

Tissue characteristics of root resorption areas in transplanted maxillary canines

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The aim of the present study was to describe some histopathologic features of tissues collected from root resorption areas of maxillary canines after transalveolar transplantation surgery. In 8 of 101 transplanted canines, complications including cervical root resorption occurred between 6 and 11 years after treatment. The resorptive processes were located at the supra-alveolar portions of the distal and/or mesial aspects of the teeth and were scheduled for treatment involving surgical exploration. The resorption cavities, which extended from the cemento-enamel junction to a position immediately below the bone crest, were filled with a granulation tissue. In four of the diagnosed complication cases, this granulation tissue was carefully excised concomitant with the adjacent gingival tissue after flap elevation and placed in a buffered fixative. After proper soft-tissue healing, the cavities were filled with a glass-ionomer material. The collected biopsy specimens were, after fixation and, in one case, decalcification in ethylenediaminetetraacetic acid, dehydrated and embedded in Epon. Sections 3 µm thick were produced, stained in periodic acid-Schiff and toluidine blue, and used for histometric and morphometric analyses. The histologic analysis showed that the dissected tissue harbored well-encapsulated areas of inflammatory infiltrates. The lesions comprised a relatively low volume of collagen and a large number of inflammatory cells, predominantly lymphocytes. □ *Biopsy; histology; human teeth; tooth root*

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Treatment alternatives in children and adolescents with impacted maxillary canines generally include surgical exposure and orthodontic treatment. Adult patients, however, often reject proposed orthodontic treatment owing to (i) the considerable long treatment period required or (ii) the visible orthodontic appliance. Transplantation of teeth is one alternative, although the prognosis for teeth with complete root formation is suggested to be questionable (1). A modified technique, called transalveolar transplantation, may serve as an additional treatment alternative of impacted maxillary canines. This technique has, in particular, been demonstrated to be useful in cases in which the impacted canine had a severe malposition (2, 3). In a critical evaluation of the transalveolar transplantation technique Sagne & Thilander (4) reported good results for up to 17 years of monitoring. In 8 of 101 treated maxillary canines, however, complications occurred. The complications consisted of radiographically and clinically diagnosed root resorptions in the cervical portion of the root and were observed between 6 and 11 years after the transplantation procedure (Fig. 1). The reason for these late-developing root resorptions is hard to explain. To elucidate possible mechanisms involved in the diagnosed processes, soft tissue from the resorption sites was excised in four of the patients developing complications. The present study aims to describe some histopathologic features of the tissues collected from the resorption areas of the maxillary canines.

Materials and methods

Subjects

One hundred and one maxillary canines in 85 patients were monitored by annual clinical and radiographic examinations after transalveolar transplantation (for details, see Sagne & Thilander (4)). In eight cases, however, complications including cervical root resorption occurred between 6 and 11 years after treatment. The resorptive processes were in all cases located at the supra-alveolar portions of the distal and/or mesial aspects of the teeth and were scheduled for treatment involving surgical exploration.

Clinical procedures

The site at which the resorptive process was identified was anesthetized (Xylocaine[®]; 2%; 1:80,000 adrenaline; Astra, Sweden), and an incision was made with a scalpel at least 2–3 mm away from the proposed biopsy area (Fig. 2). The resorption cavities, which extended from the cemento-enamel junction to a position immediately below the bone crest, were filled with granulation tissue. In four of the patients with complications (two female and two male, 25–58 years of age), this granulation tissue was carefully excised concomitant with the adjacent gingival tissue after flap elevation and placed in a buffered fixative (5). In one of the four cases the affected tooth was extracted along with the soft-tissue biopsy. Bone resection was per-

