Principles of Endodontic Surgery

Categories of endodontic surgery

1- Periapical surgery.
2- Hemisection/root amputation.
3- Intentional replantation.
4- Corrective surgery.

1- PERIAPICAL SURGERY (i.e., periradicular) :-

includes resection of a portion of the root that contains undebrided or unobturated (or both) canal space. It can also involve reverse filling and sealing of the canal when conventional root canal treatment is not feasible. It is often performed in conjunction with apical curettage for reasons explained later.

Indications

The success of apical surgery varies considerably, depending on the reason for and nature of the procedure. With failed root canal treatment, often retreatment is not possible or a better result cannot be achieved by a coronal approach.

Indication for periapical surgery :-

1- Occasionally an unusual entity in the periapical region requires surgical removal and biopsy for identification
2- Occasionally when the cause of root canal failure cannot be identified so surgical exploration may be necessary
3- Anatomic problems preventing complete debridment /obturation
4- Restorative consideration that compromise treatment
5- Horizontal root fractures with apical necrosis
6- Irretrievable material preventing canal treatment or retreatment
7- Procedural error during treatment
8- Large periapical lesion that do not resolve with root canal treatment
1- Occasionally an unusual entity in the periapical region requires surgical removal and biopsy for identification

When there is any possibility that periapical radiolucencies is of non odontogenic origin Like the example bellow

Surgical removal of pathosis. A, Pulp is responsive; this indicates that radiolucent lesion is not endodontic (i.e., pulpal) in origin. B, Because roots must be resected while removing the lesion, root canal treatment is performed. C, Distal root is resected and lesion is excised. D, Biopsy shows this to be an ossifying fibroma.
2- Occasionally when the cause of root canal failure can not be identified so surgical exploration may be necessary

Occasionally can occur when the radiographical investigation reveal no thing this can occur with small longitudinal fracture

3- Anatomic problems.
   A- Calcifications or other blockages .
   B- Severe root curvatures .
   C- Constricted canals (i.e., calcific).

They may compromise root canal treatment, through out preventing instrumentation, obturation, or both . Because a canal is always present (even if very small), failure to debride and obturate may lead to failure.

Although the outcome may be questionable, it is preferable to attempt conventional root canal treatment or retreatment before apical surgery. If this is not possible, removing or resecting the uninstrumented and unfilled portion of the root and placing a root end filling may be necessary.

A, Very small canal (i.e., calcific ) with pulp necrosis and apical pathosis Canal could not be located with occlusal access. B, Apical resection and root end retrograde amalgam to seal in irritants.
4- **Restorative considerations.**
When there is crown on a mandibular incisor. An opening could compromise retention of the restoration or perforate the root. Rather than attempt the root canal treatment, root resection and root-end filling may be preferred treatment option.

A common requirement for surgery is failed treatment on a tooth that has been restored with a post and core. Many posts are difficult to remove or may cause root fracture during removal.

5- **Horizontal root fracture.**
Occasionally, after a traumatic root fracture, the apical segment undergoes pulp necrosis. Because this cannot be predictably treated from a coronal approach, the apical segment is removed surgically after root canal treatment of the coronal portion.

The following pictures shows (A, Horizontal root fracture, with failed attempt to treat both segments. B, Apical segment is removed surgically and retrograde amalgam placed. C, Healing is complete after 1 year).

6- **Irretrievable material in canal.**
Canals are occasionally blocked by objects such as separated instruments, restorative materials, segments of posts, or other foreign objects. If evidence of apical pathosis is found, those materials must be removed surgically, usually with a portion of the root.
7- Procedural error. Separated instruments, ledging, gross overfills, and perforations may result in failure. Although overfilling is not in itself an indication for removal of the material, surgical correction is frequently necessary in these situations.

A, Overfill of injected obturating material has resulted in pain and paresthesia as a result of damage to inferior alveolar nerve. B, Corrected by retreatment, then apicectomy, curettage, and a root end amalgam fill.
8- Large unresolved lesions after root canal treatment.
Occasionally, very large periradicular lesions do not heal or may even enlarge after adequate debridement and obturation.

