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Cervical external root resorption in vital teeth

X-ray microfocus-tomographical and histopathological case study

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Abstract

External resorptions associated with inflammation in marginal tissues present a difficult clinical situation. Many times, lesions are misdiagnosed and confused with caries and internal resorptions. As a result inappropriate treatment is often initiated. This paper provides three-dimensional representations of cervical external resorption, based on X-ray microfocus-tomographical scanning of a case, which will aid the dental practitioner in recognizing characteristic features during clinical inspection. In addition, histopathological examination reveals the cellular morphology of the adjacent tissues.

Key words: cervical resorption; external root resorption; peripheral inflammatory root resorption; tooth resorption; XMCT

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Introduction

External resorption is a process that leads to an (ir)reversible loss of cementum, dentin and bone. It takes place in both vital and pulpless teeth and the identification is mostly made during routine radiographic or clinical examination as the majority of cases are asymptomatic. External resorptions may be physiological or pathological. Andreasen suggested an advanced classification in 1985 (Andreasen 1985). Today, his categories of surface, inflammatory and replacement-ankylosis resorption are commonly used. However, other investigators have introduced subgroups or new categories. Consequently, a lack of uniformity in nomenclature is still present, thus confusing the dental practitioner.

Cervical external resorption, frequently called invasive cervical resorption (Heithersay 1999a) or peripheral inflammatory root resorption (PIRR) (Gold & Hasselgren 1992), presents a special type of pathological tooth condition that could be classified in the group of inflammatory resorptions. In recent years, several etiologic factors have been advocated and some morphological descriptions were made. Nevertheless, prediction and prevention are still impossible and an exact diagnosis and treatment is often far from easy, depending on the severity and localization of the defect.

Clinically, cervical external resorption is associated with inflammation of the periodontal tissues and does not have any pulpal involvement (Frank & Torabinejad 1998). The pulp remains protected by a thin layer of predentin until late in the process and it has been postulated that bacteria in the sulcus sustain the inflammatory response in the periodontium (Tronstad 1988, Heithersay 1999a). This feature differentiates cervical external resorption from another type of inflammatory resorption called external inflammatory resorption, which is continued by necrotic pulp tissues and an infected root canal content (Andreasen 1985).

Cervical external resorption occurs immediately below the epithelial attachment of the tooth. As a result, it must be noticed that the location is not always cervical but related to the level of the marginal tissues and the pocket depth. Unless proper treatment is initiated, this type of resorption continues and a large irreversible loss of tooth structure may appear by time.

As mentioned before, the pulp plays no role in cervical external resorption and is mostly normal in these situations. However, a number of cases observed in recent years have suggested that part of this pathology may be associated with intracoronal bleaching procedures in endodontically treated teeth (Harrington & Natkin 1979). Although this relationship has not been firmly established by scientific study, strong suspicions exist that bleaching agents such as 30% H_2O_2 were able to penetrate the dentin from the inside

(Rotstein 1991), alter the root surface structure and irritate the periodontal ligament and surrounding tissues (Friedman et al. 1988, Dahlstrom et al. 1997). In particular, teeth with cementum deficiencies related to previous trauma (Cvek & Lindvall 1985) or a cemento-enamel disjunction (10%) due to histological variation (Schroeder & Scherle 1988) seemed to be at high risk. This type of cervical resorption, which is occasionally found after bleaching of a non-vital tooth, is often excessive, as it can rapidly progress through the root without being hindered by pulp and predentin.

This article will review the clinical and therapeutic concepts associated with cervical external resorption in vital teeth. The purpose of the joined case report is to describe a clinical case of a central incisor with massive external resorption of cervical crown and root structure that had to be extracted. It gave us the opportunity to observe the resorptive defect *in vivo* by standard and digital radiology and clinical examination, and also *in vitro* by means of histological sections and X-ray microfocus computed tomography (XMCT). The outcome of this examination will be discussed.

Pathogenesis, clinical features and treatment options

The exact etiology of cervical resorption is still unknown. It appears, though, that for it to occur there must be an unprotected, locally destroyed or altered root surface which has become susceptible to resorbing clastic cells during an inflammatory response of the periodontal ligament to traumatic (injury) or bacterial (irritation) stimulus, maintained by infection in the adjacent marginal tissues (Gold & Hasselgren 1992). It has been suggested that the periodontal ligament, the cementum, and especially the intermediate cementum, may serve a resorption-preventing function on the root surface (Lindskog & Hammarström 1980, Lindskog et al. 1985). The resistance to resorption of uncalcified, newly formed tissue on cemental surfaces (cementoid) has been observed (Gottlieb 1942). In addition, it appears that a hard tissue matrix is a barrier that has to be broken to trigger osteoclastic activity (Chambers 1981). This can be caused by damage to the root surface.

