

GUIDELINES FOR SURGICAL ENDODONTICS

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The aetiology of periapical (periradicular) periodontitis is microbial (Kakehashi et al 1965, Sundqvist 1976, Moller et al 1981,). The presence of micro-organisms within the root canal system induces an inflammatory and immune response within the periradicular tissues resulting in discrete bone destruction. In addition, contamination of the periradicular tissues by micro-organisms and root filling materials may initiate a foreign body reaction and healing cannot then take place

Evidence level IV

It is recognised that the aim of root canal treatment is to clean and disinfect the root canal system to reduce microbial numbers and remove necrotic tissue, and then seal the system to prevent recontamination. Success rates of up to 95% have been quoted for de novo root canal treatment but failure may occur subsequent to treatment. Options for the treatment of these failures can be non-surgical and surgical (Briggs & Scott, 1997). Non-surgical retreatment may provide a better opportunity to clean the root canal system than a surgical approach, where the coronal part of the root canal system remains untouched (Danin et al 1999). However there are instances when non-surgical intervention is inappropriate.

Evidence level IV

Evidence level Ib

The clinical evidence comparing particular endodontic procedures is sparse. There have been only two randomised controlled trials comparing root canal retreatment using surgical and non-surgical approaches (Danin et al 1999; Kvist & Reit 1999). However, there have been a number of pragmatic trials using various materials and procedures.

Evidence level Ib

Surgical endodontics as described in this text includes root-end resection, apical curettage and root-end filling. Other procedures such as apical curettage alone, root resection, hemisection, intentional replantation and regenerative procedures have not been included.

INDICATIONS FOR SURGICAL ENDODONTICS

1. Presence of periradicular disease, with or without symptoms in a root filled tooth, where non surgical root canal re-treatment cannot be undertaken or has failed, or where conventional re-treatment may be detrimental to the retention of the tooth. For example, obliterated root canals, small teeth with full coverage restorations where conventional access may jeopardise the underlying core. It is recognised that non-surgical root canal treatment is the treatment of choice in most cases

2. Presence of periradicular disease in a tooth where iatrogenic or developmental anomalies prevent non surgical root canal treatment being undertaken.
3. Where a biopsy of periradicular tissue is required.
4. Where visualisation of the periradicular tissues and tooth root is required when perforation, root crack or fracture is suspected.
5. Where procedures are required that require either tooth sectioning or root amputation.
6. Where it may not be expedient to undertake prolonged non surgical root canal re-treatment because of patient considerations.

el-Swiah JM, Walker RT (1996)

Evidence level III

CONTRAINDICATIONS TO SURGICAL ENDODONTICS

There are few absolute contraindications to endodontic surgery.

1. Patient factors including the presence of severe systemic disease and psychological considerations.
2. Anatomical factors including :
 - unusual bony or root configurations
 - lack of surgical access
 - possible involvement of the neurovascular bundle where the tooth is subsequently unrestorable
 - where there is poor supporting tissue
3. The skill, training and experience of the operator also has an influence.

CLINICAL ASSESSMENT

Patients may or may not suffer from symptoms. Initial assessment should include a full medical and dental history, extra oral and intra oral examination. Appropriate special investigations including sensitivity testing, periodontal pocket measurement and radiographs should be undertaken.

Clinical assessment should be carried out with the aim of assessing the status of the offending tooth and to exclude other causes of the symptoms. A complete examination should include:-

Extraoral examination

- regional lymph nodes

Intraoral examination

- the general status of the mouth, including the soft tissues, and the teeth
- the presence of local infection, swelling and sinus tracts
- the presence and quantity of restorations, caries and cracks in the teeth
- if the tooth is crowned the quality of the crown in terms of fit and shade must be assessed, as well as whether the crown has ever become decemented
- periodontal status, including the presence of marginal periodontal disease with pocketing, especially isolated deep pockets
- occlusal relationship. Is the tooth a functioning unit?
- sensitivity and percussive testing of the suspected tooth, adjacent teeth, and its contralateral partner. Radiological assessment is essential prior to surgery.

