Abstract
The purpose of treating furcal perforation is to seal the artificial communication between the endodontic space and the periradicular tissue to prevent alveolar bone resorption and damage to the periodontal ligament. These complications are not infrequent in cases of furcal and/or old perforations, which show a worse prognosis than fresh, small, coronal, and apical perforations. Mineral trioxide aggregate (MTA) is widely used to seal perforations because of its biocompatibility and sealability. Ten cases of furcal perforation were selected at the department of Endodontics, University of Florence. All the perforations were cleaned with NaOCl, EDTA, and ultrasonic tips and sealed with MTA without internal matrix. Finally, the teeth were endodontically treated and coronally restored. Clinical and radiographic follow-ups were done at 6 months, 1 year, 2 years, and 5 years. After 5 years, the absence of periradicular radiolucent lesions, pain, and swelling along with functional tooth stability indicated a successful outcome of sealing perforations in 9 out of 10 teeth. One patient dropped out of the study after the 1-year follow-up and could not be contacted for further recalls. The results confirm that MTA without matrix provides an effective seal of root perforations and clinical healing of the surrounding periodontal tissue. (J Endod 2008;34:1130–1133)

Key Words
Furcal perforation, mineral trioxide aggregate, root perforations

Furcal perforation may be the consequence of procedural error or a pathologic process such as caries and root resorption (1). The etiology and location of the perforation as well as the size and the time delay before perforation repair are significant factors for the prognosis and treatment planning (2).

A good prognosis can be expected in case of fresh, small, coronal, and apical perforation (2, 3). When left untreated, perforations in the cervical third of the root or on the floor of the pulp chamber have the worst prognoses.

The time elapsed from the development of the defect is another critical factor influencing the posttreatment prognosis; a delay in repairing a perforation opens the way to bacterial contamination. In animal studies, teeth with contaminated intentional lateral perforation were associated with a poorer repair process than teeth with no contaminated defects (4, 5).

Ideally, a material with good sealability might be used to prevent continuous exposure to a contaminating environment (6). Using different leakage approaches, fluid filtration technique (7, 8), dye-leakage model (9, 10), bacterial leakage model (11, 12), and dye-extraction leakage method (13), mineral trioxide aggregate (MTA) experimentally showed better sealing ability than other materials, such as amalgam (11), zinc oxide-eugenol cement (10), resin-modified glass ionomer cements (9), and resin materials (7).

The use of biocompatible materials to repair perforations might be advocated to reduce the incidence of inflammatory reactions in the surrounding tissues (6, 14). When MTA was used to seal intentional furcal perforations in dog teeth, cementum was formed over the MTA; furthermore, there was no inflammatory cells infiltrate (15). In addition, the material of choice for repairing root perforations should be nontoxic and insoluble in the presence of moisture, and it should be able to promote the healing of the periradicular tissue (16). MTA has the properties of the ideal material for perforation repair.

In cases of teeth with large-size furcal perforation, the repair material can extrude into the interradicular area, triggering tissue inflammation and foreign body reaction (17, 18). The use of biocompatible material has been advocated to avoid extrusions and the ensuing complications (18, 19).

In a recent animal study in which MTA without internal matrix was used to repair contaminated intentional furcal perforations, there was a low score of inflammation and a high score of bone deposition (17). Treating contaminated root perforation is not infrequent in daily clinical practice.

A recent PUBMED search for MTA to repair root and pulp chamber perforation produced one long-term case series study (20) and numerous case reports showing the good healing results when MTA was used to seal root and pulp chamber perforations (21–23). There are no other results of human control studies or case series studies.

The purpose of this report was to present the 5-year follow-up results of 10 cases treated for furcal perforation repaired with MTA without internal biocompatible matrices.

