Root Damage and Repair after Contact with Miniscrews

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Various auxiliary devices have been introduced in recent years for skeletal anchorage, including "onplants",[1] implants,[2] microplates,[3] and miniscrews.[4,5] Of these, miniscrews have been used most frequently because of their small size and versatility, relatively low cost, and ease of insertion and removal.[6-10]

Possible insertion sites for miniscrews include the palate, mandibular retromolar area, maxillary tuberosity, anterior nasal spine, mandibular symphysis, and edentulous areas of the alveolar ridge.[4,10-12] One of the most common locations is the interradicular space between adjacent teeth. Root damage may occur during insertion of a screw in an interradicular site, however, or when a root moves against the screw during treatment. A recent study showed that miniscrews are not absolutely stable, with an average screw head movement of as much as .5mm and an even greater potential movement of the screw body.[13] Some types of miniscrews require drilling a pilot hole, which can also endanger the root.

Despite the widespread use of miniscrews, few studies have been conducted on the possibility of root damage due to screw contact. We investigated the effects of contact between a drill, a miniscrew, or both and the roots of four upper premolars in two adolescent orthodontic patients by means of histological analysis.

Materials and Methods

Two 13-year-old male patients who had been referred for treatment because of bilateral maxillary crowding or protrusion participated in this preliminary study. Each treatment plan included extraction of the upper first premolars, which was postponed until completion of the study. The study design was approved by the appropriate ethics committee, and both patients and their parents gave informed consent.

Orthodontic miniscrews* (1.5mm in diameter, 8mm long) were inserted adjacent to the patients' four upper first premolars, three mesially and one distally. After brackets were bonded in the upper arch, an .016" × .022" stainless steel archwire was placed. In the three mesial miniscrew sites, a 150g superelastic open-coil spring was placed between the second and first premolars to move the roots of the first premolars against the screws (Fig. 1). In the distal miniscrew site, an open-coil spring was placed between the canine and the first premolar to move the premolar distally against the screw.

Periapical radiographs confirmed that the miniscrews were not initially in contact with the roots. Each patient was checked every 20 days for two months. As soon as contact between a miniscrew and the root surface was observed clinically and radiographically (Fig. 2), the spring force was increased to 200g for an additional two months, simulating the clinical situation of incisor retraction with sliding mechanics during Class II treatment.[14] The open-coil springs were removed after three months of contact between the screws and roots on the patients' right sides, but left in place on the patients' left sides for an additional two months.

Next, to simulate root damage from a pilot drill, a notch was made with a bur on the distal root surface of each of the three premolars with mesial miniscrews, and on the mesial root surface of the premolar with the distal miniscrew. In two of these locations, screws were inserted until they touched

*K1 Spider Screw, registered trademark of HDC Company, Via dell'Industria 11, 36016 Sarcedo, Italy; www.hdc-italy.com. Distributed in the U.S. by Ortho Technology, www.orthotechnology.com.


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the roots, simulating the combined effects of drill contact and subsequent screw contact. These two miniscrews were removed seven days later (Fig. 3); after a 30-day healing period, the teeth were extracted under local anesthesia. On the contralateral sides, where no miniscrews had been inserted after damaging the roots with the pilot drill, the teeth were left in place for an additional 27 days before being extracted.

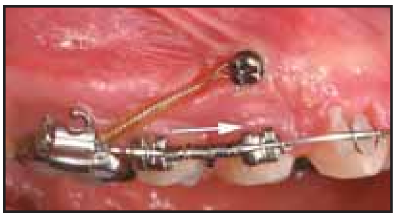
Immediately after extraction, the teeth were fixed in a 4% formalin solution, and they were then demineralized in 10% trifluoroacetic acid for 60 days. After rinsing with tap water and dehydration in serial solutions of ethanol, the teeth were embedded in Technovit 7100** and sectioned using a rotary microtome.*** The sections were stained with methylene blue and basic fuchsin.

Results

The two patients reported no discomfort related to root-screw contact throughout the study.

**Heraeus Kulzer GmbH, Hanau, Germany.

***Reichert-Jung AG, Heidelberg, Germany.



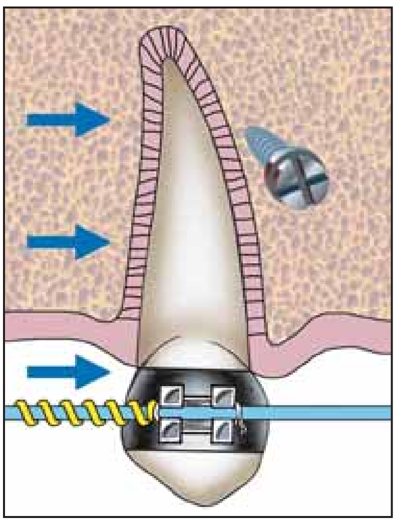


Fig. 1 Experimental setup: Upper first premolar moved toward miniscrew with superelastic open-coil spring.

