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Characteristics of patients with severe root resorption

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Structured Abstract

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Objectives – The purpose of this study was to compare a group of patients in whom all four maxillary incisors were resorbed at least 20% with a matched group.

Materials and Methods – Retrospective, case–control. Root resorption was measured on pre- and post-treatment periapical radiographs collected from 868 patients treated in private practices in southern California. Diagnostic and treatment factors were recorded, and vertical and horizontal apical movement calculated from cephalometric films. Root shape was assessed with a six-object non-parametric rating system. From this patient population, 25 patients were found who had >20% root resorption on all four maxillary incisors. A case control group without severe root resorption matched by sex, treating office, age at start, ethnicity, and duration of treatment was created with two controls for each severe case.

Results – There were no statistically significant differences found for extractions, use of Class II and finishing elastics, transverse treatments, overjet, overbite, vertical, tooth length, habits, and root shape. Higher estimated risk was found for abnormal root shape for both maxillary incisors, and tongue thrust. Horizontal apical displacement was not significantly different ($p = 0.07$) but severely resorbed incisors were retracted an average of one millimeter further.

Conclusions – Twenty-five of 868 patients were found to have over 20% of all four of their maxillary incisors resorbed. This is <3% of the total patients. Matching this group by sex, ethnicity, office, treatment time, and age greatly reduced the number of factors that would differentiate these patients from 50 who did not get severe root resorption. We conclude that horizontal root displacement, tongue thrust, and abnormal root shape may have higher estimated risk but interoffice variability and treatment time cannot be underestimated.

Key words: case–control; root resorption; root shape; severity

Introduction

The process of root resorption in humans is an interesting biological phenomenon. Occurring as a natural process during the exchange of primary and secondary dentitions, it is a necessary and positive step toward the physiological maturation of the individual. However, in rare cases, the body attacks the dentition in an unknown immunological response and tries to destroy the roots. This has been called idiopathic root resorption. Other types of resorption occur usually from trauma or disease and infection. Of greatest interest to orthodontists is the root resorption that occurs secondary to tooth movement. Because resorption of bone must occur before teeth can move, clastic cellular activity must also take place in the PDL. It stands to reason, therefore that the same cascade of events that lead to differentiation of clastic cells will also precipitate such events on the root surface, and, in fact, this has been observed and documented. Clearly the most clinically severe root resorption is the irreversible type that starts at or near the apex and progresses coronally.

Although there is agreement that severe root resorption is a problem, there is less consensus on what the meaning is of severe. Indeed, the definition of root resorption is problematic in itself. Part of the problem is the various ways root resorption has been reported in the literature. Direct linear measurement, percent root lost, most resorbed tooth, average resorption of maxillary incisors, and non-parametric scales have all been reported.

Clinically, what is severe root resorption? A tooth with half a root lost? Involvement in two teeth, or maybe three? Perhaps severe root resorption can be defined as any occurrence resulting in a change in retention plan or requiring periodontal follow-up. Premature tooth loss is the defining event but this has not been well documented. Or do our societal peers in a court of law decide what is really severe (1)? Epidemiological terms like 'mortality' and 'morbidity' do not apply to root resorption.

A lot about root resorption is known and there are several excellent papers that summarize the literature (2–5) and no shortage of papers investigating the host of diagnostic and treatment factors either in groups of factors, or singly, with many research designs (e.g. 6–12). The many factors that remain on the list of usual suspects coupled with the rarity of severe root resorption make the task of discovery a difficult one.

The literature tends to agree with the clinician that the most commonly resorbed teeth are the maxillary incisors (11). The average resorption is around 1.2–1.5 mm per incisor, and the average length ranges from approximately 12–15 mm. Thus on average, tooth movement produces a 10% shortening of the root. Shorter roots in all four teeth have a higher risk of future problems because a single tooth can be splinted to its neighbors or removed from functional occlusion with minimal interference to normal function, esthetics, and stability.