After partial resolution, root end resection and filling with amalgam are performed.

Contraindications (or Cautions)
If other options are available, periapical surgery may not be the preferred choice:-

1- When conventional root canal treatment is possible
2- When retreatment of treatment failure is possible.
3- Anatomical structures e.g. adjacent nerve or vessel are in jeopardy.
4- Structures interfere with access and visibility.
5- Compromise of crown/root ratio.
6- Systemic complication (like bleeding disorder)

1- When conventional root canal treatment is possible.
In most situations orthograde conventional root canal treatment is preferred. Surgery is not indicated just because debridement and obturation are in the same visit, although there has been a long-held, incorrect notion (concept or belief) that single-visit should be accompanied by surgery, particularly if a periradicular lesion is present.

2- Anatomic considerations.
Most oral structures do not interfere with a surgical approach but must be considered.
A- An example is the maxillary sinus, which may become exposed. Creating a sinus opening is neither unusual nor dangerous. However, caution is necessary to not introduce foreign objects into the opening and to remind the patient not to exert
pressure by forcibly blowing the nose until the surgical wound has healed (in 1 to 2
weeks).
B- The external oblique ridge over the mandibular second and third molars. In most
cases this structure prevents adequate access to the root apices; periapical surgery of
these teeth is often not feasible. Other approaches, such as intentional replantation,
may be indicated.
C- The zygomatic buttress may inhibit access to maxillary molar apices.
D- Prominent chin creates a shallow vestibule with limited access to mandibular
anteriors.
E- The mental foramen is of concern but is easily avoided by identifying its position
radiographically and during flap reflection.
Intentional replantation. A. Failed treatment of what is likely C-shaped canal. Because of external oblique ridge, apex is inaccessible to surgery. B. Tooth is extracted. C. Root end is resected, prepared for amalgam in C-shaped canal, and (D) replanted. E. At 4-year recall, bone has regenerated and tooth is immobile.

3- **Poor crown and root ratio.**
Teeth with very short roots have compromised bony support and are poor candidates for surgery; root end resection in such cases may compromise stability.

4- **Medical (systemic) complications.**
The general health and condition of the patient are always essential considerations. No specific contraindications for endodontic surgery exist that would not be similar to those for other types of oral surgical procedures.
Surgical Procedure

The following eleven steps, with modifications as appropriate, make up the typical approach: (1) flap design, (2) incision and reflection, (3) access to the apex, (4) curettage, (5) root end resection, (6) root end preparation and filling, (7) radiographic verification, (8) flap replacement and suturing, (9) postoperative instructions, (10) suture removal, and (11) long-term evaluation.

1- Flap design.
A properly designed and carefully reflected flap will result in good access and uncomplicated healing. The basic principles of flap design should be followed.

2- Incision :-
the three most common incisions are (1)Semilunar, (2) submarginal, (3) Sulcular. The submarginal and full mucoperiosteal incision will have either a three-corner (i.e., triangular) or four-corner (i.e., rectangular) design.

A- Semilunar incision. This is a slightly curved half-moon horizontal incision in the alveolar mucosa.
Advantages
1- The location allows easy reflection.
2- Easy suturing.
Disadvantages include
1- Access to the periradicular structures is restricted.
2- Excessive hemorrhage.
3- Delayed healing.
4- Scarring;
This design is contraindicated for endodontic surgery.

B- Submarginal incision.
The horizontal component is in attached gingiva with one or two accompanying vertical incisions. Generally the incision is scalloped in the horizontal line, with obtuse angles at the corners. It is used most successfully in the maxillary anterior
region or, occasionally, with maxillary premolars with crowns. Because of the design, prerequisites are at least 4 mm of attached gingiva and good periodontal health. The major advantage
1- Esthetics is the major advantage, Leaving the gingiva intact around the margins of crowns is less likely to result in bone resorption with tissue recession and crown margin exposure.
2- Compared with the semilunar incision, the submarginal provides less risk of incising over a bony defect and provides better access and visibility.

