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Multiple Endodontic Guides for Root Canal Localization and Preparation in Furcation Perforations: A Report of Two Cases

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Perforations are managed by surgical or nonsurgical approach depending on the relationship of the perforation site to the crestal bone level and attachment apparatus. Relocating the canal orifice or root canal close to the perforation site is quite challenging even with the aid of a dental operating microscope. In these two case reports, guided endodontics was applied in root canal localization and preparation in cases of furcation perforations. This is the report of two patients (42 and 15-year-old, respectively) who were referred for root canal treatment of the mandibular right first molar. The first case complained of pain on biting, foul odor, and bad taste. The referring dentist noted a furcation perforation and an inability to locate the mesial canals. Radiographic examination showed furcation radiolucency. Definitive diagnosis was symptomatic apical periodontitis. The second case complained of severe throbbing pain along with pain on biting. Mesial canals could not be detected due to a furcation perforation as noted by the referring dentist. Radiographic examination revealed a large furcation perforation and related bone resorption. Definitive diagnosis was acute apical abscess. In each case, a silicone impression of the mandibular arch was obtained and scanned along with cone-beam computed tomography scan to plan for localization and preparation of the mesiobuccal canals using implant planning software. Multiple guides were fabricated through rapid prototyping and allowed for the correct orientation and insertion of endodontic files through the canal. Canals were prepared and then obturated using warm vertical compaction technique and the perforation were repaired by mineral trioxide aggregate (MTA). Six-month and one-year follow-ups revealed no symptoms and evidence of radiographic healing. Thus, multiple endodontic three-dimensional guides can be successful in root canal localization and preparation in cases of furcation perforations.

Keywords: Case Report; Cone-beam Computed Tomography; Furcation Perforation; Guided Endodontics; Multiple Guides

Introduction

By definition, perforation is communication that arises between the periodontium and the root canal space that decrease the prognosis of the treated tooth [1]. According to Ingle [2], perforation is considered the second most common cause of failure of endodontic treatment.

Perforation can be either pathological or iatrogenic. Causes of pathological perforations are extensive caries, internal root resorption, and external root resorption [2-4]. Iatrogenic perforations arise during operative procedures of root canal treatment or restoration of endodontically treated teeth. Theoretically, a perforation alone into supporting tissues might not necessarily cause irreversible inflammation. However, perforation contamination with bacteria results in inflammation that leads to gingival down growth of epithelium, bone resorption, and/or necrosis [1, 5].

Early detection and management of root perforations have a great effect on tooth prognosis. However, if a perforation is left untreated, unfavorable sequelae occurs such as periodontal ligament inflammation, granulomatous tissue formation, bone resorption, and down growth of gingival epithelium with pocket formation [5, 6].

Management of perforations may be surgical or nonsurgical depending on the relationship of the perforation site to the crestal bone level and attachment apparatus. Relocating canal orifice or root canal close to the perforation site is quite challenging even with the aid of dental operating microscope.

Cone-beam computed tomography (CBCT) scan is a promising and valuable aid in the treatment of complex endodontic cases and the management of procedural errors. The guided endodontic technique is used successfully in locating calcified canals and apically extended access cavities [7-10]. According to the European Society of Endodontology statement in 2019 about the applications of CBCT in endodontics, it is recommended for the management of most retreatment cases and the management of iatrogenic procedural mishaps [11].

In this report, we describe root canal localization and preparation in mandibular first molars with furcation perforations using multiple endodontic guides.

Case Reports

Case 1

On the 19th of December 2020, a 42-year-old female patient was referred for root canal treatment of the mandibular right first molar. Medical history was not relevant. She complained from pain on biting, foul odor, and bad taste. The referring dentist perforated the furcation area unintentionally during coronal access cavity preparation. The patient was referred due to the inability to locate both mesial canals. Clinical examination revealed tenderness on palpation and percussion with localized soft tissue gingival swelling close to the furcation area of the tooth periodontal examination revealed no clinical attachment loss and probing depths were within normal limits. Radiographic examination revealed furcation radiolucency on periapical radiographs. Definitive diagnosis of previously initiated therapy with symptomatic apical periodontitis was reached.