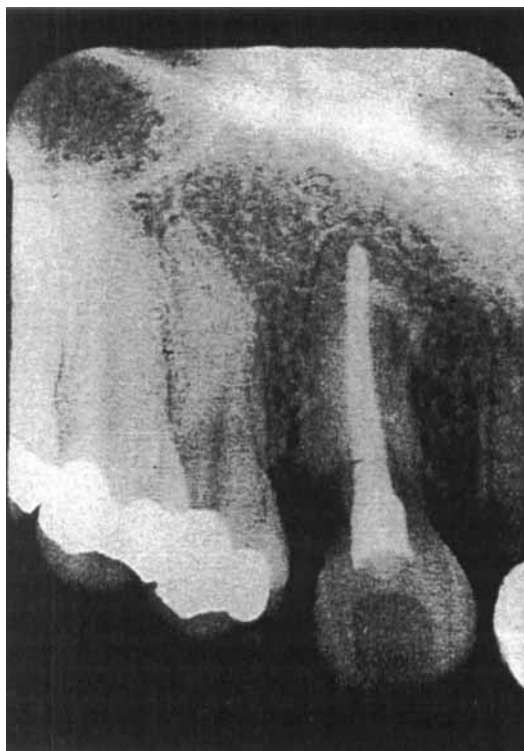


Fig. 1. Radiograph of a maxillary canine 6 years after transplantation. Resorptive cavities are identified in the cervical areas.

formed after flap elevation in all treated patients, to expose the remaining cavities in a supragingival position. After proper soft-tissue healing, the cavities were filled with a glass-ionomer material (Ketac-Fil[®], ESPE, Germany) (Fig. 3).

Histologic procedures

The collected biopsy specimens were, after fixation and, in one case, decalcification in ethylenediaminetetraacetic acid (EDTA), dehydrated and embedded in Epon (6). Sections 3 μ m thick were produced, stained in periodic acid-Schiff (PAS) and toluidine blue, and used for histometric and morphometric analyses. The histometric analysis, which included assessment of the size of the identified infiltrates within the dissected soft tissue from the resorption site, was performed in a Leitz DM-RBE microscope (Leica, Germany) equipped with an image system (Q-500 MC; Leica). Using a mouse cursor, the outline of the infiltrate was delineated and expressed in square millimeters. The morphometric analysis of the connective tissue was performed at the locations identified at the resorptive processes in accordance with well-established methods described by Schroeder & Münzel-Pedrazzoli (7) and Berglundh et al. (8, 9). The analysis was carried out in a Leitz DM-RBE microscope equipped with an image system (Q-

500 MC). The computer grid comprised 100 light points and was superimposed over the connective tissue at a magnification of $\times 1000$. The volume fractions occupied by collagen, vascular structures, fibroblasts, macrophages, lymphocytes, plasma cells, polymorphonuclear cells, multinuclear giant cells, and residual tissue (matrix, nerves, and unidentified structures) were determined.

Results

Clinical observations

The resorptive processes had developed rapidly before detection. Radiographic examinations carried out at each annual recall interval could not reveal the occurrence of the processes during the first years. At the time of disclosure, the amount of destruction at the cervical portion of the teeth was substantial and reached apical to the marginal bone level. While there were no signs of marginal bone loss at the teeth examined, the resorption cavities seem to emerge from the supra-alveolar connective tissue attachment area and progress apically to a position about 0.5 mm below the bone crest.

The treatment procedure, exposing the cavities into a supragingival position by bone recontouring, was successful. Thus, after healing, the cavities were accessible for conventional filling therapy. In one of the treated cases, however, the resorption progressed after treatment and additional treatment was carried out.

Histologic observations

The specimens sampled were of various sizes (2–3 mm high, 1–2 mm wide, and about 1 mm thick) and comprised a healthy gingival tissue lateral to the lesion at the resorption cavity. An oral epithelium covered the soft tissue towards the oral aspect, and the underlying connective tissue had numerous collagen fibers aligned in a circular direction, surrounding the resorptive lesion. Thus, the reaction site (the infiltrate) in the sampled

Table 1. Mean and standard deviation (*s*) of the composition (in percentage) of identified inflammatory infiltrates within the soft-tissue biopsy specimens collected from the resorption cavities

Composition	Mean	<i>s</i>
Collagen	35	4.1
Vessels	15	2.9
Residual tissue	21	3.7
Fibroblasts	9	1.0
Macrophages	1	0.2
Lymphocytes	13	2.7
Plasma cells	4	1.1
Polymorphonuclear cells	2	0.5
Giant cells	1	0.2



Fig. 2. Clinical photograph illustrating the incision performed at biopsy.

