Targeted Endodontic Microsurgery: A Novel Approach to Anatomically Challenging Scenarios Using 3-dimensional–printed Guides and Trephine Burs—A Report of 3 Cases

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Abstract

Endodontic microsurgery (EMS) techniques have increased success rates over traditional approaches. Despite surgical advances, anatomically challenging scenarios can preclude EMS in certain cases. The aim of this article was to introduce targeted EMS, which uses 3-dimensional–printed surgical guides (3DSGs) and trephine burs to achieve single-step osteotomy, root-end resection, and biopsy in complex cases. In each of 3 cases, a 3DSG with a trephine port was printed using computer-aided design/computer-aided manufacturing implant planning software. The osteotomy site, angulation, and depth of preparation were defined preoperatively to avoid sensitive anatomic structures. The 3DSG was inserted at the target site to achieve precise osteotomy and root-end resection during surgery. A hollow trephine rotated within the 3DSG port produced single-step osteotomy, root-end resection, and biopsy. Root-end preparation and fill were accomplished, and tissues were sutured in place. Targeted EMS potentiated successful surgical treatment in 3 anatomically challenging scenarios: (1) a palatal approach to the palatal root of a maxillary second molar, (2) a facial approach to a fused distofacial-palatal root of a maxillary first molar, and (3) a mandibular second premolar in close proximity to the mental foramen. Trephine burs guided by 3DSGs produce efficient targeted osteotomies with a predictable site, angulation, and depth of preparation. Apical surgery in challenging anatomic cases such as the palatal root of the maxillary second molar, fused molar roots, and root ends in approximation to the mental nerve are possible with targeted EMS. *(J Endod 2018;■:1–7)*

Key Words

3-dimensional printing, apical surgery, endodontic microsurgery, palatal root, surgical guide, trephine stent

Significance

Targeted EMS is useful for osteotomy and root-end resection when exacting control of depth, diameter, and angulation of osteotomy and root-end resection is necessary.

Advances in endodontic microsurgery (EMS) have steadily accumulated over the past 20 years resulting in its widespread use, greater efficiency, and improved outcomes (1). Nonsurgical root canal treatment and EMS provide viable options for dealing with irreversible pulpitis, pulp necrosis, and apical periodontitis in a majority of cases (2). EMS achieves desirable outcomes through enhanced visualization, magnification, and illumination; microsurgical instruments; ultrasonic root-end preparations; and the use of biocompatible materials (2). For EMS, a 35% increase in weighted, pooled success over antiquated techniques has been reported (1, 3).

Cone-beam computed tomographic (CBCT) imaging provides increased visualization of canal morphology, periodontal ligament and bone aberration, root resorption, and appreciation of surrounding anatomic structures (4, 5). CBCT Digital Imaging and Communications in Medicine (DICOM) files converted into stereolithography files have been used in the production of 3-dimensional–printed surgical guides (3DSGs) for implant placement (6, 7). A limited number of articles document the applications of 3-dimensional (3D) printing in endodontics for use as presurgical planning models, endodontic access guides, surgical soft tissue retraction, and localization of the osteotomy perforation site (8–12). The precision and usefulness inherent in preoperatively designed 3DSGs has yet to be fully developed and implemented in EMS.

Trephine burs have been used for the removal of failed implants and autogenous bone graft harvesting but have not previously been described in EMS (13–15). The second and third authors developed a technique (targeted EMS) that combines CBCT and computer-aided design/computer-aided manufacturing to generate 3DSGs for use with trephines. Targeted EMS produces a single-step osteotomy; root-end resection; and biopsy with a defined perforation site, angulation, depth, and diameter. Previous reports have used 3DSGs to locate an ideal bone perforation site, but none have used trephine burs within a stent to define all parameters of osteotomy and root-end resection (12, 16).

Targeted EMS Technique Overview

An 80 × 80 mm preoperative CBCT scan was required (3-D Accuitomo 170; J Morita USA, Inc, Irvine, CA) and a polyvinyl siloxane (PVS) impression (Aquasil Ultra; Dentsply Caulk, Milford, DE) was made and poured. To overcome restoration-

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associated artifacts, a digital 3D scan of the poured model, or in 1 case with minimally restored dentition a CBCT scan of the PVS impression, was made and merged with the preoperative DICOM files. Care was taken to capture the alveolus at the surgical site during impression. The cast was imaged by a benchtop scanner (3Shape D1000; Whip Mix Corp, Louisville, KY). The digital impression file was merged with the CBCT DICOM file in implant planning software (Mimics [Materialise, Leuven, Belgium] or Blue Sky Plan 3 [Blue Sky Bio, LLC, Grayslake, IL]) for the design of the surgical guide. A guide port accommodating the trephine (BIOMET 3i, LLC, Palm Beach Gardens, FL) diameter and specifying the depth of penetration, angulation, and the site of root resection was designed (Fig. 1). Guide ports had a minimum depth of 7 mm to ensure trephine stabilization as determined during *in vitro* testing. The trephine diameter was selected based on root-end width, adjacent anatomic structures, and requirements for visualization. An irrigation window was created in the guide port allowing direct access for copious sterile saline for lubrication and cooling (Fig. 1). A stereolithography file was produced and exported to a 3D printer (Objet 260 Connex3; Stratasys Ltd, Austin, TX), a 3DSG was printed, and an intimate fit was verified on the poured cast.