Cervical root resorption can have several etiologic factors and many theories have been presented. Other than systemic and idiopathic forms, this type of external resorption in vital teeth can occur late after orthodontic tooth movement, orthognathic and other dentoalveolar surgery, periodontal root scaling or planing, trauma, bruxism, fracturing, developmental defects or a combination of these predisposing factors (Cvek 1981, Tronstad 1988, Trope & Chivan 1994, Heithersay 1999b). It remains to be seen whether even vital bleaching in some teeth will result in cervical root resorption at a later date.

As with most external resorptions, the cervical root resorptions are usually painless and go unnoticed by the patient unless pulpal or periodontal infection supervenes. In addition, a deep resorptive cavity can result in sensitivity to changes in temperature because of proximity to the pulp. In most cases, cervical resorptions are detected during routine radiographic or clinical examination. If the lesion is located marginally, there may be no external signs, or a pink coronal discoloration of the tooth crown may be noticed (Fig. 1). The latter is caused by the translucent appearance of granulation tissue, which has a deep red color under the overlaying enamel structure. It bleeds freely on probing. By investigating the resorption cavity walls with an explorer, a hard, mineralized tissue sensation will be felt, accompanied by a sharp, scraping sound. This feature and the appearance of knife-edge cavity borders are important in the differential diagnosis with root caries. Caries lesions are rather soft because the organic component of the dentin has been disintegrated not by the bacterial acid production but by proteolytic enzymatic degradation. If the lesion is more apically or proximally situated, it may be detectable by deep probing. When the local 'pocket' is probed, copious bleeding and a spongy feeling are commonly observed as the granulation tissue of the resorptive defect is disturbed. Radiographs may reveal the lesions once a certain critical dimension has been reached. In a study from Andreasen et al. (1987) conditions favoring radiographic visibility of cervical resorptive defects were a lesion diameter of greater than 1.2 mm and the use of high contrast X-ray technique. Cavities located on the proximal surface are more easily detected than those located on the buccal surface. In addition, if the site of entry is visible on the radiograph, the accompanying bone resorption may be noticed. In most instances, the appearance of the crestal bone remains unchanged. A comparison with previously taken radiographs can increase the rate of detection. Furthermore, the use of varying X-ray angles has been suggested to distinguish internal resorption from external resorption and to locate the site of entry (Seward 1963). Because the pulp in the root canal is not involved in cervical external resorption, it is usually possible to clearly distinguish the radiopaque mineralized outline of the canal through the radiolucency of the external resorptive defect (Fig. 1). As the cervical root resorption is long standing, a mottled appearance may be seen due to deposition of calcified reparative tissue within areas of the cavity surface (Goldman 1954).

Fig. 1. (Left) Pinkish discoloration of the left central incisor caused by invasion of the cervical region of the tooth by fibrovascular tissue derived from the periodontal ligament. (Right) The parallel radiograph shows a rather irregular radiolucency (*), involving not only the coronal dentin but also extending to the coronal third of the root. The characteristic radiopaque line separating the lesion from the root canal can be identified.

It has to be emphasized that electric and thermal pulp tests remain positive throughout the continuation of the pathological process. The resorption starts on the root surface, but when the predentin is reached, the resorption proceeds laterally and in an apical and coronal direction, progressively enveloping the root canal (Figs 2, 3 and 4). This coronal extension process results ultimately in cavitation of the overlying enamel (Tronstad 1988). Furthermore, a series of channels containing resorptive tissue are present, and they usually have connections further apically with the periodontal ligament (Heithersay 1999a).

In severe external resorptions, only a

thin layer of dentin remains protecting the pulp (Makkes & Thoden van Velzen 1975) (Fig. 5). This could be explained by the fact that predentin possesses a resistance to resorption, as was demonstrated by Stenvik & Mjör (1970). It has been suggested that the organic phase of the predentin contains an enzyme inhibitor against resorption (Wedenberg & Lindskog 1985).