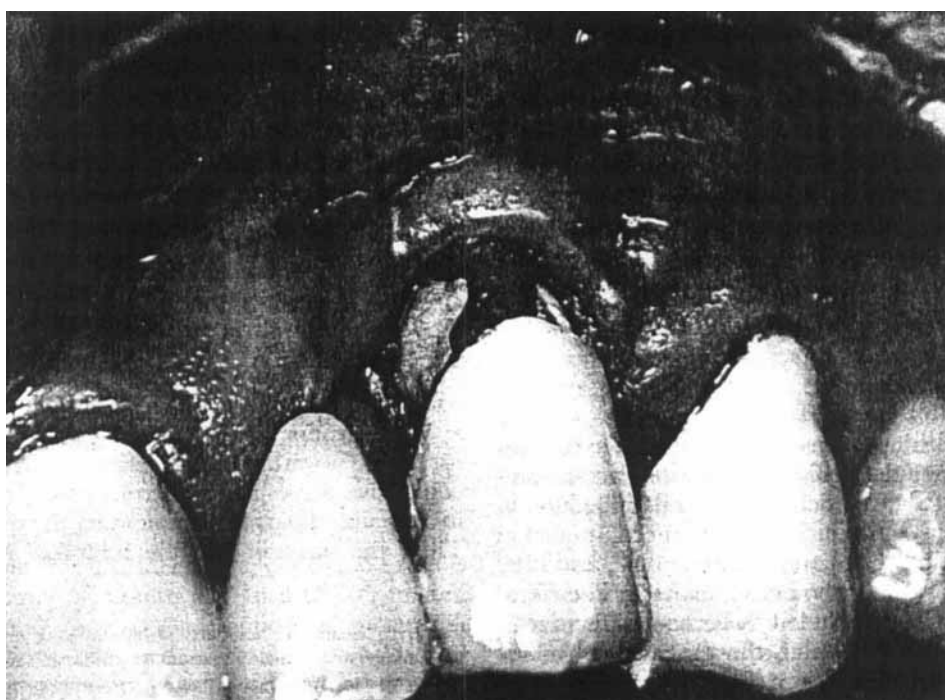


Fig. 3. Clinical photograph illustrating the resorption area 1 month after surgery. The mesial and distal cavities are filled with a glass-ionomer material.

tissue was encapsulated by a dense, non-infiltrated connective tissue. The size of the lesion was on the average $1.57 \pm 0.52 \text{ mm}^2$. The composition of the connective tissue components of the infiltrate is presented in Table 1. The relative volume of collagen, vessels, and residual tissue was 35%, 15%, and 21%,

respectively. The largest proportions of cells observed were lymphocytes (13%) and fibroblasts (9%), whereas plasma cells, polymorphonuclear (PMN) cells, macrophages, and giant cells occurred in lower numbers.

In the tooth-sampled site, microbial plaque was observed on the most coronal part of the root surface,

