Literature Review

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Successful strategy for periradicular surgery

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Abstract

Periradicular surgery is a surgical procedure which is used in cases of failed endodontic treatments of a tooth with a persistent periapical lesion, which cannot be managed with endodontic retreatment. Various techniques and strategies have been trailed and applied to achieve with most minimally invasive procedures the cure of this pathology. Success in this procedure is predicated on many factors by preventing bacterial leakage from the root-canal system into the periradicular tissues. The precise placement of the root-end filling material following root-end resection could be critical for the treatment outcome. The presence of bacteria in the root canals is a prerequisite for the development of periapical lesions. With modern approaches the rate of successful combined endodontic and surgical approach has drastically increased, this is due to the wide ranges of endo systems, microscopes, ultrasonics and compatible root and root-end filling materials which will result in less trauma to the patient and quicker post endo and post-surgical healing. With the uses of such instruments and materials, advantage can be taken in the treatment process including easier identification of root apices, root filling, microsurgical approach as smaller osteotomies, shallower resection angles of root, and hermetic sealing within the prepared root-end cavity. With this review we aim to describe the current successful strategies for periradicular surgery.

Keywords: apical surgery, endodontic surgery, periradicular surgery, root-end filling, root-end resection, retrograde filling

Introduction

In cases of primary endodontic or endodontic retreatment failure, periradicular surgery is indicated (1,2,3). Endodontic surgery should be restricted to cases in which a non-surgical approach is impossible or has failed and recent advances in endodontic surgery have enabled practitioners to save teeth that would have been extracted previously (1). Peri-radicular surgery includes four critical steps to eliminate persistent endodontic pathogens:
1) precise, fresh endodontic treatment/ retreatment(if possible);
2) surgical removal of the periapical lesion,
3) root-end resection,
4) root-end cavity preparation, and
5) root-end filling or filling of root perforation. (1)

The end goal of periradicular surgery is to establish and provide conditions that facilitate healing and repair of periapical tissue (1). The incision and flap design should be chosen according to clinical and radiographic parameters, anatomical conditions, gingival phenotype and width of gingival tissues, presence of a restoration margin, location and extent of the periapical lesion, and patients' aesthetic demands (3). Success rates ranging from 25-95% for surgical endodontic procedures have been reported in the literature (3-12).

Aim

The aim of peri-radicular surgery is to remove the periapical lesion(granuloma, cyst) or overfilled material completely and to achieve a good sealing the root canal system(with or without a retrograde filling or filling of perforation), and thus allowing periradicular healing.

Material and Methods

We have searched the following electronic databases: Pub med, Med line form 2000 to 2023. We included English language articles only. We hand-searched the reference lists of the studies retrieved and journals in the area of endodontic/ periradicular surgery.

Selection criteria: We included randomised controlled trials, literature reviews involving periradicular surgery cases of periapical pathosis. Studies are directed to strategies leaded to successful endodontic surgery. Successful outcome includes healing of the periapical lesion evaluated through radiographs.
Data collection and analysis: Two review authors independently extracted data from selected studies. This literature review will summarize the current up-to-date successful strategies that physicians currently use to perform successful peri-radicular surgery.

Results

Several conditions are important for successful combined endo-surgical treatment and preservation of natural teeth.
Successful endo treatment includes root canal instrumentation, shaping, decontamination of microorganisms and obturation.

Precise endo treatment, endodontic filling materials:

The reason for endodontic treatment/ retreatment in cases of peri radicular lesion development is if there is presence of viable bacteria in the root canals system that act as a prerequisite for this. Convential endodontic treatment is carried out to treat such cases, however if the treatment has failed or is not possible then, we think about surgery as the next option for treatment. Several factors are responsible for a successful endodontic treatment. More specifically, preoperative factors, such as general patient factors (age, sex, general medical health), root canal anatomy of each tooth type and the preoperative status of the tooth have shown to play an important role. In parallel, intraoperative factors like rubber dam placement, accurate biomechanical preparation, irrigation protocol, medicaments, root filling techniques and materials are of major importance. Finally, the number of visits and the quality of the coronal restoration could affect the endodontic treatment. A successful endodontic treatment would be defined as the one that has no clinical signs or symptoms of infection or inflammation following treatment, no radiographic signs of ongoing pathology and reduction in the size and density of any previously existing periapical radiolucency (2,4,5,11,13)

Biomechanical instrumentation can lead to changes to the original root canal system anatomy which can be difficult to prevail over and consist of ledges, transportations, perforations, internal and external resorptions, or separated instruments. This may result in residual microphlora near to the apical constriction or apical foramen because of inadequate biomechanical irrigation and disinfection (13,14,15,16).

