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Review Article

Before and After Endodontic Surgery

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Abstract

Endodontic surgery is an application that can be considered before tooth extraction if root canal retreatment fails or if access to the root canal through orthograde approach is limited. Endodontic surgery allows teeth to be retained and well-functioned in the oral cavity. Appropriate treatment should be determined by evaluating the current tooth prosthesis, restorability, periodontal status, anatomic neighbourhoods and with explicit consideration of the factors affecting success before and after the intervention. The aim of this article is to review existing literature that evaluates the factors affecting treatment with special clinical cases of endodontic surgery.

Keywords: Endodontic Surgery; Hemisection; Resection; Root Amputation

Introduction

Endodontic surgery was originally started with an incision made by the Greek physician Aetius to drain an acute abscess more than 1,500 years ago [1]. In the 1900's, the need for endodontic surgery was emphasized with the importance of focal infection in dentistry and a basis for application techniques and concepts was established in the 20th century by the foundation of the American Association of Endodontists. It is nowadays routinely practiced [2].

Although endodontic therapy usually produces successful results, symptoms persist or recur in 10 - 15% of observed cases [3]. Treatment failure can be due to a persistent infection in the tissue as well as technical factors such as instrument breakage in the canal, apex transportation, perforation, lack of apical plug formation, short or overflow of the canal filling. Technical factors constitute only 3% of cases requiring surgery [4]. Failure to complete the restoration of the tooth or failure to provide adequate adaptation usually results in failure in one year or several years following canal treatment [5]. The rate of persistent apical periodontitis after treatment is 65% in different populations [6].

While Friedman [7] recommended endodontic retreatment to remove existing microorganisms in the root canal system of a treated tooth, Nair [8] stated that healing could not be achieved with traditional root canal treatment since some of the radicular cysts do not open into the canal. When the root canal retreatment and endodontic surgery are evaluated, there was no significant difference between the success rates, although the prognosis differed between the observed cases [9]. Torabinejad., *et al.* [10] reported that the success rate of surgical applications and endodontic treatment were 77.8% and 70.9% after 2 - 4 years of follow-up. However, these rates changed after 4 - 6 years of follow-up, with a successful rate of 83% in conventional canal retreatments and 71.8% in endodontic surgical procedures.

Although the endodontic retreatment seems more conservative, the rate of tooth fracture increases because of the re-instrumentation of the tooth, removal of the existing posts, and removal of the dental structures.

Treatment alternatives, as well as their costs, should be presented before the final treatment to the patient. Apical surgery can be considered especially in cases where replacement of existing prostheses is not considered, while tooth extraction and subsequent dental implantation is an alternative to endodontic surgery [5]. According to Danin., *et al.* [9], an appropriate management plan should include clinical and radiographic examinations to determine indications and preservation of the tooth by root canal treatment or endodontic surgery.

Pre-Treatment Evaluation

Similar to many other dental applications, radiographs are necessary for endodontic surgical applications. There are at least three factors which should be considered during radiographic and clinical evaluations for the endodontic surgery decisions.

- Restorability (Can teeth be restored? Will this affect the prognosis?)
- Canal filling (Is the canal filled? Is the canal treatment good? If not enough, canal treatment should be done again)
- Relationship between apex and anatomical structures (mental foramen, mandibular canal, maxillary sinus)

Periapical radiographs are frequently used to determine the root and canal structures, their numbers, and their anatomic neighbourhoods. However, in cases where the root canals are distributed differently, a single periapical radiograph is not sufficient in the presence of an extra-canal, which is present in 90% of maxillary molars and 40% in mandibular incisors; and periapical radiographs with different angles are necessary [11,12].

Indications of Endodontic Surgery

Many factors are important in determining the indications for conventional endodontic treatment and endodontic surgery applications. According to the American Association of Endodontists, more than 14 million root canal treatments are performed annually in the United States [13]. Although non-surgical endodontic treatments have a high success rate, failures are also seen. Retrospective studies reported endodontic success rates as low as 53% and as high as 96% [14,15]. In addition, the number of canal retreatments has increased in recent years, while the success rates in studies vary from 62% to 93%. The high success rate of canal retreatments decreases the need for endodontic surgery [16,17].

Treatment of irreversible pulpitis and all periradicular diseases is made primarily by conventional canal treatment. The size of the periradicular lesion does not affect the decision of using the canal treatment as the first choice. Surgical treatment should be considered if it is necessary after canal treatment. Failure of poorly constructed canal fillings does not constitute an indication for surgery; canal retreatment should be considered first (Figure 1). Periradicular lesions that persist after primary endodontic treatment are treated with canal retreatment [11].

