	N	%	N	%
0	1	16.67	0	0	0	0
1	3	49.99	0	0	0	0
2	2	33.34	2	66.67	14	87.5
3	0	0	1	33.33	2	12.5

Correlations between IOTN and root resorption

Analyzing the data we got, there was not found any correlation between the seriousness of the anomaly, estimated by IOTN degrees, and root resorption prevalence.

Correlations between root resorption and the interested tooth's topography

Three hundred teeth were examined, which correspond to the two-maxillary and mandibullary frontal groups (Table 4).

Table 4 – Correlation between the severity of root resorption and the tooth's topography

Root resorption	Superior central incisor		Superior lateral incisor		Superior canine		Lower central incisor		Lower lateral incisor		Lower canine	
	N	%	N	%	N	%	N	%	N	%	N	%
0	13	26	12	24	14	28	7	14	13	26	11	22
1	27	54	22	44	24	48	19	38	26	52	32	64
2	10	20	16	32	10	20	23	46	11	22	7	14
3	0	0	0	0	2	4	1	2	0	0	0	0

The mandibullary frontal teeth showed a higher root resorption (79.33%; $n = 119$), compared to the maxillary ones (74%; $n = 111$). The highest prevalence of root resorption was seen in inferior central incisor (86%, $n = 43$), and the lowest in the upper canine (72%) (Figure 5).

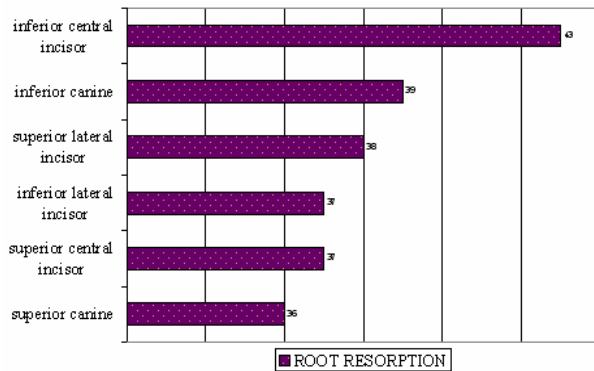


Figure 5 – Correlation between the prevalence of root resorption and tooth's topography.

At the maxillary frontal teeth, the highest prevalence of root resorption was seen at the lateral incisor, then at the central incisor, and the lowest at the canine. At the mandibullary frontal teeth, the highest prevalence of root resorption was present at the central incisor, then at the canine and lowest at the lateral incisor. Severe root resorption (3rd degree) was recorded at the level of upper canine and the lower central incisor.

Correlations between the morphology of the apical third of the root and root resorption

At the level of 37.67% ($n = 113$) there was recorded a normal form of the apical third and at the level of 62.33% ($n = 187$) a modified form. 9.33% ($n = 28$) presented a flat form, 27.67% ($n = 83$) a narrowed form and 25.33% ($n = 76$) an angulated form. The prevalence of root resorption was higher at the teeth which showed a modified apical morphology (85.03%; $n = 159$) compared to those with normal morphology (62.83%; $n = 71$). The highest prevalence of root resorption was recorded when the roots were angulated, then when were flat, narrow and rarely when they had a normal morphology (Figure 6).

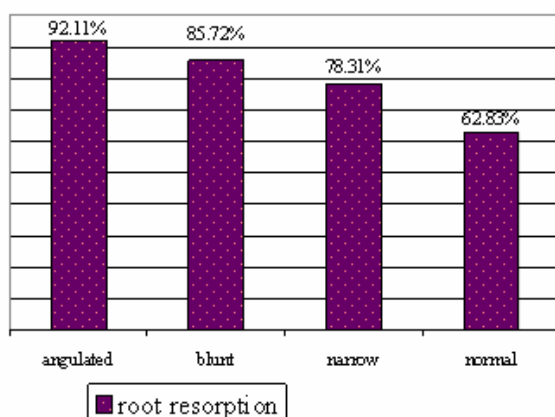


Figure 6 – The prevalence of root resorption in correlation with the morphology of the apical third of the root.