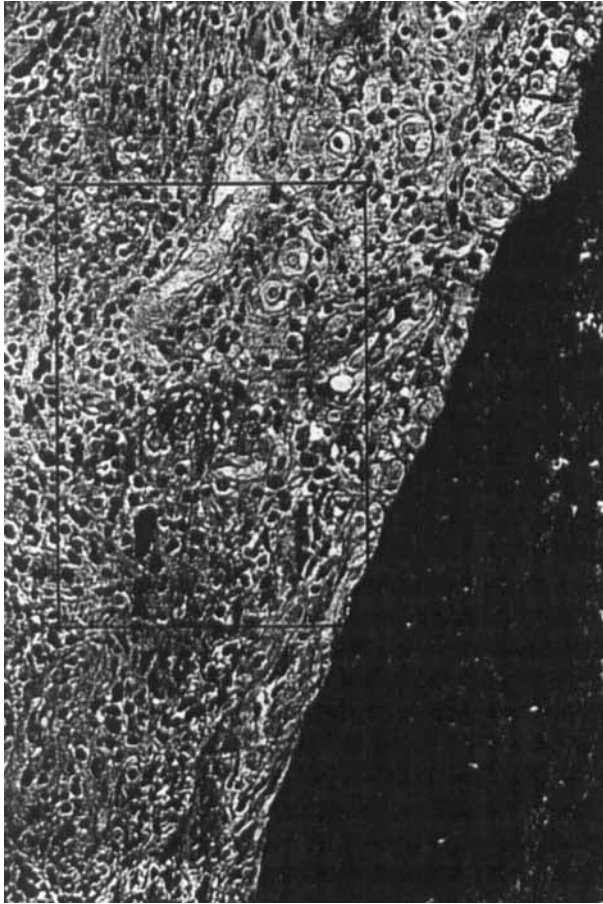


Fig. 4. Microphotograph of the soft tissue adjacent to the root surface of the tooth-containing biopsy. Resorption areas in the cementum are identified (arrows).

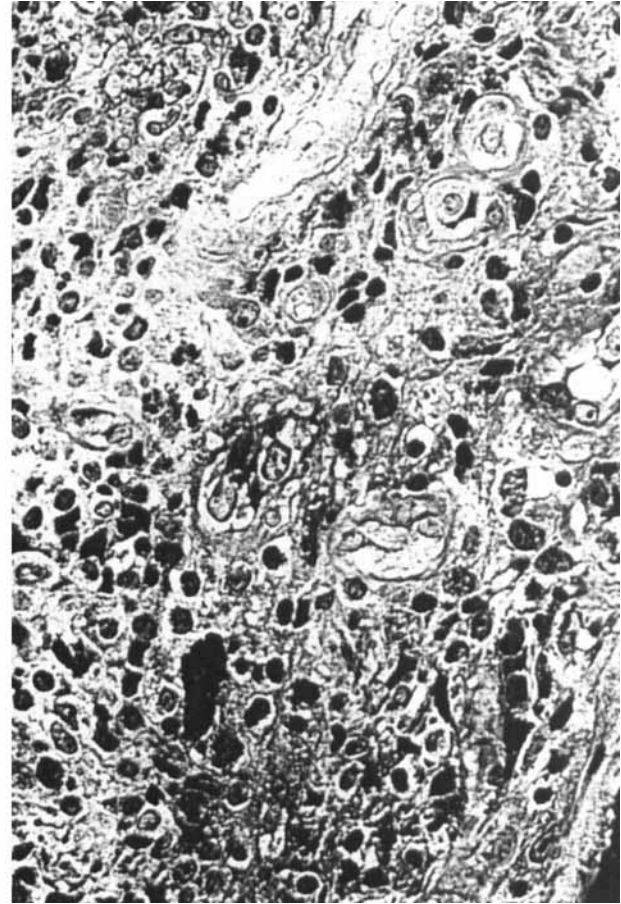


Fig. 5. Higher magnification of an area in Fig. 4, illustrating inflammatory cells close to the cementum surface (periodic acid-Schiff and toluidine blue; original magnification, $\times 200$).

and a pocket epithelium outlined the soft tissue towards the tooth at this level. Resorptive processes of various degrees (Figs. 4, 5) were identified at different levels of the root surface, and, occasionally, signs of cementum repair could be detected. The signs of repair were characterized by layers of new cementum laid down on dentin surfaces previously exposed to active root resorption. Resorption could also be observed on such repaired root cementum.

Discussion

The histologic analysis performed in the present study demonstrated that the tissue dissected from resorption cavities of transplanted canines harbored well-encapsulated areas of inflammatory infiltrates. The lesions, in contrast to normal gingival connective tissue, were composed of a relatively low volume of collagen and a large number of inflammatory cells, predominantly lymphocytes.

For ethical reasons, the observations made in the present study are based on analyses performed on tissue samples from four of the eight diagnosed teeth with complications. These four teeth had a radiographic appearance characteristic for all the eight teeth with resorption and may thus represent the features observed for the entire group of lesions.