Figure 1A: Radiographs of the symptomatic teeth number 25 and number 26 teeth show radiolucent areas on their apical surfaces. Previous inadequate root canal fillings are seen.

Figure 1B: Radiograph after root canal retreatment.

Figure 1C: Despite the root canal retreatment, the symptoms persisted (positive response to percussion and palpation tests). Apical surgery was decided. Apical resection was performed in buccal and palatal roots of tooth number 25 tooth and the mesial root of tooth number 26.

Figure 1D: Radiograph taken 2 weeks after root apical resection. Clinical examination revealed that the teeth were asymptomatic.

Endodontic surgery can be performed if it is difficult to remove the prosthetic or conservative restorations or if symptomatic periradicular inflammation develops after well-made conventional canal therapy or canal retreatment [18].

Surgical applications may be considered for those teeth with different canal variations that can limit canal therapy or with highly curved root canals or inaccessible due to pulp stone and calcifications or with developmental anomalies or periradicular pathology, and in iatrogenic conditions (Figure 2). There are also studies indicating that endodontic surgery is appropriate if the diameter of the radiolucent lesion is 8 - 10 mm [18,19].

Figure 2A: Radiograph of the symptomatic tooth number 32. There is a lesion at the apical region, the continuity of lamina dura is impaired but root canal is not observed due to calcification.

Figure 2B: Since orthograde access was not possible for canal treatment, a flap is raised for retrograde access.

Figure 2C: The cortical bone was removed, curettage and resection of the root tip were performed, and the retrograde cavity was closed with MTA.

Figure 2D: Radiograph of tooth number 32 which was asymptomatic 2 weeks after the procedure

Surgery is used for periradicular tissue biopsy, suspected perforation at the root surface, direct evaluation or treatment of root fracture or crack [20,21].

When root amputation or hemisection is planned in the case of periodontal or endodontic disease, endodontic surgery is performed following conventional root canal treatment.

Contraindications of Endodontic Surgery

Endodontic surgery is usually performed under local anaesthesia and the number of contraindications is relatively low. Most of them are relative contraindications and only a few contraindications are absolute. This is limited by patient's medical condition, anatomical neighbourhoods, and skills and experience of the physician. The survival rate and life expectancy in current diseases are increasing proportionally to developments in medicine. Therefore, a comprehensive medical history of the patient is required (cardiovascular, respiratory, digestive, liver, kidney, immunological or locomotor system disorders). The medical risks should be thoroughly assessed, and a consultation should be requested before the endodontic surgery to prevent complications that may occur due to patient's comorbid diseases and medications. Information related to the procedure, the anaesthetic agent to be used, the time required for the procedure should be provided to consultant physician [22].

The most important causes of anxiety in endodontic surgical applications are anatomic limitations. Endodontic surgical applications can be limited due to the inadequate view of the surgical field and application and neighbourhood to nasal floor, maxillary sinus, mandibular canal or mental foramen. The difficulties encountered can be successfully overcomed with the knowledge and experience of the physician [2,22].

Classification of Endodontic Surgical Procedures

1. Surgical Drainage
    - 1a. Incision and drainage
    - 1b. Cortical trephination
2. Periradicular surgery
    - 2a. Curettage and biopsy
    - 2b. Root-end resection, root-end preparation and filling
    - 2c. Corrective surgery
    - $2c_1$. Mechanical (iatrogenic)
    - $2c_2$. Resorptive (internal and external)
    - 2d. Root resection (amputation)
    - 2e. Hemisection
3. Replacement surgery (extraction/replantation)
4. Implant surgery
    - 4a. Endodontic implants
    - 4b. Root-form osseointegrated implants

Incision and Drainage/Cortical Trephination

It is performed to reduce the exudate pressure that causes pain and to eliminate infection and inflammation by-products to prevent damage to teeth and surrounding tissues. Periarticular inflammation spreads to the soft tissues by passing through the medulla and cortical bone. Exudate and toxins can be drained with an incision over the focal point in the presence of a localized, fluctuating, swollen intraoral mass [2,13] (Figure 3).

