Long-term evaluation of root resorption occurring during orthodontic treatment

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The present study was undertaken to evaluate the long-term status of teeth that had undergone root resorption during active orthodontic treatment. A total of 100 patients who exhibited root resorption during appliance therapy were recalled at a mean period of 14.1 years (SD 0.4) after treatment. At those examinations full-mouth sets of periapical radiographs were taken and tooth mobility evaluated. Pretreatment, posttreatment, and long-term periapical radiographs were examined and compared for changes in root length and contour with time. At each stage scores were given on a scale from 0 to 4, depending on the degree of resorption. The maxillary incisors were affected more frequently and to a greater degree than the rest of the teeth during active treatment. The long-term evaluation showed no apparent changes after appliance removal except remodeling of rough and sharp edges. Hypermobility was observed in only two instances. (Am J Orthod Dentofac Orthop 1989;96:43-6.)

Numerous investigators have reported that routine orthodontic treatment is associated with a risk of apical root resorption.[1-13] The occurrence of mean root shortening on a group basis is only slight.[4,5,12,13] However, a limited number of patients are severely affected.[2-4,6,11-13] Attempts to identify predictors unfortunately have resulted in few cause-and-effect relationships. There is general agreement, however, that the presence of preexisting root absorption increases the risk factor[2,3,7-9,11] and speculations prevail as to the involvement of a genetic predisposition.[2,7] In addition appliance type and mechanics may influence the degree of root resorption.[1,6,12] However, there is no consensus on the effect of hormonal insufficiency, previous tooth trauma, and amount and type of tooth movement performed as aggravating factors.

Histologic studies have shown that root resorption occurs on all teeth exposed to orthodontic forces only a few weeks after application of these forces.[14-16] However, the signs of active resorption discontinue after cessation of the forces and reparative processes take over.[14,15,17] It may therefore be speculated that the resorption status is stable once active tooth movement is stopped. Although many practitioners share this clinical observation,[18] quantitative data are scarce.[6,10,12,13] Copeland and Green[13] followed their subjects only through the retention period; others evaluated patients with only mild degrees of resorption.[10,12] The purpose of this investigation was to use a large sample size to evaluate the long-term status of teeth that have undergone root resorption during active orthodontic treatment and to determine whether the resorptive process is progressive or stabilizes after appliance removal.

MATERIALS AND METHODS

Full-mouth sets of periapical radiographs, taken before and after active orthodontic treatment of patients from the Department of Orthodontics, University of Washington, and in several private orthodontic practices in the Seattle area, were examined. The occurrence of apical root resorption during treatment was the accepted diagnosis if the patient's crown/root ratio and/or the contour of the apical third of the roots were altered during treatment. Among those identified, a total of 100 patients, 27 boys and 73 girls, were able to meet for a follow-up examination, which included a full-mouth set of periapical radiographs and examination of tooth mobility. Radiographic signs of root resorption before orthodontic therapy were not observed. Mean age before active treatment was 13.6 years (SD 0.3); mean treatment time, 2.2 years (SD 0.8); and mean time lapse from end of active treatment to time of follow-up examination, 14.1 years (SD 0.4).

For each patient the entire series of three sets of

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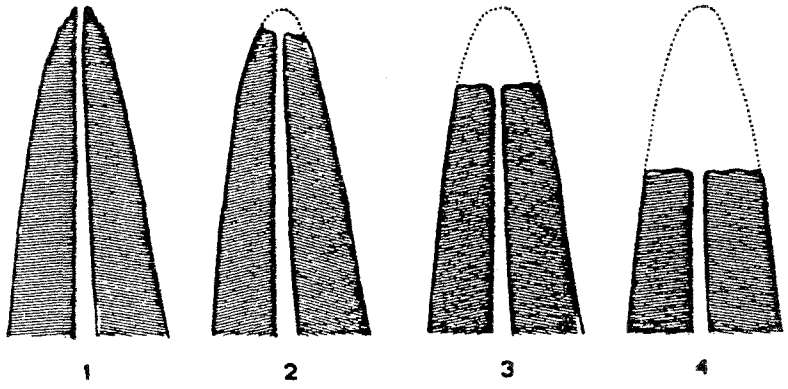

Fig. 1. Grading scale to evaluate root resorption. *Score 0,* Normal apical contour, same length as pretreatment. *Score 1,* Apical irregularity, same length as pretreatment. *Score 2,* Apical root resorption of less than 2 mm. *Score 3,* Apical root resorption more than 2 mm, less than one third original root length. *Score 4,* Apical root resorption more than one third original root length.