Following the administration of local anesthesia, rubber dam isolation and removal of the temporary filling were performed.

Using a #10 K-file (Mani, Ultsunomiya, Japan), both distal canals and the mesiolingual canal were located and negotiated. The mesiobuccal canal could not be located and the K-file slips into the perforation site. Cleaning and shaping of the three located canals were performed using Fanta blue (Fanta, Shanghai, China) 17/0.12, 20/0.04, 25/0.04, and 35/0.04 rotary nickel-titanium files.

All treatment options were explained to the patient. The use of three-dimensional endodontic guides was decided, and the patient signed informed consent. A gypsum cast of the mandibular arch was obtained from a rubber-based addition silicon impression (Elite, Zhermack, Germany). CBCT scan of the area of interest was obtained in Endo Mode of Planmeca mid (Planmeca, Helsinki, Finland) (90 kV, 12.5 mA, 10×10 FOV, Resolution of 150 µm) in addition to gypsum cast scanning as well. Both scans were used for planning, designing, and guide fabrication. Four guides were fabricated with different diameters; 0.5, 1, 1.5, and 1.7 mm to fit different file sizes. In the following visit, the smallest guide, 0.5 mm, was fitted in place and K-file #15 was introduced through the guide and radiographed to confirm the file's location inside the mesiobuccal canal. The larger guide, 1 mm, was then fitted and K-file #15 was introduced to ensure canal patency. The working length was confirmed using the electronic apex locator (Dentaport, Morita, Japan). The larger guide, 1.7 mm, was fitted in place and the orifice opener was used through the guide. The final guide, 1.5 mm, was fitted and the primary and secondary files of the rotary file system were used sequentially through the guide. The largest rotary file 35/0.04 was used without any guidance. 2.5% NaOCl was used as an irrigant during the cleaning and shaping procedures. Finally, manual dynamic agitation was done for five min in all canals with gutta-percha cone 35/0.04. The master gutta-percha cone was placed and radiographed. A warm vertical compaction technique was used using an E&Q obturation system (Meta Biomed, Chungcheongbuk-do, Korea) and AH-Plus sealer (Dentsply, Tulsa Dental, Tulsa, OK, USA). Repair of the perforation was performed under magnification using DOM (Seiler, St. Louis, MO, USA) with MTA Angelus (Angelus, Londrina, Brazil). The coronal access cavity was then sealed using resin-modified glass ionomer restoration (Figure 1).

Case 2

On the 28th of January 2021, a 15-year-old female patient presented for completion of root canal treatment with her parents. She was referred for root canal treatment of the mandibular right first molar. The referring dentist failed to locate both mesial canals following iatrogenic furcation perforation during access cavity preparation.

Clinical examination revealed a previously initiated therapy. The right mandibular first molar was positive on percussion and palpation. A small localized intraoral swelling in the attached gingiva corresponding to the tooth was noted. Radiographic examination showed furcation radiolucency in addition to a large apical radiolucency related to both roots. CBCT scan (Planmeca mid, 90 kV, 12.5 mA, 10×10 FOV, Resolution of 150 µm) of the area of interest was obtained in an Endo Mode. The scan revealed a very large furcation perforation with root separation in addition to the apical radiolucency related to both root apices.

Following the administration of local anesthesia, rubber dam isolation and removal of the temporary filling was performed. Using a #10 K-file (Mani, Ultsunomiya, Japan), both distal canals

