CASE REPORT/CLINICAL TECHNIQUES

The Application of “Bone Window” Technique in Endodontic Microsurgery

ABSTRACT
Endodontic microsurgery for a tooth with a large periapical lesion and an intact cortical plate may necessitate the removal of extra bone and cause delayed or unfavorable healing. In such cases, the “bone window” technique offers excellent exposure to the operative field and preserves cortical bone without placing any additional graft material. In the reported cases, root-end surgery was performed on the maxillary and mandibular molars with a large periapical lesion. The bone window was fashioned with the aid of thin osteotomy instruments and repositioned to the original site at the end of the procedure, which resulted in minimizing bone loss and acted as an autogenous graft for the surgical site. At 12- and 16-month follow-ups, clinical examinations and cone-beam computed tomographic scans revealed the healing of the lesion without symptoms or complications. Cone-beam computed tomographic imaging was used as a presurgical assessment tool for indication selection and precise design of the bone window. The use of a bone window in endodontic microsurgery, which appears to be a reliable technique, should be the method of preference when the large lesion is deeply positioned between intact buccal and lingual cortices. (J Endod 2020; : j–j.)"
the need of 2 separated osteotomies for the sake of bone preservation. Moreover, the bone window serves as autologous graft material, which has been approved as the gold standard for regeneration without the need of additional alternative materials. With the incorporation of CBCT imaging, the procedure can be planned more accurately and conducted more efficiently with reduced possible risks. The purpose of this case report and review was to describe this novel technique using bone window ostectomy along with the modern microsurgical technique and materials.

INDICATION SELECTION USING CBCT IMAGING

CBCT imaging has revolutionized the way of case assessment and treatment planning in the field of endodontics. CBCT scanning shows the 3-dimensional location of anatomic structures, provides accurate measurements in depth and length, and improves localization of the periapical lesion, which quickly facilitates the transition of dental diagnosis from 2 dimensions. Furthermore, CBCT imaging has high sensitivity to detect the presence of a bony defect in the cortical plate. Importantly, CBCT imaging allows the measurement of the thickness of cortical plates precisely and also indicates the bone density not only in cortical but also medullary bone and the margins of radiolucent areas. In the axial view of CBCT scans, the thickness of the cortical bone needs to be measured at 3 locations:

1. the apical margin of the periapical lesion,
2. the level of root tip(s), and
3. a level approximately 3 mm coronal to the root apex.

In addition, CBCT scans verify the approximate relationship between the inferior alveolar nerve, the mental nerve, and the apical margin of the bone window, which avoids the risk of damage to the nerves by instrumentation. By combining this information in the design of the bone window, endodontic microsurgery can be performed with improved accessibility, reducing the potential risk of transient or permanent neurologic injuries.

In addition, a large lesion that needs access to 2 roots or the complete enucleation of the cystic lesion is also indication for the bone window technique. The 2 root apices can be visualized by preparing 1 single bone window without the performance of 2 osteotomies, which has been shown to cause substantial loss of the buccal cortical plate. In addition, the single large bone window provides better access to enucleate the disease tissue without interruption.

INSTRUMENTS AND MATERIALS

In cases such as mandibular molars with some bone loss in the medullary bone but the cortical plate is intact, the cortical plate, or “bone window,” is removed using a special device, which avoids the formation of bony defects by adopting an immediate reconstruction approach. This method involves fashioning a bone window with the aid of thin osteotomy instruments. Piezoelectric instruments (Fig. 1D and E) further provide a meticulous and soft tissue paring system for bone cutting. Additionally, ultrasonic vibrations break down the irrigation liquid into very small particles that wash away from the operation field, which results in a low bleeding tendency, reduces intraoperative bleeding, and creates a better visibility of the surgical field with a consequent increase in safety, especially in anatomically difficult areas.

In addition, to achieve hemostasis during endodontic microsurgery, 2 to 3 cartridges of 2% lidocaine with 1:50,000 epinephrine local anesthetic need to be applied into multiple infiltration sites throughout the entire surgical field 20–30 minutes before the initiation of the surgery. After removing all granulation tissue, an epinephrine pellet needs to be placed into the bony crypt followed by dry sterile cotton pellets with pressure for about 2 minutes, which will be removed before the final irrigation and closure. Additionally, small bleeding sites in the bone cavity can be gently brushed with ferric sulfate solution and washed with saline.

