Treatment Outcome of Mineral Trioxide Aggregate: Repair of Root Perforations—Long-term Results

Johannes Mente, DMD, PhD, Meltem Leo, DMD,* Dimos Panagidis, DMD,† Daniel Saure, MSc,‡ and Thorsten Pfefferle, DMD**

Abstract

Introduction: This historical cohort study follows on a previously reported trial, with the aim of assessing the outcome for teeth with root perforations managed by the orthograde placement of mineral trioxide aggregate (MTA) and identifying potential outcome factors for such treatment with a larger sample size and longer follow-up periods than in the first phase of the project. **Methods:** The treatment outcomes of 64 root perforations repaired between 2000 and 2012 with MTA were investigated. The root perforations were located in different areas of the root. Calibrated examiners assessed clinical and radiographic outcomes by using standardized follow-up protocols 12–107 months after treatment (median, 27.5 months). Preoperative, intraoperative, and postoperative information was evaluated. The outcomes were dichotomized as healed or diseased. **Results:** Of the 64 teeth examined (85% recall rate), 86% were healed. The univariate analyses (χ^2 tests) identified 2 potential prognostic factors, experience of the treatment providers (odds ratio, 2.14; 95% confidence interval, 0.39–11.74; $P < .01$) and placement of a post after treatment (odds ratio, 0.06; 95% confidence interval, 0.01–0.27; $P < .01$). In the multivariate stepwise logistic Cox regression, none of the potential prognostic factors displayed a significant effect on the outcome at the 5% level. **Conclusions:** MTA appears to have good long-term sealing ability for root perforations regardless of the location. The results of this historical cohort study confirm the results of the first phase of this project. *(J Endod 2014;40:790–796)*

Key Words

Mineral trioxide aggregate, MTA, perforation repair, root perforation, treatment outcome

From the *Division of Endodontics and Dental Traumatology, Department of Conservative Dentistry, †Department of Prosthodontics, and ‡Institute of Medical Biometry and Informatics, Ruprecht-Karls-University of Heidelberg, Heidelberg, Germany.

Address requests for reprints to Priv.-Doz. Dr Johannes Mente, Division of Endodontics and Dental Traumatology, Department of Conservative Dentistry, University Hospital Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany. E-mail address: johannes.mente@med.uni-heidelberg.de

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2014.02.003

The repair of iatrogenic, resorptive, or carious root perforations poses a challenge even for the endodontically experienced treatment provider. The visualization of the perforation area itself can be problematic, because bleeding often makes access to the perforation area difficult. Many different materials and techniques were described before the introduction of mineral trioxide aggregate (MTA) (1–4). Prognosis was poor when these materials were used, particularly for larger or epicrestally located perforations (4–6). This was probably often due to poor biocompatibility or the inadequate sealing ability of these materials. At the beginning of the 1990s, MTA, a material that set new standards with regard to these properties, was developed at Loma Linda University (California) (7, 8). Several studies have demonstrated that MTA is not only biocompatible but also bioactive (9–11).

A number of animal studies (12–14) and the first clinical studies (15–19) on the use of MTA for perforation repair are now available. Although these studies provide useful insights, their value as a reliable assessment of the long-term prognosis for this treatment option is limited. The actual number of cases reported is small, and the follow-up periods are sometimes relatively short.

In 2010, Mente et al (17) published the results from Phase I of this study project. In Phase I, 86% of the 21 teeth examined were healed. None of the potential outcome factors analyzed displayed a significant effect on the outcome (17). These results suggested that the study was underpowered, highlighting the problems of earlier studies. A power calculation performed after Phase I indicated that at least 40 teeth would be needed for Phase II to determine a 95% confidence interval (CI) for the healing rate with a width of ± 0.108. The aim of this second phase of the project was 2-fold: to elicit the outcome of the treatment of teeth with root perforations managed by the orthograde placement of MTA into the perforation area and to reinvestigate the potential outcome predictors with a larger sample size and longer follow-up periods than those applied in Phase I.

Materials and Methods

The study protocol of Phase II of this project was approved by the Ethics Committee of the University of Heidelberg (Ref. 095/2010). Subjects for this historical cohort study were identified from among patients who had received endodontic treatment with root perforations managed by the orthograde placement of MTA (ProRoot MTA; Dentsply Maillefer, Ballaigues, Switzerland) into the perforation area at the Department of Conservative Dentistry at the University Hospital of Heidelberg between 2000 and 2012. To evaluate as many long-term results as possible, all of the patients involved in Phase I were recalled for another follow-up examination in Phase II.

Some aspects of the procedures and methodologies for data collection (eg, recruitment of patients, radiographic calibration, evaluation of preoperative and intraoperative data, performance of follow-up examinations, and outcome assessment) were very similar to the procedures in Phase I of this project (17) and to other clinical projects undertaken by our group (20, 21). Therefore, in spite of inevitable repetition, these procedures are again described in detail.

Inclusion and Exclusion Criteria

The inclusion criteria for this historical cohort study were as follows: patients who had undergone root perforation repair by using MTA at the Department of Conservative

Dentistry at the University Hospital of Heidelberg. The interval between the endodontic treatment with perforation repair and the last follow-up examination was at least 1 year (with a tolerance of 14 days). Subjects with compromised immune status, those who were pregnant at the time of follow-up, those who declined to participate in the study, or those who had incomplete pretreatment or intra-treatment records were excluded. Teeth with a longitudinal root fracture or a periodontal-endodontic lesion (diagnosed on the day of endodontic treatment) were also excluded from the study.