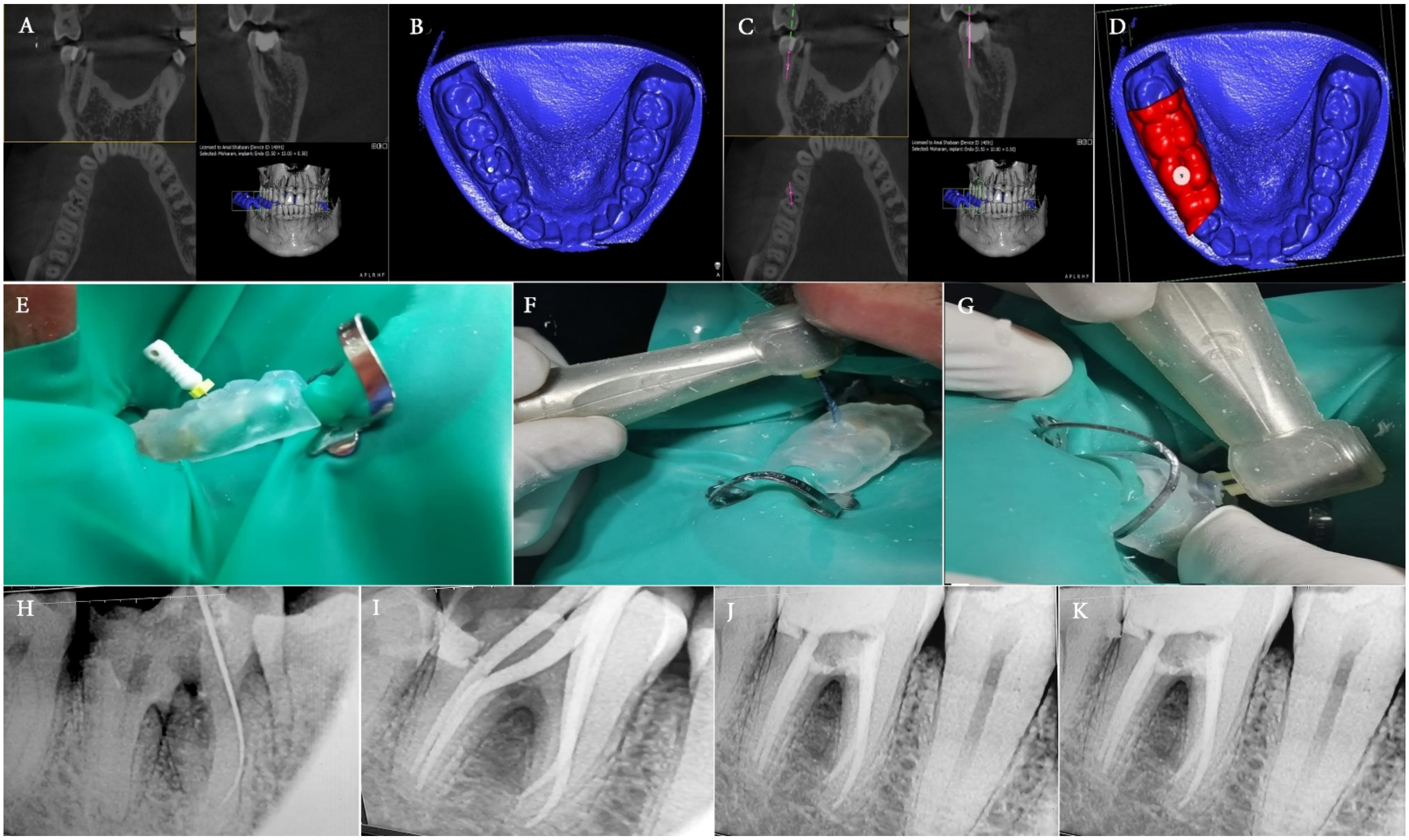

Figure 1. A) CBCT scan showing furcation perforation; *B)* STL file of cast scan of the mandibular arch; *C)* CBCT scan showing planning of the 3D endodontic guide; *D)* Designing of the 3D endodontic guide; *E)* K-file #15 inserted through the 3D endodontic guide in the mesiobuccal canal; *F)* Rotary file inserted through the 3D endodontic guide in the mesiobuccal canal; *G)* Preparation of the mesiobuccal canal with the rotary file reaching the woCrking length; *H)* Periapical radiograph showing K-file #15 in the mesiobuccal canal; *I)* Periapical radiograph showing the master gutta-percha cones reaching the working length; *J)* Immediate postoperative periapical radiograph showing the obturated canals and the MTA sealing the furcation perforation; *K)* One-year-follow-up periapical radiograph showing evidence of healing

and the mesiolingual canal were located and negotiated. The mesiobuccal canal could not be located and the K-file slips into the perforation site. Mechanical preparation of the three canals was performed using the rotary file system M3-Pro Gold (Udg, Jiangsu, China) with the following sequence 17/0.04, 20/0.04, 25/0.06, 30/0.04, and 35/0.04.

