



Contact damage to root surfaces of premolars touching miniscrews during orthodontic treatment

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Introduction: Our aim in this clinical study was to examine premolar root surfaces after intentional contact with miniscrews. **Methods:** Ten patients (5 male, 5 female; mean age, 15.8 years; range, 13.5-23.2 years) with 2 maxillary first premolars to be extracted as part of their orthodontic treatment participated in the study. Two miniscrews were placed in each patient, and the first premolar roots were tipped into contact with the miniscrews by using tipping springs with a standardized force. Half of the experimental teeth were kept in contact with the screws for 4 weeks (mild resorption) and the other half for 8 weeks (severe resorption). In 5 patients, the screws were removed, and, in the remaining 5, the springs were removed to allow the roots to move back. The roots were allowed to recover for 4 or 8 weeks before extraction. Two premolars with accidental direct contact were used as controls. All teeth were prepared, coated, and examined with scanning electron microscopy. **Results:** In the control group, the periodontal ligament was removed and the dentin surface denuded. The experimental groups showed signs of resorption with structural surface irregularities. However, no apparent denuded dentin surfaces were seen. Although some resorption lacunae were still discernible at 8 weeks, the collagen fibers fully covered the affected areas. The immature fiber organization in the deepest crater represented the ongoing process of fiber reorganization, compared with the fully matured surface areas surrounding the crater. **Conclusions:** The results indicate that root surfaces that touch miniscrews show swift repair and almost complete healing within a few weeks after removal of the screw or the orthodontic force. These findings are based on 10 patients only; verification in a larger study sample is needed. (*Am J Orthod Dentofacial Orthop* 2008;134:353-60)

Screw-like titanium fixtures—miniscrews, micro-implants, mini-implants, and temporary anchorage devices—used as anchorage reinforcement or as the only source of anchorage, appear to be useful supplements to fixed appliances in contemporary clinical orthodontics.¹ Although not osseointegrated, miniscrews can be stable enough to withstand orthodontic forces. They should be biocompatible, simple to place and use, small enough to cause little discomfort to the patient, immediately loadable, and reasonably inexpensive.¹ Most commonly used miniscrews in orthodontics meet these requirements.²⁻⁶

Miniscrews should be placed into the alveolar bone without risk of damage to adjacent roots.⁷ When titanium screws are placed between premolar roots in orthodontic patients, the available space increases in an apical direction, as the interradicular distances increase from the cemento-enamel junction to the apical foramen. It was suggested, therefore, that miniscrews should be placed in the apical region.⁸ However, the problem with this might be that screws placed in unattached gingiva can lead to periodontal soft-tissue complications because of difficulties in maintaining proper oral hygiene. Placement in the attached gingiva or on the border between attached and unattached gingiva is therefore preferable.^{7,8} The area between roots for miniscrew placement is sometimes limited, making it inevitable for clinicians to place the screws close to the roots. Moreover, miniscrews might not remain absolutely stationary during orthodontic loading and can tip forward in some patients.⁹ Thus, a 2-mm safety clearance between the miniscrew and the dental roots was recommended in tooth-bearing areas to prevent the screws from causing injury to roots.⁹ Using digital volumetric tomography with a cone-beam technique, Poggio et al¹⁰ evaluated anatomical sites for safe implantation of mini-

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screws between the roots of maxillary and mandibular teeth and established a map of the safe interradicular spaces.

There are no reports at present on possible complications when miniscrews accidentally come in contact with root surfaces during orthodontic treatment. Therefore, our aim in this study was to examine the clinical consequences of injury to the root surfaces when miniscrews intentionally were moved into direct contact with premolar roots for defined periods (4 and 8 weeks) in an experimental human model. The changes in the periodontal ligament (PDL), cementum, and dentin during these periods of contact and repair were examined by using scanning electron microscopy (SEM).

A 3-dimensional microcomputed tomography study of the root surfaces will be reported separately.