Materials and methods

Pre- and post-treatment full-mouth X-rays and lateral cephalometric radiographs for 868 patients were culled from blocks of consecutively treated patients from six university-trained, experienced, orthodontists in full-time exclusive practice (11). The following factors were recorded: age at start of treatment, gender, office, and ethnicity. Treatment variables were extractions, slot size, wire type, elastic use, months in treatment, orthognathic surgery, and transverse treatments. Dental characteristics included root length, root shape, crown length, overjet, overbite, presence of previous endodontic treatment, history or evidence of pre-existing trauma, pre-treatment decalcification, pre-existing root resorption, and presence of habits (bruxism, tongue thrust, nail biting). Apical displacement was measured on cephalometric films (9, 11).

Root length was measured on magnified (2x) scanned images from the apex to the midpoint of the right and left cementoenamel junctions using Sigma Scan (SPSS Scientific, Chicago, IL, USA). Crown length was measured from the same midpoint to the incisal edge or cusp tip. Six categories of root shape (normal, blunted, pipette or bottle-shaped, pointed, dilacerated, and incomplete) were used to classify all twenty-four teeth included in this study. Method error was evaluated by making replicate scoring of 10 sets of 24 teeth approximately 2 weeks apart. Agreement was tested with intraclass coefficients generated by Cohen's Kappa test.

From the main archive, 25 cases were found in which all four maxillary incisors were resorbed more than 25% (See previous discussion on severity, above). Fifty cases were matched by sex, age at start of treatment,

ethnicity, and office of treatment, from the same original set of 868 records.

Frequency statistics (chi-square) were calculated for all nominal variables, and odds ratios and estimated risk computed where appropriate. Analysis of variance was calculated for ratio variables. Significance was established at $\alpha = 0.05$ by convention.

Results

Out of the original 868 patients, the following numbers emerged:

Number of patients with at least one maxillary incisor with over one-third of original root length lost = 41

Number of patients with at least one maxillary incisor with over 50% of the original root length lost = 4

Number of patients with over one-third loss of original root length in a mandibular incisor = 13

Number of patients with at least one maxillary incisor with over 4 mm of root resorption = 94 (11%)

Number of patients with at least 20% root resorption in all four maxillary incisors = 25

Number of patients with at least 30% root resorption in all four maxillary incisors = 5

Number of patients with at least 40% root resorption in all four maxillary incisors = 1

Table 1 compares the two groups for selected variables. There are no significant differences between start age and treatment time as expected. There are also no significant differences in overjet, overbite, and apical displacement as measured on pre- and post-treatment cephalometric films, although the severe case horizontal apical displacement was greater by 1.0 mm.

Out of the 25 severe cases, the majority was Caucasian (68%), then Hispanic (24%), with one Asian and one African–American case. (The small cell sizes obviated statistical comparisons with the larger whole group.)

Another matched variable was by office. Figure 1 shows the distribution of severe cases from each office. Office 7 (note there is no office No. 2) clearly had a disproportionate representation. A high percentage of Spanish–American patients, a large number of extraction cases (70%), almost no adults, and an average treatment time of 25 months characterized this office.

The results of the Chi-square analysis for extractions are shown in Table 2. There is no significant difference

Table 1. **Severe cases (n = 25) and matched control group (n = 50) – continuous variables**

	Severe cases		Matched cases		
	Mean	SD	Mean	SD	*p*
Age at start	15.2	4.8	15.5	5.1	0.87
Months in treatment	29	8	28	8	0.59
Overjet	5.0	2.4	5.4	3.3	0.69
Overbite	3.9	2.9	3.8	2.5	0.85
Horizontal tooth movement	0.8	3.0	−0.2	1.8	0.69
Vertical tooth movement	−1.3	2.6	−1.6	2.3	0.07

No significant differences.