After soft tissue reflection, the precise fit of the 3DSG was verified. Two retractors cleared soft tissue from the trephine site. The trephine bur port itself provided added protection of the soft tissue. A 5- or 6-mm outer-diameter hollow trephine was rotated at 1200 rpm with maximum torque in an electric handpiece (Anthogyr SAS, Sallanches, France) with sterile water irrigation, incrementally cutting through the bone, root end, and soft tissue with a light pecking motion over 1 to 2 minutes depending on the depth of insertion. For root-end resection of each case, respectively, adequate depth of penetration was designed and determined when the proximal extent of the trephine cylinder was flush with the orifice of the stent guide port (case 1); a depth-defining washer was designed, printed, and placed over the shaft of the bur such that the washer pressed against the guide port limiting penetration depth (case 2); and the handpiece head touched the guide port (case 3) (Fig. 1). Trephine burs with side venting (Figs. 1 and 2), constant copious irrigation, and a gentle pecking motion allowed for osteotomy without excessive heat generation (17).

After cutting, the trephine was removed, and a cylindrical core of bone, root end, and soft tissue was removed. The core specimen was submitted for biopsy. For brevity, the preceding steps will be referred to as "targeted EMS" hereafter. Cases were completed under a surgical operating microscope (OPMI ProErgo; Zeiss Inc, Thornwood, NY) to include ultrasonic root-end preparation and root-end filling (cases 1 and 2) with Endosequence BC Root Repair Material (Brasseler USA, Savannah, GA) (2). Tissue was reapproximated and sutured.

Case 1: Maxillary Second Molar Palatal Root

A 66-year-old American Society of Anesthesiologists (ASA) class I woman taking no medications presented with biting pain in the posterior maxilla. Approximately 1 year before evaluation, tooth #1 was extracted, tooth #2 received nonsurgical root canal treatment, and tooth #3 received retreatment for a long-standing perforation and missed second mesiofacial canal. Tooth #3 had a 9-mm probing depth at the mesiolingual and a 6-mm probing depth at the distolingual. Tooth #2 probings were all 4 mm or less. A sinus tract was present at the base of the lingual papilla between teeth #2 and 3 and traced radiographically to the palatal root of tooth #3. A second sinus tract was present overlying alveolar bone 4 mm posterior to the distal marginal ridge of tooth #2 and traced to the palatal root of tooth #2. For tooth #2, CBCT imaging revealed a $7 \times 5 \times 5$ mm low-density area at the apex of the palatal root with osseous healing at the mesiofacial and distofacial root ends compared with images from 1 year earlier. For tooth #3, CBCT imaging revealed an $8 \times 8 \times 6$ mm low-density area at the apex of the palatal root extending into the furcation, indicating failure of an attempted perforation repair with a hopeless prognosis. Tooth #2 diagnosis was previously treated with a chronic apical abscess, and the patient elected to have palatal root-end surgery in conjunction with extraction and ridge preservation of tooth #3.

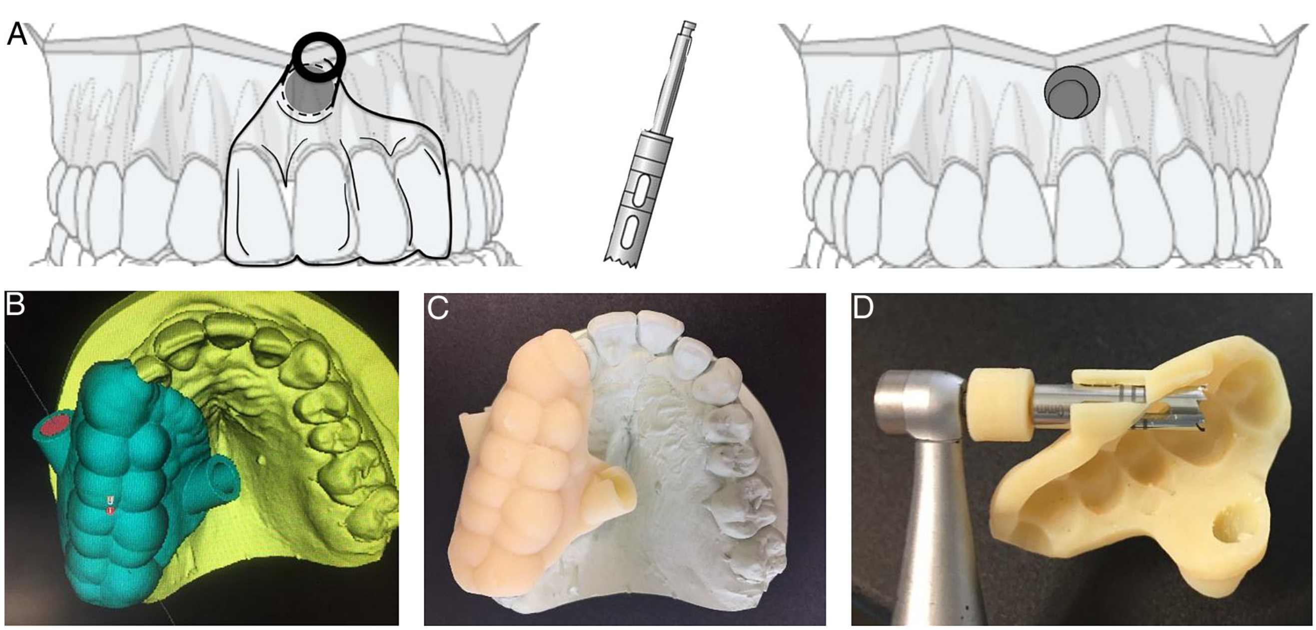

Figure 1. Targeted EMS Overview. (*A*) Illustration of trephine port, trephine, and resultant osteotomy. (*B*) 3DSG with palatal root port and facial port angulated for simultaneous resection of both MF and DF roots. (*C*) Printed 3DSG seated on stone model. (*D*) Trephine placed in port with 3D-printed washer for depth control. Depth control can also be achieved when the handpiece contacts the port or with demarcation lines on the trephine.