Disadvantages include
1- Hemorrhage along the cut margins into the surgical site.
2- Occasional healing by scaring, compared with the full mucoperiosteal sulcular incision.

C- Full mucoperiosteal incision. This is an incision into the gingival sulcus, extending to the gingival crest. This procedure includes elevation of interdental papilla, free gingival margin, attached gingiva, and alveolar mucosa. One or two vertical relaxing incisions may be used, creating a three- or four-corner design. When feasible the full mucoperiosteal design is preferred over the other two techniques. The advantages include
1- Maximum access and visibility.
2- Not incising over the lesion or bony defect.
3- Less tendency for hemorrhage.
4- Complete visibility of the root, allowance of root planing and bone contouring.
5- Reduced likelihood of healing with scar formation.
The disadvantages:
1- More difficult to replace and to suture.
2- Gingival recession frequently develops, exposing crown margins or cervical root surfaces (or both)

**Incision and reflection.** A firm incision should be made through periosteum to bone. It is important to incise and reflect a full-thickness flap to minimize hemorrhage and to prevent tearing of the tissue. Reflection is with a sharp periosteal elevator beginning in the vertical incisions, then raising the horizontal component. To reflect the periosteum the elevator must firmly contact bone while the tissue is raised.
3- Periapical exposure.
Frequently, the cortical bone overlying the apex has been resorbed, exposing a soft tissue lesion. If the opening is small, it is enlarged using large surgical round bur, until approximately half root and the lesion are visible. With a limited bony opening, radiographs are used conjunction with root and bone topography to locate the apex. A measurement may be made with a periodontal probe on the radiograph, then transferred to the surgical site to determine the apex location. Avoid air emphysema. Regardless of the handpiece used, there should be copious irrigation with syringe or through the handpiece with sterile saline solution. Enough overlying bone should be removed to expose the area around the apex and at least half \(\frac{1}{2}\) length of the root. Good access and visibility are important; the bony window must be adequate.
4- Curettage.
Most of the granulomatous, inflamed tissue surrounding the apex should be removed to
gain access and visibility of the apex, to obtain a biopsy for histologic examination
(when indicated), and to minimize hemorrhage.
If possible the tissue should be enucleated in one piece with a suitably sized sharp
curette, although total lesion removal usually does not occur. A cleaner bony cavity will
have the least hemorrhage and the best visibility. Tissue removal should not jeopardize
the blood supply to an adjacent tooth. In addition, some areas of the lesion may be
inaccessible to the curettes, such as on the lingual aspect of the root. Portions of
inflamed tissue or epithelium may be left, without compromising healing; total removal
is not necessary.
If hemorrhage from soft or hard tissue is excessive to the extent that visibility is
compromised, homeostatic agents or other control techniques are useful. These agents
should be removed after use. The best hemorrhage control is to apply and hold direct
pressure over a bleeding site with gauze and to also minimize suction; the site of a
bleeder.

Curettage. Much of lesion that is accessible is removed with large curettes. Usually,
remnants of tissue remain, which is not a problem. A, Frontal view. B, Cross-section.
5- Root end resection.
Root end resection is often, but not always, indicated. It is useful in two situations:
(1) To gain access to the canal for examination and placement of a root end preparation and restoration.
(2) To remove an undebrided or unobturated (or both) portion of a root.
This may be necessary in cases with dilacerated roots, ledged or blocked canals, or apical canal space that is inaccessible because of restorations, as well as in accessing of lingual structures.
The resecting is with the tapered fissure but, depending on the location and whether a root end preparation is to be placed, a bevel of varying degrees is made in a faciolingual direction. The amount of root removed depends on the reason for performing the resection. Sufficient root apex must to removed to provide a larger surface and to expose additional canals. In general, approximately one half to one third of the root is resected—more if necessary for apical access; less if too much removal would further compromise stability of an already short root.