Accurate biomechanical preparation with preserving as much as possible of radicular dentin while achieving a good instrumentation and disinfection of root canal system and 3 D obturation of canal system is essential for successful endo treatment and following periradicular surgery if necessary (large periapical lesions, perforations etc). (2)

Characteristics of orthograde/retrograde filling:

Materials used as endodontic fillings or retrograde filling include: zinc oxide-eugenol-based, resin-based, glass ionomer-based, silicone-based, calcium hydroxide-based, and bioactive endodontic sealers, bioceramic sealers, epoxyde resins, cortisomol, gutapercha, MTA, Portland cement, biodentin etc.(1,2, 9,17)

Orthograde filling is the use of this material through the coronal access point which differs from retrograde filling, which is the use of this material through the apex of the tooth. The aim of the orthograde filling material is to hermetic 3D seal the communication between the root canal system and its surrounding tissues (13,17,18,19). Optimal root-end filling material should be biocompatible and bactericidal. They should also be uninvolved to next lying tissues and have excellent sealing ability.

The main ideal characteristics of this materials should include that they are nontoxic, noncarcinogenic, nongenotoxic, biocompatible, insoluble in tissue fluids and stable (19,20). This biocompatibility is the ability to achieve a good healing process due to appropriate host response. The extrusion of sealer should be avoided because of possible toxicity of periradicular tissues. A minor problem with cements based on zinc oxide and eugenol is that their radiopacity is similar to that of gutta percha. Ideally, root-end filling materials should be readily distinguishable from tooth structure and obturating materials. Grossman previously listed the properties of an ideal sealer: (a) exhibits tackiness when mixed to provide good adhesion to the canal wall, (b) establishes a hermetic seal, (c) is radiopaque, so that it can be observed through radiographic observation, (d) is a very fine powder that can be easily mixed with liquid, (e) does not shrink on setting, (f) does not stain tooth structure, (g) is bacteriostatic (or at least does not promote bacterial growth), (h) displays a slow setting, (i) is insoluble in host tissue fluids, (j) is biocompatible, i.e., without irritant potential to periradicular tissue, and (k) is soluble in common solvent, allowing for removal when necessary. (20)

For teeth that could not be treated with orthograde root canal therapy, or if it has failed, retrograde root filling is a good alternative. Until the 1990s, amalgam was the root-end filling material in use. However, as amalgam has many disadvantages, its safety, integrity, and use have been questioned in recent years. Some of its disadvantages are: release of ions, mercury toxicity, corrosion and electrolysis, delayed expansion, marginal leakage, and its tendency to cause tissue tattoos (1-3).

Mineral trioxide aggregate (MTA) was introduced to endodontics as a root-end filling material as it has an excellent sealing ability and it promotes osteoblast activity because it is biocompatible material and induces osteogenesis and odontogenesis. Consequently, MTA appears to have become the gold standard for a root-end filling material (3). It would appear to be a most promising material for use in a variety of clinical applications, including vital pulp treatments, apical filling of teeth with open apices, apexification, repair of root, furcal perforations, and root end fillings. However, MTAs major disadvantages are: prolonged setting time, difficulties in manipulation and cost. The other option is Portland cement, which as well could be used to seals the root canal from the root apex. (21-24)

Chemical properties of MTA – MTA has a long setting time, high pH and low comprehensive strength (21). MTA contains calcium oxide (CaO) and silicon (SiO). Many reports state that the main elemental components of MTA are calcium, silica and bismuth (21). MTA in today's use is available in 2 forms, gray (GTMA) and white (WMTA). It is important to know that MTA was first available in gray, but due to its aesthetically displeasing colour potential, WMTA was industrialised. Investigations showed that lower amounts of iron, aluminium and magnesium are present in WMTA than GMTA. GTMA consists of dicalcium and tricalcium silicate and bismuth oxide, whereas WMTA is primarily composed of tricalcium silicate and bismuth oxide (22). When MTA powder is mixed with water, calcium hydroxide $Ca(OH)_2$ and calcium silicate hydrate are initially formed and eventually transform into a poorly crystalized and porous solid gel (21-24).

