The Cortical Window:
Part Two
Computer Guided Endodontic Surgery (CGES)

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Innovations in the micro-armamentarium, techniques and materials used for endodontic microsurgery are seminal to enhanced predictable outcomes by comparison with historical microsurgical procedures. The superior magnification and illumination of surgical operating microscopes heightens identification of root peripheries, ensures a lesser degree of root reduction and diminishes the size of osteotomies thus retaining greater residual bone. Smaller resection angles (perpendicular to the long axis of the root) reduce the number of tubuli exposed. Lateral canals, canal deltas, isthmus connections and micro-cracks can be identified prior to root resection, retro-preparation and retro-sealing.[1]

Studies of positive treatment outcomes for conventional endodontic surgical therapy show a diverse range of success dependent upon an array of predictors.[2,3] A study by Wang et al reported an overall healed rate of 74% of assessed teeth; root filling length and size of preoperative lesions proved to be important predictors of treatment outcomes.[4] Positive treatment outcomes (94%) were demonstrated by microsurgical techniques.[5] Retreatment of failing endodontic procedures demonstrate statistically less positive treatment outcomes than those done by microsurgical techniques (86%); fewer failures ensue.[6] These conditions are more readily addressed with microsurgical techniques.[7]

The Computer Guided Cortical Window Approach

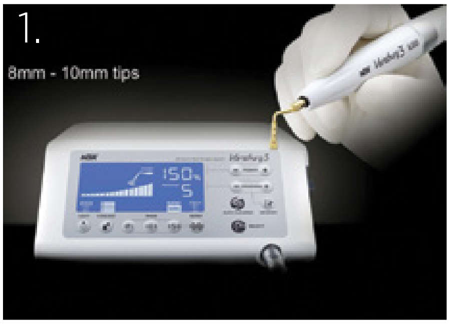
A cortical window (bone lid) access to the apical region is less invasive, minimizes bone loss and is less traumatic in comparison to alternative techniques. The perimeter of the window is determined from radiographs of the area. Radiographs are essential to all aspects of endodontics; however, flat films are two-dimensional images of three-dimensional structures; as such, data interpretation is subjective. Cone beam computed technology (CBCT) enables the clinician to visualize structures in sagittal, axial and coronal planes. Three-dimensional imaging provides more substantial data for diagnosis, pre-treatment planning, post-treatment assessment and reassessment evaluations.[8-9] A printed stereolithographic surgical template can guide the osteotomies during the surgery minimizing deviation from the digital surgical plan. Surgical templates printed from three-dimensional imaging optimize site preparation, the perimeter of the osteotomy, depth of cortical bone, extent of pathology and volume of bone graft required.[10-13]

Piezotome Osteotomy

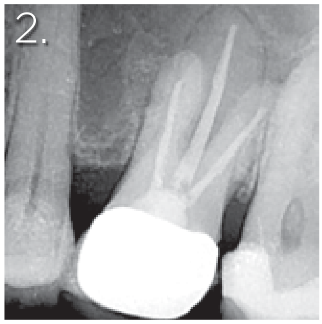
Traditional osteotomies use large round burs which remove significant cortical bone. Delayed healing, increased post-operative pain and other complications may ensue. With microscopes, piezotomes and ultrasonic tips, a smaller osteotomy is created thus minimizing the aforementioned sequelae. Piezo surgery enables micrometric saw cuts which preserve cortical bone loss and facilitates preservation of root length by lower resection angles and enhanced visiblity. In deep spaces, ultrasonic vibrations break down irrigant into small particles readily washed from the crypt. Less vascular presence in the crypt minimizes use of hemostatic agents (Viscostat®Clear UPI South Jordan UT) and interference with retro-seal setting time. The use of a piezo surgical devices **(Fig. 1)** enables accurate shaping of the cortical window and diminished osseous removal.[14] This is in contrast to traditional crypt creation which are free hand guided.

Case Report

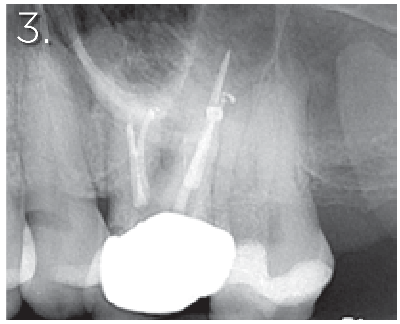
The patient presented to our office with a history of "sporadic discomfort in the gum" overlying tooth #2.6. A two-dimensional intraoral radiograph revealed a prior history of root canal therapy and a porcelain fused to metal (PFM) crown (both completed approximately 10 years past) **(Fig. 2)**. Swell-



A variety of piezotomes are commercially available; saw-toothed tips of 8 to 10 mm are essential. Piezotomes ensure precise and safe cutting of mineralized tissues and preserve soft tissues (blood vessels, nerves, and mucosa).