Root end resection. Approximately one third of apex is removed with tapered bur. Amount removed and degree of bevel varies according to situation. A, Frontal view. B, Cross-section.
6- Root end preparation and restoration.
This is indicated if there likely is an inadequate apical seal. The preparation should extend at least 3 to 4 mm into the root to include the canal. The shape of the preparation should mimic the shape of the cut surface of the root. The outline must include other canals and aberrations, such as an isthmus. Root end preparation may be done by slow-speed, specially designed microhandpieces or by ultrasonic tips.

Ultrasonic instruments offer some advantages of control and ease of use; they also permit less apical root removal in certain situations; Another advantage of the ultrasonic tips, particularly when diamond coated, is the formation of cleaner, better shaped preparation. Evidence suggests that success rates are significantly improved with ultrasonic preparation.

![Root end preparation. Microhandpiece with small round or inverted cone bur should prepare several millimeters into root. A, Frontal view. B, Cross-section.](image1.png)

Ultrasonic preparation tips are available in several designs and shapes for different applications. On right are micro-handpiece and conventional handpiece.
A. Ultrasonic tips are good alternative for root end preparation. B. These permit preparation with better control and less root removal.

7- Root end-filling materials.
The root end-filling material is placed into the cavity preparation. These materials should seal well, be tissue tolerant, easily inserted, minimally affected by moisture, and visible radiographically. Importantly, the root end-filling material must be stable and nonresorbable indefinitely.

A- Amalgam (preferably zinc free).
B- Mineral trioxide aggregate (MTA) has shown favorable biologic and physical properties and ease of handling it has become a widely used material.
C- Intermediate restorative material (IRM), and Super ethoxy benzoic acid cement have been commonly used materials.
D- Glass ionomer cement can be used but has less clinical documentation of success.

No single, all-purpose, superior root end-filling material exists. Those that demonstrate the best combination of physical and biologic properties, as well as documentation of clinical success, are amalgam, MTA, composite resin and reinforced zinc oxide cements (e.g., IRM and Super EBA); one of these materials should be selected, according to the conditions.

Amalgam should not be used if the field is bloody or if the root end preparation is less than 3 millimeters, or if access is limited.
Composite resin with a bonding agent must be placed in a dry field. This material may be used in a shallow, concave preparation and has shown to be successful in molar root end surgeries.

MTA, with its good properties, may be placed in a field in which some hemorrhage has occurred; the final set is not adversely affected by blood contamination. The long-term
stability of MTA is unknown, because the material is relatively new. It likely has good longevity.

8- Irrigation.
The surgical site is flushed with copious amounts of sterile saline to remove soft and hard tissue debris, hemorrhage, blood clots and excess root end-filling material.

9- Radiographic verification.
Before suturing, a radio-graph is made to verify that the surgical objectives are satisfactory. If corrections are needed, these are made before suturing.

10- Flap replacement and suturing.
The flap is returned to its original position and held with moderate digital pressure and moistened gauze. This expresses hemorrhage from under the flap and gives initial adaptation and more accurate suturing. Silk sutures are generally used, although other materials are suitable, including 4-0 absorbable suture. Interrupted sutures are common, although both horizontal and vertical mattress and sling sutures are applicable in certain situations. After suturing, the flap should again be compressed digitally with moistened gauze for several minutes to express more hemorrhage. This encourages less postoperative swelling and more rapid healing.

11- Postoperative instructions.
A- Both oral and written information should be supplied in simple, straightforward descriptions.
B- The wording should minimize anxiety arising from normal postoperative sequelae (i.e. swelling, discomfort, possible discoloration, and some oozing of blood) and the ways in which these sequelae can be prevented, managed, or both.
C- The surgical site should not be disturbed, and pressure should be maintained.
D- Cold packs over the surgical area until bed-time might help.
E- Oral hygiene procedures are indicated everywhere except the surgical site; careful brushing and flossing may begin after 24 hours.
F- A chlorhexidine rinse, twice daily, reduces bacterial count at the surgical site. This will minimize inflammation and enhance soft tissue healing.
G- Proper nutrition and fluids are important but should not traumatize the area.
E- Analgesics are recommended, although pain is frequently minimal; strong analgesics are usually not required. Analgesics for moderate pain will usually suffice and are most effective if administered before the surgery or at least before the anesthetic wears off.
F- Antibiotics are not indicated as a prophylactic measure or even with a localized abscess.