RADIOLOGICAL ASSESSMENT

Radiographic Examination

Radiographic examination should provide the information necessary for adequate assessment of the tooth.

A periapical view of the tooth provides the highest diagnostic yield. A long cone, paralleling technique provides less distortion of the image. It may be necessary to take more than one radiograph, from different angles, especially in multi-rooted teeth or where perforation by a post is suspected. At least 3 mm of the tissues at the apex of the roots should be included. If a large periradicular lesion is suspected a panoramic radiograph should be taken. Occasionally a vertex occlusal or lateral skull view is required for orientation of intracanal restorations.

All radiographs should be of a diagnostically acceptable standard.

Radiological Evaluation

The purpose of careful radiological evaluation is to complement the clinical examination by providing information about the periradicular and marginal hard tissues around the tooth, including the size of any periradicular lesion as well as the length, number and shape of the roots of the tooth, and adjacent teeth. In addition, the presence and type of restorations present should be noted and also the anatomy of the root canal including the presence of sclerosis, root fillings and posts. If a sinus tract is present then a radiograph should be taken with a gutta-percha cone in place to delineate the tract. The presence of important anatomical landmarks such as floor of nose, maxillary sinus, mental foramen and inferior dental canal should also be noted. This is necessary in order that a reasoned decision regarding the proposed surgical procedure may be made.

Historical radiographs, if available, provide a longitudinal guide to changes in periradicular status.

REFERRAL

Once it has been decided that surgical endodontics is required, consideration should be given as to the appropriate setting for treatment. Referral should be to an appropriate specialist.

The basis for this decision should take account of the general suitability of the facilities for operative procedures and recovery and the competence and training of the practitioner and support staff. In addition, each case should be assessed with due regard to the patient's medical history and expected degree of difficulty of the surgical treatment.

The referring clinician should provide information as to the clinical findings on presentation, medical history and any radiographs relevant to the case. In addition, an indication of the proposed further restorative treatment of the tooth should be given.

All pre-operative radiographs should be transferred between clinicians concerned with the assessment and treatment of the patient. When treatment is complete, radiographs should be returned to the originating clinician. The operating surgeon should, if possible, retain duplicate radiographs.

The surgeon should confirm by letter receipt of the referral and outline the diagnosis, treatment plan, specific information provided to the patient, the anaesthesia to be used and what follow-up arrangements are required.

A discharge letter should always be sent to the referring clinician indicating what procedures were undertaken, any difficulties or complications encountered and the state of the patient at discharge.

CLINICAL MANAGEMENT

Every effort should be made at the time of operation to avoid or minimise complications and side effects of the operative procedures.

PREOPERATIVE MANAGEMENT

Preoperative management requires, as a minimum, the taking of a detailed history plus clinical and radiological assessment. Once a decision to undertake a surgical approach has been made and fitness for surgery established, informed

surgical approach has been made and fitness for surgery established, informed consent must be obtained.

After referral, but prior to surgery, interim measures should include chlorhexidine mouth rinses (Martin & Nind 1987) and, possibly, systemic antimicrobial administration if prophylaxis is required for medical reasons. In any event, the use of chlorhexidine mouth rinses and systemic NSAID therapy should be considered prior to surgery (day before/hours before) (Jackson et al 1989).

Evidence level IIa

Evidence level III

Referring practitioners should contact the surgeon to expedite treatment if a patient on a waiting list experiences recurrent bouts of infection.

ANAESTHESIA

Methods of anaesthesia include local anaesthesia, local anaesthesia with intravenous sedation and general anaesthesia. Where possible, local anaesthesia should be the method of choice. In addition, haemostasis is more easily achieved after a local anaesthetic containing a vasoconstrictor is used (Gutmann 1993, Witherspoon & Gutmann 1996, Kim & Rethnam 1997).