MATERIAL AND METHODS

Ten patients (5 male, 5 female; mean age, 15.8 years; range, 13.5-23.2 years) with Class II Division 1 malocclusion, who were to receive routine orthodontic fixed-appliance treatment by postgraduate students in a university environment, participated in the study. For each patient, the bilateral extraction of 2 maxillary first premolars and the need for maximum anchorage mechanics were parts of the treatment plan. All adult patients and the parents of those under 18 years of age agreed to participate and completed an informed consent form. The study protocol was approved by the Research Ethics Committee of Cukurova University in Adana, Turkey. The ethical considerations of intentionally moving first premolar roots into direct contact with miniscrews in clear-cut extraction patients should be comparable to the experimental setups in recent histologic and SEM studies on the incidence and repair of root resorption after the application of heavy forces with orthodontic springs to move the teeth against compact cortical bone¹¹⁻¹⁶ and in caries studies when premolars were used as an in-vivo cariogenic model.^{17,18} The risk of inducing any permanent iatrogenic damage to teeth and periodontal structures with our design appeared to be minimal. For example, in a recent animal study,¹⁹ 3 teeth were accidentally damaged on placement of miniscrews, but almost complete repair of the periodontal structures (cementum, PDL, and bone) took place in 12 weeks after removal of the screws. Furthermore, in 55 patients with mandibular fracture receiving transalveolar screws for postoperative control of their occlusion, the screws had come in contact with the adjacent teeth, but the incidence of clinically significant damage was found to be low after the screws were removed.²⁰

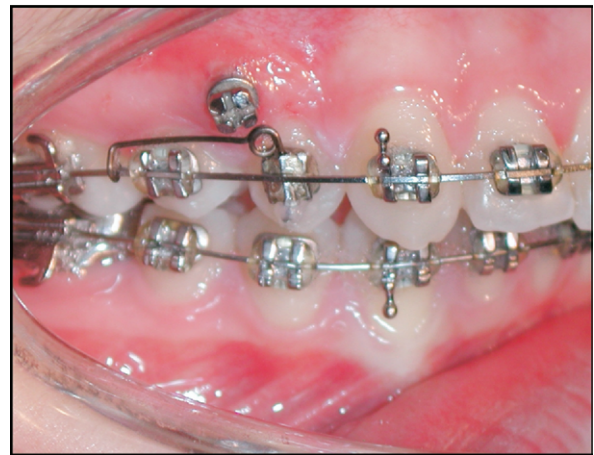


Fig 1. Clinical experimental model. A custom-made spring inserted in a vertical tube in the first premolar bracket tipped this tooth into direct contact with a mini-implant (spider screw) placed close to the first premolar root. When the premolar had touched the mini-implant for 4 or 8 weeks, either the screw or the spring was removed. The subsequent observation period was either 4 or 8 weeks (Table) before the SEM evaluation.

As shown in Figure 1, long-neck mini-spider screws, 1.5 mm in diameter and 8 mm long (HDC, Sacredo, Italy), were placed (by O.K. and T.B.) between the first and second premolars bilaterally. After placement, the first premolars were tipped distally to be in direct contact with the miniscrew, by using custom-made tipping springs of .016-in Australian wire with a standardized force of approximately 100 g. The springs were placed into vertical tubes soldered between the bracket wings of the first premolars (Fig 1).

The miniscrews were placed as close as possible to the distal root surface of the first premolars to avoid long periods of distal tipping movement of the root. Periapical radiographs were taken at each appointment to determine the type of contact. The time of the direct hit was determined by observing the irregularity at the root surface on the radiographs; this was approved by at least 2 authors (O.K. and T.B.).

The Table shows the study design. In group 1, the premolar roots were moved into contact with the miniscrew, and the contact was maintained for 4 weeks (mild resorption) on 1 side and for 8 weeks (severe resorption) on the contralateral side. Then, the miniscrews were removed, and the tissues were left to repair for 8 weeks.

In group 2, the premolar roots were kept in contact with the miniscrew for 4 weeks before the tipping spring was removed. Then the tissues were left to repair

Table. Study design

<i>Move premolar to contact miniscrew</i>				
<i>Group 1</i>			<i>Group 2</i>	
<i>Root moved to contact screw</i>			<i>Root moved to contact screw Tipping spring removed after 4 wks</i>	
Contact 4 wks Screw removed Repair 8 wks (n = 4)	Contact 8 wks Screw removed Repair 8 wks (n = 4)	Direct hit Screw removed Control (n = 2) Extraction and SEM Evaluation	Contact 4 wks Spring removed Repair 4 wks (n = 5)	Contact 4 wks Spring removed Repair 8 wks (n = 5)

