Orthodontic and Nonorthodontic Root Resorption: Their Impact on Clinical Dental Practice

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Abstract: Occasionally, general dentists are challenged with providing restorative treatment for a postorthodontic patient who has had moderate to severe root resorption. When this happens, a number of questions about the cause of such resorption and the appropriate treatment arise in the dentist's mind. This article will describe the orthodontic and restorative management of three patients with severe maxillary incisor root resorption, provide a thorough discussion of the currently available literature on the topic of root resorption, and answer clinical questions regarding this relatively infrequent but devastating sequel to orthodontic treatment.

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Occasionally, general dentists are challenged with providing restorative treatment for a postorthodontic patient who has had moderate to severe root resorption. When this happens, a number of questions often arise in the minds of dentists: What causes root resorption? Is it due to heavy orthodontic forces placed on the teeth? What is the incidence of root resorption among orthodontic patients? Is the tendency for root resorption inherited? What is the prognosis for teeth that have had significant root resorption? Will the resorptive process continue? Can these teeth be safely restored? Do they require root canal therapy? Do they need to be splinted to the adjacent teeth? Should they be replaced with implants? What if the patient requires further orthodontic therapy? Will the resorption continue? Get worse? How does all of this affect the placement of restorations? The answers to these questions are important for the dentist who inherits a patient with significant root resorption.

This article will describe the orthodontic and restorative management of three patients with severe maxillary incisor root resorption, provide a thorough discussion of the currently available literature on the topic of root resorption, and answer the aforementioned clinical questions regarding this relatively infrequent but devastating sequel to orthodontic treatment.

Orthodontic and Restorative Management of Three Patients

Case 1

This thirty-six-year-old female lobbyist was concerned about the esthetics of her smile (Figure 1A). She had received orthodontic treatment during childhood, and her appliances were removed at age fifteen. Two maxillary first premolars had been removed to reduce her anterior overjet, but her maxillary incisors suffered severe root resorption during the orthodontic treatment (Figure 1B). Her maxillary right lateral incisor was hopeless and was extracted. A resin-bonded lingual splint had been in place for twenty years to replace the maxillary right lateral incisor and stabilize the remaining anterior teeth. Now she wanted to improve the appearance of her smile. She had an anterior open bite and excess overjet (Figure 1C). How would you restore this patient's anterior teeth?

The options included extraction of the remaining incisors and the placement of either four implants or two implants and an implant-supported maxillary anterior bridge. Another option would be to leave the central incisors and replace the maxillary left lateral incisor and missing right lateral incisors with