Discussion

The results suggests the existence of a direct dependence between the high prevalence of external root resorption and the type of orthodontic appliance used, age, presence of modified morphology of some structures, and the topography of some anatomical elements.

When removable orthodontic appliance was used, no root resorption was found. When a fixed appliance was used, it was present in 96% of cases (77% of teeth). Our results are in concordance with the study of Brin I *et al.* [13]. Others, like Stuteville consider that the orthodontic forces which appear by using a removable appliance is more aggressive than those that appear using fixed appliance [1].

Regarding for the age, we found higher prevalence of severe root resorption in older patients. This thing is confirmed by other studies, which reveal that at an older age there is a higher risk of root resorption [14–17].

We found that the prevalence of root resorption is higher in males than in females. Nigul, Kaley, Sameshima and Linge found out the same thing [18–20]. Other studies showed a higher rate of root resorption in women [16, 21]. Other researchers found no statistically important difference between men and women [1].

In our research, the root resorption of the patients with fixed orthodontic appliances had a prevalence of 96%. Other studies also reported high values [12]. The most frequent degree of root resorption was the first degree (50%). This is confirmed by Linge and Linge who reported that the orthodontically treated teeth had an average of root resorption of 0.5 mm and by Smale I *et al.* who considered that root resorption at the level of the incisors is about 0.53 mm [1, 12]. The most serious root resorption (3rd degree) was identified at 12% of the patients and 1% of the teeth. The data provided by the literature is between 1–5%, but the way of placing the patients in severity classes differs [6, 10].

We observed that root resorption is present in all Angle classes, which is also confirmed by other studies [1]. We found higher severity in class II and III patients compared to class I patients. Taner T *et al.* found out that in cases with extraction, the patients with Angle class II have twice more root resorption compared to those with class I (explainable due to the greater difficulty of the treatment) [22]. Other authors also reported high values of root resorption in class II and III patients [13, 15]. Some authors did not consider that the presence of a certain Angle class of dental anomaly is a risk factor for root resorption to appear [23].

Studies that include correlations of facial divergency and IOTN with root resorption were not found.

In our study the mandibullary frontal teeth had a higher prevalence of root resorption (79.33%) compared to the maxillary ones (74%), an aspect confirmed by some researchers [24]. Others authors found that the maxillary teeth are more affected by root resorption [14, 19, 25]. We found that the

most frequently affected tooth by root resorption was the lower central incisor. Majority of the studies shows that the maxillary laterally incisor is the most frequent affected tooth [1, 12, 25–27].

The root resorption prevalence was higher in the teeth with modified apical morphology (85.03%), compared to those with normal morphology (62.83%). Thongudomporn and Freer also found the same thing in a study on 1600 teeth, by Lee, Sameshima and other authors [19, 23, 28]. We found that the angulated roots are resorbed more frequently, underlining that in general, these were considered narrow, but they were introduced in the first category. Various authors present similar results using radiographs and experimental models [29–31]. Other authors found different results showing a higher prevalence of root resorption with roots having form of a pipette and narrowed [1, 14, 32, 33].

☒ Conclusions

In cases treated with removable orthodontic appliances there has not been found root resorption on the radiographs, and in cases in which fixed appliances were used the root resorption was found, and generally presented a high prevalence and low severity.

Prevalence of root resorption is influenced by the gender and age of the patients (it is greater for males than for females and higher in older patients).

Topographically differences were found in prevalence of root resorption. Lower frontal teeth presented more frequent root resorption. The highest prevalence of root resorption was found in the lower central incisor.

Prevalence of root resorption is higher when there are alterations of the normal anatomy (facial hypo- or hyperdivergence, Angle class II and III malocclusion, angulated roots).

Some anatomical aspects may represent a fact of prevision of the appearance of root resorption within the orthodontic treatment.

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