Materials and Methods
The experimental study was conducted on 10 adult patients aged between 25 and 35 years who were referred to the University Dental School of Florence, Italy, from February 2001 to May 2002 for the treatment of perforations of the furcal area with the absence of pathologic periodontal probing. During the first visit, ethical approval was requested and granted, and informed consent was obtained from all patients. The

From the Department of Endodontics, The University of Florence, Florence, Italy.
Address requests for reprints to Dr Riccardo Pace, Department of Dentistry, University of Florence, Via del Ponte di Mezzo 46-48, 50127 Florence, Florence, Italy. E-mail address: r.pace@odonto.unifi.it. 0099-2399/50 - see front matter
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diagnosis of perforation was confirmed by clinical and radiographic examinations. The clinical findings including the presence of pain, episodes of swelling, or abscess were recorded along with the date of the last treatment of the affected tooth. In three cases, additional radiographs, with different angulations, were needed to properly assess the location of the perforation and to detect the presence of radiolucent lesions.

**Perforation Repair Technique**

We isolated the teeth with a rubber dam and removed the coronal temporary filling material. We corrected the access opening with ultrasonic tips in order to visualize the access to the root canals and found the site of the perforation under microscopic vision. We irrigated copiously with 5% sodium hypochlorite; we gently cleaned the site using ultrasonic diamond-coated CPR 3 (Spartan, Fenton, MI) tips and then irrigated the defect with 5% sodium hypochlorite (NaOCl, 3 mL) and 10% EDTA.

Under microscopic vision (Global Surgical Corp, St Louis, MO), we applied a thermoplasticized gutta-percha plug into the orifice of the root canals to avoid filling endodontic space with filling perforation material and then irrigated abundantly with 5% sodium hypochlorite with a final rinse of saline solution.

We sealed the perforation with MTA-sterile saline paste mixed in a 3:1 proportion as suggested by the manufacturer, gently dried the floor of the pulp chamber with a cotton pellet, and delivered the Gray ProRoot MTA cement (Maillefer, Ballaigues, Switzerland) into the perforation with an Endo-Gun (Maillefer). We used a hand plugger to accommodate the MTA inside the defect with minimal pressure.

We placed a moist sterile cotton pellet into the pulp chamber and temporarily sealed the access cavity with glass ionomer cement (Ketac Fill; 3M ESPE AG, Seefeld, Germany); a radiographic examination was performed to control the correct positioning of the MTA. After 72 hours, we reaccessed the root canal system and checked the hardening of the MTA (Fig. 1) before proceeding with root canal therapy. The coronal restoration was performed 1 week later. A final x-ray was taken immediately after the procedure.

The findings of the clinical controls at 6 months, 1 year, 2 years, and 5 years after treatment were absence of a periodontal defect in the area of perforation, absence of pain, absence of swelling, and fistula. The radiographic criteria for healing were absence of radiolucency adjacent to the repair site and absence of periradicular lesions.

### Results

Table 1 shows the clinical findings. Out of the 10 clinical cases included in this study, only one patient reported an episode of swelling before the treatment. The time between the creation of perforation and the repair ranged from 1 to 6 months. Furcal and periapical radiolucent lesions were present in all teeth.

Starting from the follow-up at 6 months through to the end of the 5-year period, 9 of 10 cases were clinically healed. There were no episodes of swelling or pain, and the periodontal probing depths were less than 4 mm in all teeth.

At the 6-month recall, radiographs showed a reduction of periapical radiolucent lesions in all teeth (Fig. 2A and B). At the 1-year radiographic follow-up, only one case showed the persistence of furcal and periapical lesion (Fig. 2C); in this case, the time elapsed from the creation of perforation to repair of the defect was 6 months. This patient was dropped from the study because he did not present for the 2- and 5-year recall visits. The remaining nine teeth did not present radio-

### Table 1. Patients’ Variables

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Tooth #</th>
<th>Size of Perforation (diameter in mm.)</th>
<th>Position of Perforation</th>
<th>Follow-up Time</th>
<th>Final Clinical Assessment</th>
<th>Adverse Effects Observed Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>F</td>
<td>#18</td>
<td>1</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td>One episode of swelling before the treatment</td>
</tr>
<tr>
<td>34</td>
<td>M</td>
<td>#30</td>
<td>1.5</td>
<td>Floor of the pulp chamber near distal root (Fig. 2 A–C)</td>
<td>6 months, 1 year</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>M</td>
<td>#30</td>
<td>1.5</td>
<td>Cervical third of distal root (Fig. 3 A–D)</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical radiographic healing</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>F</td>
<td>#3</td>
<td>1.5</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical radiographic healing</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>F</td>
<td>#15</td>
<td>1</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>F</td>
<td>#19</td>
<td>1</td>
<td>Cervical third of the mesial root</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>M</td>
<td>#12</td>
<td>&lt;1</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>F</td>
<td>#31</td>
<td>1.5</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>M</td>
<td>#5</td>
<td>&lt;1</td>
<td>Cervical third of the buccal root</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>F</td>
<td>#30</td>
<td>&lt;1</td>
<td>Floor of the pulp chamber</td>
<td>6 months, 1, 2, 5 years</td>
<td>Clinical and radiographic healing</td>
<td></td>
</tr>
</tbody>
</table>
graphic lesions nor did they develop radiolucent lesions during the radiographic examinations at 1, 2, and 5 years (Fig. 3A–D).