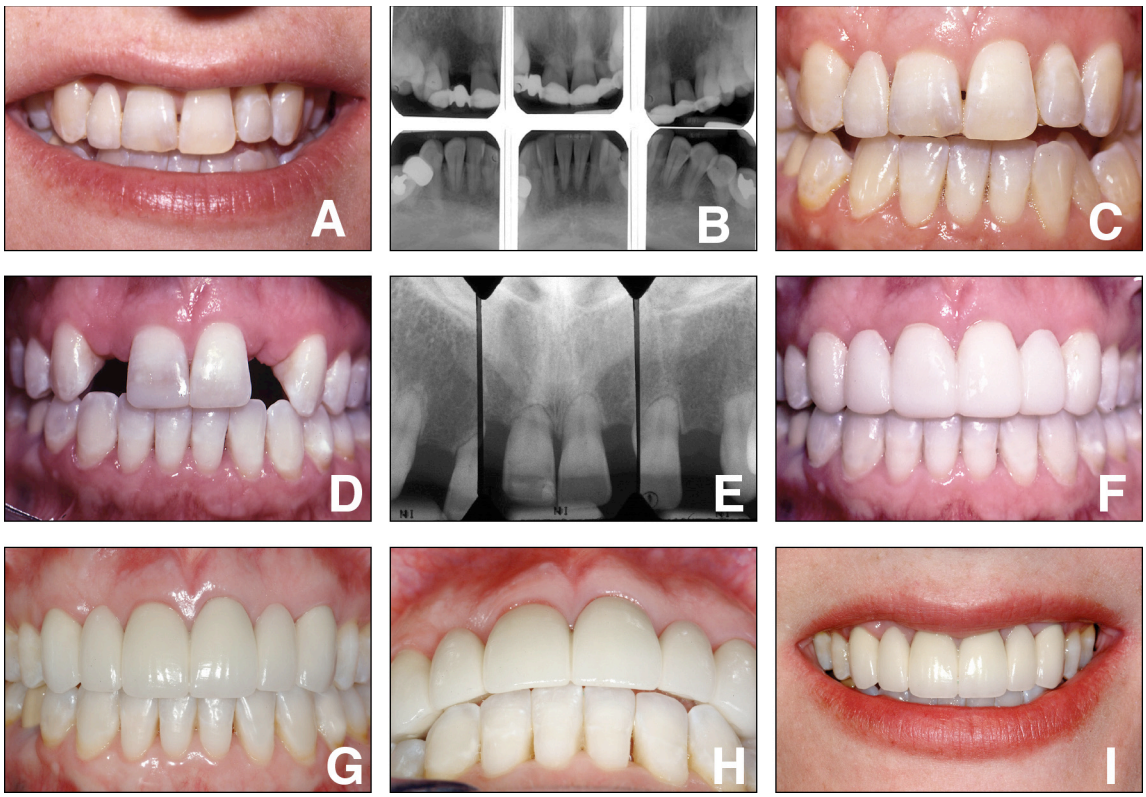

Figure 1. Orthodontic and restorative management of patient 1

This thirty-six-year-old patient was unhappy with the appearance of her maxillary anterior teeth (A). She had had previous orthodontic treatment, including the extraction of two maxillary first premolars. Moderate to severe root resorption had occurred, so her anterior teeth were splinted with a cast lingual splint (B). However, her root length had not diminished in twenty years. So her malocclusion was corrected (D), and the roots did not get shorter during the orthodontic retreatment (E). A provisional bridge (F) was worn for one year. A six-unit porcelain-fused-to-metal bridge, shown five years after orthodontics (G, H, I), has successfully restored esthetics and function and stabilized the teeth.

implants. A third option would be to place another resin-bonded splint. A fourth option would be to remove the maxillary left lateral incisor and place a six-unit conventional bridge attached to the maxillary canines and central incisors replacing the lateral incisors. However, all plans required further orthodontic therapy in order to reduce the overjet, align the mandibular incisors, and close the open bite.

After a thorough discussion among the periodontist, orthodontist, general dentist, and patient, it was decided that extraction of the left lateral incisor and restoration of the remaining teeth with a conventional fixed bridge would not only improve the esthetics, but would also stabilize the central incisors and canines with the short roots. Since the patient had not suffered further root resorption of the central incisors during the twenty years after the original orthodontics, it was believed that further resorption was not likely. Orthodontic appliances were placed on all teeth, the maxillary right central incisor was intruded to level the gingival margins between the central incisors, the overjet was corrected, and the open bite was closed (Figure 1D). No further root resorption occurred during the orthodontic therapy (Figure 1E). A maxillary anterior provisional bridge was worn for one year after the orthodontic treatment (Figure 1F), and then a porcelain-fused-to-metal bridge was placed on the maxillary canines and central incisors and has been stable for five years (Figure 1G, H, and I).

Case 2

This thirteen-year-old female had been under the care of a pediatric dentist since age six. Her mother decided to transfer her daughter to their family general dentist. She was in the transitional dentition and was erupting her maxillary canines (Figure 2A).

The patient was congenitally missing her maxillary right and left second premolars. Current periapical radiographs showed that the maxillary right and left lateral incisors had severely resorbed roots (Figure 2B). This girl had never had previous orthodontic treatment. Periapical radiographs taken by the pediatric dentist of the girl at age eight years showed that no root resorption had occurred up until that time (Figure 2C). So, over the past four years, the pressure of the erupting maxillary canines had caused the resorption of the maxillary lateral incisor roots.[1] How would you eventually restore this patient? She obviously needed orthodontic therapy. Would implants be necessary to replace the lateral incisors? If so, when?

Since the patient was already missing her maxillary right and left second premolars, and since she was too young for implants, it was decided that the maxillary lateral incisors should not be extracted until after the orthodontic treatment, so they could provide space for eventual implants. The orthodontic treatment lasted over two years. However, at the end of orthodontic therapy the patient was only fifteen years of age, still growing, and therefore too young