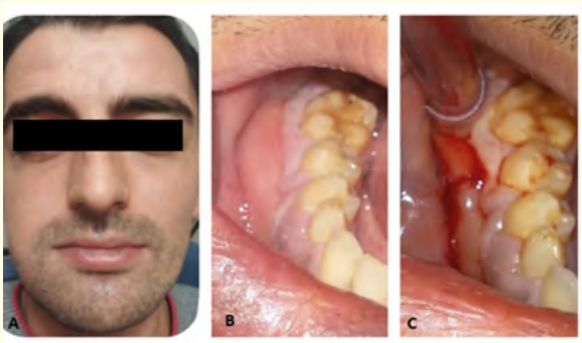

Figure 3A: Extraoral swelling is observed due to acute apical abscess of tooth number 45.
Figure 3B: Intraoral appearance of the fluctuating swelling.
Figure 3C: Vertical incision and drainage were made at the center of the swelling.

However, if diffuse swelling is present and it spreads to extraoral muscles and facial tissues, surgical drainage should be supplemented with antibiotics [2].

Trephination is the perforation of the cortical bone in moderate to severe painful conditions caused by exudate deposition in the alveolar bone without intraoral or extraoral swelling. There are only two reported clinical applications. These studies evaluated the effectiveness of the prophylactic use of trephination in canal filling phase of teeth with the lesion and reported reduced postoperative pain after prophylactic trephination [23,24].

Periradicular Surgery

Curettage

It is the removal of soft tissues or foreign substances on the lateral side of the root tip after a view is provided with the removal of the medulla and cortical bone after mucoperiosteal flap. A biopsy is necessary when a persistent periapical pathology or enlargement of the lesion on follow-up radiography is seen after endodontic treatment or in the presence of an overflowed canal filling [2,13,22].

Root tip resection, root tip preparation, and filling

It is the excision of apical 3 mm section, where the apical delta and lateral canals are intensely located, and the removal of soft tissues when a pathology is observed at the root tip or the size of the lesion is increased after endodontic treatment or when orthograde access to the apex is not achieved in the presence of an overflowed canal filling that prevents healing or a retrograde occlusion is required. Then the prepared root tip should be closed with the appropriate material [13] (Figure 4).

Figure 4A: Apical radiolucency and broken instrument at apical triplet were observed in tooth number 11 previously treated with canal treatment. The canal treatment was renewed and the canal filling was completed by passing by the instrument. However, the symptoms persisted. It has been decided to do a root tip resection.
Figure 4B: The appearance of the root surface of the corresponding tooth after raising a semilunar flap.
Figure 4C: Observation of the canal fills at the root tip after the root tip has been resected.
Figure 4D: Closure of retrograde cavity with MTA.
Figure 4E: Radiograph of tooth number 11 which was asymptomatic after 1 month.

El-Swiah and Walker [4] assessed the indication for periapical surgery in 517 resected teeth and identified 60% biologic and 40% technical factors. Biological factors are related to the presence of symptoms and lesion, while technical factors are composed of the presence of post, crown, unremoved canal fillings and application errors (Figure 5).

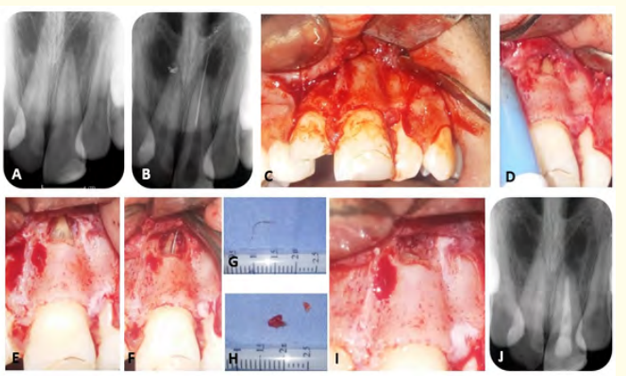

Figure 5A: Radiograph of a tooth traumatized 4 years ago shows a deep class IV filling, increased periodontal gap, and apical radiolucency.
Figure 5B: Pushing from the apex to remove a broken hand piece during canal forming.
Figure 5C: Triangular flap design was used.
Figure 5D: Removal of the cortical bone and appearance of the root tip.
Figure 5E: Opening a window at the root tip to see the broken instrument.
Figure 5F: Expanding the window to provide access to broken tool.
Figure 5G: Extracted broken hand piece.
Figure 5H: Curetted granulation tissue.
Figure 5I: The root tip is resected perpendicular to the tooth axis.
Figure 5J: Control radiograph of the asymptomatic tooth two weeks after resection and orthograde and retrograde MTA filling.

Three aspects are important in root resection: instrumentation, resected root size, resection angle.

Root Amputation and Hemisection

Hemisection is the removal of a root with the corresponding crown from furcation level in a multirooted teeth (Figure 6,7). Amputation is leaving the coronal part and cutting off the root from the crown-root joint.

