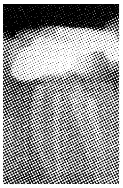

CLINICAL ARTICLE

Perforation repair with mineral trioxide aggregate: a modified matrix concept

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Abstract

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Aim To present a modified matrix concept for repair of root perforations using mineral trioxide aggregate (MTA).

Summary Root perforations may occur during preparation of endodontic access cavities or during post-space preparation. The perforation creates the potential for an inflammatory reaction in the periodontal ligament. A concept for the repair of root perforations is presented using a matrix of resorbable collagen. This matrix reconstructs the outer shape of the root and facilitates the adaptation of MTA. The indications for the use of MTA are discussed. Two clinical cases of 5-year successful root perforation repair using the technique are presented.

Key learning points

• Long-term perforations with periodontal inflammation can be successfully treated with MTA.

• Matrices for MTA placement can be developed with commercially available collagen.

• Infection control within the root canal and at the perforation site is required for satisfactory perforation repair and healing.

Keywords: matrix concept, mineral trioxide aggregate, perforation repair, root perforation.

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Introduction

Root perforation may occur during preparation of access cavities, coronal shaping and during post-space preparation. Such a perforation results in loss of the integrity of the root and further destruction of the adjacent periodontal tissues. Mineral trioxide aggregate (MTA) (ProRoot; Dentsply Maillefer, Ballaigues, Switzerland) is a material that is

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recommended for several dental purposes. The suggested indications for the use of MTA include root-end fillings (Torabinejad *et al.* 1993, 1994), pulp capping (Pitt Ford *et al.* 1996), repair of root perforations (Soluti *et al.* 1993, Pitt Ford *et al.* 1995, Holland *et al.* 2001), apical filling of teeth with open apices and apexification therapy (Torabinejad & Chivian 1999, Shabahang & Torabinejad 2000, Giuliani *et al.* 2002). Similar or even better biocompatibility of MTA when compared with other materials used for these purposes has been reported (Torabinejad *et al.* 1995a, Mitchell *et al.* 1999, Keiser *et al.* 2000). Perforated roots treated with MTA showed a noninflammatory tissue layer and root cementum attached to the MTA in nine of 12 cases after 180 days (Holland *et al.* 2001). The same has been found in histological investigations of tissues adjacent to apical root-end fillings, where after a period of 60 days genesis of periodontal ligament was apparent (Regan *et al.* 2002). Additionally, in an SEM investigation, the margins between the root canal surface and MTA both in teeth with root-end fillings and root perforations sealed with MTA showed significantly smaller gaps than in similar studies using Super-EBA, IRM or amalgam (Torabinejad *et al.* 1995b). The degree of penetration of endotoxins (Tang *et al.* 2002) and bacteria (Fischer *et al.* 1998, Nakata *et al.* 1998) was also equal or significantly less for MTA than for other materials. This high degree of biocompatibility makes MTA a suitable material for the treatment of root perforations with the goal of regenerating a periodontal attachment (Main *et al.* 2004).

Report

The modified matrix concept

Lateral root perforations, caused accidentally and unnoticed during post-space preparation, frequently show large bone defects in recall radiographs (Figs 1 and 2). For successful treatment of such defects, the root surface should be reconstructed in order to allow reattachment of periodontal ligament. Success of such treatment obviously depends on elimination of bacteria from the root canal system and the perforation site. To achieve this goal, the post and the infected root canal filling (if present) must be removed and chemo-mechanical debridement and shaping of the root canal performed. In some cases, granulation tissue may have grown into the perforation. This granulation tissue must be displaced from the perforation to allow exact reconstruction of the root surface (Fig. 3). Lemon (1992) introduced the 'internal matrix concept' for treatment of root perforations. He recommended the use of amalgam for sealing the perforation, which would be condensed against an external matrix of hydroxyapatite, carefully pushed through the perforation thus serving as an external barrier or matrix. For the application of MTA, no such pressure-resistant support is necessary. Freshly mixed MTA has a soft consistency and may be applied without pressure. Small pieces of collagen (Kollagen-Resorb; Resorba, Nuremberg, Germany) are used to push the granulation tissue out of the perforation and keep it in place outside the root (Figs 4 and 5). Using an application device (MTA-gun; Dentsply Maillefer), MTA may be layered against the collagen until the perforation is repaired (Figs 6 and 7). For this process, no pressure is required at any time due to the consistency of the material. Direct observation of the perforation site through the operating microscope is very helpful to avoid inadvertent blockage of the still empty root canal space with MTA and to control correct placement of the repair material.