Recruitment of Patients

Seventy-five patients who met the inclusion criteria were contacted by mail and subsequently by phone and invited to attend the follow-up examinations. All potential participants were mailed detailed information about the study. On the day of the follow-up examination, the patients were again provided a detailed explanatory information sheet and were asked to sign a declaration of informed consent to participate in the study. Clinical and radiographic follow-up examinations were undertaken after written informed consent had been provided.

Clinical Calibration

The follow-up examinations in Phase I of this study project (17) were performed by 2 investigators, both of whom had been clinically calibrated by independently examining 21 patients on 1 day. The clinical calibration for this and another clinical study project was running at the same time (17, 22). The results displayed a high level of consensus with regard to probing depth, attachment loss, furcation involvement, tooth mobility, type of restoration, cold and percussion tests, and assessment of the quality of the coronal restorations by both examiners for the 21 patients examined (between 99% and 100% agreement). For this reason, calibration of all clinical parameters was not considered necessary in Phase II of this study project.

In Phase II of this study project, the follow-up examinations were performed by 3 examiners (M.L., D.P., T.P.). To save the patients from having to undergo a 3-fold calibration in 1 day by all 3 examiners but at the same time ensuring a high level of inter-examiner reproducibility, a calibration of the examiners with respect to probing depth and furcation involvement measurements was undertaken by using study models (A1 and B1; KaVo, Biberach, Germany). The study models consist of both an upper and lower jaw and simulate a state of generalized moderate, localized severe chronic periodontitis (A1) and generalized severe chronic periodontitis (B1).

Each examiner took measurements of the study models A1 and B1 on 3 consecutive days. The probing depths were measured at 6 specific sites on each tooth (distobuccal, buccal, mesiobuccal, distolingual, lingual, and mesiolingual) by using a periodontal probe (PCPUNC 15; Hu-Friedy, Chicago, IL). The measurement of furcation involvement was undertaken with a Naber probe (PQ2N6; Hu-Friedy). Each examiner started with measurements on study model A1. All data regarding the determined probing depths and furcation involvements were dictated to a study nurse (I.M.) who entered them immediately into a specifically designed database. The data of 1 of the 3 examiners (T.P.) served as gold standard data with which the data of the other 2 examiners were compared. The recorded data were analyzed for inter-examiner reliability. A tolerance range of 1 mm was defined for probing depth measurements. No tolerance range was accepted regarding furcation involvement.

The examiner was considered to be calibrated if there was $\geq$90% inter-examiner and intra-examiner agreement regarding probing depths or furcation involvement in all study models. If the inter-examiner or intra-examiner agreement remained below 90%, the examiner had to proceed with additional calibration exercises by repeating the procedure described above not less than 3 days after the last calibration. During this training process, 1008 measurements of probing depth and 144 measurements concerning furcation involvement were undertaken by each examiner and checked statistically in respect of concordance with the authorized measurements.

Radiographic Calibration

One examiner (T.P.) was designated to determine the periapical index (PAI) of all intraoral periapical radiographs taken. Before evaluating the study radiographs, this examiner was calibrated with the PAI calibration kit, including 100 periapical radiographs (23). Intra-examiner reliability and inter-examiner agreement with the calibration kit's gold standard were assessed by using Cohen kappa.

Endodontic Treatment Intervention

Supervised undergraduate students (ST) treated 8 teeth (13%). General dentists (GD) treated 34 teeth (53%), and dentists whose practice was limited to endodontics (EN) treated 22 teeth (34%). All treatment providers used a dental operating microscope when applying MTA into the perforation area. The EN group performed the entire root canal treatment with the aid of a dental operating microscope (Zeiss, Oberkochen, Germany). In all cases in which the treatment was performed by ST, the application of MTA to seal the root perforation was undertaken by an endodontically experienced supervisor. The remaining root canal treatment was performed by the student.

The step-by-step procedures of placement of MTA into the perforation area, bleeding control, and cleaning and shaping procedures of the root canal system have been described in detail previously (17).

Preoperative and Intraoperative Data

Preoperative and intraoperative information pertaining to clinical variables was gathered from the patient records and radiographs and entered into a specifically designed database. Preoperative data included the following: age, gender, tooth location, time interval between occurrence and repair of perforation, number of roots, clinical signs and symptoms, response to cold test, tooth mobility, probing pocket depths and attachment loss, furcation involvement, sinus tract, periapical radiolucency, signs of root resorption, and previous root canal filling. Intraoperative data included the following: date of perforation repair, number of treatment sessions, cleaning and shaping technique, intracanal medication, root canal filling technique, complications, temporary seal, and experience of the treatment provider.

Follow-up Examination

The follow-up examinations were performed by 3 calibrated examiners (M.L., D.P., T.P.) at different time intervals ranging from 12 to 107 months after treatment. The presence of clinical signs or symptoms, response to cold testing (carbon dioxide snow), tooth mobility, type and quality of restoration, probing of pocket depth and attachment loss, furcation involvement, and presence of a sinus tract were recorded and entered in a structured recall form that was specially designed for this study.

The quality of the coronal restoration was assessed clinically by visual and tactile inspection and radiographically by evaluating signs of restoration breakdown or caries. The main purpose of this was to judge whether bacteria penetration into the root canal system of the tooth might be expected. Periapical radiographs were assessed as described next.