G- The patient is instructed to call if excessive swelling or pain is experienced. Postoperative complications are a response to injury from the procedure; infection after this type of surgical procedure is rare. However, the patient should be evaluated in person if there are difficulties.

12- Suture removal and evaluation.
Sutures ordinarily are removed in 7 days, with shorter periods being preferred to enhance healing. By the 4th days swelling and discomfort should be decreasing. In addition, there should be evidence of primary wound closure; tissues that were reflected should be in apposition. Occasionally, a loose or torn suture may result in nonadapted tissue. In these cases the margins are readapted and resutured.

CORRECTIVE SURGERY
Corrective surgery is managing defects that have occurred by a biologic response (i.e., resorption) or iatrogenic (i.e., procedural) error. These may be anywhere on the root, from cervical margin to apex. Many are accessible; others are difficult to reach or are in virtually inaccessible areas. A corrective procedure is necessary. Generally, the procedure involves exposing, preparing, then sealing the defect.

Indications
1- Procedural errors.
Procedural errors are openings through the lateral root surface created by the operator, typically during access, canal instrumentation, or post space preparation. The result is perforation. Perforations often require restorative management and completion of the root canal treatment, usually in conjunction with the surgical phase. The location of the perforation influences success; some are virtually inaccessible. If the defect is on the interproximal, in the furcation, or close to adjacent teeth or to the lingual, adequate repair may not be possible or is compromised. Defects that are too far posterior (particularly on the distal or lingual aspects) may be very difficult to reach. The nature and location of the perforation should be determined with angled radiographs before the decision is made whether to repair surgically, to remove the involved root, or to extract.
Postperforation repair. A, Lesion developing lateral to off-centered post suggests perforation that (B) is identified (arrow) on flap reflection. C, Post is reduced to within root and cavity filled with amalgam (D).

2- Resorptive perforations.
Resorptive perforations may be internal or external in origin resulting in a communication between pulp and periodontium. A more serious defect is one that extends to include cervical exposure to the oral cavity.
Resorption occurs for several reasons, but most cases include inflammation from an irritant. These irritants include sequelae to trauma, internal bleaching procedures, orthodontic tooth movement, restorative procedures, or other factors causing pulp or periradicular inflammation. Occasionally, resorptions are idiopathic, with no demonstrable cause.

As with procedural errors, the considerations as to treatability and surgical approach are similar.

External resorption repair. A, Mesially angled radiograph shows defect (arrow) to be lingual. B, After flap reflection, crestal bone reduction, and rubber dam isolation, defect is prepared (arrow). Margins
must be in sound tooth structure. C, Cavity is filled with amalgam and flap apically positioned. D, Long-term radiographic and clinical evaluation is necessary; at times, resorption recurs.

**Contraindications**

**Anatomic considerations.** Consideration must be given to structural impediments to a surgical approach. Few exist, and most can be managed or avoided. Included are various nerve and vessel bundles and bony structures, such as the external oblique ridge.

**Location of perforation.** As mentioned previously, the defect must be accessible surgically. This means the clinician must be able to locate and, ideally, to readily visualize the surgical area.

**Accessibility.** A handpiece or an ultrasonic instrument generally is necessary to prepare the defect. Therefore the defect must be reachable, without impedance by structures or by lack of visibility.