The PFM crown appears to be fitting appropriately. The root filing demonstrates incomplete sealing and there is no evidence of the expected MB2 canal.



The post-operative radiograph shows four treated canals.

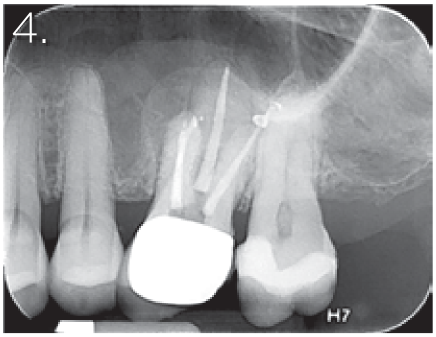
ing began the evening prior to the appointment; the patient reported that the throbbing necessitated analgesics for relief of the pain. No sensitivity to pressure nor reaction to temperature were noted; the patient could not localize the tooth causing the distress. Treatment options were discussed with the patient; retreatment through the PFM crown was chosen.

Anesthesia was administered (Posterior Superior Alveolar nerve block – 2% Xylocaine with epinephrine 1:100,00 and infiltration facially and palatally 2% Xylocaine with epinephrine 1:50,000). A conservative access preparation was made; decay was identified proximal to the palatal canal and no fractures or cracks were noted. Cavit™ was present beneath the composite core and the untreated MB2 canal[15] was discovered. A reservoir was made in the gutta-percha (ultrasonic tip (ProUltra-Dentsply Tulsa Dental Specialties Tulsa OK). EndoSolv E16 was used to soften the gutta-percha. After debridement and shaping, Ca(OH)2 (UltraCal XS – UPI South Jordan UT) was placed in the root canal space to further enhance disinfection. Prior to obturation, drainage was noted coming from the MB2 canal; drainage was arrested and the canals root filled with VCWG (vertical condensation of warm gutta-percha) and AH-Plus® sealer (Dentsply DeTrey GmbH) **(Fig. 3)**. The patient returned in six months for reassessment. Tooth #2.6 was within normal limits to percussion, bite, palpation, mobility and probing. Eighteen months later, the patient returned for a second reassessment appointment **(Fig. 4)**. Tooth #2.6 was slightly sensitive to percussion and the overlying gingival tissues were inflamed. The patient was referred for a CBCT; the scan (www.canaray.com) **(Fig. 5)** revealed a common area of rarefying osteitis surrounding the mesial buccal and distal buccal roots which had caused elevation of the sinus floor. As the endodontic pathology had not resolved, treatment options were proposed. The patient chose to have microsurgical therapy performed.

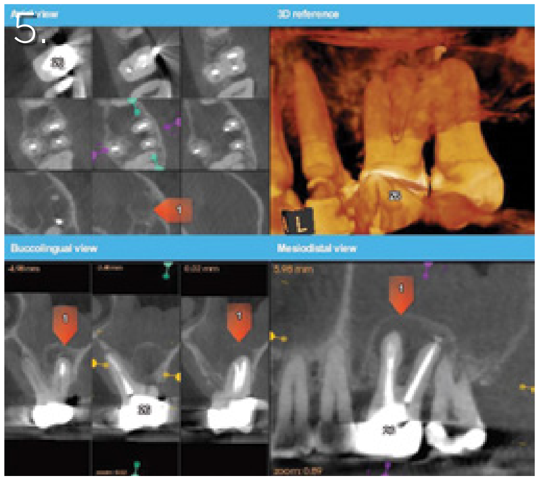
A 3D printed stereolithographic template was created by combining the cbCT scan data with an intra-oral scan's (3Shape TRIOS® intraoral scanner) digital data. The data was then imported into software (Co-Diagnostix – Dental Wings) in order to treatment plan our approach and design our cortical window dimensions for optimal access to the roots **(Fig. 6)**. The guided microsurgical approach would facilitate an osteotomy design to minimize the potential for sinus membrane perforation. The 3D printed guide for the cortical window will guide the length and angle of the osteotomies using the piezosurgical saw **(Fig. 7)**.