Evidence level IIa

Evidence level III

SURGICAL PROCEDURE

The use of the dental operating microscope has been shown to be of benefit during surgery (Pecora & Andreana 1993)

Evidence level IIa

Soft Tissue Management

The surgical flap design is variable and depends on a number of factors. These include size of the periradicular lesion, periodontal status, state of coronal tooth structure, the nature and extent of coronal restorations and operator's choice. Relieving incisions should be vertical and placed on sound bone. All flaps should be full thickness and are either extended to the gingival sulcus or , where there is sufficient attached gingivae and no evidence of periodontal disease, a scalloped submarginal incision can be used (Lubke-Oschenbein). The lack of predictability in determining the size of the periapical lesion, combined with increased incidence of scarring associated with a semilunar flap precludes its use in endodontic surgery. (Chindia & Valderhaug 1995)

Evidence level IIa

It is not necessary to remove either all bleeding tags of tissue on the exposed bone or periodontal ligament fibres that were severed during tissue reflection. (Harrison & Jurosky 1991a)

Evidence level IV

The raised flap must be protected from damage during operation and should not be allowed to become desiccated.

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Hard tissue management

Osteotomy

An assessment of the length of root should be made prior to bone removal. The axis of the root should also be assessed to ensure that bone is removed from over the root itself. If the cortical bone plate is thin or absent (fenestration or dehiscence) then curettes may be used to expose the apex of the root. Further bone removal should be carried out with a bur cooled by copious water or sterile saline, preferably, or sterile water. Steel or tungsten carbide burs produce less heat than diamond burs.

The superficial osteotomy should be done with a light shaving motion to reduce the heat generated and allow adequate visibility. Sufficient bone is removed to allow adequate access to the root end.

A bony lid technique has been advocated for mandibular molar teeth (Khoury & Hensher 1987)

Evidence level IV

Periradicular curettage

The soft tissue in the periradicular region should be removed with curettes to allow adequate vision of the root apex. In some cases it may not be possible to remove all the soft tissue around the root-end until the latter has been resected. The majority of the inflammatory soft tissue should be removed, if possible, but the peripheral tissues may be reparative in nature and if other anatomical structures are likely to be violated then this tissue should be left (Lin et al 1996). Pathological material should, if possible, be sent for histopathological examination (Thompson et al 1992)

Evidence level III

Evidence level III

Root-end resection

Resection of the root should be carried out as close to 90 degrees to the long axis of the tooth as possible to reduce the number of exposed dentinal tubules (Gilheany et al 1994). If possible, at least 3mm of root end should be removed to eliminate natural or iatrogenic anomalies in the root canal system. Resection should be done with a rotating bur using saline or water coolant. The resected root surface should be examined, preferably under magnification with a micro-mirror, to ensure that the surface is smooth and that there are no cracks in the root, and to check for canal irregularities (Hsu & Kim 1997, Wada et al 1998). The application of a neutral, buffered, sterile dye to the root face may help visualisation of cracks as well as the outline of the root.

Evidence level IV

Evidence level IV

Root-end preparation

Root-end preparation is best carried out with an ultrasonically- or sonically-

powered tip (Gutmann et al 1994, Min et al 1997, Waplington et al 1997, Testori et al 1999; von Arx & Walker 2000). Where a bur is used it should be in a miniature headed handpiece. Both should be used with sterile saline or water as a coolant. The ultrasonic tips allow good access to the root end and provide a better shape to the root end preparation. These should be used at low power and with a light touch to reduce the risk of root cracking. The preparation should be 3mm deep, if possible, incorporate the whole root canal shape and be in the long axis of the tooth. Consideration should be given to removing the smear layer with EDTA or citric acid especially if a bur has been used. The root end cavity should be examined to ensure that the walls are free of debris, including gutta-percha root filling. Any gutta-percha on the wall should be removed or packed into the floor of the cavity with a small plugger.

