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ORIGINAL ARTICLE

Evaluation of three obturation techniques in the apical third of mandibular first molar mesial root canals using micro-computed tomography

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Abstract *Background/purpose:* Recent studies have demonstrated a high incidence of isthmuses in mandibular first molar mesial roots, and intratubular mineralization following mineral trioxide aggregate obturation. This study assessed the filling quality of three obturation techniques in the apical 5 mm of mandibular first molar mesial root canals.
Materials and methods: Sixty extracted human mandibular first molar mesial roots with two separate canals that had interconnecting isthmuses, were prepared to an apical size of 40/0.06. They were allocated to three groups of 20 roots for obturation by either cold lateral compaction (CLC) or the continuous wave of condensation (CW) that used gutta-percha and AH Plus sealer, or by an orthograde canal obturation using OrthoMTA. The obturated roots were scanned by micro-computed tomography and assessed for the volumetric ratio (%) of gutta-percha, sealer, and OrthoMTA within the main canals or isthmuses in the apical 5 mm area. Measurements were analyzed statistically for differences among three obturation techniques.
Results: In the main canals, filled volume ratios were not significantly different among groups. Within isthmuses, the filled volume ratio for CLC was lower than in CW ($P = 0.025$) or

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OrthoMTA (P = 0.002). In isthmuses, the gutta-percha volume ratio in CLC was lower than in CW (P = 0.005), although the sealer volume ratio was higher than in CW (P = 0.049).
Conclusion: CLC demonstrated lower filling densities in isthmuses in the apical region than either CW or OrthoMTA. Orthograde MTA obturation showed comparable filling quality to gutta-percha with sealer.

Introduction

The main purpose of root canal obturation is to obtain a three-dimensional seal of the entire canal system that prevents communication between the root canal and periapical tissue.[1] However, it is difficult to achieve this goal because of intricate anatomy in the canals. Isthmuses are a thin communication between two or more canals within the same root.[2] They are inaccessible to instruments and harbor pulp tissue and microbes after root canal treatment.[3]

Anatomical variations in mandibular first molar mesial root canals have been studied by micro-computed tomography (Micro-CT).[4] The reported incidence of isthmuses between two mandibular molar mesial canals ranges from 50% to 85% in the apical 5 mm, when using Micro-CT.[5,6] The filling quality of these canals has been studied for various obturation techniques.[7] Most root canal filling techniques employ a core material, which is most commonly gutta-percha,[1] and a sealer. However, gutta-percha placed by the traditional technique of cold lateral compaction (CLC), is inadequate for filling canal irregularities.[8] Therefore, heated gutta-percha techniques were developed, such as warm vertical compaction, thermo-plasticized injection, and continuous wave of condensation (CW), to better replicate irregular canal anatomy.[9] Additionally, root canal sealers are used to seal the space between gutta-percha and the canal wall, since gutta-percha does not adhere to dentin. However, most root canal sealers undergo dimensional changes after root canal obturation that compromises their seal.[10]

By contrast, a superior seal and enhanced biocompatibility can be obtained with mineral trioxide aggregate (MTA).[11] Although it was originally developed as a root-end filling material in surgical endodontics, MTA is now widely used for pulp capping, pulpotomy, and perforation repairs in nonsurgical treatment.[12,13] Furthermore, a hydroxyapatite-like interfacial layer forms at the MTA-dentin interface in the presence of phosphate buffered saline.[14] Orthograde MTA obturations showed less salivary leakage than gutta-percha with sealer in single root canals that had been prepared to an apical size 40/0.06.[15] OrthoMTA (BioMTA, Seoul, South Korea) is a kind of MTA developed specifically for orthograde root canal obturation. OrthoMTA contains less heavy metals than ProRoot MTA (Dentsply, Tulsa, OK, USA),[16] and has demonstrated intratubular mineralization following the obturation of single canals.[17,18]

Recently, Micro-CT has been used to obtain cross-sectional images of the obturated canals without damaging the teeth, and to calculate quantitative three-dimensional volumes for the root canal fillings.[19,20] These cross-sectional Micro-CT images correlate well with histological sections.[21] Therefore, the purpose of this study was to use Micro-CT to evaluate the filling quality of the apical 5 mm of the main canals and their isthmuses, in mandibular first molar mesial roots that were obturated by either CLC, CW, or OrthoMTA obturation (OMTA) in an orthograde manner.

Materials and methods

Sample selection and root canal preparation

Study approval was obtained from the Institutional Review Board of Seoul National University Dental Hospital (CRI 12006), Seoul, South Korea. Extracted human mandibular first molars were collected and stored in 10% neutral buffered formalin. Sixty teeth were selected with mesial roots with two separate canals extending from the pulp chamber to the apex, as confirmed on radiographs.

Endodontic access preparations were prepared with a No. 330 bur. Working lengths were established by inserting a No. 10 K-file into the mesiobuccal and mesiolingual canals, until the tip of the file was just visible at the apical foramen with a dental operating microscope (OPMI Pico, Carl Zeiss Surgical GmbH, Oberkochen, Germany). Prior to instrumentation, canal curvatures were viewed on radiographs taken from both buccal and mesial directions, with No. 15 K-files inserted into the mesiobuccal and mesiolingual canals.[22] Their curvatures (radius and degree) were measured with paint.NET software version 3.5 (dotPDN LLC, Kirkland, WA, USA). The teeth were then randomly divided into three groups of 20, so that there was an equitable distribution of canal curvature (radius and degree) between groups, as confirmed by one-way analysis of variance (Table 1).

The mesial root canals were cleaned and shaped with ProTaper Next Ni-Ti rotary files (Dentsply Maillefer, Ballaigues, Switzerland) according to the manufacturer's instructions, until the X4 file (apical size 40) reached working length. Between each instrumentation step, the canals were irrigated with 1 mL of 3.5% sodium hypochlorite (NaOCl) solution, delivered in a syringe with a 30-gauge needle (Max-i-Probe needle; Dentsply Rinn, Elgin, IL, USA). After instrumentation was completed, each canal was rinsed with 10 mL of 17% ethylenediaminetetraacetic acid (EDTA) to remove the smear layer, and then flushed with