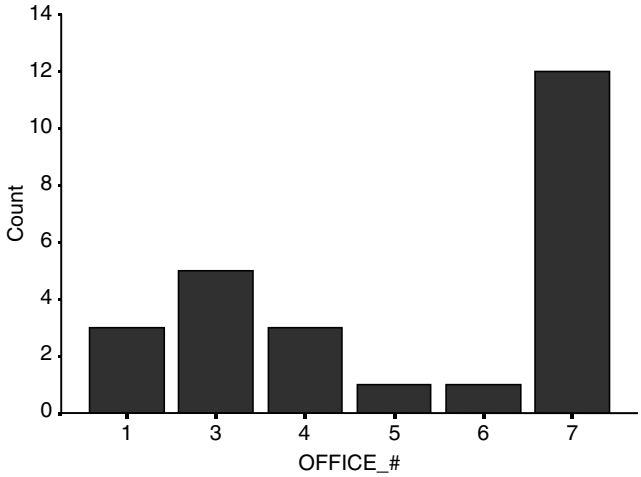

Fig. 1. Number of severe cases by office.

Table 2. **Frequency of extractions between severe and control groups**

	Casetype		
Count	Control	Severe	Total
Extraction			
F	16	11	27
N	20	11	31
O	13	3	16
U	1		1
Total	50	25	75

F, four bicuspids extracted; N, non-extraction; O, other (e.g. second bicuspids); U, maxillary first bicuspids only.
No significant differences between the two groups by chi-square analysis, $p = 0.430$.

for frequency of extractions in general, and for each type [Four bicuspids, upper bicuspids only, and other (second bicuspids, combinations)]. None of the severe cases had expansion of any type; two of the controls had an rapid palatal expander (RPE) (Table 3). Neither group reported the use of slow expansion or surgically-assisted expansion.

Five of the 25 severe cases were reported to have a tongue thrust or tongue habit compared with four of the 50 controls (Table 4), but the chi-square statistic was not significant ($p = 0.147$). Note, however, that estimated risk was nearly three times greater for patients with a documented tongue habit when comparing severe (RR = 1.53) to the control (RR = 0.545). Neither group reported nail biting or bruxing.

Fewer of the severe cases reported using either class II elastics or finishing elastics. The difference was not significant ($p = 0.356$ and 0.132, respectively.)

The results of root shape are shown in Tables 5 and 6. Results for right and left were very similar; the table shows the left incisors. Although there were no significant differences, over half the lateral incisors for the severe group had an abnormal shape. The most frequent abnormal shape was dilaceration in both groups. The severe cases also had twice as many abnormal root shapes (proportionally). The p-value of 0.075 misses significance but the estimated risk for the severe group (1.42) was nearly double the risk for the control group (0.79).

Table 3. **Transverse treatments: control vs. severe**

	Case type		
Count	Control	Severe	Total
Transverse			
N	4	2	73
R	2		2
Total	5	2	75

N, no transverse problem; R, rapid palatel expansion.
No significant differences by chi-square statistic, $p = 0.31$.

Table 4. **Habit frequency between severe and control groups**

Habit	Control	Severe	Total
None	46	20	66
Tongue	4	5	9
Total	50	25	75

No significant difference by chi-square analysis ($p = 0.132$).

Table 5. **Frequency of abnormal maxillary lateral incisor root shape**

	Case type		
Count	Control	Severe	Total
UR2 shape			
B	2	1	3
N	16	9	25
D	30	12	42
O	1		1
P	1	3	4
Total	50	25	75

Key: B, blunted; D, dilacerated; N, normal; O, pointed; P, pipette shaped.
Chi-square = 0.388 (not significant).

Table 6. **Frequency of abnormal maxillary central incisor root shape**

	Case type		
Count	Control	Severe	Total
UL1 shape			
B	3	1	4
D	2		2
N	40	17	57
O	3	7	10
P	2		2
Total	50	25	75

Key: B, blunted; D, dilacerated; N, normal; O, pointed; P, pipette shaped.
Chi-square = 0.075 (not significant).

Table 7 shows that there were no significant differences in root length by single classification ANOVA. No differences were also found for the factors of malocclusion, archwire type and slot size, history of trauma, decalcification, and crown size.