Physical properties of MTA – with the hydration of the MTA powder produces a viscous gel that soon after hardens into a compact structure. Characteristics of the mixture can be affected by powder/liquid ratio, method of mixing (i.e., the amount of entrapped air), pressure used for condensation humidity of the environment, the type of MTA, the type of storage media, the pH value of the environment, the type of vehicle, the length of the time between mixing and evaluation, thickness of the material, and temperature (21). MTA is prepared by mixing the powder with sterile water in a 3:1 powder-to-liquid ratio. The mean setting time of MTA is 165 +/- 5 minutes, which is longer than amalgam, Super EBA and intermediate restorative material (IRM) (21). GMTA exhibits significantly higher initial and final setting time than WMTA (21,22).
MTA is a bioactive material and its antibacterial properties of MTA are present depending on the powder-to-liquid ratio (20). Several investigations reported that MTA has limited antimicrobial effect against some microorganisms (21,22,23).

In recent years MTA has received widespread attention, adhering to the ideal characteristics that differ it from standard orthograde filling materials (23,24) although the new root-end filling material containing zirconium oxide (NRFM-Zr) on base of hydroxyapatite may be promoted for periradicular surgery because of stimulating effect of osteoblast differentiation and in future could be used. (21)

Indications for endodontic retreatment/surgery

In the presence of endodontic failure or a persistent endodontic lesion, the alternative for the recovery and preserve the tooth is endodontic retreatment or endodontic surgery, which consists in the surgical removal of the root apices with retrograde filling/hermetic closure/ of the endodontium (13,17,18,19).
Peri radicular surgery may be performed after unsuccessful endodontic retreatment or when orthograde retreatment is contraindicated or risky(1, 6). The success rate for peri radicular surgery is lower than that of root canal retreatment and is strongly affected by the ability to achieve sustained tissue haemostasis (1,2, 13). More specifically, when the complete disinfection and cleansing of the root canals, from the presence of microorganisms and from potentially infected pulp endodontic tissue, is violated, an endodontic retreatment is recommended (19). Narrow or curved canals not treated during the initial procedure as well as complicated canal anatomy that went undetected in the first procedure indicate the need for an endodontic retreatment. Also, the placement of crown or other restoration that was delayed, cracked or broken tools following the root canal treatment and restoration that did not prevent salivary bacterial contamination to the inside of the tooth, require an additional treatment to the root canals. Furthermore, decays that can expose the root canal filling material to bacteria in oral cavity causing a new infection and also tooth that sustained a fracture are more likely to receive an endodontic retreatment. Finally, a post-treatment disease following a root-canal treatment is most often associated with poor quality procedures that do not remove intra-canal infection. This scenario can be corrected via a non-surgical approach (3,18).

Endodontic surgery is indicated in a variety of circumstances. (2)

1. If ORCT (orthograde root canal treatment) could not be done because of persistent exudation despite of accurate bio, chemo, mechanical debridement
2. If there is no healing process or there is progression of periapical pathosis of optimally endodontically treated tooth(ORCT)
3. Non healed, symptomatic or progressing periapical pathosis in which orthograde root canal retreatment: has failed; might be associated to the structural integrity of the tooth; would be destructive to a final restoration; would involve the removal of a post with a high risk of root fracture.
4. Symptomatic or progressive periradicular pathosis associated with a tooth in which iatrogenic circumstances or anatomical and physiological anomalies prevent accurate orthograde root canal treatment
5. In case of exploration biopsy of periradicular tissue.
6. When needed visualisation of the periradicular tissues and tooth root is required, removal of overfilled material, smoothing of resorbed root end,
7. In case of fracture of apical 1/3 of root,
8. For sealing of perforation,
9. When needed visualisation of the periradicular tissues and root fracture is suspected. (2)

ORCT retreatment could be considered if:
- there is potential for improvement of the quality of the root canal treatment.
- removal of the coronal restoration poses minimal risk to the remaining tooth structure.