**Surgical approach.**

Repair presents a unique set of problems. The defect may wrap from facial to proximal to lingual, creating not only difficulties in visualization but also problems with access and hemostasis and material placement. A general guideline is that the defect is larger and more complex than it appears on a radiograph. Generally, the defect must be enlarged to provide a sound cavosurface margin and to avoid knife-edge margins. Occasionally, the repair is internal (from inside the canal), with material being extruded through the defect. The excess is removed and contoured with burs or sharp instruments. The objective is to seal and stabilize the defect with a restorative material. If a post or other material is perforating the root, it must be reduced with burs to within root structure and a cavity prepared. Then the defect is restored with one of the materials mentioned previously.

**Repair material.**

A- External repair is often with amalgam.
B- if the field is dry, glass ionomer or dentin-bonding agent with composite resin.
C- MTA or Super EBA.
One major difference is in the repair of a defect that will be exposed to oral fluids; Super EBA or MTA are contraindicated, because they will gradually wash out of the cavity. More stable materials—composite resins, amalgam, or glass ionomers—are preferred. Certain glass ionomers have promise and have indicated the possibility of tissue attachment to the material, although long-term studies are lacking.

**Prognosis.**

A- Repairs in the cervical third or furcation in particular have the poorest prognosis. Communication often is eventually established with the junctional epithelium, which will result in periodontal breakdown, loss of attachment, and pocket formation. This would mean that a periodontal procedure (e.g., crown lengthening) would be required in conjunction with the defect repair.

B- A defect in the middle or apical third that is properly prepared and sealed will have a very good long-term prognosis

**Surgical Procedure**

A- Flap designs are similar but are more limited.

B- A sulcular incision is usually required, with at least one vertical incision to form a three-cornered flap. A full-thickness flap is reflected.

C- Bone removed to expose the defect. Bone removal must be adequate to allow maximal visualization and access. If possible, a rim of cervical bone should be retained to support the flap and possibly to enhance reattachment; this is frequently not possible with cervical defects.

D- The preparation of a facial or lingual defect is similar to that of a class I cavity preparation.

E- Flap replacement, suturing, and digital pressure are as described earlier.

F- Suture removal should be within 7 days.

G- Postoperative instructions are similar to those after periapical surgery.
A, Misdirected post is perforating distally. B, Full mucoperiosteal (i.e., sulcular incision) three-corner flap is raised and bone removed to expose defect.

A, Post is reduced to well within root, and cavity is prepared. B, In this cross-section through defect, a lingual wall to the preparation is evident.

HEALING

Healing after endodontic surgery is rapid because most tissues being manipulated are healthy, with a good blood supply, and tissue replacement enables repair by primary intention. Both soft tissues (i.e., periosteum, gingiva, alveolar mucosa, periodontal ligament) and hard tissues (i.e., dentin, cementum, bone) are involved. Time and mode of healing varies with each, but involve similar processes.

RECALL

Recall evaluations to assess long-term healing are important. Some failures after surgery are evidenced only by radiographic findings.

A 1-year follow-up is generally a good indicator. If, after 1 year, radiographic evidence shows no decrease in lesion size or lesion size increases, it generally indicates a failure and persistent inflammation.

A decrease in lesion size (indicating hard tissue formation) may lead to complete healing and requires evaluation at 6 to 12 months. Of course, persistent symptoms, such
as pain or swelling (or both), presence of sinus tract, deep probing defects, or other adverse findings would also indicate failure.

Healing by scar tissue after surgery occurs primarily in the maxillary incisors. This is unusual and has a unique radiographic appearance with an irregular distinct outline, often separated from the root end. Healing by scar tissue is considered to be a successful outcome.

Frequently, structures over the apex do not regenerate to a normal appearance. At times, connective tissue or bony arrangements leave a slightly "widened" periodontal ligament space. This should have relatively distinct, corticated margins and not be diffuse (which indicates inflammation and a failure).

Healing by scar tissue. A, Failed treatment because of transportation and perforation, leaving area of canal (arrow) undebrided and unobturated. B, Root end resection, curettage, and root end filling. C, After 2 years, an area of radiolucency is seen. Sharp border, separation from apex, and distinct radiolucency show this to be a scar.