Figure 6A: Radiograph of tooth number 36 with an acute apical abscess. Large radiolucent areas in mesial and distal roots.
Figure 6B: A rotating Ni-Ti file that was broken in the apical part of the mesiobuccal canal during canal shaping and a hand file that breaks when trying to pass by.
Figure 6C: Although bone formation around the distal root was observed after the application of the intramedullary medicament, dental hemisection was decided since symptoms persisted, and the mesial root was resected. Post-procedure radiography.
Figure 6D: Intraoral appearance of teeth after removal of mesial root.
Figure 6E: The final prosthesis was designed without pontic because the distance between the existing healthy roots was short for to put any pontic. The occlusal table was made narrower in order to reduce the occlusal forces to which it was exposed. View of the final prosthesis from the occlusal side.
Figure 6F: In relation to the teeth of closing, the preliminary contacts were removed, and a lightened occlusal relationship was established in order to reduce the forces. View of closing teeth with the final prosthesis from buccal side.
Figure 6G: Control radiograph of asymptomatic tooth 3 months after procedure.

If the management with canal treatment and root tip excision is not possible, hemisection and amputation are performed in the presence of a root with inadequate bone level in class III and class IV periodontal furcation defects in a multirooted teeth (Figure 8), if it is not possible to reach the root surfaces due to decay, root resorption, perforation defects, or in vertical fractures [13].

Factors Affecting Healing

The periapical tissue healing after periradicular surgery is evaluated with clinical and radiographic controls. Follow-ups with 3-month intervals are planned in the early period and yearly visits are planned up to 4 years. Rud., *et al.* [25] classified the healing by evaluating the continuity of lamina dura, the periodontal gap, and

the periapical bony opacity on radiography after surgical applications. Complete recovery requires lamina continuity, normal periodontal gap, and complete bone formation. On healing with scar tissue, the size of the lesion on the control radiography decreases or it stays at 2 mm around the apex. Bone formation is irregular. There are irregularities in the periodontal gap. Lamina dura can be observed at the apex with bone formation. In the suspicious healing, bone formation is limited in the control radiography and the periodontal gap is twice as high as normal, and the lamina dura disappears from coronal to the apex. In the case of inadequate healing, lesion size in the control radiography is the same or larger compared with preoperative radiography. Clinical and radiographic findings, symptoms are evaluated, and complete and incomplete healing is considered successful.

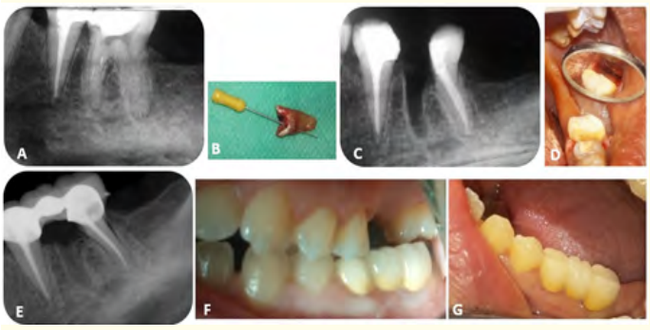

Figure 7A: Instrument fractures are seen in the mesiobuccal and mesiolingual roots of tooth number 36 that had previously undergone root canal treatment. The mesial root of the teeth, which had increased periodontal gap, periapical radiolucency of mesial and distal roots, is narrow and curved at the points where the broken files are located.

Figure 7B: A perforation occurred while attempting to pass by the broken instrument in the mesiobuccal canal. Hemisection of the mesial root by filling the distal canals was decided. The appearance of resected mesial root.

Figure 7C: Radiograph of the tooth after hemisection.

Figure 7D: Intraoral image of the tooth.

Figure 7E: Control radiograph of asymptomatic tooth 3 months after prosthetic restoration.

Figure 7F: Implant treatment was planned for the opposing arc. The treatment was postponed due to socio-economic reasons. In this process, the prosthesis of the region where the endodontic surgery was performed was made according to appropriate criteria. Buccal closing view of the final prosthesis.

Figure 7G: The occlusal tables of the support teeth of the prosthesis were made narrower than normal, and the pontic was made a little narrower than the support teeth. View of the final prosthesis from the occlusal side.

Figure 8A: A deep mesiooclusal class II filling is observed in the radiograph of tooth number 16 with acute apical abscess. It is observed that the bone level in the mesial of the tooth is at the apical triple level of the root, and there is a wide radiolucent area from the mesial root to the furcation area.