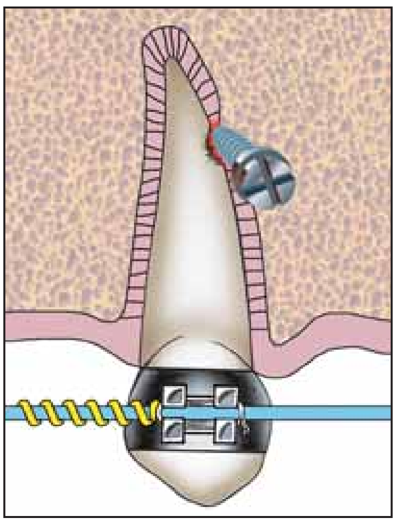


Fig. 2 Premolar root in contact with miniscrew.

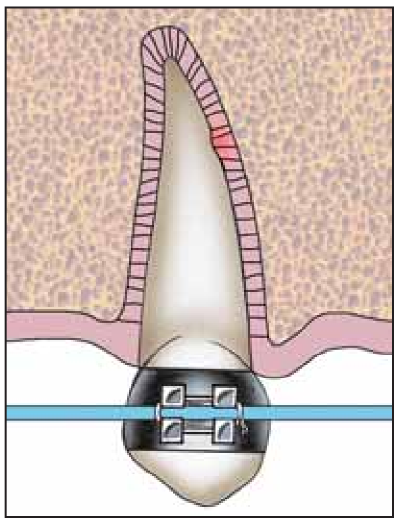


Fig. 3 Premolar after removal of miniscrew.

There was no radiographic evidence of ankylosis, as confirmed during the extractions. Macroscopically, the roots of the extracted teeth showed granulation tissue at the damaged sites (Fig. 4).

Histological examination showed active resorption lacunae without signs of repair in the teeth whose roots were pushed against the screws until extraction (Fig. 5). In the teeth where contact with the screw had been discontinued before extraction, however, cellular cementum had been deposited, almost entirely filling the resorption craters within two months after removal of the force (Fig. 6).

In a site where the root was damaged by the pilot drill and subsequent miniscrew insertion, the original contour of the resorption area was evident, as well as incomplete repair of the resorption lacunae with cellular cementum (Fig. 7). Clear signs of inflammatory cells could be seen in the periodontal ligament. Similar results occurred when the root was contacted by the pilot drill, but no screw was inserted (Fig. 8).

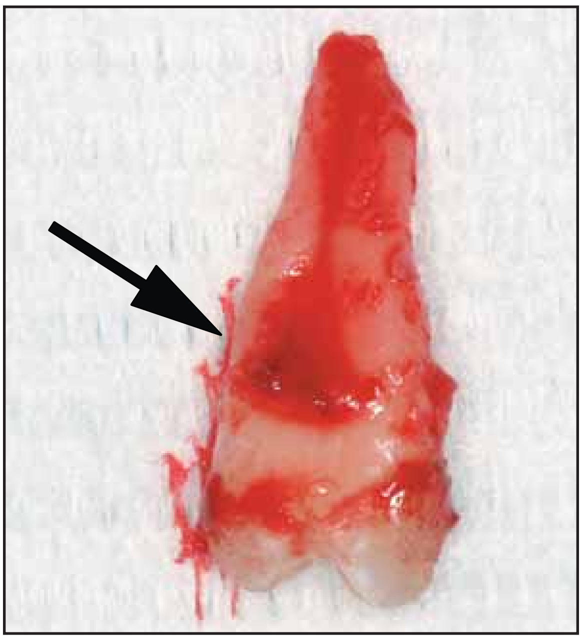


Fig. 4 Premolar after extraction, with root showing granulation tissue at damaged sites (arrow).

Discussion

Given the extensive use of miniscrews to enhance anchorage, it is important to understand the potential hazards of screw-root contact. The ethical situation involved in intentionally moving premolars into direct contact with miniscrews in extraction cases is comparable to that in human studies of root resorption following orthodontic tooth movement,[15-20] or in caries studies where premolars are used as in vivo cariogenic models.[21,22]

Previous studies have reported that orthodontically induced root resorption is repaired, pri-

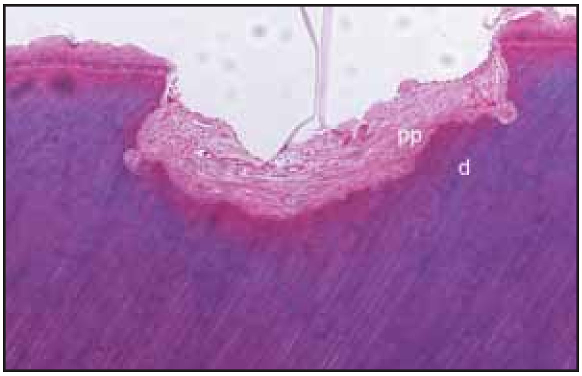


Fig. 5 Irregular resorption lacunae without substantial signs of repair in tooth whose root was moved against screw until extraction (d = dentin, pp = periodontal ligament; magnification 10×).