The harvested bone window is placed in Hanks’ balanced salt solution (HBSS; Life Technologies, Grand Island, NY) until the end of the procedure. HBSS maintains the viability of bone cells in the bone block during the procedure and reduces the possibility of bone necrosis. The window is removed to access the surgical site and then restored to its original position at the end of the surgical procedure. The bone block is usually stabilized with collagen-based material (Foundation; J Morita Manufacturing Corp, Kyoto, Japan) wedged in the margin of the bone window.

OUTCOME ASSESSMENT

Periapical (PA) radiography has been used to evaluate healing after endodontic surgery. The classic assessment of endodontic surgery outcome is based on Rud and Molven’s criteria; the outcome is classified as follows: complete healing, incomplete healing, uncertain healing, and unsatisfactory healing. However, a recent study has shown that these 2-dimensional criteria are not applicable and useful for the evaluation of 3-dimensional images. CBCT scans in endodontics provide detailed available information for treatment planning and outcome assessment. Furthermore, the 2-dimensional radiographic outcome assessment after apical surgery using the bone window technique would be challenging because of the presence of the original cortical plate, which appears radiopaque immediately postoperatively. Therefore, computed tomographic imaging has been chosen to evaluate the healing of the bone window technique with the availability of buccolingual assessment for bone healing. Recently, the new Penn criteria were introduced for evaluating 3-dimensional scans of endodontic surgical outcome. These new CBCT-based criteria (ie, complete healing, limited healing, and unsatisfactory healing) were simplified from the classifications from Chen’s animal study and made it more clinically relevant and similar to Rud and Molven’s criteria.

CASE REPORT

Case 1 (Tooth #19)

A 59-year-old man was referred to Penn Dental Family Practice for the evaluation and treatment of a left mandibular first molar. He complained of pain on biting and palpation in the area. His medical history was noncontributory. In his dental history, he reported that tooth #19 was endodontically treated 16 years ago. Clinical examination revealed moderate to severe percussion and palpation sensitivity. Periodontal probing and mobility were within normal limits when compared with contralateral and adjacent teeth. PA and bitewing radiographs were obtained and revealed the absence of recurrent caries (Fig. 2A and B). In addition, PA radiographs and CBCT scans (Peraviewepocs 3D F40, J Morita Manufacturing Corp) displayed a PA low-density lesion 14 mm in diameter extending from the apex of the mesial root to the apex of the distal root as well as extruded root canal filling materials from the apex of the mesial and distal roots (Fig. 2A and C–E). The thickness of the buccal cortical plate was 3–5 mm. The radiograph also showed a post in the distal root. The tooth had porcelain fused to a metal crown with good margins and esthetics. Based on the history and clinical and radiographic examination, a diagnosis of previous root canal treatment with...
symptomatic apical periodontitis was established. The patient was offered all treatment options; he opted for microsurgical retreatment. Written consent was obtained.

The microsurgical technique, as suggested by Kim and Kratchman, was performed in addition to the creation of a bony window osteotomy. After rinsing with 0.12% chlorhexidine solution (Peridex; Zila Pharmaceuticals Inc, Phoenix, AZ) for 60 seconds, the patient was administered 2 cartridges of 2% lidocaine for inferior alveolar nerve block and buccal infiltration. After ensuring profound anesthesia, a full-thickness flap was elevated, with 1 release incision distal to tooth #21, and an intact cortical plate was detected. A square window consisting of 2 parallel vertical and 2 parallel horizontal grooves was created using a long tapered needle diamond bur (NTI-Kahla GmbH, Kahla, Germany) and a surgical high-speed handpiece (Aseptico, Woodinville, WA) (Fig. 2F and G). The shallow round grooves were created at the upper mesial corner and the center of the bony window (Fig. 2H). The carved bony window was lifted off with a curved osteotome (Fig. 2I). Two vertical and 2 horizontal grooves were joined to create a bony window of approximately 6 × 12 mm (Fig. 2J), and the bone block was stored in HBSS in order to keep it hydrated (Fig. 2K). The granulation tissue at the surgically exposed site was removed with curved periodontal curettes (Fig. 2L). After 3 mm of root tips including extruded filling materials was resected with a high-speed carbide Lindemann surgical bur (Hu-Friedy, Chicago, IL) at a 0° bevel, healthy bone margins were encountered, and the root tips were clearly visible (Fig. 2M). The resected root surfaces were stained with methylene blue and inspected under high magnification (×16) with a surgical operating microscope (Zeiss OPMI Pico; Carl Zeiss, Oberkochen, Germany) to detect any fracture, missed canals, or isthmus. Root-end preparation was achieved using ultrasonic surgical JetTips (B&L Biotech USA Inc, Fairfax, VA) (Fig. 2N), and the root-end