Cervical recession and decay were in evidence about teeth #2.4 and 2.5 in addition to exposure of the crown margin of tooth #2.6. The cervical area of tooth #2.7 was severely abraded. An intra-sulcular full thickness muco-periosteal flap was raised; a vertical releasing incision was positioned mesial to tooth #2.5. The surgical stent was placed over the maxillary teeth **(Fig. 8)** and a piezotome guided surgical window was developed using the margins of the stent **(Fig. 9)**. A chisel was used to elevate the cortical plate and root resection performed with Lindeman burs **(Fig. 10)**. The cortical window was placed in sterile saline while the endodontic microsurgery was completed. After resection (Lindemann burs – Brasseler USA®, the root periphery was stained with methylene blue and examined for anomalies,the root canal space was retro-prepared with ultrasonic tips to a depth of 3 mm creating a reservoir for the retro sealing materials.

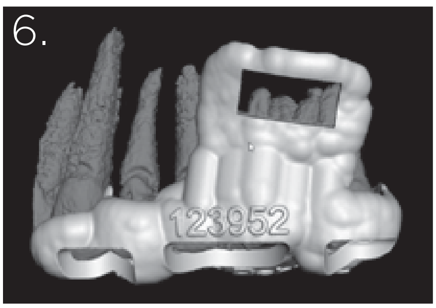
The retro-preparation was rinsed with EDTA and dried with paper points. Super-EBA® (Bosworth Super-EBA–West Columbia SC) was placed **(Fig. 11)** and the root end burnished with a multi-fluted carbide bur. Radiographs were taken at the retro-preparation stage and the retro-sealing stage to ensure accuracy of direction and material placement. The defect thoroughly debrided and was grafted with allograft (Straumann® Canada AlloGraft – Burlington ON) **(Fig. 12)**. The cortical bone window replaced back into position and ensured to have no mobility **(Fig. 13)**



Eighteen months post endodontic re-treatment therapy. Apical pathology appears to be present.

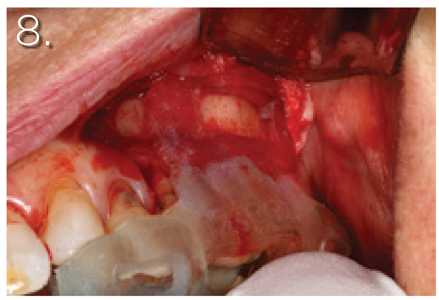


CBCT scan results showing rarefying osteitis and sinus cortical floor elevation along the mesiobuccal and distobuccal roots.

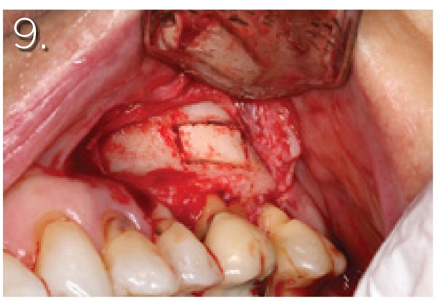


Digital rendering of the surgical stent used to guide the cortical bone window osteotomies.

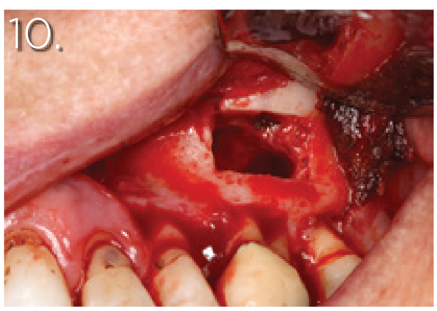
3D printed model and surgical stent to guide our cortical bone window access.



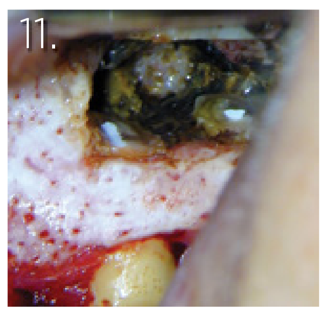
Sugical stent in place against the bone to guide the piezosurgical saw osteotomies.



Clinical view of the completed osteotomies of the cortical bone window.

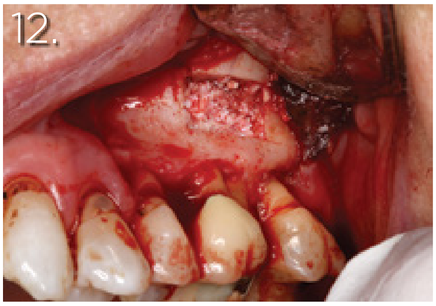


Clinical view of the surgical site once the cortical window has been removed and the roots resected.