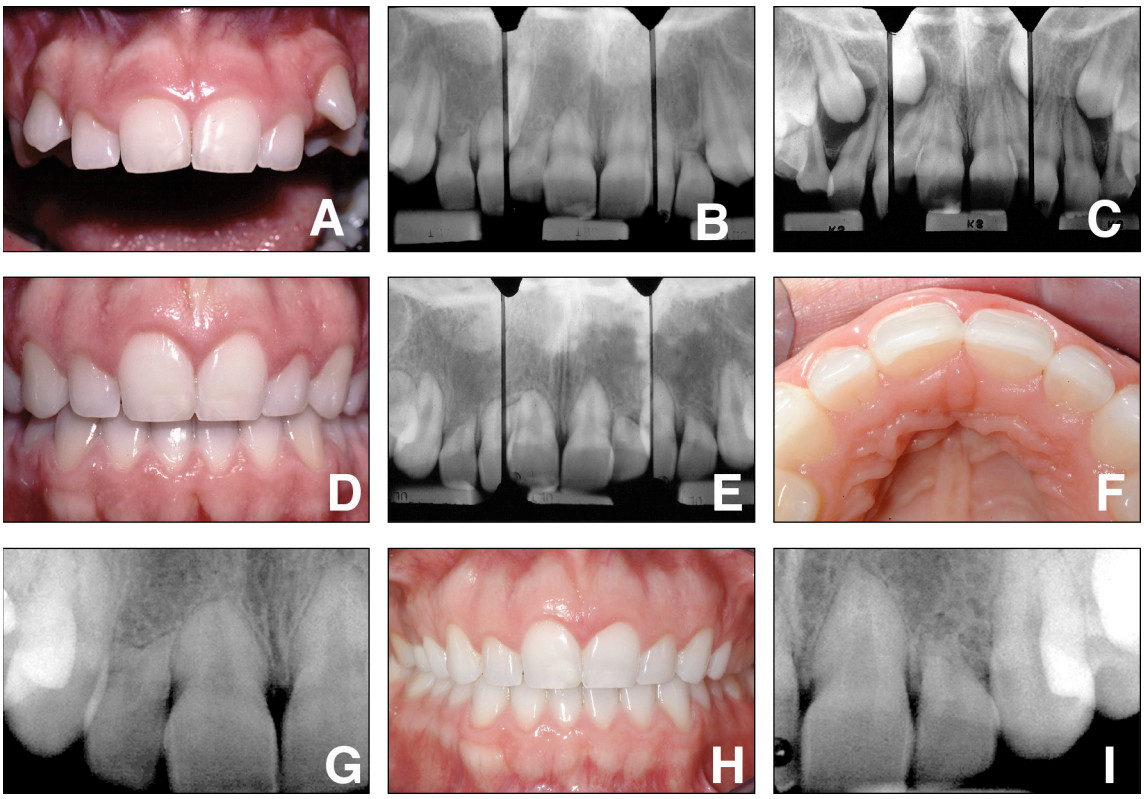

Figure 2. Orthodontic and restorative management of patient 2

This thirteen-year-old female had been under the care of a pediatric dentist since age six years. She was now transferring to the family dentist. Current periapical radiographs (B) reveal extensive resorption of the maxillary lateral incisor roots. Comparison with radiographs taken four years earlier (C) show that the root resorption was caused by the erupting maxillary canines. Because the patient was too young for implants, the lateral incisors were maintained during the orthodontics (D), and she had no further root resorption after bracket removal (E). The teeth were not mobile nor did they need restoration, so they were left for the next thirteen years. At twenty-eight years of age, the patient's alignment, esthetics, occlusion, and root length appear stable (G, H, I).

for implants. So the maxillary lateral incisors were not extracted (Figure 2D). No further root resorption had occurred over the two years of orthodontics (Figure 2E). An Essix retainer was worn in the maxillary arch to help stabilize the teeth. After two years, when the patient had completed her growth, the maxillary lateral incisor roots had not shortened further, and the teeth were relatively stable (Figure 2F). So they were not extracted. Thirteen years after completion of the orthodontic treatment, the patient was now twenty-eight years of age, and the lateral incisors were still stable with no further root resorption (Figure 2G, H, and I).