Evidence level IV

Root-end filling

The cavity should be isolated from fluids, including blood. A suitable haemostatic agent should be placed in the bony crypt (Witherspoon & Gutmann 1996, Kim & Rethnam 1997) and the root-end cavity dried. The material to be used as the root end filling should be compacted into the cavity with a small plugger to ensure a dense fill. There should be no excess material on the resected root face. A biologically compatible material should be used where possible. Mineral trioxide aggregate (Torabinejad et al 1995a,b,c,d; Torabinejad et al 1997; Torabinejad et al 1998; Torabinejad & Chivian 1999), super EBA, glass ionomer (Zetterqvist et al 1991), composite resin (with a dentine bonding agent) (Rud et al 1996a,b) and reinforced zinc oxide-eugenol are the materials considered most suitable. Amalgam is not recommended Allen et al 1989, Dorn & Gartner 1990, Jesslen et al 1995, Pantshev et al 1994). There should be careful debridement of the bony crypt to ensure that haemostatic agents, root-end filling material and debris are removed.

Evidence level III

Evidence level IIa
Evidence level IV
Evidence level IIa
Evidence level IIa

CLOSURE OF THE SURGICAL SITE

The soft tissue is re-apposed with sutures and the best results are obtained with primary closure. After suturing the tissues should be compressed with a damp gauze for 3-5 minutes. Sutures are removed after between 48 and 96 hours when reattachment of the periodontal fibres at the gingival margin has taken place (Harrison & Jurosky 1991b,). Sutures left longer than this may become infected by 'wicking' (Grung 1973).

Evidence level IV
Evidence level IIa

POST SURGICAL CONSIDERATIONS

Post-operative complications should be uncommon. Post-operative pain may be controlled with non-narcotic analgesics. A long-acting local anaesthetic given at the end of the procedure may also be beneficial. Post-operative swelling can be minimised by applying cold compresses with an ice pack for the first 4-6 hours after surgery (Gutmann & Harrison 1991). Chlorhexidine mouthwashes help to keep the surgical site clean and allow quicker healing. If possible, telephone communication should be made when the patient returns home to ensure that they are comfortable. This avoids misunderstandings and allows further supportive care and advice.

Evidence level IV

further supportive care and advice.

COMPLICATIONS ASSOCIATED WITH TREATMENT

As with all surgical procedures there is a risk of operative and post-operative complications. However, these should be unusual provided appropriate precautions are taken. These include avoidance of unnecessary rinsing and raising the blood pressure, particularly through exercise.

a) Haemorrhage

Haemorrhage must be controlled at the time of operation. Soft tissue bleeding is controlled by haemostatic agents delivered via the local anaesthetic, and with sutures. Bleeding in the bony crypt is also affected by the vasoconstrictor in the local anaesthetic agent and topically applied agents. The latter should be removed from the crypt prior to closure of the surgical site.

b) Pain

Postoperative pain is unusual but if present is controlled, in nearly all cases, by systemic non-narcotic analgesics (Seymour et al 1996, Ahmad et al 1997, Mehlich et al 1990) Long-term pain as a result of surgical damage to the peripheral nerves occurs rarely.

c) Ecchymosis

Patients should be informed that bruising may occur, is self-limiting and will usually resolve within two weeks of surgery

d) Infection

Infection of the soft tissues may result in secondary haemorrhage, cellulitis or local abscess formation. It is best prevented by the use of chlorhexidine mouthwashes immediately pre-operatively and post-operatively. Where signs of systemic involvement are present with pyrexia and regional lymphadenopathy then antimicrobials should be prescribed. (Freedman & Horowitz 1999)

Evidence level Ib
Evidence level Ia
Evidence level IIa

Evidence level IIa

OUTCOMES OF SURGICAL ENDODONTIC INTERVENTION

Outcomes may be classed as successful, unsuccessful, incomplete and uncertain. Outcomes must be defined and quantified to enable audit to establish best practice. The success or otherwise of the procedure should be viewed from the patient's perspective.