Sealers used for conventional root fillings show a significant dependence between the apical seal and the dryness of the root canal (Hosoya *et al.* 2000). Therefore, optimal dryness of the canal is required before filling. When treating a perforated root, intracanal dryness may be difficult to achieve, as there may be fluid flow into the canal, due to the large surface of granulation tissue outside the perforation. As MTA is able to harden and to

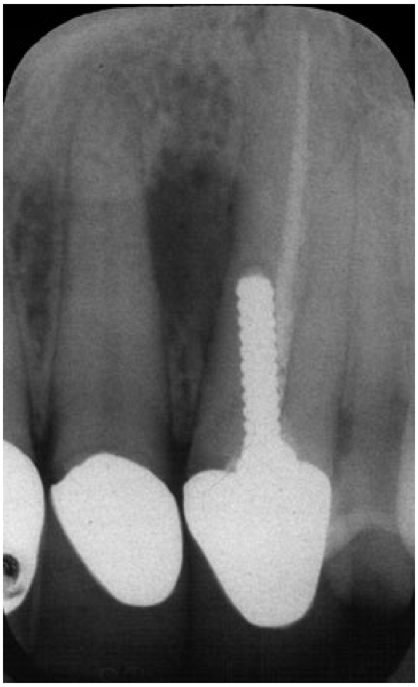

Figure 1 Tooth 23: preoperative radiograph showing an inhomogeneous root filling and a lateral ostitis.

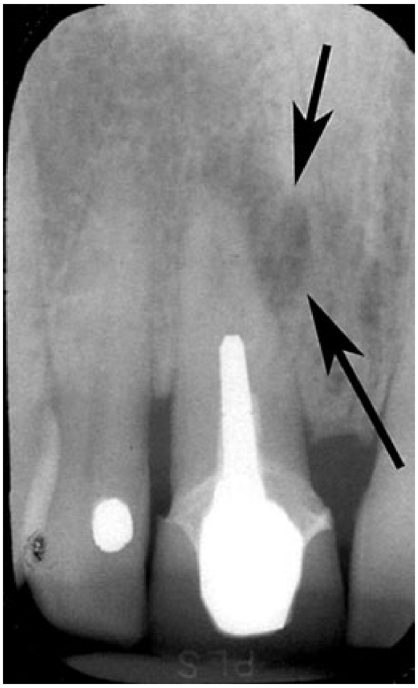

Figure 2 Tooth 11: preoperative radiograph demonstrating the lack of a root filling and a seemingly well-centred post. A discrete lateral ostitis (arrows) is visible.

Figure 3 After post-removal and primary cleaning of the root canal some granulation tissue is located inside the perforation defect.

Figure 4 With small pieces of collagen the granulation tissue is pushed out of the perforation. The direct view to the perforation site through the operating microscope is very helpful.

Figure 5 A matrix of collagen recreates the outer form of the root surface.

form a barrier even when in contact with either water or blood (Soluti *et al.* 1993, Torabinejad *et al.* 1994) complete dryness is not mandatory for repair of the perforation.

Following application of the collagen the sealed perforation and the newly accomplished reconstruction of the root surface are monitored radiographically (Figs 8 and 9). MTA powder is mixed with sterile water, to form a paste with a soft consistency that takes several hours to harden (Torabinejad & Chivian 1999). In order to deliver the necessary dampness for the hardening MTA, a wet cellulose-swab (Sugi steril; Kettenbach, Eschenbach, Germany) is placed inside the remaining root canal space for 1 day. This fibrous material is superior to a cotton pledget, single cotton fibres of which may stick to the MTA. Additionally, a temporary filling can be applied without the risk of bacteria reentering the cavity along cotton wool fibres extending through the temporary filling. At the next appointment, the root filling or the post-endodontic restoration can be completed.

