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Periodontal Tissue Regeneration Including Cementogenesis Adjacent to Dentin-Bonded Retrograde Composite Fillings in Humans

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The roots of two incisors were treated by apicoectomy and a retrograde dentin-bonded composite filling. Periapical healing was observed a few months later by radiography. Later, due to root fracture and marginal bone resorption, the apical parts were removed including adjacent periapical bone. A histological and scanning electron microscopic examination of the tissue showed reformation of periodontium adjacent to the composite, including reformation of a lamina dura, inserting Sharpey's fibers and cementum deposited in intimate contact with the composite. This finding is in agreement with previous observations of tissue surrounding retrograde dentin-bonded composite fillings placed in monkeys, indicating that tissue regeneration including cementogenesis may occur on composite material and consequently form a biological closure of the root canal.

In the past, a number of retrograde filling materials and techniques have been used. However, none of these has so far appeared to satisfy all treatment objectives, namely, to establish a permanent bacteria-tight seal of infected root canals without evoking foreign body reaction, periapical inflammation, and/or root resorption (1). Thus, in a recent in vivo study in monkeys, using a replantation model, it was shown that amalgam failed these demands, whereas zinc oxide-eugenol compounds and glass ionomer cements in short-term experiments (8 wk) resulted in periapical healing (1). However, the long-term in vivo stability of these materials can be questioned.

Since 1984, however, a new retrograde filling procedure has evolved, using dentin-bonded composites (2-9). Tests showed a gap-free interface between the composite and dentin. A clinical and radiographic study of 388 operated teeth in humans showed that after 1 yr the number of successful healings increased by 16% compared with those of amalgam, a significant difference (5). So far results have been stable up to 7 yr, indicating permanent stability. The tissue reactions to the retrograde bonded composite fillings were tested in monkeys (3). A unique healing response with deposition of cementum and insertion of new Sharpey's fibers, which entered a new formed apical lamina dura, was found.

The aim of this report was to describe by histological and scanning electron microscopic technique the tissue regeneration and response around two bonded retrograde composite fillings placed in humans.

CASE REPORTS

Two men, 31 and 28 yr old, were treated for root fractures of upper incisors by one of the authors (J. R.). As part of this treatment retrograde dentin-bonded composite resins were placed to cover the resected apical root surface. In both cases the teeth had to be removed 3 yr afterward due to a second fracture in the first case and marginal infection in the second. The apical fragments were removed along with a narrow zone of surrounding bone via a flap procedure.

The composite resin was composed of a microfilled, chemically curable resin containing 25% colloidal silver to give radiographic contrast (2). The dentin-bonding agent was identical to Gluma Bond and Gluma Cleanser (Bayer AG). Gluma and composite were placed on a shallow, dry root surface according to a standardized procedure as described by Rud et al. (7, 9).

The removed apical fragments were fixed in 10% formaldehyde and decalcified in 10% EDTA after double embedding in colloid paraffin. The apical blocks were serial sectioned in a labial-palatal direction. The sections were stained with hematoxylin and eosin as well as a modified Gram stain for bacteria (10).

When histological sectioning had exposed the entire retrograde root filling, the remaining part of the tissue was prepared for scanning electron microscopy with a coating of 20 nm of gold palladium and a magnification up to ×5000.

Case 1

Postoperative healing was uneventful and 1 yr after treatment periapical healing was seen, which included reformation of a narrow periodontal ligament space as seen by radiography. Three years after the retrograde filling had been placed, the radiograph still showed apical healing (Fig. 1). Figure 1 also shows that the bulk of the composite had been lost during the histological procedure. The lack of inflammation in the periapical area suggests that the bacteria of the potentially infected root canal had been adequately sealed off. The Gram stain was not found to be conclusive, as the silver particles in the composite showed a positive staining very similar to Gram-positive bacteria. A new cementum-periodontal ligament-alveolar bone complex had been formed directly upon the composite. This complex included a thick cementum layer as well as periodontal ligament fibers which were inserted into both cementum and bone.

Continuity was found between cementum on the lateral surface of the root and the calcified material in direct contact with the composite. These findings were consistent throughout the series of sections examined.