An initial review appointment within two to three days is required

- To remove sutures and assess early healing
- When complications arise
- At the patient's or referring dentist's request
- To allow a postoperative radiograph to be taken, although it is expedient to take a radiograph after the root end filling has been placed, prior to suturing

Thereafter, regular review appointments should be made to assess healing using criteria based upon clinical and radiological examination. Radiological examination should be conducted at annual intervals until healing is observed (Halse et al 1991).
(Worral 1996)

Evidence level IIb
Evidence level IV

Successful outcome

Clinical

This is achieved when the presenting symptoms and signs of the disease associated with the tooth have been eliminated. There should be no tenderness to palpation and percussion and normal mobility. There should be no evidence of a sinus tract or periodontal pocketing. There should be no signs of infection or swelling and the patient should not have discomfort. The tooth must be functional.

Radiographic

Radiological examination of the treated tooth should show a normal periodontal ligament width or a slight increase, not wider than twice the periodontal ligament space on the lateral aspect of the tooth. The periradicular rarefaction should be eliminated and the lamina dura and osseous pattern should be normal. There should be no root resorption evident. The treated area should be compared with an area of the tooth that has normal lamina dura (Rud et al 1972a)

Evidence level IIa

Success rates

Success rates vary from 30% (Jansson et al 1997) up to over 80% (Rud et al 1972b). A review of studies has been undertaken (Friedman 1998)

Evidence level IIa
Evidence level III

Clinical criteria cannot be used to determine the amount and type of repair histologically. The aim should be to provide an environment that allows regeneration of the cementum and periodontal ligament over the resected root apex. However, in many cases repair of the tissue takes place with the formation of a fibrous tissue scar.

Success rates for repeat surgery is low (35.7%) (Peterson & Gutmann 2001)

Evidence level Ia

Unsuccessful outcome

Clinical

- Persistent disease

The presence of a sinus tract or swelling, with discomfort to palpation and percussion. There may be persistent subjective symptoms which may not allow the tooth to function adequately.

- Root fracture

The tooth may fracture irreparably

- Peripheral nerve damage

Surgical damage to the peripheral nerves is a rare complication. This may result

in complex regional pain syndrome type II (causalgia)

- *Damage to adjacent teeth*

Radiological

There is no regeneration of periapical bone

Uncertain outcome

Clinical

There may be vague symptoms which may include mild discomfort or a feeling of pressure and fullness around the treated tooth.

Radiological

There is partial regeneration of periapical bone

Incomplete outcome

Clinical

There are no signs and symptoms

Radiological

There is partial regeneration of the periapical bone. This may be due to the formation of fibrous scar tissue and is often associated with a through and through lesion where both buccal and lingual cortical plates have been perforated by infection or during the surgical procedure.

An audit trail should be set up to enable outcome to be monitored, both clinically and from the patient's viewpoint.

Should failure occur after surgery then the cause needs to be established prior to a plan of treatment. Further surgical intervention has a low success rate. In some cases extraction of the tooth is required.

PATIENT INFORMATION

It is recognised that good communication is pivotal to the clinician-patient relationship. Patients require information concerning the diagnosis of their complaint and the options available for management. It is important to explain the reason why a surgical approach is being advocated rather than non-surgical root canal retreatment. A detailed explanation of the procedure should also be given.

At the pre-operative appointment, the potential outcome of any chosen course of treatment – adverse or otherwise – should be explained to the patient in a way that they can easily understand. Details should be noted in the patient's records.

The information provided should be sufficient to enable the patient or their carer to make a valid informed decision and give consent. The US National

Institutes of Health recommend that patients should be informed of potential surgical risks including any transitory condition that occurs with an incidence > 5% and any permanent condition with an incidence of >0.5%.

At the time of surgery, the patient should be reminded of the possible complications and side-effects of the operation. The operator should ensure that consent has been obtained, that the patient still wants to proceed with the procedure, and a note made on the patient's records.

At the time of operation, the patient should know:

- How to contact the surgery in case of emergency
- How to care for their mouth post-operatively
- Possible complications and side effects of the operation in general and any problems specific to the operation undertaken.
- Any drug therapy required
- When a review appointment is required
- That following the operation a letter will be sent to the referring practitioner detailing the treatment undertaken.