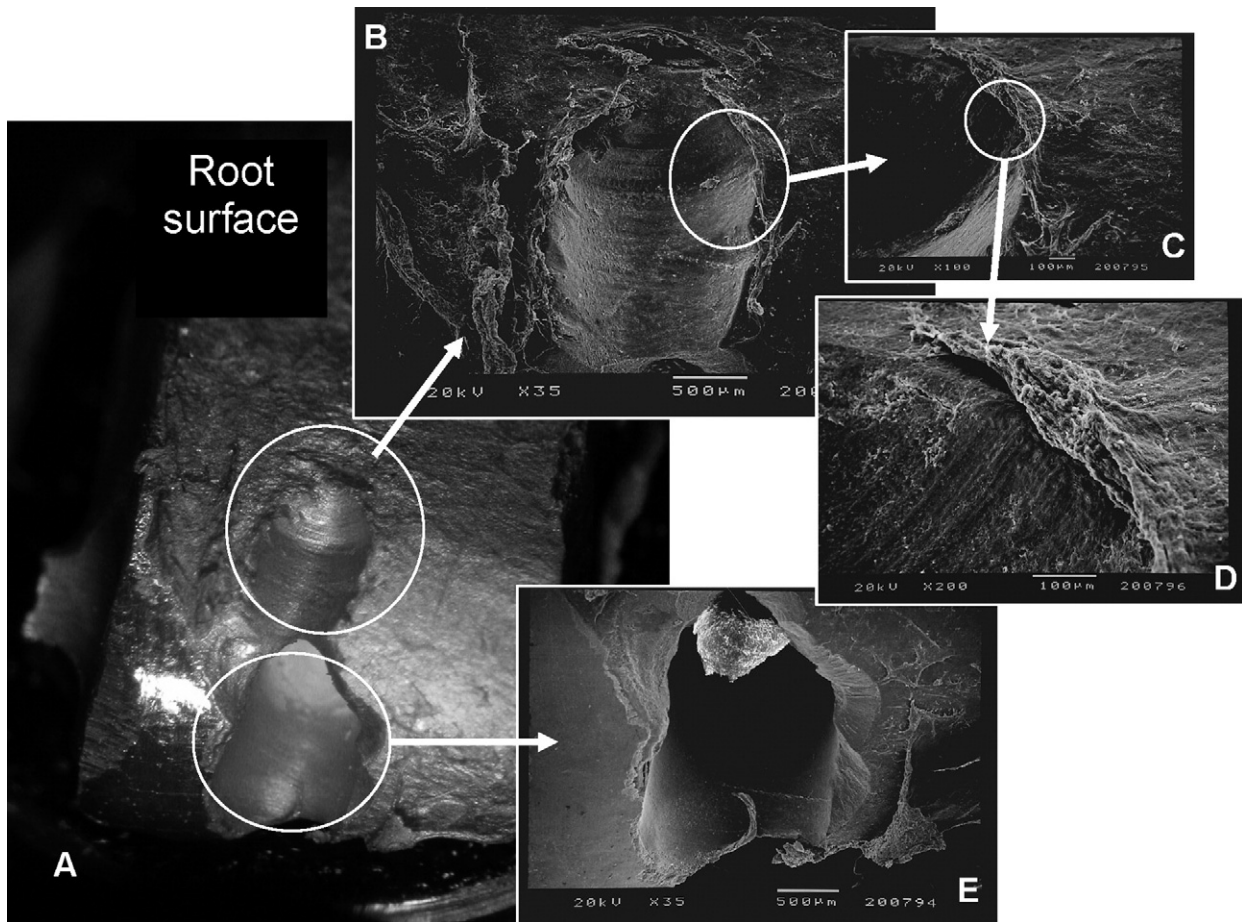


Fig 2. SEM illustration of direct contact between miniscrew and premolar root surface during miniscrew insertion (control specimen). **A**, The tooth was extracted immediately after 2 accidental hits by the miniscrew. **B-D**, Denuded dentin surface and extensive damage. Note the marked difference between the damaged root surface and the intact PDL. **E**, The first hit shown in higher magnification.

for 4 weeks on 1 side and 8 weeks on the contralateral side. When placing the screws as close to the first premolars as desired, 2 screws in group 1 accidentally made direct contact with the root, and these teeth were

used as controls to demonstrate the immediate damage to the root surface during miniscrew placement.