Besides extraction, different approaches have been suggested by several authors for the treatment of cervical external root resorptions of various origins. Arresting the resorption may be attempted by means of subgingival curettage, but with a 'high failure rate due to recurrence, or rather persistence, of the resorptive tissue' (Heithersay 1985). The use of calcium hydroxide to neutralize external resorption has been suggested. Webber (1983) has comprehensively summarized the benefits of this approach in some cases. Exposure of the resorption defects for the purpose of restoration has been recommended by means of orthodontic extrusion (Latcham 1986), intentional replantation (Heithersay 1985) or ostectomy by contouring the alveolar crest some 2 mm apical to the defect margins (Meister et al. 1986). The invasive nature of the resorption may necessitate a considerable reduction of bone, and the filling of the irregular cavities, with subsequent difficult clinical control. Regarding the restoration of the resorptive defects, glass ionomers (Heithersay 1985) or light-cured resin composite materials have been recommended, recognizing, however, that any subgingival restoration may well cause periodontal complications (Heithersay 1985, Meister et al. 1986). Performing the periodontal surgery as a preliminary stage has also been recommended, restoring the resorption defects only after the periodontal tissues have healed (Heithersay 1985, Meister et al. 1986). It is important that most external cervical resorptive lesions not be treated as endodontic problems. In many cases, this resorptive condition may be treated without sacrificing the pulpal vitality.

Fig. 2. The reconstructed image (XMCT) was longitudinally sectioned and partially cleared by means of software to visualize the thin layer of dentin that remained, protecting the pulp in this case from severe cervical external resorption.

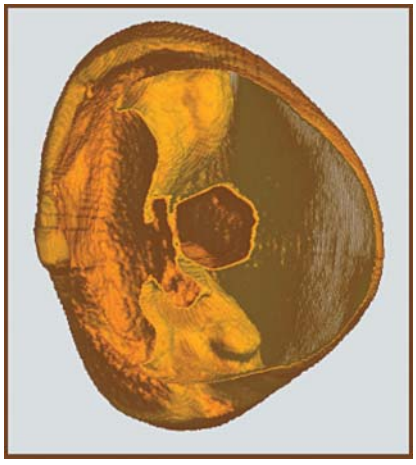

Fig. 3. Upper part of the crown (bottom view) visualized through a horizontal sectioning and partial clearing of the reconstructed image (XMCT) by software. When the predentin is reached, the resorption proceeds laterally to gradually envelop the root canal, preserving the pulpal vitality.

Fig. 4. Reconstructed images (XMCT) of the extracted tooth were partially cleared by software to three-dimensionally investigate the extent and characteristics of the resorption process.

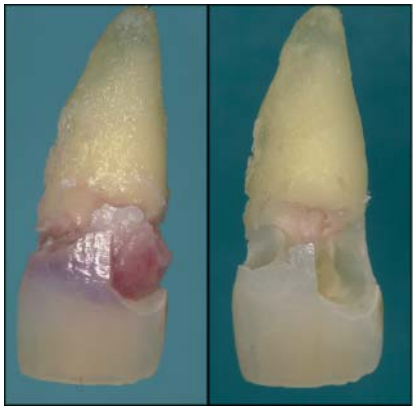

Fig. 5. (Left) Tooth immediately after careful extraction. (Right) Same tooth after excavation of the granulation tissue. Notice the layer of dentin and predentin that separated the resorbing tissue from the dental pulp.

Histological findings

The histological presentation of cervical peripheral inflammatory root resorption (PIRR) is identical to that of other inflammatory root resorption. Early investigators observed a similarity between tooth resorption and osteoclastic bone resorption, including resorption bays or Howship lacunae and resorbing cells (Coyler 1910, Black 1920, for review see Shafer et al. 1974). There are differing reports in the literature regarding the morphology of these resorbing cells for dentin. The presence of large cells with multiple nuclei, similar to osteoclasts, in contact with dentin has been described (Dragoo & Sullivan 1973). In general, all hard tissue-resorbing cells appear to be remarkably similar and therefore they are referred to as osteoclasts. Osteoclasts are multinucleated giant cells with cytoplasmic vacuoles that originate from bloodborne leukocytes from the bone marrow. They have two kinds of membranes: one that attaches the cell to the hard tissue surface and another that is conceivably involved in the resorption process (Hammarström & Lindskog 1985).

The presence of fibrovascular tissue adjacent to an unprotected root surface has been postulated as the condition necessary for root resorption (Gold & Hasselgren 1992). The cellular components of this soft tissue portion of the

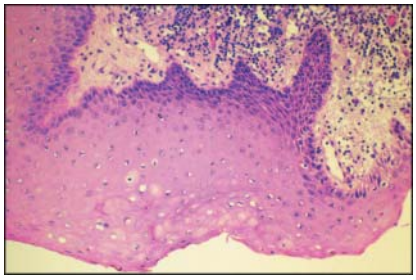

Fig. 6. The fibrovascular tissue connected with the periodontal tissues is infiltrated by mononuclear cells, mainly lymphocytes and plasma cells, and entirely re-epithelialized. (Hematoxylin-eosin stain, × 200).