RECOMMENDATIONS FOR AUDIT AND RESEARCH

Well designed and managed randomised controlled trials (RCTs) regarding endodontic surgery that incorporate a sufficiently large sample population to detect clinically important differences have not been carried out. The outcome of a prospective international large multicentre trial over five years may provide valuable information.

There are a number of areas where well defined research or audit studies could provide significant information. These include:

- What factors affect morbidity after endodontic surgery?
- What are the relative cost benefits of undertaking endodontic surgery in different clinical settings (general dental practice, specialist practice, hospital)?
- How does the outcome of endodontic surgery compare with extraction and placement of an implant or a fixed or removable partial denture?
- An audit of the necessities and frequencies of therapeutic intervention after endodontic surgery
- How does endodontic surgery influence quality of life for the patient?

Key Messages for patients

These key messages are not intended for general dissemination to patients, but may be incorporated into local patient information materials.

The pros and cons of undertaking endodontic surgery

- All forms of surgery carry some risk of complications. There may be some pain and swelling and, with lower premolar and molar teeth there may be some altered sensation in the lower lip. Even in the best hands, accidents may occur.
- The decision to undertake a surgical approach rather than to treat the tooth non-surgically is dependent on many factors. The presence of an intricate and expensive coronal restoration may preclude that restoration being removed. In addition, removal of a post-retained restoration may lead to irreversible damage to the remaining tooth root. However, if dental caries is present in the crown of the tooth, this should be treated before surgery is contemplated.
- Other situations where it may be in the patient's best interests to have endodontic surgery include those where there are difficulties in obtaining expert alternative treatments.

How will the decision be made?

- Your dentist will carry out a thorough and complete assessment, including taking your medical and dental history, and a clinical examination to see if surgical endodontics is indicated and advisable. Surgery may be appropriate where recurrent infection has been associated with a root-filled tooth and the patient is unwilling to undergo extraction. There are considerable risks and costs associated with repeated antimicrobial treatment. He or she will discuss with you the advantages and disadvantages of surgery in your particular case, as well as the possible risks of the operation. You will also have one or more radiographs taken of your teeth before any decision on an operation is agreed. The clinician should also explain the implications of a decision not to remove the tooth and any possible problems in the future.

The operation itself:

- Local anaesthesia is used in most cases. It carries much less risk than a general anaesthetic.
- Bruising and swelling may occur after surgery, but this usually goes within 10 days
- Post-operative pain may occur but this is well controlled by non-narcotic pain killers
- Other common complications of endodontic surgery include bleeding, minor infection and damage to the adjacent teeth. Your dentist will inform you if any problems arise during the surgery and discuss with you if any further treatment is needed

After the operation

- Your dentist will advise you how to care for your mouth following the operation, e.g. with warm salt or chlorhexidine mouthwashes; and what painkillers to take, e.g. paracetamol or ibuprofen
- There is no evidence to suggest that antimicrobials should be prescribed

routinely after endodontic surgery, but they may be needed in some cases.

- Before leaving the surgery, you should know how to contact the surgeon in case of emergency. A review appointment will be arranged. A letter will be sent to your own dentist, if he or she did not carry out the surgery, to let him or her know about the operation and the follow-up arrangements.

References

Allen RK, Newton CW, Brown CE. A statistical analysis of surgical and nonsurgical endodontic retreatment cases. *J Endod* 1989; 15: 261-266

Ahmad N, Grad HA, Haas DA, Aronson KJ, Jokovic A, Locker D. The efficacy of nonopioid analgesics for postoperative dental pain: a meta analysis. *Anesth Prog* 1997; 44: 119-26.

Briggs PF, Scott BJ. Evidence-based dentistry: endodontic failure- how should it be managed. *Br Dent J* 1997; 183: 159-64.

Chindia ML, Valderhaug J. Periodontal status following trapezoidal and semilunar flaps in apicectomy. *East Afr Med J* 1995;72:564-7.