Case 3

This fourteen-year-old female had been under the supervision of a general dentist since she was eight years of age (Figure 3A). However, for the past four years she had not been seen by the dentist due to the divorce of her parents and custody issues regarding their children. Current periapical radiographs show that this patient has had severe resorption of the maxillary right and left lateral incisors (Figure 3B). A review of the periapical radiographs taken at ten years of age showed that the root resorption occurred gradually as the maxillary canines erupted (Figure 3C). This girl was unhappy with the hypoplastic appearance of her maxillary anterior teeth and wanted to have her smile improved. The general dentist planned to temporarily bond the facial surfaces of the central incisors with composite and to restore these teeth with porcelain veneers when she was older. But what should be done with the maxillary lateral incisors? This girl was still growing and too

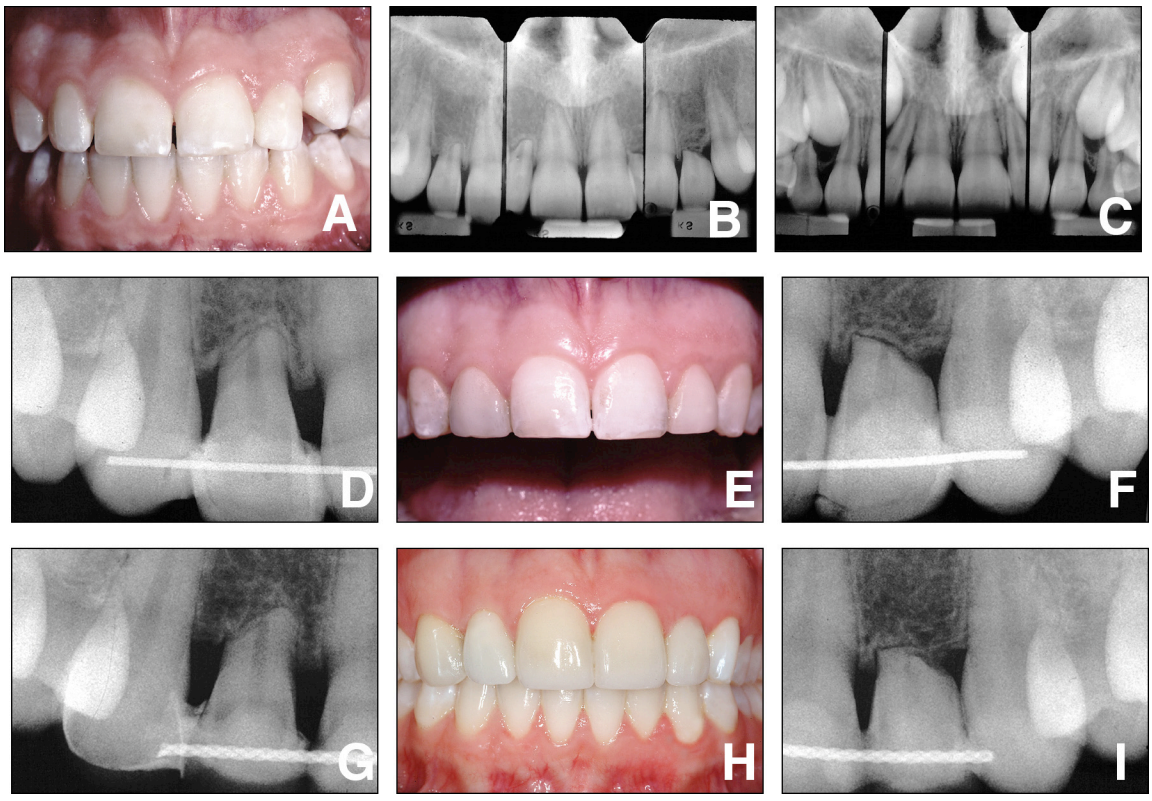

Figure 3. Orthodontic and restorative management of patient 3

This fourteen-year-old girl had not seen her dentist for four years (A). Current radiographs (B), compared with those taken at age ten (C), show that severe resorption of the maxillary lateral incisors occurred during the eruption of the maxillary canines. Minor orthodontics was accomplished in nine months, and a bonded lingual splint was used to stabilize the teeth (D, E, F). Eventually, porcelain veneers were placed on all four maxillary incisors, and after fifteen years, the maxillary anterior esthetics, occlusion, and root length appear stable (G, H, I).

young for implants. She needed some minor corrective orthodontic treatment.

After consultation among the general dentist, the orthodontist, and the patient and her mother, it was decided that the lateral incisors not be extracted until after orthodontics. The orthodontic treatment lasted for nine months, and the roots of the lateral incisors did not get any shorter during that time (Figure 3D and F). The incisors were bonded with composite (Figure 3E), and a wire splint was bonded on the lingual to stabilize the teeth until the patient was old enough to have implants. At seventeen years of age, the patient had stopped growing and was ready for implants. However, the gingival tissue and papillae around the lateral incisors were healthy, at normal levels, and the lateral incisors were immobile with the lingual splint. So it was decided that the resorbed teeth, instead of being extracted, would be restored (along with the central incisors) with porcelain veneers and stabilized with a bonded lingual wire. Fifteen years after orthodontics, the lateral incisors were still present, the gingival and restorative esthetics were good, and the roots had not resorbed any further (Figure 3G, H, and I).