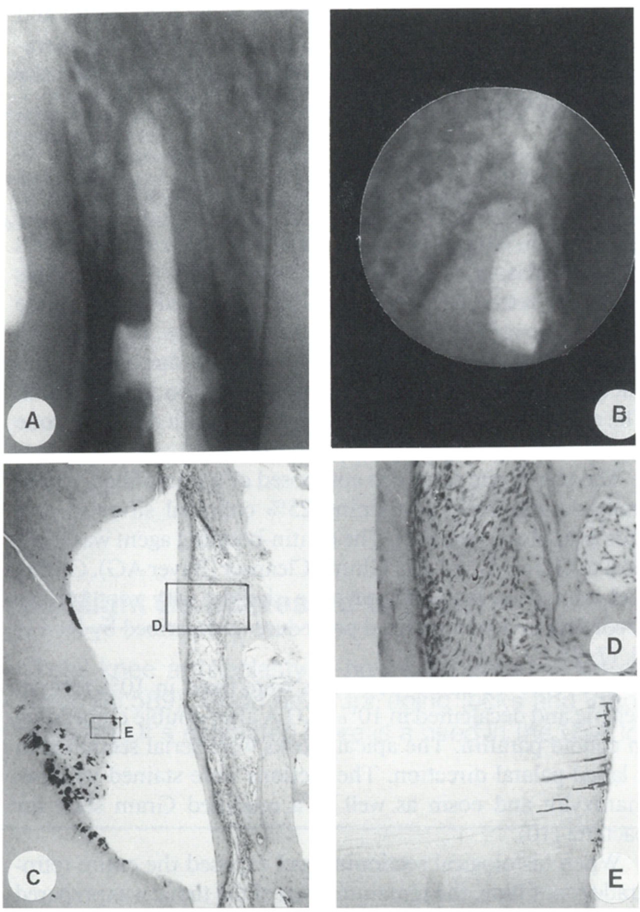

FIG 1. *A*, Radiographic appearance of right lateral incisor 3 yr after retrograde root filling with dentin-bonded composite. A second root fracture necessitated removal. *B*, The apex was removed separately along with periapical bone. A lateral radiograph of the specimen illustrates healing. *C*, An axial histological section illustrates intact labial bone reformation of a periodontal ligament. The empty space represents the lumen after the composite was lost during preparation of the section (original magnification ×25). *D*, Higher magnification of the *boxed area* showing deposition of cementum upon the composite and reformation of fibers very likely to be Sharpey's fibers (original magnification ×90). *E*, Higher magnification showing invasion of silver-stained composite in dentinal tubules (original magnification ×190).

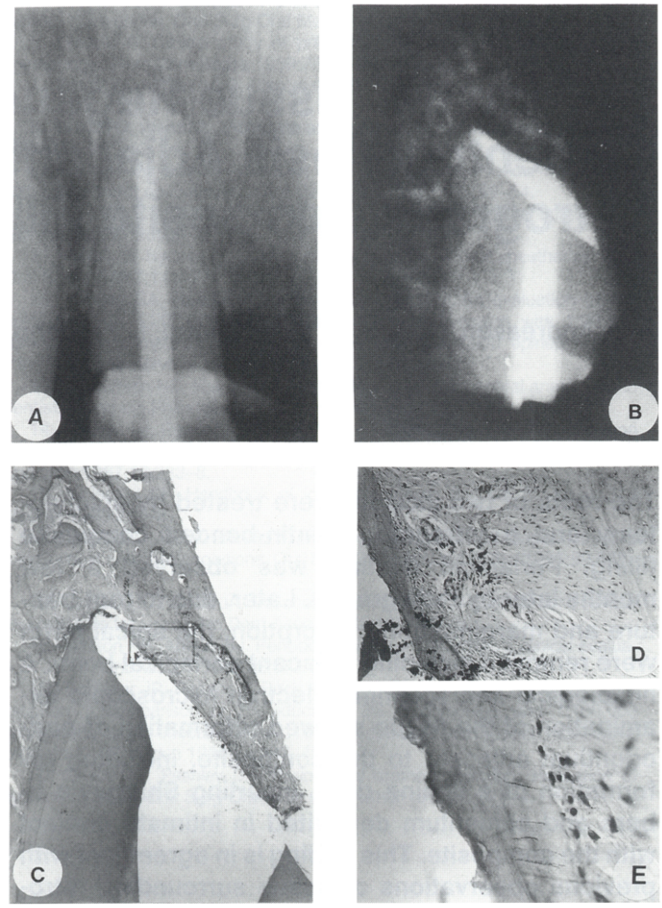

FIG 2. *A*, Radiographic appearance of right lateral incisor 3 yr after marginal bone resorption and treatment of a retrograde root filling with dentin-bonded composite; root fracture necessitated removal. *B*, The apex was removed separately along with periapical bone. A lateral radiograph of the specimen illustrates the degree of healing. *C*, An axial histological section illustrates intact labial bone reformation of a periodontal ligament. The empty space represents the lumen after the composite was lost during preparation of the section (original magnification ×25). *D*, Higher magnification of the *boxed area* showing deposition of tissue, which apparently is cementum upon the composite and reformation of fibers very likely to be Sharpey's fibers (original magnification ×125). *E*, The silver content of the composite has stained the inserting of fibers very likely to be Sharpey's fibers (original magnification ×400).