Figure 8B: In the intraoral image of the concerned tooth, attachment loss, and gingival retraction are seen in the mesial area. It was decided to amputate the mesial root of the tooth, which had a class IV furcation defect on radiographic and clinical examination.

Figure 8C: After application of intracanal medicaments, palatal and distal canals were filled and the triangular flap was lifted for mesial root resection.

Figure 8D: Image of the resected mesial root.

Figure 8E: Radiograph after root amputation.

Figure 8F: Gingival margin compliance of final prosthesis was checked. The gingival margin of prosthesis is designed to cover furcation area of the teeth. Buccal view of the final prosthesis.

Figure 8G: Occlusal contacts were checked. The occlusal tables of the teeth have been narrowed and grinded for lightened occlusion. View of the final prosthesis from the occlusal side.

Figure 8H: Control radiograph of asymptomatic tooth 3 months after prosthetic restoration.

Factors affecting the success of periradicular surgery applications are grouped as patient, tooth, or treatment related. Factors related to the patient include age and gender. There are two studies showing the prognostic effect of age [26,27]. The results of these studies are contradictory. Barone., *et al.* [26] reported a success rate of 84% in patients over 45 years of age and 68% in younger patients; Kreisler., *et al.* [27] stated that the 31 - 40 age group had the best outcome with 95% success rate. Similarly, the effect of gender on treatment outcome is not certain because there is only one study. In this study, the success rates in males and females were 60% and 40%, respectively [28].

Lesion size is the most investigated tooth related factor. In Barone., *et al.* [26] study, which had the longest follow-up period after periradicular surgery with 4 and 10 years follow-up, it was seen that 80% success was detected in teeth with lesions smaller than 10 mm in diameter while success rates reduced to 53% with time in largest lesions. Successful results were obtained after periradicular surgery if the diameter of the periapical lesion was less than 5 mm [11,19,29]. The teeth with apical cysts have the worst outcome after 1 year of follow-up [18]. Its incidence is not mentioned in the literature.

Post-surgical prognosis of the teeth with endodontic and periodontal lesions is poor [30]. Kim., *et al*. [31] achieved 95.2% healing in endodontic lesions, late recovery in endoperiodontic lesions and 77.5% success rate after 1-year follow-up. In addition, Von Arx., *et al.* [29] evaluated the effect of crestal bone level on healing after endodontic surgery. They found that the prognosis of teeth with a bone level less than 3 mm from the enamel cement border was better (78.2%) and bone loss of more than 3 mm affected the prognosis severely (52.9%). Blomlof and Jansson [32] reported a survival rate of 89% during the 10-year follow-up of molar teeth with a healthy periodontium. Basten., *et al.* [33] reported this rate as 92% after 12 years of follow-up. For the success of periradicular surgery of periodontally weakened teeth, the prosthetic restoration should be performed with appropriate criteria. To reduce the destructive forces exposed by the teeth, a narrower occlusal table, occlusal scheme with canine protected articulation, decreased vertical overlap, flattened posterior cusps, correct formation of occlusal contacts, and coverage of furcation by crown margins help to achieve a successful outcome [34,35].

The prognostic effect of tooth type is not yet clear. Many researchers have reported that the success rates after endodontic surgery for canines or incisor is higher due to the fact that a favorable coverage is achieved at the apex with good visibility and accessibility of the surgical field [11,19,26,28,29]. While Penarrocha., *et al.* [19] observed higher success rate in maxillary canines and incisors, Kreisler., *et al.* [27] reported lower rates in the incisors and higher values in the premolar teeth. Song., *et al*. [30] compared the treatment success rates in the lower and upper incisors and found no statistical difference.

Good canal treatment affects the healing after endodontic surgery [29]. Canal fillings shorter than operating length can be completed retrogradely during surgery and overflowed canal fillings can be cleaned. But all of this has a negative effect on healing. As the number of roots increases, the negative effect on healing is further increased [26].

Periradicular surgery may involve conventional and modern applications. For example, making of a root canal resection at a 45° angle, preparation of the cavity with carbide round drills are traditional practices. Cutting of the root tip at a 90° angle, preparation of the retrograde cavity with ultrasonic ends, use of MTA as a filling material, studying under the microscope are modern applications [36].

In 1998, Friedman., *et al*. [37] reported a 60% success rate with conventional applications, but in 2006, Tsessi., *et al.* [38] reported over 90% success rate with modern applications.

Conclusion

As a result; endodontic surgery is gaining increased attention in terms of ensuring that the teeth are kept and well-functioned in the mouth by properly evaluating the indications and factors affecting the success of the treatment.

Conflict of Interest

The authors declare that they have no conflict of interest.

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