Discussion

This article has demonstrated the long-term treatment and management of three patients with severe root resorption. In one case, the root resorption was most likely caused by the orthodontic movement. In the other two cases, eruption of the maxillary canines caused the resorption of the lateral incisor roots.[1] However, the resorbed teeth were maintained. In two cases they were restored, and in all three cases they have remained functional and esthetically natural in appearance many years after completion of the orthodontics and restorative dentistry.

When a general dentist inherits a patient with moderate to severe orthodontic or nonorthodontic root resorption, the shortened roots on the periapical radiograph make the outlook for these teeth seem hopeless. However, as one can see from these three cases, the outcome is far from hopeless. It is therefore important that general dentists understand the incidence, cause, and outcome of root resorption in order to provide the best follow-up treatment for their patients who experience this devastating problem.

The first question to address is the incidence of root resorption in orthodontic patients. Several clinical studies have compared pre- and post-treatment periapical radiographs to determine the incidence of root resorption after orthodontic treatment.[2-6] However, radiographs only provide a crude two-dimensional assessment of root resorption and will usually underestimate the true amount of root resorption. Therefore, the only accurate assessment of root resorption must come from a histologic assessment of the root surface after orthodontic movement. These studies have been accomplished in both animals[7] and humans,[8-10] and they clearly show that root resorption occurs in over 90 percent of the cases when a tooth root is compressed against the alveolar socket. Therefore, root resorption is a common sequel of orthodontic movement.

Why does root resorption occur in response to compression of the periodontal ligament? This phenomenon is not completely understood, but recent studies have found that the presence or absence of hyaline in the periodontal ligament affects the incidence of root resorption.[11] Hyalinization is a common sequel after a compressive load is placed on the periodontal ligament. Hyaline has been termed sterile necrosis[10] and forms in the interstitial space within the periodontal ligament after a compressive load is placed on a tooth root. Hyalinization of the periodontal ligament usually occurs after a few days, and the hyaline may remain within the periodontal ligament up to four to eight weeks after initiation of the compressive load.[12,13] During this time, resorption of the alveolar socket is virtually prevented, and undermining resorption of the alveolar bone may occur.[11] In addition, root resorption near the areas of hyalinization will occur. After about eight weeks in experimental animals, the hyaline has been removed from the periodontal ligament by macrophages, and at this time resorption of the alveolar socket wall occurs that permits the tooth to move.[11] However, by this time, extensive resorption lacunae are typically found along the length of the root surface.

Why don't we see more radiographic evidence of root resorption in larger numbers of orthodontic patients? Actually, these resorption lacunae will repair themselves after the hyaline has been removed from the periodontal ligament and cementoblasts begin to secrete cellular cementum.[11,14-17] Since most of these resorption lacunae repair themselves with time, there is little or no radiographic evidence of root resorption in the majority of orthodontic patients. What if the cementoblasts do not repair the resorption lacunae? Then the patient may suffer moderate to severe root resorption.

What is the incidence of moderate to severe root resorption after orthodontic treatment? Several radiographic assessments of consecutively treated populations of patients have been made to determine the prevalence of moderate to severe root resorption in both adolescent and adult populations of orthodontic patients. Moderate to severe root resorption is typically described as a greater than 20 percent reduction in the original root length. Using this definition, the incidence of moderate to severe root resorption in an adolescent sample[2,5] is about 3 percent. In adults,[18] researchers have shown that the incidence of moderate to severe root resorption is near 4 percent.

Can root resorption be predicted? Previous studies have used statistical comparisons of gender, pre-treatment root form, pre-treatment root length, length of orthodontic treatment, premolar extraction, and linear amount of root movement as independent variables to determine if there are any accurate predictors of root resorption related to orthodontic treatment. In general, three of these variables show an association: amount of linear root movement, length of orthodontic treatment, and premolar extraction.[5,6,19-22] If a patient were susceptible to significant root resorption, then the farther the tooth is moved and the longer the duration of the orthodontic treatment, the more root resorption would likely occur. In addition, epidemiological studies show that premolar extraction cases tend to demonstrate more root resorption in susceptible patients, probably because of the increased distance that the teeth move in extraction cases.