Danin J, Linder LE, Lundqvist G, Ohlsson L, Ramskold LO, Stromberg T. Outcomes of periradicular surgery in cases with apical pathosis and untreated canals. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999;87:227-32

Dorn SO, Gartner AH. Retrograde filling materials: a retrospective success-failure study of amalgam, EBA and IRM. *J Endod* 1990; 16: 391-393

el-Swiah JM, Walker RT. Reasons for apicectomies. A retrospective study. *Endod Dent Traumatol* 1996;12:185-91.

Frank AL, Glick DH, Patterson SS, Weine FS. Long-term evaluation of surgically placed amalgam fillings. *J Endod* 1992; 18: 391-398.

Freedman A Horowitz I Complications after apicoectomy in maxillary premolar and molar teeth. *Int J Oral Maxillofacial Surg* 1999; 28:192-4.

Friedman S. Treatment outcome and prognosis of endodontic therapy. In: *Essential Endodontology*, eds. PittFord TR & Orstavik D pp367-401 Blackwell, Oxford

Gilheany PA, Figdor D, Tyas MJ. Apical dentin permeability and microleakage associated with root end resection and retrograde filling. *J Endod.* 1994;20:22-6.

- Grung B. Healing of gingival mucoperiosteal flaps after marginal incision in apicoectomy procedures *Int J Oral Surg* 1973; 2: 20-25.
- Gutmann JL. Parameters of achieving quality anesthesia and hemostasis in surgical endodontics. *Anes Pain Control in Dent* 1993; 2: 223-226
- Gutmann JL, Harrison JW *Surgical Endodontics* 1991 Cambridge MA, Blackwell.
- Gutmann JL, Saunders WP, Nguyen L, Guo IY, Saunders EM. Ultrasonic root-end preparation. Part 1. SEM analysis. *Int Endod J.* 1994;27:318-24.
- Halse A, Molven O, Grung B. Follow up after periapical surgery: the value of the one-year control. *Endod Dent Traumatol.* 1991; 7: 246-50.
- Harrison JW, Jurosky KA. Wound healing in the tissues of the periodontium following periradicular surgery. 2. The dissectional wound. *J Endod.* 1991a;17:544-52.
- Harrison JW, Jurosky KA. Wound healing in the tissues of the periodontium following periradicular surgery. I. The incisional wound. *J Endod.* 1991b; 17:425-35.
- Hsu YY, Kim S. The resected root surface. The issue of canal isthmuses. *Dent Clin North Am.* 1997; 41: 529-40.
- Jackson DL, Moore PA, Hargreaves KM. Preoperative nonsteroidal anti-inflammatory medication for the prevention of postoperative dental pain. *J Am Dent Assoc* 1989; 11: 641-7.
- Jansson L, Sandstedt P, Laftman A-C, Skogland A. Relationship between apical and marginal healing in periradicular surgery. *Oral Surg, Oral Med, Oral Pathol Oral Radiol Endod* 1997;83:596-601.
- Jesslen P, Zetterqvist L, Heimdahl A. Long-term results of amalgam versus glass ionomer cement as apical sealant after apicoectomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;79:101-3.
- Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg, Oral Med, Oral Pathol.* 1965; 20:340-344.
- Kim S, Rethnam S. Hemostasis in endodontic microsurgery. *Dent Clin North Am.* 1997; 41: 499-511
- Khoury F, Hensher R. The bony lid approach for the apical root resection of lower molars. *Int J Oral Maxillofacial Surg* 1987; 16: 166-170.

Kvist T, Reit C. Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures. *J Endod* 1999;25:814-7.

Layton S, Korsen J. Informed consent in oral and maxillofacial surgery: a study of the value of written warnings. *Br J Oral Maxillofac Surg* 1994; 32: 34-6.

Lin LM, Gaengler P, Langeland K. Periradicular curettage. *Int Endod J* 1996; 29:220-7.