The fact that root resorption may occur in conjunction with orthodontic treatment and/or autotransplantation after trauma is not new. While apical root resorption in orthodontic therapy is observed at a varying prevalence in adults (10, 11), cervical root resorptions is considered to be (i) more difficult to diagnose and (ii) related to specific types of orthodontic movements (12, 13). In the present study cervical root resorption, never apical, was observed between 6 and 11 years after the active treatment in 8 of 101 treated maxillary canines. In addition, the orthodontic therapy carried out in these subjects included only minor forces and tooth movements of adjacent teeth to accomplish proper tooth position (4). The transplanted canines were

included in the orthodontic (fixation) appliance to stabilize, not to immobilize, the tooth. It may therefore be suggested that the orthodontic fixation could not be a reason for the diagnosed late-developing cervical root resorptions.

Replantation and transplantation of teeth may also result in various amounts of root resorption. Andreasen et al. (14) found that in a material of 322 patients and 400 replanted teeth during a mean observation period of 5.1 years about 30% of the teeth were lost, and only 24% were free from signs of external root resorption. In the study referred to the mean age of the patients was quite low (mean, 13.7; range, 5–52 years), and, as a consequence, many teeth had incomplete root formation. The authors further reported that tooth loss was more frequent in teeth with incomplete root formation. This observation may support the findings in the present study, in which 85 patients (11–76 years) with 101 teeth with completed root formation were treated, and only 8 teeth developed complications including cervical root resorption. On the other hand, Andreasen et al. (15) reported in a long-term study of 370 autotransplanted premolars that root resorption (i) occurred in 52 of the 370 teeth, (ii) was diagnosed within 6 months, and (iii) was related to increasing stages of root development. Although Andreasen et al. (15) conclude that the trauma to the periodontal ligament during the transplantation procedure and the subsequent orthodontic treatment is the main factor in the development of root resorption, the question still remains for the relatively late-appearing cervical resorptions observed in the present study.

The features of external root resorptions have been thoroughly described (for a review, see Gold & Hasselgren (16)). The destructive mechanisms involved in such processes have been suggested to be attributed to multinuclear 'osteoclast-like' giant cells in contact with resorption bays of the dentin surface. Gold & Hasselgren (16) suggested, in addition, three important environmental factors for the resorptive process: (i) destruction of the protective surface (cementoblasts, pre-dentin, cementoid, epithelium, and periodontal ligament) covering the mineralized tissue, (ii) presence of a vascular connective tissue, and (iii) presence of an inflammatory stimulus (infection/trauma). The suggested presence of a vascular connective tissue is supported by observations made in the present study. Hence, the biopsy material sampled from the resorptive processes contained inflammatory infiltrates rich in vascular structures. Furthermore, the biopsy that was collected concomitant with the tooth in the present study showed signs of destruction of cementum but also signs of cementum repair.

On the basis of the observation that cementum repair may occur and the fact that the soft-tissue samples in the present study were easily removed from the resorptive cavities during biopsy, it may be suggested that the resorptive processes undergo different stages during

development: active (destructive) and resting (healing including cementum repair). Such features have, in addition, been reported in a scanning electron microscopic study on resorption damages in extracted human teeth by Sismanidou & Lindskog (13).

A general radiographic finding in the present study was that the resorptive processes in all complication cases included the supra-alveolar portion of the root. Thus, the destructions did not in any case involve the subcrestal part of the root (Fig. 1). A clinical finding was the absence of an increased probing depth around the teeth studied. In other words, the destruction of the supracrestal portion of the teeth was not associated with periodontal disease including loss of attachment. Furthermore, the composition of the identified lesions in the soft tissues sampled (Table 1) had a traditional content of cells as suggested by Gold & Hasselgren (16). The densities of lymphocytes and plasma cells in the lesions of the present study, however, seem to differ from those observed in plaque-associated infiltrates in human periodontal disease sites (17). Owing to the relatively larger proportion of lymphocytes observed in the lesions of the present study compared with infiltrates of periodontal disease, and the fact that the resorptive processes developed quite late after initial treatment, it may be suggested that complex cellular mechanisms are involved in the initiation and continuation of such destructive processes. Further studies, however, are needed to confirm such a hypothesis.

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