One of the severe cases is shown in Fig. 2. The pre- and post-treatment periapical radiographs clearly show the amount of apical root resorption in this 12-year-old white female who was treated for 35 months for mild crowding and dentoalveolar protrusion with fixed, edgewise appliances. This patient had a negative health history, no history of trauma to the teeth, no oral

Table 7. **Pre-treatment root lengths compared between severe and control groups**

	Case type	Mean	SD	SE
UR2 Pre-root length	Control	13.6	2.01	0.30
	Severe	13.7	2.05	0.41
UR1 Pre-root length	Control	13.5	2.02	0.30
	Severe	13.1	1.89	0.38
UL1 Pre-root length	Control	13.4	2.27	0.33
	Severe	13.1	1.89	0.38
UL2 Pre-root length	Control	14.0	1.88	0.28
	Severe	14.2	1.88	0.38

No significant differences between the control and severe groups for each root length by ANOVA.

habits, and no other factors of note. This class I malocclusion was treated non-extraction, and the patient wore class II and finishing elastics. The maxillary central incisors were displaced <2 mm. The lateral incisor root shapes are pointed but the centrals are normal.

Discussion

First and foremost, this investigation showed that severe resorption as defined by all four maxillary incisors losing 25% of the original root length is not uncommon (28%), but if the definition is extended to 30 and 40% of root loss, then the number of severe cases is reduced dramatically. Out of approximately 900 cases, only four maxillary incisors had over 50% root resorption.

The severe cases were matched by sex, ethnicity, office, age at start, and duration of treatment. These factors generally reflected the larger group with the exception of age and office. There was only one severe case that started treatment over age 18, and office 7 had the clear majority of cases. In a previous study, office 7 was shown to have a statistically higher prevalence of root resorption than the other five offices (12). One of the main reasons for the present study was to account for this known difference.