The experimental first premolars were extracted after their respective observation periods (Table), im-

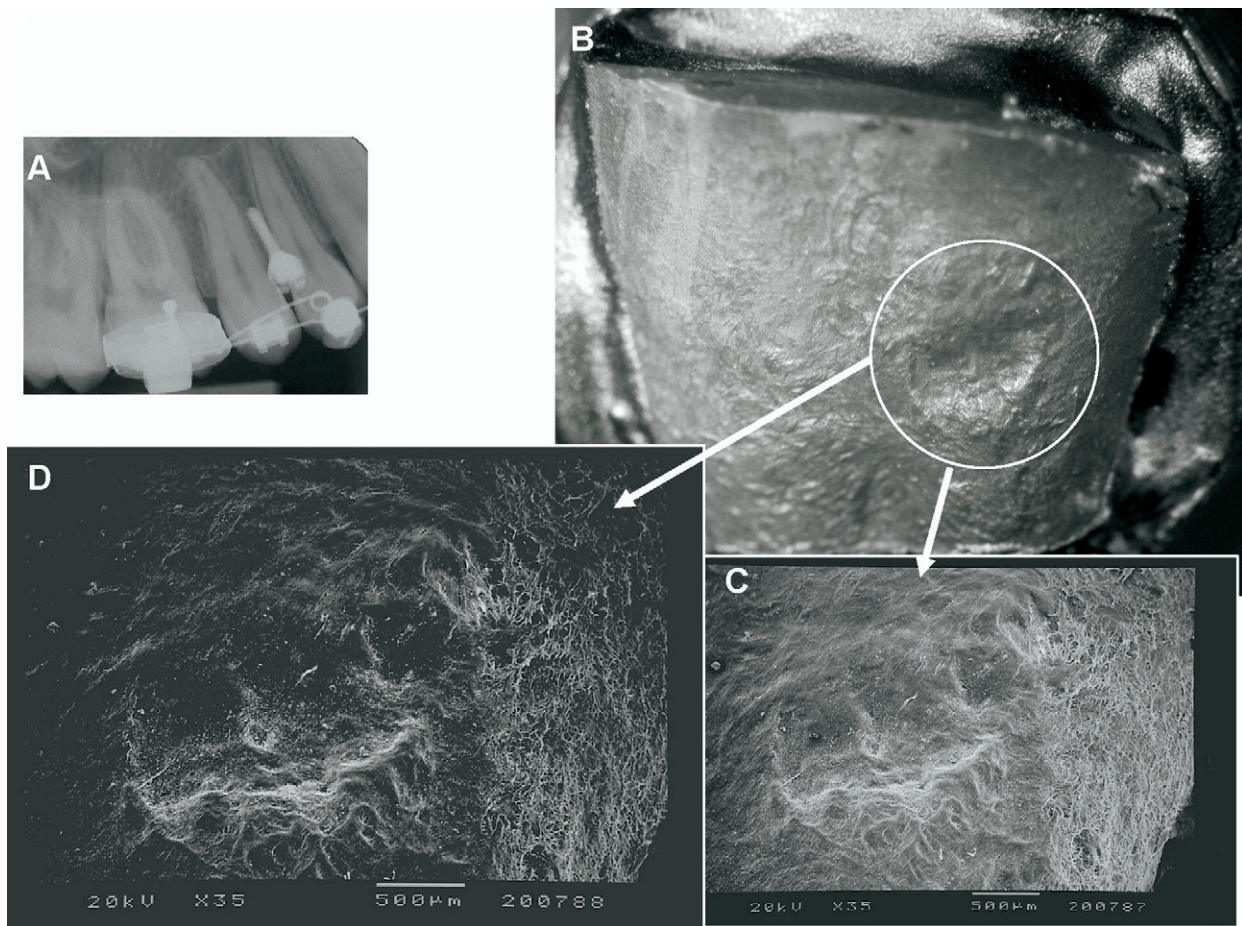


Fig 3. **A**, Radiographic and, **B-D**, SEM representations of the contact area after 4 weeks of miniscrew-root surface contact, removal of the screw, and 8 weeks of repair. Note that the damaged area on the root surface is hardly visible (**B**). At higher magnifications (**C** and **D**), shallow resorption craters can be seen.

mediately washed with phosphate buffer solution, and stored in 2.5% glutaraldehyde solution at 4°C. Before SEM examination, the roots were removed by cutting with a water-cooled diamond disk and dehydrated by ascending grades of alcohol. The samples were then mounted on aluminum stubs, sputter-coated with gold-palladium, and examined under an SEM (JSM 5200, Jeol, Tokyo, Japan) operated at 20 to 25 kV.