The 1-year recalls of the presented cases show nearly complete healing of the radiolucencies, caused by the perforation, with new bone filling the defects (Figs 10 and 11). The 5-year recalls demonstrate excellent healing with a visible continuous periodontal ligament space in both cases (Figs 12 and 13).

Discussion

The most important factor to determine the likelihood of success of treatment of perforations is the time elapsed since occurrence of the perforation, or, more exactly, the question whether the wound site is already infected or not (Seltzer *et al.* 1970, Fuss & Trope 1996). However, when planning treatment of such a perforated root, this question seems not to be so important, as perforations often occur unnoticed and therefore the dentist repairing the perforation hardly ever has a possibility to influence the time factor and the circumstances of this perforation. The site of the perforation relative to the ‘critical

Figure 6 Small portions of MTA are layered against the collagen barrier.

crestal zone' appears to be more important. Therefore, infection of the perforation site should always be assumed. The following questions are far more important for treatment planning:

- May effective elimination of bacteria from both the root canal and the perforation area be achieved?
- May contamination of both the extraradicular area and the perforation area with unwanted materials (for example, infected root filling materials) be prevented?
- May a connection between the periodontal perforation defect and the oral environment via the periodontal pocket be excluded?

If the answer to any one of these questions is negative, the repair of the periodontal tissue will be permanently disturbed and will most likely not result in successful treatment. When planning endodontic treatment of such cases, the final goal of root canal treatment, and therefore the best possible elimination of bacteria from the root, must not be forgotten. This requires a combination of antibacterial irrigants inside the root canal system for sufficient length of time (Sen *et al.* 1999, Spratt *et al.* 2001).

The treatment of perforations, which are connected to the oral flora via a periodontal pocket, presents a variety of problems. Although MTA offers a high degree of compatibility to the periodontal ligament (Keiser *et al.* 2000), there is yet no evidence of attachment to the dental epithelium or the gingival attachment. Therefore, it must be assumed that those areas will have constant contact with the oral flora and the MTA will be continuously contaminated. The development of subgingival plaque could be promoted

Figure 7 After closure of the perforation the collagen will be resorbed in a few weeks.

Figure 8 Tooth 23: after root canal retreatment and perforation repair with MTA.

Figure 9 Tooth 11: after perforation repair and a temporary coronal restoration.

Figure 10 Tooth 23: the 1-year follow-up demonstrates a nearly complete remineralization of the defect.

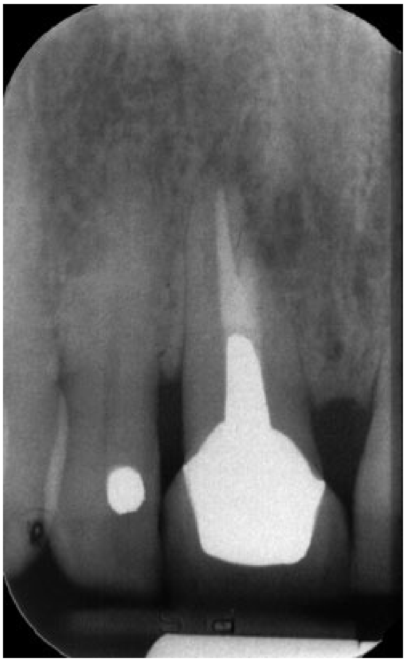

Figure 11 Tooth 11: the 1-year follow-up shows no signs of inflammation and a normal bone structure.

Figure 12 Tooth 23: 5-year follow-up with complete bone refill and a visible periodontal space.

due to the rough surface of MTA (Fridland & Rosado 2003). As MTA is not a hard material, it could be partially scraped off during mechanical cleaning of the root surface and stable periodontal healing might not be expected (Torabinejad *et al.* 1995c).

Figure 13 Tooth 11: the 5-year follow-up demonstrates complete bone regeneration without any sign of inflammation.

The modified internal matrix concept uses, in contrast to other treatment concepts (Lemon 1992, Hartwell & England 1993, Bogaerts 1999), collagen as a completely resorbable barrier material and MTA for sealing of the perforation. This not only results in repair of the defect, but also promotes healing of the periodontal ligament as shown by the cases. Further clinical studies are necessary to investigate the predictability of the outcome of the technique.

Disclaimer

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