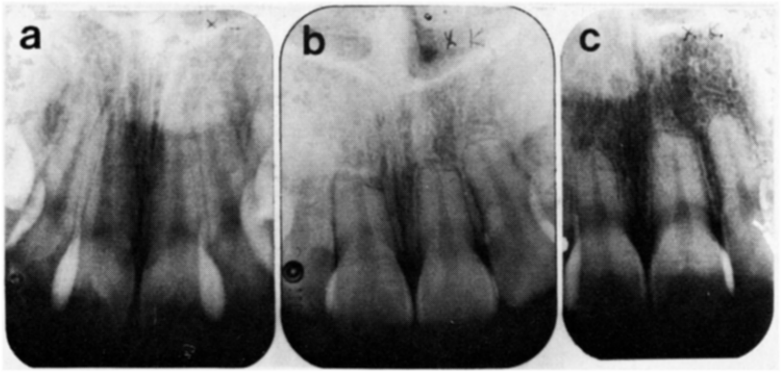

Fig. 2. Radiographs of severely resorbed maxillary incisors during orthodontic treatment. **a,** Before treatment. **b,** After treatment. **c,** Posttreatment at 15.3 years. Note remodeling of sharp edges.

radiographs taken at each time period were examined simultaneously to evaluate changes in root length and contour during appliance therapy and from the end of orthodontic treatment to long-term follow-up examination. At each stage scores were given to each tooth according to a scale from 0 to 4[11] (Fig. 1). Scoring was performed jointly by three of the authors. Averaging scores from right and left sides, mean scores were calculated for each individual tooth in the sample. In addition to computing mean score per tooth per patient, mean scores also were calculated separately for anterior teeth (canines and incisors) and posterior teeth (premolars and molars) in each jaw. If a single tooth could not be scored at any interval, the whole series of scores was eliminated for that particular tooth. Mobility was scored subjectively as physiologic or increased.

RESULTS

Teeth that resorbed during orthodontic therapy were frequently found to have rough, jagged, and often notched contours of the root on appliance removal (Fig. 2). A widened periodontal ligament space at this stage often accentuated the rough appearance. Three patients had severe external root resorption of maxillary lateral incisors resulting from ectopically erupting maxillary canines. In these three patients, rough contours and sharp corners also were evident. Of the teeth receiving numeric scores at the end of treatment, 52% were given a score of 0 or 1, 40% a score of 2, 7% a score of 3, and only 1% received a score of 4 (Table I). Three teeth that were endodontically treated showed less resorption than both adjacent and contralateral teeth (Fig. 3). Mean resorption scores for anterior teeth were 1.9 in the maxilla and 1.3 in the mandible. For both maxillary and mandibular posterior teeth, the score was 0.6. The mean resorption score per patient was 1.2.

The long-term evaluation showed no apparent increase in root resorption after termination of active orthodontic therapy (Figs. 2 and 3). However, a progressive remodeling of the root surface was evident;

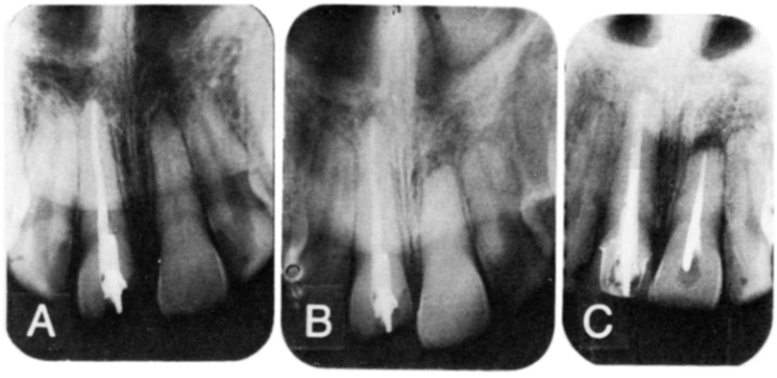

Fig. 3. Radiographs of resorbed maxillary incisors during orthodontic treatment. **A,** Before treatment. **B,** After treatment. **C,** Posttreatment at 23.9 years. Note differences in resorption between endodontically treated teeth and contralateral incisor.