Indications for surgical management of a perforation include: persistent periradicular pathosis subsequent to RCT, which is not accessible with non-surgical approach.
Long term success depends on: absence of bacterial contamination and associated periodontal lesion, the size and location of the perforation, the bone level of the neighbouring teeth etc. (2,11)

Contraindications for peri-radicular surgery

Outcomes might be not successful if:

1. the periradicular pathosis has not been affected and stabilised
2. the seal is poor and not hermetic
3. the tooth is not prospective and is unrestorable
4. the prognosis of the tooth is limited by compromised bone support or not sufficient root length
5. in case of a root fracture
6. access to the root end and the associated lesion is difficult or the risk of access because affecting anatomical structures considered to be greater than the potential advantages
7. comorbidity - medical history factors of relevance (precautions related to medical history are as for any other surgical procedure to be carried out under local anaesthesia). Systemic diseases are known to interfere with periapical healing, such as diabetes, hypertension, osteoporosis, or any uncontrolled systemic disease, bisphosphonates therapy etc.
8. the operator skills, experience, equipment or materials are poor. (2)

Clinical Evaluation and Evaluation Timing

The selection of experts, oral surgeon, endodontist and radiologist, increases the chances of 'true' diagnosis and thus reliability of the investigation (4). The reason for the clinical evaluation procedures are to correctly allow the physician to evaluate the signs and symptoms such as loss of function, tenderness to percussion or palpation, subjective discomfort, mobility, sinus tract formation, signs of infection or swelling and periodontal pocket formation/edoperiodontal lesion (1,3). The determinant that allows periradicular surgery to be classed as successful is the absence of the symptoms previously mentioned and recovery of the periapical radiolucency after treatment. Posttreatment disease is diagnosed when a periapical radiolucency remains at 4 years after treatment (1). Endodontic surgery cases are nearly all clinically symptomless at the follow-ups, and so the radiographic assessment of healing will be of great importance (5). Radiographs are the clinical device used to determine post-treatment results.(5,19,25,26) As mentioned before periapical radiolucencies are the determinant factor to assess the success of the peri radicular surgery, the use of a periapical radiograph alone is no longer recommended as it only captures two dimensional images.(27,28,29) In cases where the periapical lesion is confined within the cancellous bone, it is hard to be captured with the two-dimensional periapical radiograph, therefore, the use of cone-beam computed tomography (CBCT) scans allows the physician to clearly perceive presence of any periapical lesions otherwise not detected with the periapical radiograph (1,3). CBCT scans are not only used postoperatively, instead it is very essential preoperatively, as it allows for the precise details of the apical lesion and its relation to the surrounding and connected structures as well as demonstration of positive contributions to the treatment outcomes (15).

CBCT allows to make precise evaluation of a root canal system, perforation, location of separated instrument, periradicular lesion- size and location, the bone thickness over the lesion, and the proximity to adjacent anatomical structures such as the inferior alveolar nerve, mental nerve, maxillary sinus and nasal cavity, neighbouring roots. (5,18,19)

Surgical planning

Healing process following periapical surgery is affected by age, periapical lesion size, type of root-end filling material, method of root-end resection, cavity preparation technique.(2,12)

Surgery might be influenced by:
- anatomical considerations
- gingival phenotype
- endodontic filling material/technique
- design of mucoperiosteal flap
- good restoration coronal seal
- favourable periodontal attachment levels of the affected tooth, if tooth is mobile- split therapy is indicated before surgery
- absence of a potentially traumatic occlusion
- presence of a well-performed root filling (2)

Repeat surgical procedure might be considered after determined(2,12):
- The reason for failure of the first surgical procedure should be clarified- endo(persistent infection) or surgical failure(root-end resection, retrograde cavity preparation and filling)
- A second operation should be avoided because periapical healing after a second surgical procedure is not with high successful rate
- The integrity of the coronal seal should be confirmed
- Risks related to second surgery as gingival recession, periodontal defects, further loss of root length, bone etc. should be balanced against the benefits of extraction and replacement with a dental implant or other prosthetic restoration.(2)

The factors that determine the successful outcome as:
- Precise ORCT/retreatment
- General status and comorbidity
- Size of lesions(2,12)

Ahmed at al.(30) 100% successful healing was observed in patients with preoperative lesions of less than 6 mm, while 45% healing success was evident in patients with more than 6 mm of preoperative lesion size. (30)
Von Arc et al. (31) revealed that the presence of preoperative signs and symptoms discourages healing. They postulated that the healing potential of surgical wounds could be significantly affected by the stage of infection at the time of surgery, which is influenced by preoperative pain and signs.
- Preexisting infection
- The microsurgical approach has some benefits over conventional such as small osteotomy, good visualisation and identification of root apex, preservation of cortical bone and root length as much as possible by nearly 90-degree root resection(31).