Case 2

Postoperative healing was uneventful and 1 yr after treatment periapical healing was seen. The histological examination of the specimen 2 yr later showed that the composite was approximately 90% covered with a thick cementum layer with inserting Sharpey's fibers (Fig. 2). The scanning electron microscopic examination of the specimen showed that the composite filling had a complete adaptation to dentin. Furthermore, the new cementum adapted completely to the irregular composite surface. The cementum contained perpendicular Sharpey's fibers, which penetrated into the periodontal ligament (Fig. 3).

DISCUSSION

The regeneration of a new periodontal ligament complex (i.e. cementum, periodontal ligament fibers, and alveolar

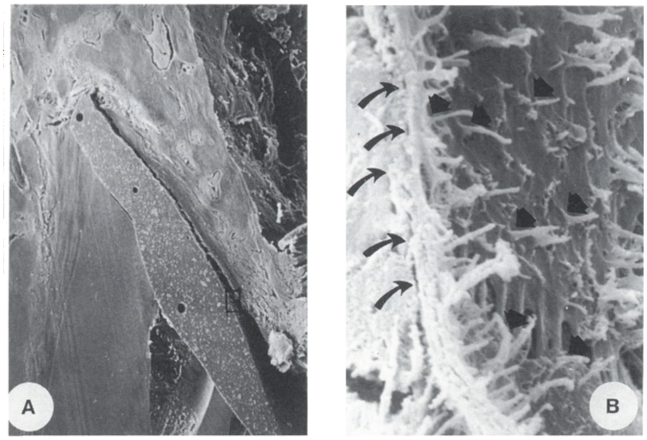

FIG 3. Scanning electron microscopic examination of case 2. *A*, The survey of the specimen shows the retrograde filling and the periodontium. In most areas the sectioning procedure has separated the periodontium from the composite (original magnification ×40). *B*, Newly formed cementum has a close adaption to the composite (*long arrows*). Sharpey's fibers extend from the cementum (*short arrows*) (original magnification ×5000).

bone) over the retrograde filling material (composite) in monkeys (3) and here in humans makes these cases unique.

In previous studies on the in vivo response of composites placed in cavities on the roots of replanted teeth in monkeys, the composites lead to severe inflammatory changes (11); a phenomenon, which can possibly be explained as a result of insufficient adaptation of the material to the dentin surface, possibly allowing microleakage. In contrast, the in vivo response of implantation of composites in a subcutaneous site in dogs over a 6-wk period showed only a very mild inflammatory response (12). In the present cases such microleakage caused by polymerization contraction was eliminated, because the filling was placed on a slightly hollow root surface and not in a cavity and because the filling was glued very strongly to the root by the dentin-bonding agent (2). The present healing modality gives new perspectives for periodontal healing after periapical inflammation caused by pulp infection. Thus, instead of sealing an infected site with a filling material, a double closure can now be performed with a dentin-bonded composite and new cementum, which apparently represent a very efficient seal against infection in the root canal and dentinal tubules (13, 14).

The mechanisms of the bond between composite and cementum can only be speculated upon at the present time. Cementogenesis has so far been shown to occur upon the following media: necrotic ligament fibers, necrotic cementum, and exposed dentin and enamel (15–17) as well as titanium (8). A common feature of the tissues mentioned is the presence of collagen, hydroxyl apatite and proteoglycans. Cementogenesis may occur because the chemical composition of the composite is accepted by the tissue as a base for cementogenesis.

The cementum covering the root end must have derived from the root cement on the side of the root. When covering the resected root end with composite, it is therefore important not to cover the periodontal ligament space, thus blocking the way for proliferating periodontal ligament cells.

The findings presented indicate that cementogenesis should be added to the desirable properties of retrograde filling materials. This capacity may give a biological closure of the root canal and increase the periodontal support of the tooth.

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