RESULTS

The 2 premolars where the miniscrews hit the first premolar roots by accident, with no repair allowed, had extensive damage to the root surfaces (Fig 2). The dentin surfaces were denuded (Fig 2, *A* and *E*). At the border of the defect, the marked difference between the damaged root and the intact PDL was evident (Fig 2, *B-D*).

In group 1, after 4 weeks of miniscrew-root

contact and 8 weeks of repair after removal of the miniscrew (Fig 3), the damaged area in the premolar was hardly noticeable (Fig 3, *B*). Even at higher magnifications, only a shallow resorption crater was evident (Fig 3, *C* and *D*). No apparent denuded dentin surfaces were observed (Fig 3). When the contact was 8 weeks, the screw was removed, and the repair period was 8 weeks; collagen fiber reorganization took place (Fig 4, *B* and *C*), and new fibers were observed at the bottom of the resorption crater at higher magnifications (Fig 4, *D*).

In group 2, after 4 weeks of contact and 4 weeks of repair, immature organic fibers, an early sign of repair, were visible in the resorption lacunae (Fig 5). When the repair time was 8 weeks (Fig 6), the collagen fibers had reorganized to fully cover the disturbed areas. These fibers apparently were fully matured and had functionally repaired the defects. Normal collagen structure of

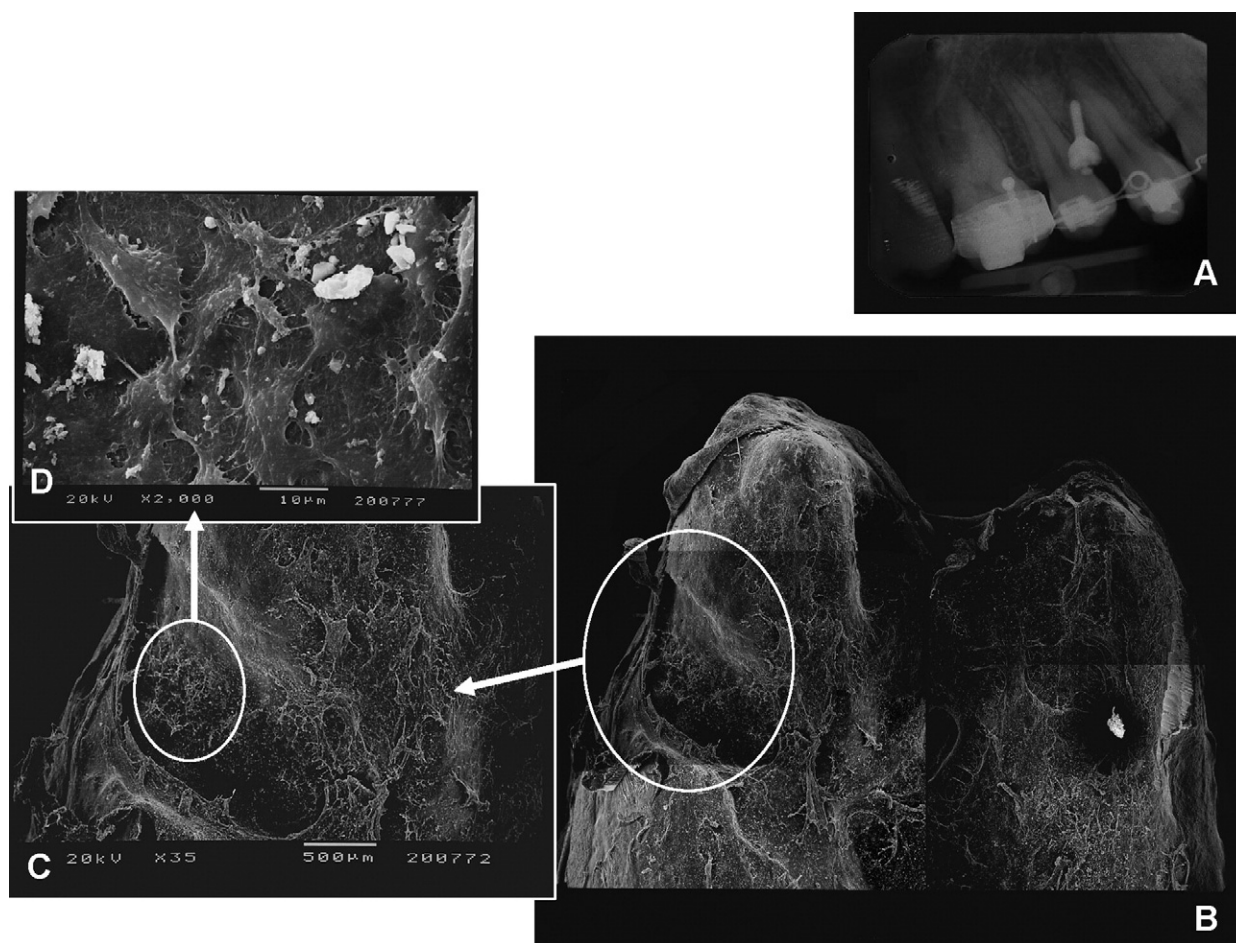


Fig 4. A, Radiographic and, B-D, SEM representations of the contact area after 8 weeks of miniscrew-root surface contact, screw removal, and 8 weeks of repair (group 1 in the Table). Fiber reorganization is taking place at the bottom of the resorption lacunae (B and C). At higher magnification, new fibers are seen in the resorption lacunae (D).