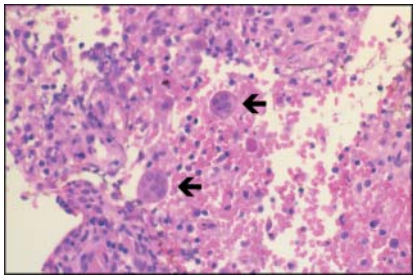

Fig. 9. Multinucleated clastic cells (arrows) present in the mass of fibrous tissue adjacent to the dentin surface. (Hematoxylin-eosin stain, × 400).

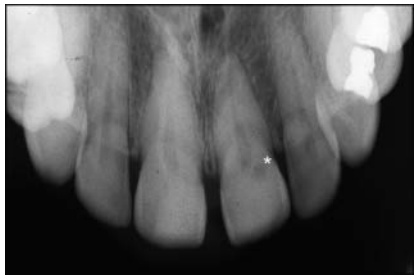

Fig. 10. The occlusal radiograph denotes a small invasive resorptive lesion (*) near the cervical area with a shallow penetration into the dentin.

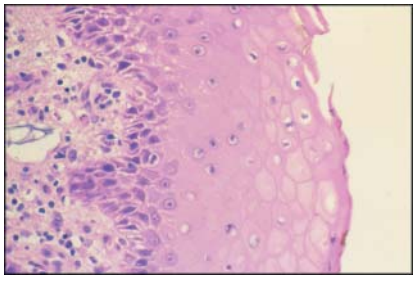

Fig. 7 Higher magnification of Fig. 8 shows chronically inflamed vascular connective tissue bordered by normal squamous epithelium of the gingiva. (Hematoxylin-eosin stain, × 400).

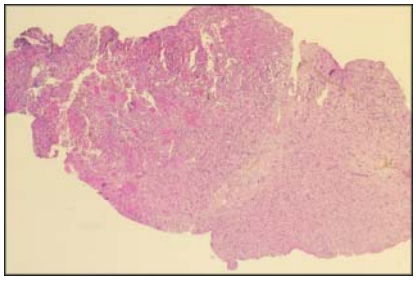

Fig. 8. Young, highly vascularized (left) and older (right) parts of granulation tissue present in the resorption cavity and surrounding space. (Hematoxylin-eosin stain, × 25).

resorptive complex include most of the inflammatory cells commonly described in inflammatory periodontal disease: lymphocytes, plasma cells, histiocytes or macrophages, and fibroblasts, in addition to the already mentioned multinuclear clast cells (Figs 6–9). In advanced lesions, ectopic calcifications can also be observed both within the invading fibrous tissue and deposited on the resorbed dentin surface (Goldman 1954). This calcified, poorly organized bone-like tissue indicates replacement or healing of the resorbed tooth structure.

X-ray microfocus computed tomography

Optical microscopes and standard radiographic equipment used to investigate the condition of cervical external resorption cannot provide accurate three-dimensional information. As a result, another technique called X-ray microfocus computed tomography has been used.

In medical and dental imaging, when the use of a reliable method for the localization and size determination of the internal body features is required, X-ray computed tomography (XCT) has proved to be a necessary tool (Tachibana & Matsumoto 1990). Its miniaturized form, X-ray microfocus computed tomography (XMCT), can be used non-destructively on bioptic specimens such as an extracted tooth (Nielsen et al. 1995, Bjørndal et al. 1999). By combining X-ray microfocus transmission technique with tomographical reconstruction, high-resolution (up to 10 µm) and magnified three-dimensional pictures based on 30-µm-spaced tomographic sections can be produced.

Case illustration

On May 2, 2000, a 36-year-old man was seen at the Department of Operative Dentistry, University Hospital of the Catholic University of Leuven, with a chief complaint of 'tenderness by palpation on the skin under the left nose entrance' combined with 'a pink colored appearance of the left front tooth' (Fig. 1). A central diastema was noted (Fig. 1), together with palato-incisal wear of the front teeth (Fig. 2). The patient said that he had consulted a dentist about 3 years previously because of a tingling sensation in the same region. There was no history of trauma. Apparently, at that time a small swelling buccal of the left central incisor was present without color change of the crown. The tooth responded to cold but on percussion no pain could be evoked. An occlusal radiograph (Fig. 10) was taken and sensitivity tests were performed, but no final diagnosis was made and the patient was advised to wait and see if any changes occurred. Three years later, with ongoing discomfort, a pink discoloration of the crown appeared and the patient was referred for suspected resorption pathology.