Does the amount of force used during orthodontics affect the amount of root resorption? It seems logical that, in a susceptible sample, greater orthodontic forces would cause more root resorption. However, this assumption is not valid. Studies in both animals and humans have shown that the amount of force placed on a tooth root has neither a positive nor negative effect on the amount of root resorption.[8,23] On the other hand, studies in humans have shown that quadrupling the force on a tooth root does not produce greater root resorption, but can increase the speed of root movement through the bone.[9] Does it make a difference if the orthodontic force is continuous or intermittent? Researchers have clearly shown that although considerable variation typically exists, continuous forces tend to produce more extensive root resorption than intermittent forces.[13,14,24]

Is the tendency or susceptibility for root resorption an inherited trait? In the past, this question has been controversial. However, recent studies have suggested that external apical root resorption can be traced to a specific locus on a specific gene.[23,25] These researchers believe that external apical root resorption is a complex condition influenced by many factors, with the IL-1B gene contributing an important predisposition to this common problem. Personally, I have treated two families of parent and child, where both experienced moderate to severe root resorption during orthodontic treatment. It is evident that more studies evaluating a genetic determination of root resorption susceptibility are needed.

Do specific types of orthodontic movement lead to greater root resorption in susceptible patients? Several authors have pointed out the negative impact of tooth intrusion on the severity of root resorption in orthodontic patients.[26,27] Perhaps this observation is due to the method of analyzing root resorption or root shortening on two-dimensional periapical radiographs. Resorption of the root apex after tooth intrusion can be seen easily on two-dimensional radiographs, whereas the root resorption seen on periapical radiographs after lateral root movement is not as clearly visible.

What is the effect of root resorption on tooth vitality? Although no studies have analyzed this relationship, from a clinical perspective I have not encountered a tooth with moderate to severe root resorption whose pulp became nonvital. Unless there is some bacterial or traumatic insult to the tooth, pulp vitality does not seem to be related to the amount of root resorption experienced during orthodontic therapy. None of the pulps of the resorbed roots of the three patients illustrated in this article were nonvital.

What happens over the long term to tooth roots that have undergone moderate to severe root resorption? Researchers have reevaluated patients with moderate to severe root resorption many years after orthodontics[28-30] and have found that root resorption stops after orthodontic treatment has been discontinued. Although there may be some remodeling of the irregular resorbed edges of the root with time due to reparative deposition of cellular cementum, this type of remodeling merely produces a smoother surface long term. However the length of the root does not continue to shorten after orthodontic appliances have been removed.

Do teeth with moderate to severe root resorption require splinting? There are no studies that provide us with the answer to this important clinical question. In two of the cases presented in this article, the teeth were splinted either with a conventional bridge

or a bonded lingual wire. But these teeth required restoration. In the third patient, no permanent retention other than a removal retainer was used for the patient. After thirteen years, the patient without a fixed retainer has retained her severely resorbed maxillary lateral incisors. However, this patient has a two-millimeter overjet in centric occlusion and does not have any parafunctional or destructive occlusal habits. I believe that parafunctional habits, crown mobility, and the need for restoration tend to determine the necessity for a permanent lingual splint. If a patient has a protrusive bruxing habit with mobile maxillary incisors and will require some sort of restoration of these teeth, then perhaps splinting will help to avoid the negative effects of each of these parameters.

If the patient requires further orthodontic treatment, will the roots continue to resorb? This research question has not been explored. However, most orthodontists have had to retreat patients who have had root resorption during an earlier phase of orthodontic treatment. The three patients described in this article all had orthodontic treatment ranging in length from nine months to over two years, and the tooth movement was started after the root resorption had occurred. None of these patients exhibited any further root resorption as a result of the orthodontic retreatment. However, in these cases I tried to limit the amount of tooth movement, limit the length of orthodontic treatment, and avoid intrusive tooth movements. Also, histologic follow-up after root resorption showed that reparative dentin and cellular cementum form after the tooth movement had ceased. Perhaps the presence of a cellular cemental layer plays some role in protecting the tooth root during orthodontic retreatment.

Summary and Conclusions

This article has described the treatment of three orthodontic patients who had experienced severe root resorption but required further orthodontics. All three patients had successful long-term outcomes by maintaining the severely resorbed roots. In addition to illustrating the logic of the treatment plans as well as the long-term effect, I have tried to answer the key questions that arise in the mind of the general dentist when he or she inherits a patient with severe postorthodontic or nonorthodontic root resorption. Hopefully, this information will be clinically useful for the general dentist and orthodontist when planning treatment for these difficult situations.

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