Table I. Distribution of root resorption scores among maxillary and mandibular teeth in 100 patients at end of active treatment—Scores from right and left sides averaged

	Maxillary teeth							*Mandibular teeth*								
Score	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Sum*	*%*
0	3	12	65	31	83	112	112	39	34	80	69	105	100	146	991	35
1	12	7	41	8	37	25	2	9	10	33	4	27	15	5	235	8
2	136	119	72	16	55	47	3	133	133	70	17	35	66	18	920	33
3	43	47	14	0	4	0	0	14	14	10	0	2	16	0	164	6
4	4	6	1	0	0	0	0	0	1	1	0	0	0	0	13	1
X	2	7	4	143	11	0	0	1	2	0	107	12	1	0	290	10
N	0	2	3	2	10	16	83	4	6	6	3	19	2	31	187	7

X, = Extracted tooth; *N,* = unscored.

jagged edges became smooth and sharply pointed root ends rounded with time (Fig. 2). The same changes were observed when resorption was caused by ectopically erupting canines. Original root contours and lengths were never reestablished during long-term evaluation. Even severely resorbed teeth appeared to be functioning in a reasonable manner, with hypermobility observed in only two patients.

DISCUSSION

In agreement with previous studies,[2-4,6,11-13] the present investigation demonstrates that few cases show extreme degrees of root shortening during active orthodontic treatment. Despite the fact that the presence of apical resorption during treatment was a criterion for including patients in this sample, mean resorption scores for the whole sample were small. In addition this study confirmed the finding that maxillary incisors seem to be affected more frequently and to a more severe extent than the rest of the dentition.[1-3,5,7-9,12]

The results of a recent study suggest that endodontically treated teeth are more subject to apical root resorption than vital teeth during active orthodontic treatment.[19] It is possible that these findings were biased by including in the sample teeth that were not successfully treated endodontically.[20] The decreased amount of resorption observed in the limited number of root filled teeth in the present study may allow speculation that an increased density of the dentin in these teeth provided resistance against root resorption.[21]

One limitation of this study was that the pre- and posttreatment radiographs were taken with a nonstandardized bisecting-the-angle technique. For that reason changes in root lengths could not be measured directly on the radiographs. Instead a visual scoring system was used, which was based on changes in crown/root ratio in addition to contour alterations in the apical third of the roots. Such adjustments are well established[3,6-11] to minimize bias caused by differences in foreshortening and enlargement. The root resorption scores are values on an ordinal scale. Accordingly another criticism may be that mean posttreatment scores and standard deviations were calculated. On the other hand, the same procedure has been followed in a number of studies

with similar scoring systems, such as the plaque index and gingival index systems.[22] The method error was not tested because no differences in scores were found when pairs of posttreatment and long-term follow-up radiographs were examined.

The present results support earlier works[6,10,12,13] and indicate that apical root resorption occurring during active orthodontic treatment does not progress after appliance removal. Although accurate measurements were not performed, subjective evaluation indicated that reparative processes took place after treatment. These included smoothing and remodeling of sharp edges and the return of periodontal membrane width to normal. There have been speculations that severely shortened teeth are less suitable for resisting masticatory functional loads[18] and that functional stress may even lead to continued apical resorption.[18] A comprehensive functional analysis was not performed in this work. However, the clinical observation was that even severely resorbed teeth appeared to be functioning in a reasonable manner many years after orthodontic intervention. In assessing tooth mobility, it must be kept in mind that the apical portion of the root is of relatively minor importance for total periodontal support.[5,23] Approximately 3 mm of loss of apical support has been found to be equivalent to 1 mm of crestal bone loss.[23] Accordingly the present finding that greater mobility of the resorbed teeth is rare may not be unusual. In general the patients evaluated were not aware that the roots of their teeth were shorter than the ideal.

When analyzing the long-term prognosis for dentitions with resorbed teeth, one should consider that teeth with unfavorable crown/root ratios in some instances may be less suitable as abutments for prosthetic replacement. Periodontally a critical stage may be reached prematurely if marginal periodontitis is a factor and it may also be speculated that such teeth are less resistant to trauma. None of the patients included in this investigation presented with fixed prostheses involving severely resorbed teeth. The combined effect of apical root resorption and crestal alveolar bone loss for residual periodontal attachments was not evaluated, and information on trauma was not collected. These interactions should be evaluated to provide data for future studies.

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