The patient was a healthy young man without significant medical antecedents and was not taking any medication. There was some minor gingivitis, but the patient had fairly good control of his dental plaque. No caries or restorations were present in the left central incisor. Vitality tests disclosed a vital tooth. There was slight gingival swelling and the sulcus was intact at the site of the resorption, which could be probed (sulcular depth of 4 mm). There was no sinus tract and the tooth was a little tender to percussion, indicating advanced involvement of the periodontal ligament. As the cervical root resorption was long standing, granulomatous tissue could be seen undermining the enamel of the crown of the tooth, giving it the pinkish appearance. This should not be confused with the pathognomonic clinical picture of internal root resorption (Fig. 1).

Radiographs are presented in Figs 1, 10 and 11. Reexamination of the oc-

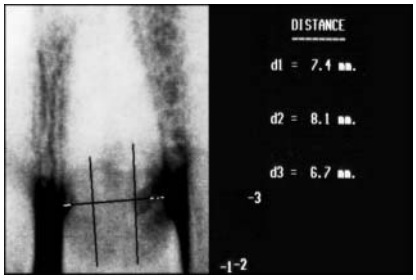

Fig. 11. Digital radiography (Sens-a-Ray) allows distance measuring and can be used to provide views from different angles with a reduced dose of radiation.

clusal radiograph from 1997 (Fig. 10) disclosed a small radiolucent spot that had initially been overlooked and which corresponded to the ongoing resorption. Examination of the resorption defect on the newly taken radiagraphs (Fig. 11) revealed an intact circumferential outline of the alveolar crest without resorption. The lamina dura was intact, the width of the adjacent periodontal ligament space was normal mesially but widened distally. Measurements made by digital radiography (Sens-a-Ray) (Fig. 11) revealed maximum distances of 7.4 and 8.1 mm (coronal-apical direction) and 6.7 mm (mesiodistal direction). There seemed to be more loss of tooth structure on the distal side. There was no evidence of resorption elsewhere on the root.

Because the restorability of the tooth was severely compromised, extraction was performed. Getting sound crown margins would have been difficult because the resorptive defect was below the bony crest. Furthermore, periodontal surgery as an alternative option, consisting of an apically repositioned flap on the labial and a gingivectomy on the palatal surfaces, would be associated with extensive gingival recession and unaesthetic exposure of the cervical root surfaces.

The curettage of the resorption defect and the removal of the resorptive tissue are illustrated in Fig. 5. After cleaning the defect, no perforation from the resorptive defect into the cervical pulpal area was found.

The pathology report (Van Damme 2000) described the excavated tissue as histologically consisting of chronically inflamed vascular connective tissue (Figs 6–9). The fragment was lined by normal epithelium of the gingiva. The cellular components of this inflammation infiltrate were mainly lymphocytes and plasma cells. A few multinucleated resorbing cells were seen, indicating an active resorptive process. Lacunae were not histologically examined because the tooth itself was used for XMCT examination (SkyScan 1072, SkyScan N.V., Belgium).

Zusammenfassung

Zervikale externe Wurzelresorptionen bei vitalen Zähnen – Ein Fallbericht mit Röntgen-Mikrofokus-Tomographie und histopathologischer Untersuchung

Externe Resorptionen, die mit der Entzündung der marginalen Gewebe verbunden sind, stellen eine schwierige klinische Situation dar. Häufig werden diese Läsionen fehldiagnostiziert und mit Karies oder internen Resorptionen verwechselt. Als Ergebnis davon wird oft eine ungeeignete Therapie eingeleitet. Diese Veröffentlichung eines Falles liefert, durch Verwendung der Röntgen-Mikrofokus-Tomographie, eine Dreidimensionale Darstellung der zervikalen externen Resorption. Dies wird dem praktisch tätigen Zahnarzt dabei helfen, die charakteristischen Merkmale während der klinischen Inspektion zu erkennen. Zusätzlich zeigt die histopathologische Untersuchung die zelluläre Morphologie der benachbarten Gewebe.

Résumé

Résorption radiculaire cervicale externe sur les dents vivantes – Etude de cas histopathologique et microfocal tomographique

Les résorptions externes associées avec l'inflammation des tissus marginaux représente une situation clinique difficile. La plupart du temps, les lésions sont mal diagnostiquées et confondues avec des caries et des resorptions internes. Il s'en suit des traitements inappropriés. Cet article montre des représentations en trois dimensions d'une résorption externe cervicale basée sur une technique de scanner par tomographie microfocale d'un cas , ce qui aidera le praticien à en reconnaître les caractéristiques lors de l'examen clinique. De plus, l'examen histopathologique révèle la morphologie cellulaire des tissus adjacents.

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