The granulation tissue in the furcation area was removed using a sharp spoon excavator and bleeding was controlled. The root canals and the perforation site were filled with calcium hydroxide paste, Metapaste (Meta Biomed, Chungcheongbuk-do, Korea) then glass ionomer as a temporary filling.

Following a discussion with the patient and her parents regarding the prognosis and restorability of the tooth, the decision was made to continue the root canal treatment with the aid of guided endodontics to save the tooth and keep it in place if possible.

A gypsum cast of the mandibular arch was obtained from a rubber-base addition silicon impression (Elite, Zhermack, Marl, Germany). CBCT scan of the area of interest was obtained in Endo Mode (Planmeca mid, 90 kV, 12.5 mA, 10×10 FOV, Resolution of 150 µm) in addition to gypsum cast scanning as well. Both scans were used for planning, designing, and guides fabrication. Four guides were fabricated with different diameters; 0.5, 1, 1.5 and 1.7 mm to fit different file sizes. In the following visit, the smallest guide, 0.5 mm, was fitted in place and K-file #15 was introduced through the guide and radiographed to confirm the file's location inside the mesiobuccal canal. The larger guide, 1 mm, was then fitted and K-file #15 introduced to ensure canal patency. The working length was confirmed using the electronic apex locator. The larger guide, 1.7 mm, was fitted in place and the orifice opener was used through the guide. The final guide, 1.5 mm, was fitted and Fanta (Fanta, Shanghai, China) single file # 25/0.06 was used till the working length was reached. RT K-file (Mani, Ultsunomiya, Japan) #30 and #35 were used to complete canal shaping without any guidance. 2.5% NaOCl was used as an irrigant along the cleaning and shaping procedures. Finally manual dynamic agitation was done for five minutes in all canals with gutta-percha cone 35/0.04.

The master gutta-percha cone was placed and radiographed. Warm vertical compaction technique was used using E&Q