Discussion

The recent trend in evidence-based medicine underlines the importance of clinical data for evaluating clinical outcomes when new materials are used in humans. The majority of published data dealing with the use of MTA in root and furcal perforation are based on in vitro and in vivo animal studies. In 2004, Main et al (20) suggested the need for a clinical study to prove the efficacy of MTA as a perforation repair material. The present study describes the treatment of 10 cases of root perforations without pathologic periodontal probing using an ortho-grade approach to the defect; the treatment protocol consists in a primary sealing of the defect with MTA without internal matrix followed by root canal therapy of the teeth.

In this study, 9 out of 10 cases were clinically and radiographically healed. A timely sealing of the defect could prevent bacterial contamination from the pulp chamber area into the periodontum (6) as well as the possibility of bacterial ingress from the periodontum into the pulp chamber enhancing the healing process of the surrounding tissues (20). This is especially important in furcal perforations because of the greater proximity to the oral environment.

In the cases presented, the time elapsed from the creation of the perforation to repair of the defect did not exceed 6 months. Immediate repair of furcal perforations seems to reduce the possibility of bacterial contamination of the defect (4–6, 16, 20).

The control of inflammatory processes in the defect area during management of perforation represents one of the main goals of the treatment (20) in addition to promoting the health of the surrounding tissue. To achieve a better tissue response, the perforation sites were sterilized with ultrasonic tips and sodium hypochlorite irrigation (15, 17).

Recently, Holland et al (5) speculated on the importance of the debris in the defect, which could obstruct the close contact between MTA and the periodontal tissue and the subsequent healing process. To reduce the amount of debris in the perforation defect, a rinse with 17% EDTA was performed before positioning the filling materials.

The size of a perforation represents another important factor in determining the success of the repair procedure; some authors suggest the use of internal matrix to avoid the extrusion of the sealing material and consequent periradicular tissue inflammation (5, 18, 19).

In all of the cases in this study, the furcal perforations were fresh and small (<2 mm in diameter), with a low risk of filling material extrusion (24). Because the tissue response seems to be influenced by the nature of the sealing material, it is important to keep it within the limits of the defect. However, in an animal study (17), when MTA was accidentally extruded into the periradicular tissue, hard-tissue deposition and cementum were observed over the materials along with a regeneration of periodontal apparatus.

Arens and Torabinejad (25) observed better results when furcal perforations in dog teeth were repaired by using MTA without internal matrix as opposed to MTA with internal matrix. They concluded that MTA does not need a barrier when used to repair large furcal perforations.

Gray MTA with a wet cotton pellet was used to repair the perforation and maintained for 72 hours before proceeding with the root canal therapy. MTA is hydrophilic; the moisture promotes expansion inside the defect and setting (24, 26).

The disadvantage of the gray color of MTA was unimportant in the cases presented because all teeth were posterior teeth. As suggested in previous studies, gray and white MTA have similar chemical composition (27) and a high degree of biocompatibility (27), and no significant differences have been found (12, 28).

The outcome of the furcal perforations treated with MTA shows radiographic and clinical healing in 9 of the 10 teeth at the 5-year follow-up. Further studies are needed to prove the efficacy of MTA and better guide the practicioner in the use of this material. We suggest using the same protocol proposed for the treatment of furcal root perforations to have a series of comparable studies.
The use of MTA to seal small, fresh furcal root perforation is associated with a good short-term (ie, 5 years) clinical outcome.

References
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