the PDL was observed in all resorption craters (Figs 5 and 6).

DISCUSSION

These results demonstrate the swift repair of tooth surfaces that have contacted a miniscrew, once the screw or the orthodontic force is removed. Even rest periods as short as 4 weeks were sufficient for functional repair of surface resorptions created by the miniscrew contact (Fig 5). This finding agrees with previous studies on orthodontically induced root resorptions of human and animal teeth.^{11,21-23} The repair process can start as early as 7 to 10 days after release of the force that was applied,²¹⁻²³ and 75% of the repair might be completed within 8 weeks.²¹

Placement of miniscrews in the alveolar process between the roots of teeth is a critical procedure.

Even if preventive measures are taken, such as a periapical radiograph before placing the screw, root damage can occur. This happened unintentionally with 2 screws in group 1. Similarly, in a recent study in beagle dogs by Asscherickx et al,¹⁹ 3 of 20 miniscrews accidentally damaged the roots at placement. A defect was created in the root, but almost complete repair of cementum, PDL, and bone occurred in 12 weeks after removal of the screws. According to the “safe zone” map of Poggio et al,¹⁰ screws with a diameter of 1.5 mm need at least 3.5 mm of interradicular space.

Accidental damage to teeth adjacent to recently placed osseointegrated implants caused by angulation and proximity, particularly on mandibular teeth, have also been reported.^{24,25}