Peri-radicular surgery is performed under local anaesthesia. A full-thickness flap is created, gaining sufficient working and visual access by retracting the mucoperiosteum. Bone in the apical area of the affected tooth is then removed to gain direct good access to the apical lesion and root end of the affected tooth. Debridement of the cortical and cancellous bone is performed using a bur and sharp spoon excavator; the material is send for histopathological examination. (1,3,24,25). The working area is constantly irrigated with saline solution to prevent bone dehydration/heating. With the use of a water-cooled diamond bur or piezosurgery, an apical resection of around 3 mm from the apex is removed (1,3). Debridement of the pathological tissue is performed. The use of ultrasonic tips in root-end cavity preparation is the most accepted method of choice, due to its significant advantages compared to the use of small round burs or

inverted cone bur in a micro-handpiece (1,3). Comparing the use of an ultrasonic tip and a microhead handpiece, studies showed that, success rate of the ultrasonic method was higher than that of the microhead method (14). A resection within the apical 3 mm, where the biofilm is most apparent of failed root-filled cases with minimal bevel (0–12 degrees) minimises the cutting surface area of dentinal tubules for potential microleakage. The root-end preparation 3 mm with piesosurgical tips should be isolated from fluids. Radiographic verification of the quality of the root-end filling, which was compacted prior to wound closure is recommended. Any excess filling material should be removed from the bony crypts. (27,28,13,17)

The aim of the retrograde filling is to provide a tight seal, preventing the migration of remaining interradicular bacteria from entering the peri radicular tissue and essentially increasing the risk of a failed surgical treatment. In the current strategies for periradicular surgeries there are numerously established retrograde filling materials- ethoxy benzoic acid (Super EBA), calcium silicate-based material(Biodentin), intermediate restorative material (IRM), mineral trioxide aggregate (MTA), Portland cement and composite resin (1,3,23,24).MTA is still the standard root-end filling material, despite MTA has a prolonged setting time and difficulties in manipulation which major disadvantages of MTA (1,2,3,22,23,24).

1) apical resection with/without retrograde filling

Different investigations propose different conclusions about apical resection with/without retrograde filling. Successful periapical surgery includes identification and reduction of possible leakage at the root surface after apicectomy and ensure adequate root-end filling. Hermetic apical obturation with ortho or retrograde filling can allow periapical healing with excellent long-term prognosis. (32,33)

2) periapical curettage

Periradicular curettage and elimination of diseased periradicular tissues are essential for accessibility in treatment of the apical part of the root and sometimes in the removal of harmful foreign materials as overfilled material, gutapercha, separated instrument etc. (6).
Guided tissue regeneration(GTR) is a method that led to the development of synthetic bone substitutes, bone grafts and membranes or barriers that allow the cellular re-growth of periodontal defects caused by pathosis or surgical trauma. The indications suggested for GTR in endodontic surgery are: through-and-through lesions that involve the integrity of both the buccal (labial) and palatal (lingual) alveolar cortical plates, chronic periapical lesions and combined endodontic and periodontic involvement (8).

According Rud et al. (34) the radiographic healing assessment could be categorised as:

Complete - show resolution of the periapical radiolucency. The presence of a restored and continuous periodontal ligament space.

Incomplete - show reduction in size of periapical radiolucency.

Scar tissue - show an intact periodontal ligament space is seen apically with the radiolucency separated from the apex. There may be some bony infill, but the characteristic is the presence of an irregular border with the radiolucency possibly being asymmetrical around the apex.

Unsatisfactory - The radiolucency has increased in size or remained the same for 4 years. (34)

Conclusion

In conclusion, modern periradicular surgery is successful in promoting healing in periapical lesions of endodontic origin. Thus, peri radicular surgery may be performed after unsuccessful endodontic treatment/retreatment and depends of preoperative and intraoperative factors as: control of comorbidity, absent of infection preoperatively, good, dense root canal filling, high-magnification, root end preparation with piesosurgery, retrograde filling, lesion less than 5 mm, avoid repeat surgery.
Nonsurgical endo retreatment remains the first choice for most of the cases with periapical pathosis however modern endodontic surgery could be a predictable minimally invasive method for the retention of natural teeth.

CONFLICTS OF INTEREST

The authors declare no conflict of interest, monetary or otherwise.

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