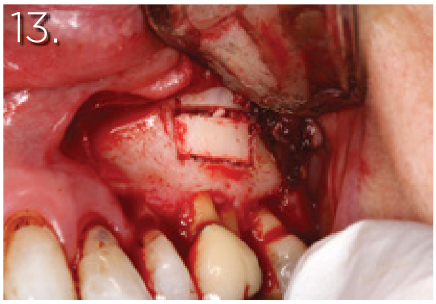


Microsurgical view of the root apical retro-preparation and apical seal.

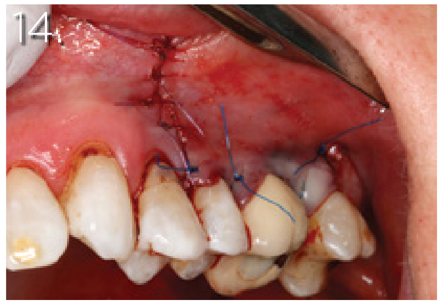
The flap was closed with Ethicon 5-O prolene monofilament sutures **(Fig. 14)** and a postoperative radiograph taken **(Fig. 15)**. The patient was directed to use 800 mg of Advil and 1000 mg of acetaminophen for pain and to rinse bid with chlorhexidine to minimize. Sutures were removed in seven days and the patient reappointed for reassessment. The re-evaluation radiograph taken at nine months showed substantial osseous regeneration **(Fig. 16)** and a post-operative



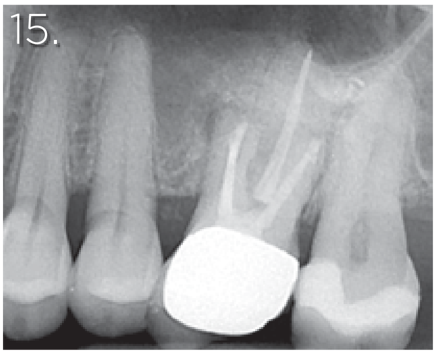
The defect is grafted with allograft cortical bone chips (Straumann Allograft).



The cortical bone window is replaced and fixated in place with gentle pressure.

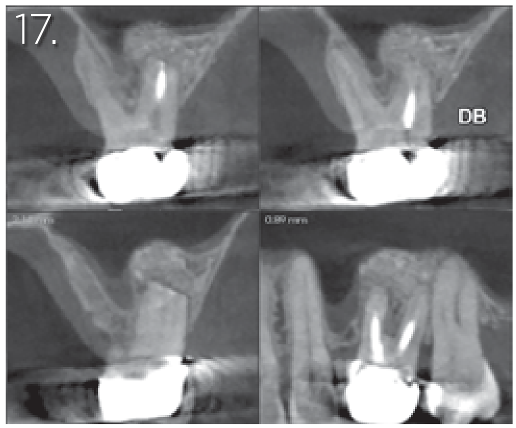


The flap is replaced and sutured with prolene monofilament sutures.



Immediate post-operative radiograph.

Nine-month post-operative radiograph showing excellent bone regeneration.



One-year post-operative CBCT scan showing complete regeneration of the defect and buccal plate.

cbCT scan was taken after one-year showing complete bone regeneration and continuity of the buccal plate **(Fig. 17)**.

Conclusions

Along with surgical operating microscopes and piezotomes, integration of optical scanners and cbCT DICOM files to 3D print stereolithographic surgical guides is yet another iteration in the advancement of endodontic microsurgery. This novel digitally guided approach used in this case report along with the intra-operative use of a 3D printed osteotomy guide allows more efficiency and accuracy for creation of the access window to the roots. The technique gives the advantage of bone preservation by allowing the cortical plate to be replaced, yet still provides adequate access for the apical root preparation. The 3D printed guide provides control for the osteotomies without risking damage to vital structures. This revolutionary digitally guided microsurgical approach provides accuracy, access, control, and bone preservation to the endodontic apical surgery procedure. As we come upon the dawn of a new age of digital dentistry we can see the future applications to be endless across the horizon. **OH**

Oral Health welcomes this original article.

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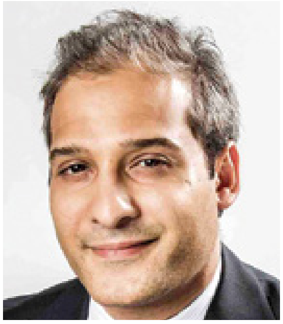

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