Although no follow-up studies on possible iatro-

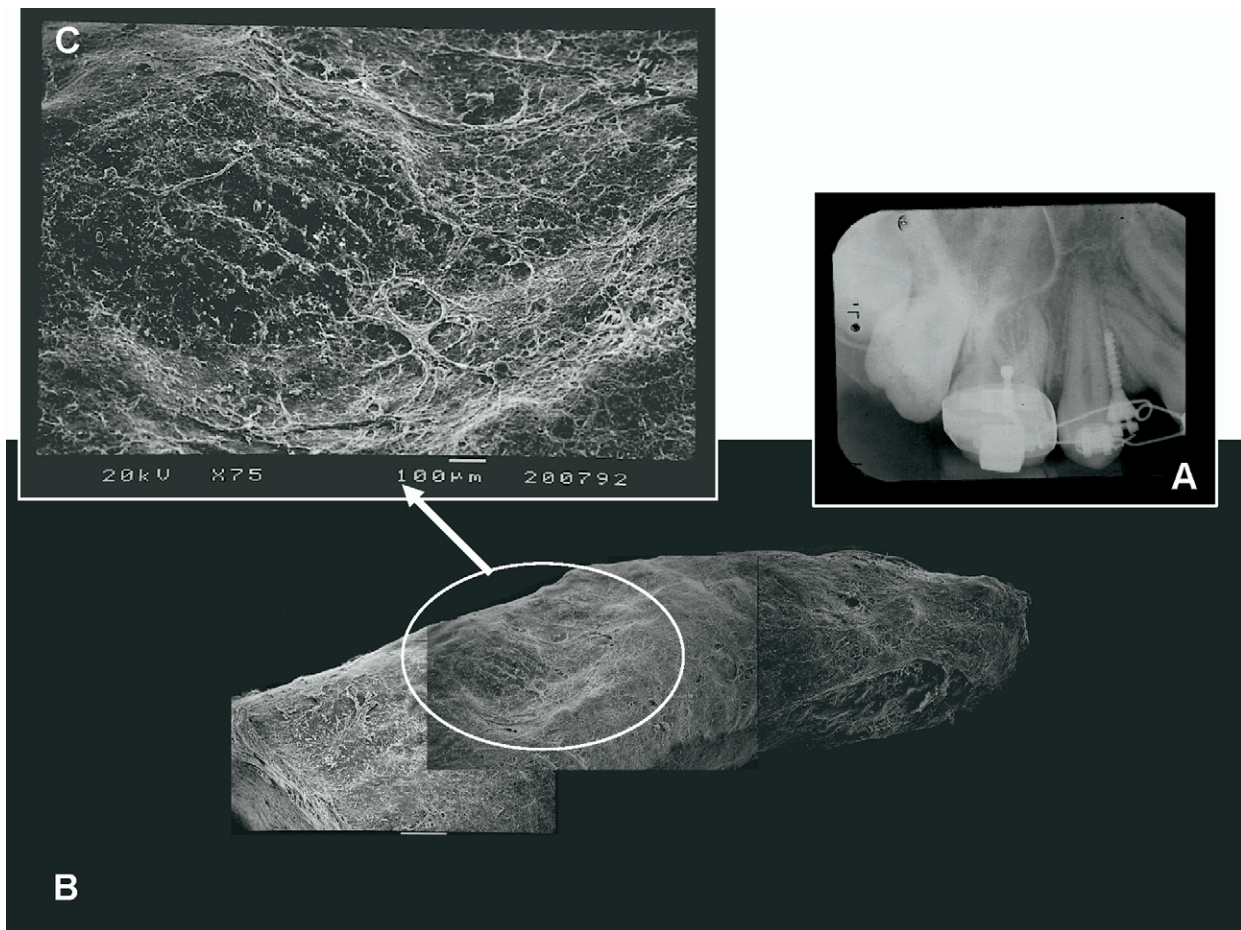


Fig 5. A, Radiographic and, B and C, SEM representations of the contact area after 4 weeks of miniscrew–root surface contact, removal of the tipping spring, and 4 weeks of repair (group 2 in the Table). Early signs of repair are shown (B and C), and higher magnification shows that the resorption lacunae are restored with immature organic fibers (C).

genic root damage after miniscrew placement in orthodontic patients have been published, there are some studies on the incidence of screw-tooth contact after placement of transalveolar screws used for fixation of patients with fractures of the mandible.²⁶ In a prospective study, Fabbroni et al²⁰ found that, of 232 screws placed in 55 patients, 26 (11.2%) had major contacts (more than 50% of the screw hole diameter impinging on the root) with adjacent teeth, and 37 (15.9%) had minor contacts (less than 50% of the diameter of the screw hole). Only 2 screws were associated with complications in 2 patients.²⁰ Those authors concluded that screw-tooth contact does occur with transalveolar screws, but the incidence of clinically significant damage appears to be low. When the damage of root-screw contact is limited to the PDL, the injury is likely to be repaired with no further consequence. If the cementum is mechanically damaged and the

dentin surface is exposed, multinucleated cells will colonize the denuded surfaces, and resorption takes place. However, the resorbing cells require continuous stimulation during phagocytosis.²⁷ Without further stimulation, the process stops spontaneously. Repair with cementum-like tissue will occur within 2 to 3 weeks, depending on the area of the root that is injured.²⁷ If the affected area is large and deep (more than 4 mm², or 20% of the root surface), ankylosis can take place.²⁷ None of the experimental premolars in our study was ankylosed, but this might be related to the small diameter of the miniscrew.