FIGURE 1 – Designing the bone window with CBCT imaging. (A) Representative linear measurements of the width and height of the periapical lesion obtained with CBCT images and the location of the inferior alveolar nerve. The sagittal section showing the bone density of the cortical and medullary bone. (B) The sagittal section presenting 3 locations for the measurement of thickness of the cortical bone plate. Axial sections showing different thicknesses of the cortical plate at the mesial and distal root: (1) the apical margin of the periapical lesion, (2) the level of the root tips, and (3) a level approximately 3 mm coronal to the root apex. Materials and instruments for a bone window technique. (C) A long tapered needle diamond bur (NTI-Kahla GmbH). (D) Piezoelectric saws (Piezomed tip). (E) The ultrasonic bone cutting system (Piezomed, W&H Dentalwerk).
cavity was filled with EndoSequence BC RRM Putty (Brasseler, Savannah, GA) (Fig. 2F–Q). Collagen graft material (Foundation) was placed in the osteotomy site (Fig. 2R), and the accurate position of the bony window was confirmed with the round groove at the upper mesial corner of the bony block (Fig. 2S). Some collagen material (Foundation) was filled in the spaces around the margins of the bone block while it was replaced and held in position (Fig. 2T), which helped stabilize the bone block. The flap was sutured with 5-0 propylene nylon sutures (Supramid; S Jackson Inc, Alexandria, VA), and a postoperative radiographic was taken (Fig. 2U). The patient was prescribed with oral analgesic (ibuprofen 600 mg 3 times a day) and instructed to rinse twice daily with a 0.2% chlorhexidine mouth rinse for 1 week. He was also instructed not to press the surgical site while applying an ice pack for postoperative management to prevent the bone block from displacement. The sutures were removed 7 days after surgery. The patient presented for follow-up at 6 (Fig. 3A) and 12 (Fig. 3B) months with radiographic signs of complete healing and no clinical signs or symptoms. CBCT scans further revealed no radiolucency on the surgery site and no trace of the bone block at the 12-month follow-up (Fig. 3C–E).

Case 2 (Tooth #14)

A 58-year-old man was referred for treatment of the maxillary left first molar. Tooth #14 was previously endodontically treated 6 years ago. Mild percussion and pain on palpation were observed during clinical examination. The radiographic examination revealed a previously treated root canal with a 10- to 12-mm periapical radiolucency (Fig. 4A–C). The thickness of the buccal cortical plate was 3–5 mm. Based on the history, clinical examination, and radiograph, a diagnosis of previous root canal treatment with symptomatic apical periodontitis was established. In discussion with the patient, apicoectomy with the bone window technique was selected as the treatment of choice. Upon flap elevation, because the cortical plate was found intact, the surgical procedure described earlier was implemented (Fig. 4D). A bone window about 12 mm horizontally and 7 mm vertically was created using a piezoelectric saw (Piezomed tip; W&H Dentalwerk, Bürmoos, Austria), and a shallow hole was made at the upper mesial corner of the bone block, which is a helpful mark for repositioning the bone block in the original location (Fig. 4E). The bone block was harvested and placed in HBSS (Fig. 4F). After the bone defect was verified (Fig. 4G), root-end resection and granulation tissue removal were performed. Root-end preparation was then completed (Fig. 4H) with JetTips ultrasonic tips (B&L Biotech USA Inc) and sealed with EndoSequence BC RRM Putty (Brasseler). Foundation was placed in the bony defect (Fig. 4I), and the bone block was replaced and held in position with some collagen material filled in the gap along the approximated bone margins (Fig. 4J). A resorbable collagen membrane (Bio-Gide; Geistlich Pharma North America, Inc, Princeton, NJ) was used to cover the bone block (Fig. 4K). The flap was sutured with 5-0 propylene nylon sutures (Supramid, S Jackson Inc), and the surgical procedure was completed (Fig. 5A).
follow-up at 16 months with radiographic signs of healing and no clinical signs or symptoms (Fig. 5B–D).

**DISCUSSION**

The present study showed the bone window technique proved to be safe and valid with these case series. Their 12- and 16-month follow-up CBCT scans revealed complete healing of the periapical lesion and adaptation of the bone window in the jaw bone without leaving any gaps or concavity (Figs. 3 and 5).

The barrier membrane has been widely used in endodontic surgery to seal off the defect and prevent unwanted soft tissue cell migration into the wound. It can also serve as a guide for bony granulation tissue to rebuild osseous tissue underneath the membrane. In case 2, it was used to maximize the stabilization of the bony block (Fig. 4K). The bone graft used underneath the membrane can help maintain the space and accelerate bone regeneration with its osteoconductive...
However, the replaceable bony window is a firm autologous build-in barrier which has the ability to maintain space and osteoinductive potential to accelerate the new bone formation\(^{23,41–43}\). For these reasons, the bony window might be a valid alternative for the endodontic microsurgery.