Fig. 6 Resorption crater completely filled with cellular repair cementum (cc) in tooth whose root-screw contact was discontinued two months before extraction (d = dentin; magnification 10×).

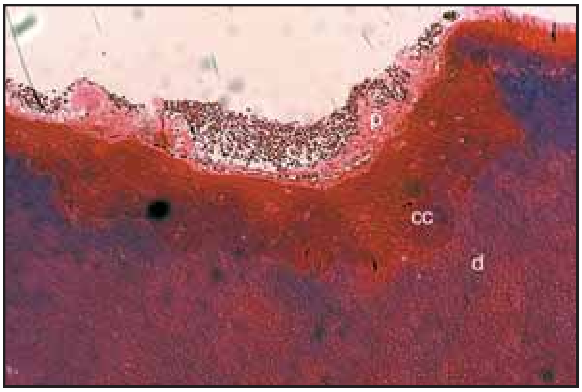


Fig. 7 Partial repair with cellular cementum (cc) and clear signs of inflammatory cells in periodontal ligament (p) after root contact with pilot drill and miniscrew (d = dentin; magnification 10×).

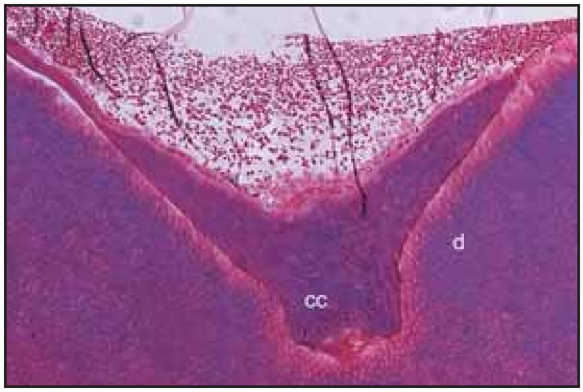


Fig. 8 Inflammatory cells in periodontal ligament and partial repair of defect by deposition of cellular cementum (cc) in premolar root with notch created by pilot drill, but with no miniscrew contact (d = dentin; magnification 10×).

marily with cellular cementum, once the cause of resorption is removed.[15,23-28] It has been hypothesized that cellular cementum is formed when the repair process is fast, capturing cells in the repair tissue.[29] Acellular cementum is associated with slow repair.[30] Bosshardt suggested that the initial reparative cementum is often acellular, but that continued repair occurs with rapidly formed cellular cementum.[31] Other investigators have concluded that repair cementum is always cellular.[26,27]

Moving a root against a screw leads to external root resorption comparable to that seen after normal orthodontic tooth movement. When the premolars in this study were moved against the screws until extraction, large resorption craters extending into the dentin could be seen, with no repair activity. This is not surprising, since the repair process begins only when the orthodontic force is removed or drops below a certain (undefined) level.[24] Vardimon and colleagues showed that the repair accelerates over the first four weeks after force removal, before slowing down and reaching a plateau after five to six weeks.[30] Owman-Moll and colleagues found no significant difference in the extent of repair after eight weeks of retention, compared with four weeks.[15]

In the present study, the force used immediately before extraction was 200g, which in sliding mechanics[32] is definitely too heavy to allow cementum repair to begin. Two months after discontinuation of the force, differing amounts of repair cementum could be seen. The extent of repair tends to vary among sites and individual patients,[15,29] although the sample size in our study was too small to confirm this. In some cases, the resorption cavity is completely covered with cementum, reestablishing the original root contour in what is known as "anatomic repair"[15] (Fig. 6).

No attempt was made after discontinuation of the force to retain the premolars in position or to limit the effects of occlusal forces. Relapse and occlusal contacts may have influenced the repair process by causing the persistence of active resorption.[15,26]

When a notch was created in the premolar root by direct contact with a pilot drill, partial repair with cellular cementum could be observed after 57 days of root resorption. Partial repair of the defect could also be seen after root contact with a pilot drill and subsequent contact with a miniscrew that was left in place for seven days, followed by a delay of 30 days until extraction of the premolar. Similarly, in a study of repair after orthodontically induced root resorption, Owman-Moll and colleagues found that almost half of the resorption lacunae were not covered or only partly covered with repair cementum after eight weeks of retention.[15]

Conclusion

Our results show that contact between a dental root and a drill, screw, or both causes resorptive root damage. After discontinuation of the contact, however, repair begins to occur through the deposition of cellular cementum.

Poggio and colleagues recommended a minimum clearance of 1mm between a miniscrew and a root for both periodontal health and miniscrew stability.[10] Therefore, it can be concluded that miniscrews with a diameter of 1.5mm or less are safe for interradicular insertion if the space between the roots is at least 3.5mm.

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