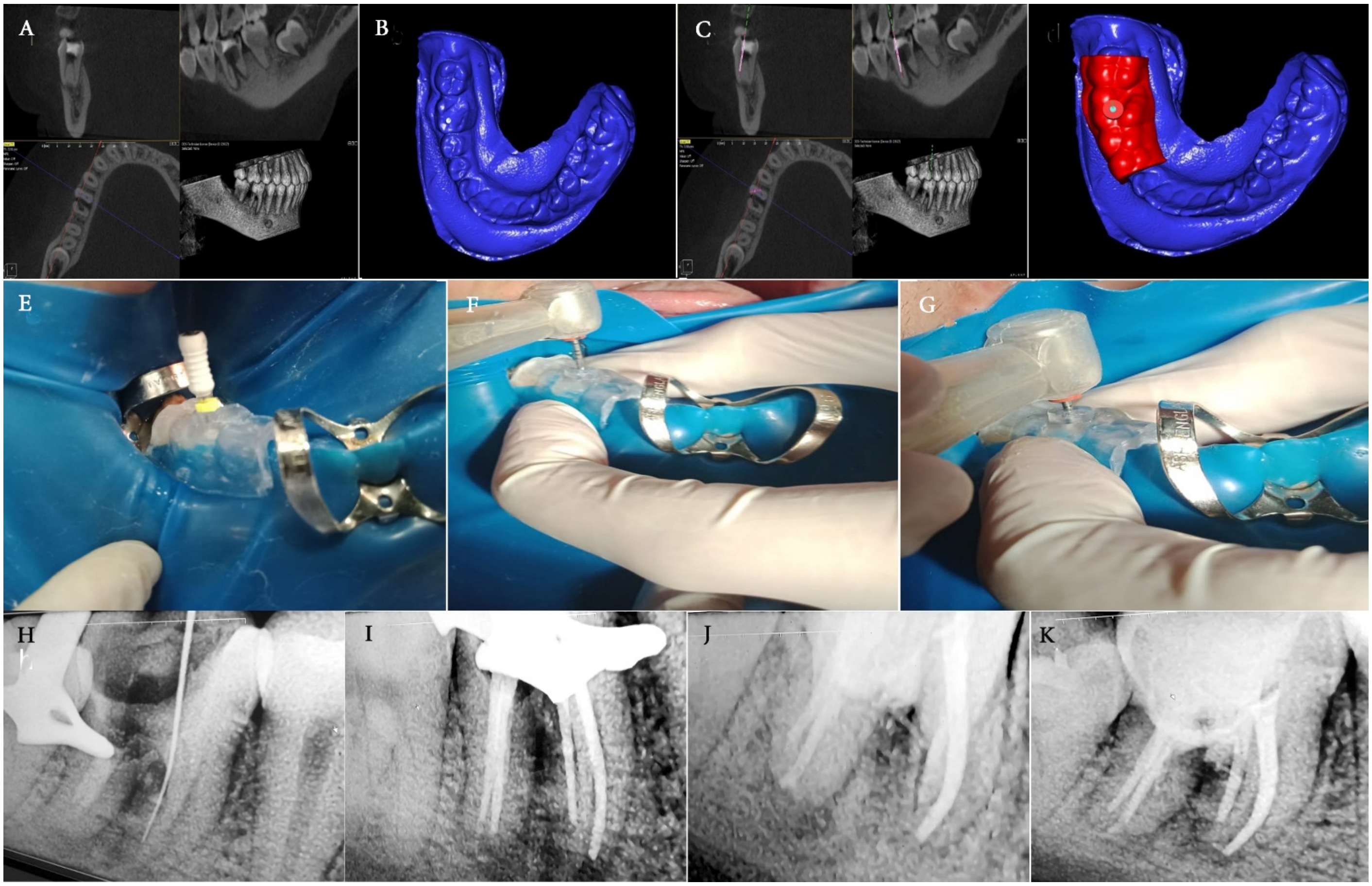

Figure 2. A) CBCT scan showing furcation perforation; *B)* STL file of cast scan of the mandibular arch; *C)* CBCT scan showing planning of the 3D endodontic guide; *D)* designing of the 3D endodontic guide; *E)* K-file #15 inserted through the 3D endodontic guide in the mesiobuccal canal; *F)* rotary file inserted through the 3D endodontic guide in the mesiobuccal canal; *G)* preparation of the mesiobuccal canal with the rotary file reaching the working length; *H)* periapical radiograph showing K-file #15 in the mesiobuccal canal; *I)* periapical radiograph showing the master gutta percha cones reaching the working length; *J)* immediate postoperative periapical radiograph showing the obturated canals and the MTA sealing the furcation perforation; *K)* Six-months follow-up periapical radiograph showing evidence of healing.

obturation system (Meta Biomed, Chungcheongbuk-do, Korea) and AH-Plus sealer (Meta Biomed, Chungcheongbuk-do, Korea). Repair of the perforation was performed under magnification using dental operating microscope (DOM) (Seiler, St. Louis, MO, USA) with MTA Angelus (Angelus, Londrina, Brazil). The coronal access cavity was then sealed using resin-modified glass ionomer restoration.

On the one-month follow-up visit, both cases were asymptomatic, and negative on palpation and percussion. On the one-year follow-up visit of the first case and the six-month follow-up of the second case, both showed good evidence of healing and normal periapical radiographic appearance.