Prognostic factors relating to the outcome of endodontic surgery have been discussed in several articles\(^{4–6,8,10,44,45}\). One of the prognostic factors is the size of the bony crypt. At the 1-year follow-up, large bony defects tend to have more nonhealed cases compared to small bony defects\(^{44}\). With the bone window technique, the size of the bony defect can be reduced to just a trench. A traditional bone window was prepared by high-speed rotary instruments, such as round or fissure burs\(^{16}\). We also used a long tapered needle diamond bur with a surgical high-speed handpiece in case 1 (tooth #19) (Fig. 2F–H). This method resulted in bur diameter–sized spaces around the bony block, which required extra attention to stabilize the bony block in its original position. In case 2 (tooth #14), we used the piezoelectric saw, which has recently been applied in the bone window technique (Fig. 4).

Bone windows created with piezotomography\(^{25,26}\) showed more viable cells on the graft with less postoperative discomfort and no damage to the mandibular nerve compared with procedures performed by high-speed burs or other thicker piezoelectric tips\(^{25,26}\). In addition, these thin piezoelectric saws produce less intraoperative bleeding, which provides better accessibility and visibility for the operator to create a bone window with precision and ease.

The stability of the wound is 1 of the key factors for predictable bone regeneration\(^{46}\). We created 2 shallow round grooves at the upper mesial corner and the center of the bony window (Fig. 2H) to help find the original position of the bony block and carefully hold it with a microsurgical tissue plier while removing and repositioning it. Once endodontic microsurgery is completed, the buccal bone plate is repositioned. Its stabilization can usually be achieved with the built-in wedge preparation of the bone window without the need of any fixation appliance. Furthermore, a resorbable collagen membrane can be placed to cover the bone block and maximize its stabilization (Fig. 4K). In addition, cutting a bone window with a longer internal beveled edge facilitates the replacement of the bone block in its original position and also enables a higher degree of fixation\(^{16,24}\). During the surgical procedures, careful attention needs to be paid to avoid altering the profile of the bone window and the preplating areas\(^{57}\). However, if the gap between the bone window and the adjacent bone wall is large, the collagen-based filling material can be used to seal the gap and help stabilize the bone window. Based on our experiences from over 100 cases, using fixing miniplates or screws is not essential for fixation of the bone window in endodontic microsurgery. However, a study and our experience claimed that the grafting material placed in the bone defect can provide additional support and stability to the bone block, which prevent it from dislodging or depressing into the surgical site\(^{17}\).

The recent case series study using the bone window technique reported that 20 of the 21 cases showed the alveolar bone volume recovery averaged more than 90%, with only 2 patients experiencing long-term complications (inferior alveolar nerve paresthesia in 1 because of the removal of a deeply impacted tooth and bone lid necrosis in the other secondary to a sport trauma 1 month after the surgical procedure)\(^{24}\). This study included
patients with various conditions like large cysts, impacted teeth with associated cysts, odontogenic tumors, and an endodontic lesion.

Even though these included cases were mostly large lesions and some of them needed fixing plates, the majority of cases completely healed without complications. Mobility of the repositioned bone block may interfere with the healing of the osteotomy margins, possibly causing bone necrosis and sequestration. To prevent displacement of the bone block, patients need to be instructed not to press the surgical site.

Most of the cases can be defined as success or failure 1 year after the endodontic surgery. Only with the situation that radiographic film categorized as uncertain healing needs to elongate the observation period to four years. However, the success rate is lower if we evaluate the healing with CBCT one year after surgery comparing with periapical film. This indicates one year is too fast to evaluate the regular surgical healing with CBCT. On the other hand, CBCT can capture obvious bone healing one year after surgery if using bone window technique, which is also agreed with our cases. Additional large scale studies using the Penn criteria are required to provide the proper timing for the CBCT outcome assessment of surgery with bone window technique.

In conclusion, the bone window technique prevents the formation of large residual bone defects after endodontic microsurgery and preserves cortical plates, thereby making additional bone grafting unnecessary. This technique enables the complete enucleation of large cystic lesions as well as accurate examination of the surgical field with easy access. Achieving successful outcomes with this technique relies on the examination of bone quality/thickness and the design of an adequate window size preoperatively with CBCT scans and stabilization of the bone block with the aid of an optimized design that enables its reintegration.

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REFERENCES