The resorption process in this study might be different from conventional root resorption caused by orthodontic tooth movement. In our experimental model, the periodontal structures were compressed against the metal screw; this is likely to have caused a less complicated biologic scenario than orthodontically

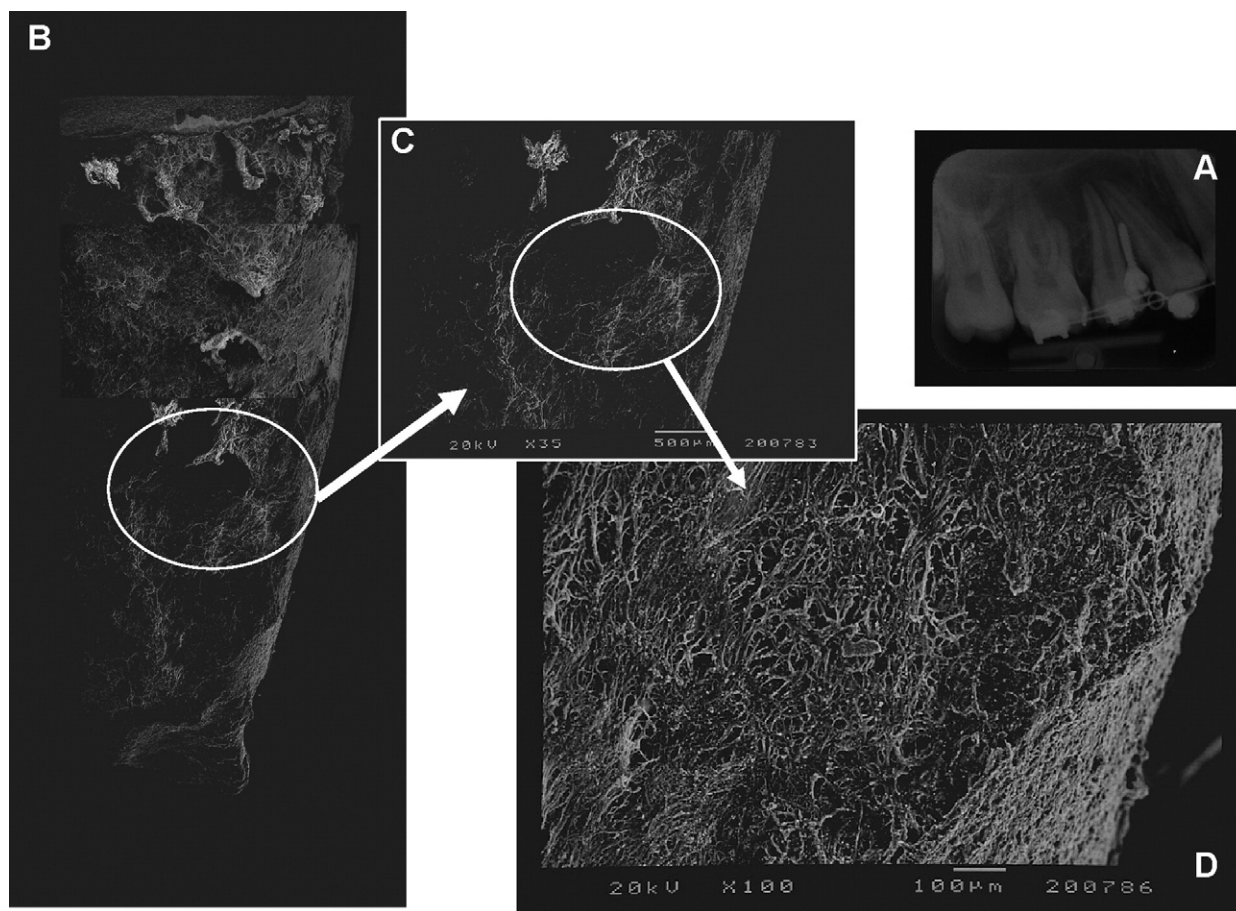


Fig 6. A, Radiographic and, B-D, SEM representations of the contact area after 4 weeks of miniscrew–root surface contact, removal of the tipping spring, and 8 weeks of repair (group 2 in the Table). Mature collagen fibers fully cover the disturbed areas and have repaired the defect. Note the healthy collagen structure of the PDL (B-D).

induced root resorption. Thus the repair periods were shorter than expected.

CONCLUSIONS

The side root resorptions caused by intentional premolar root-miniscrew contact in this study showed repair and healing within a few weeks after removal of the screws (group 1) or the tipping springs (group 2). The injuries were apparently repaired with minimal, if any, clinical consequences. Despite the absence of clinically significant damage, operators should be cautious when placing miniscrews. Our findings are limited by the small sample size; further studies are warranted to fully investigate the histologic effects of miniscrews on root surface morphology.

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