Fabrication of endodontic guides

Limited field of view, high-resolution CBCT scan for the patient was stored in Digital Imaging and Communication (DICOM) format. Record of tooth surface and soft tissue surfaces was obtained indirectly by scanning the model obtained from the impression. One quadrant was obtained to secure stable support for the guide. CBCT scan for the stone cast was exported from the DICOM file to the Surface tessellation language (STL) file using special Romexis software. Patient data in DICOM format and study cast data in STL format were imported and superimposed over each other using DDS PRO software, originally designed for guided implantology. During superimposition, three to six points or reference landmarks were marked. The software automatically merges both scans. Tracing of the canal was performed. Virtual drills with diameters coinciding with the files were used and their angle was adjusted so that the ideal angle of the virtual path ensures that the drill stays in the path of the canal away from the perforation while ensuring not to cut into the root dentin to avoid the risk of ledges and root perforations. The data was transferred to a three-dimensional printer Form 3 (Formlabs, Somerville, MA, USA), and the three-dimensional templates were fabricated (Figure 2).

Discussion

Endodontic mishaps or procedural accidents are inevitable and do occur during root canal treatments. Iatrogenic furcation perforations that occur during access cavity preparation should be sealed as soon as possible. Yet, furcation perforation close to root canal orifices may obscure canal detection and localization, so preparation and obturation will be quite challenging.

Magnification, illumination, and multiple radiographs in addition to the operator's knowledge about the pulp space morphology help in the localization of root canals. Nevertheless, root canals close to furcation perforations might not be localized.

Digital dentistry has been widely developing nowadays offering fast, easy, and reliable options for different challenging procedures. The guided endodontic technique helps in orienting an instrument into a target path. Three-dimensional (3D) endodontic guides have been previously reported in the management of root canals with calcifications. This technique has been reported to be fast, safe, and predictable [10, 12, 13]. The 3D guides direct the drill to the proper position, without the need for a dental operating microscope, and without any reported procedural errors to date reported. This technique replaced the valuable chair-side time by spending time in the digital lab designing and manufacturing the guide.

Based on our previous case reports on using 3D guides in the management of root canal calcifications [10] the authors decided to expand the use of endodontic 3D guides in the management of different challenging endodontic mishaps. To our knowledge, 3D endodontic guides have not been used previously in the localization and preparation of root canals.

In both cases, silicon impression was performed which yielded great precision. Silicon impression is readily available, easy to use, and less costly than the optical impression which was used in most previously reported cases of guided endodontics [12, 14, 15].

Templates with metallic sleeves were previously used while drilling to prevent damage to the guide [9]. In both cases, we succeeded in using resin-based templates without metal sleeves in conjunction with rotary nickel titanium files without any significant damage to the fabricated guides. Multiple guides with different diameters have been used for both cases to fit different file sizes during the preparation of the target root canal.

The first limitation of the use of 3D endodontic guides is the available inter-occlusal distance as previously reported by Connert *et al.* [16] who suggested that it might be inapplicable in posterior teeth. Similar to Lara-Mendes *et al.* [8] and Shaban *et al.* [10], it was possible to apply 3D guides in both cases in mandibular first molars. Patients with limited mouth openings might not be good candidates for the 3D endodontic guides. However successful use of intra-coronal guides was reported by Buchgreitz *et al.* [17] to overcome this constraint.

The second limitation is the inability to apply these guides beyond curvatures, limited to the straight portion of the canal. As long as the coronal portion of the root canal is usually straight, the 3D guide can be readily used in canal localization in teeth with furcation perforations.

The third limitation is that static 3D endodontic guide is not a real-time procedure like dynamic guided endodontics, but it still can save valuable chair-side time if the latter technique is not available.

Conclusion

Three-dimensional endodontic guides are valuable, predictable, safe, reliable, and accurate techniques for the localization and preparation of canals in teeth with furcation perforations. Further research and a higher level of evidence studies are needed to accept or reject this novel approach.

Clinical relevance

Three-dimensional endodontic guides can be used in localization and preparation of root canals in teeth with furcation perforation successfully.

Conflict of Interest: 'None declared'.

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