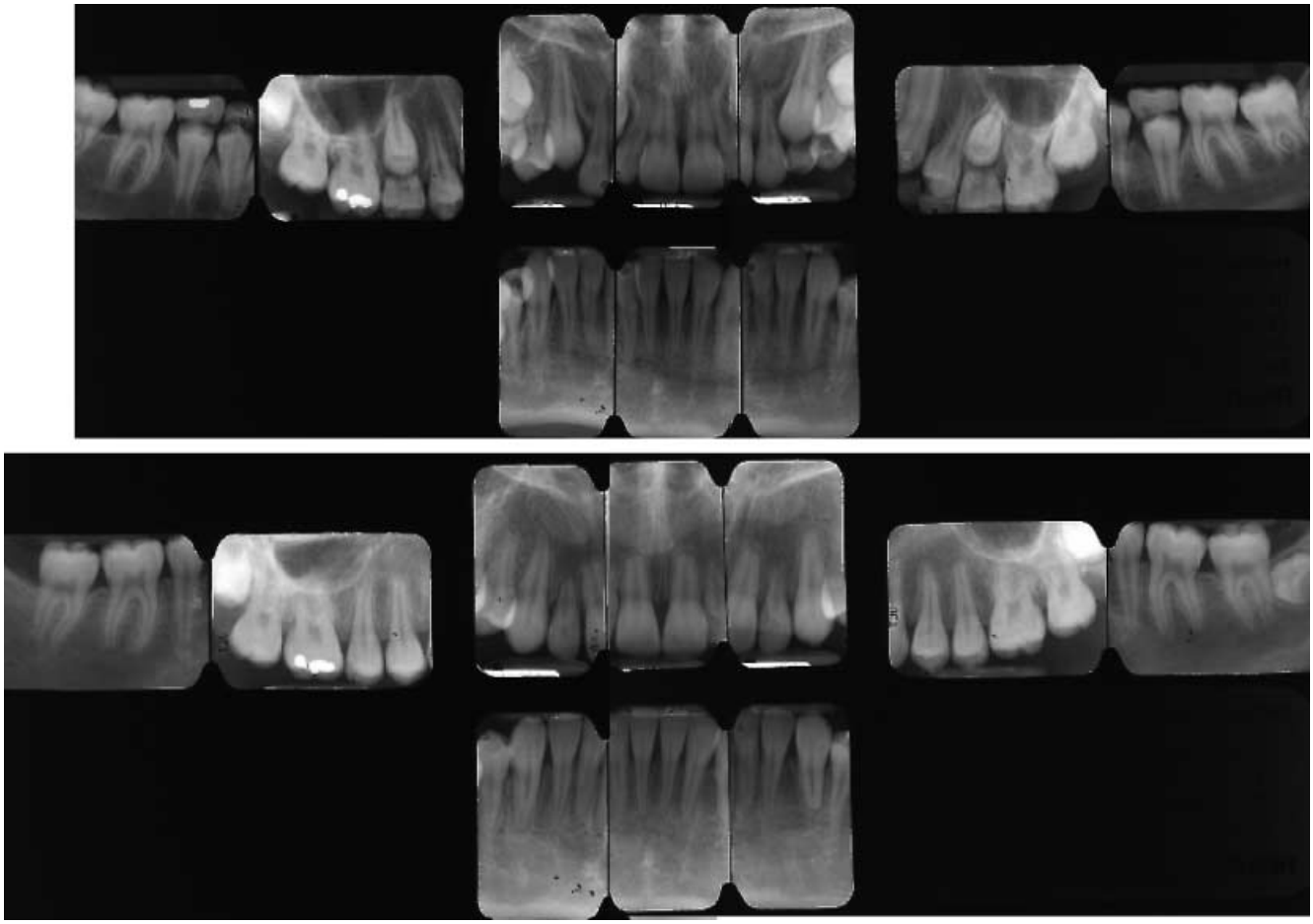

Fig. 2. Initial and final periapical radiographs of a 12-year-old patient treated for 35 months with fixed appliances. Severe apical root resorption occurred on all four maxillary incisors.

There were no differences noted for any of the studied variable, although horizontal apical displacement and abnormal root shape were very close. As discussed in previous studies, there is a covariance among overjet, apical root displacement, and possibly duration or extractions (12). In the severe cases, the apex was displaced lingually a mean difference of 1 mm more than the control group. Intrusion and extrusion did not have the effect on resorption found in other studies (13–15).

Habits, use of elastics, expansion, and habits were all non-contributory. Medical history was not included, and it is not know whether any of the severe cases had asthma. The literature is not in complete agreement on the role asthma has in the risk of apical root resorption (16–17), but asthma is one of the more common significant medical conditions in the orthodontic population.

The treatment factor of extractions was also not found to be significantly different between the two groups. It can be speculated that extractions for severe crowding do not impact upon the movement of the maxillary incisors as much as displacement for overjet correction. Thus by factoring out treatment duration, the influence of extractions (and overjet) were diminished. As stated above, the use of class II elastics was not significantly different between the two groups.

Tooth length was remarkably similar between the two groups. Previously it had been determined that longer teeth are resorbed more (12). Obviously, longer roots are at less clinical risk because of the crown-root ratio.

Most studies agree that abnormal root shape is a significant finding in root resorption (12, 18–20). The frequency of abnormal root shape was much higher in the severe cases particularly for the maxillary central incisor. Both groups showed a range of abnormal root shapes with dilacerated maxillary incisors the highest frequency.

The study design has limitations. Selection of matched controls was as random as possible but the number of matching variables was high relative to the number of subjects. The amount of root resorption was close to the mean for the group; a group with no resorption would be more ideal although impractical to find.

The low frequency of severe root resorption by any definition tends to support the theory of increased individual susceptibility. Recent work in the genetics of root resorption (21–23) will add a needed component to the prevention of resorption in at-risk patients.

Retrospective studies of root resorption have proved valuable and provided much useful clinical information. The study of severe cases is equally interesting and provocative. Difficulty in defining severity remains an issue. The rare, severe case involving multiple teeth has been experienced by most practicing orthodontists either personally, or as part of participation at peer-review or expert witness testimony. Well-designed studies of these cases warrant the attention of the profession.

Conclusions

A matched case–control study of severe cases of root resorption from orthodontic treatment showed that there were no statistically significant differences among a broad range of diagnostic and treatment variables. By matching cases by age, sex, ethnicity, office, and duration of treatment, it seems that the greater part of the variance between the groups was accounted for. Small sample size hindered the power of statistical analysis but increased risk was noted for abnormal root shape, tongue thrust, and possibly horizontal apical displacement. Further investigation of severe cases will be beneficial.

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