Martin MV, Nind D. Use of chlorhexidine gluconate for pre-operative disinfection of apicectomy sites. *Br Dent J* 1987 20;162:459-61

Mehlich DR, Sollecito WA, Helfrick JF, Leibold DG, Markowitz R, Schow CE, Shultz R, Waite DE. Multicenter clinical trial of ibuprofen and acetaminophen in the treatment of postoperative dental pain. *J Am Dent Assoc* 1990; 121: 257-63.

Min MM, Brown CE Jr, Legan JJ, Kafrawy AH.. In vitro evaluation of effects of ultrasonic root-end preparation on resected root surfaces. *J Endod* 1997;23:624-8.

Moller AJR, Fabricius L, Dahlen G, Ohman AE, Heyden G. Influence on periapical tissues of indigenous oral bacteria and necrotic pulp tissue in monkeys. *Scand J Dent Res* 1981; 89: 475-484

Molven O, Halse A, Grung B. Incomplete healing (scar tissue) after periapical surgery--radiographic findings 8 to 12 years after treatment. *J Endod* 1996;22:264-8.

Morgan LA, Marshall JG. A scanning electron microscopic study of in vivo ultrasonic root-end preparations. *J Endod* 1999; 25:567-70

Pantschev A, Carlsson AP, Andersson L. Retrograde root filling with EBA cement or amalgam. A comparative clinical study. *Oral Surg, Oral Med, Oral Pathol* 1994; 78: 101-104.

Pecora G, Andreana S. Use of the dental operating microscope in endodontic surgery. *Oral Surg Oral Med Oral Pathol* 1993; 75: 751-8.

Peterson J, Gutmann JL. The outcome of endodontic resurgery: a systematic review. *Int Endod J* 2001; 34: 169-175.

Rud J, Andreasen JO, Jensen JE. Radiographic criteria for the assessment of healing after endodontic surgery. *Int J Oral Surg.* 1972a;1:195-214.

Rud J, Andreasen JO, Jensen JF. A multivariate analysis of the influence of various factors upon healing after endodontic surgery. *Int J Oral Surg.* 1972b;1:258-71.

Rud J, Rud V, Munksgaard EC. Long-term evaluation of retrograde root filling with dentin-bonded resin composite. *J Endod.* 1996a;22:90-3.

Rud J, Rud V, Munksgaard EC. Retrograde root filling with dentin-bonded modified resin composite. *J Endod* 1996b;22:477-80

Seymour RA, Ward-Booth P, Kelly PJ. Evaluation of different doses of soluble ibuprofen and ibuprofen tablets in postoperative dental pain. *Br J Oral Maxillofac Surg* 1996; 34: 110-4.

Sundqvist G Bacteriological studies of necrotic dental pulps. 1976 Thesis, Umea University.

Testori T, Capelli M, Milani S, Weinstein RL. Success and failure in periradicular surgery: a longitudinal retrospective analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999; 87:493-8

Thompson IO, Phillips VM, Kalan M. Metastatic squamous carcinoma manifesting as a periapical lesion. *J Dent Assoc S Afr* 1992; 47: 481-3.

Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. *J Endod.* 1999;25:197-205.

Torabinejad M, Ford TR, Abedi HR, Kariyawasam SP, Tang HM. Tissue reaction to implanted root-end filling materials in the tibia and mandible of guinea pigs. *J Endod.* 1998 ;24:468-71.

Torabinejad M, Hong CU, Lee SJ, Monsef M, Pitt Ford TR Investigation of mineral trioxide aggregate for root-end filling in dogs. *J Endod.* 1995a;21:603-8.

Torabinejad M, Hong CU, McDonald F, Pitt Ford TR Physical and chemical properties of a new root-end filling material. *J Endod.* 1995b; 21:349-53.

Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD Cytotoxicity of four root end filling materials. *J Endod.* 1995c;21:489-92.

Torabinejad M, Pitt Ford TR, McKendry DJ, Abedi HR, Miller DA, Kariyawasam. Histologic assessment of mineral trioxide aggregate as a root-end filling in monkeys. *J Endod.* 1997 ;23:225-8.

Torabinejad M, Rastegar AF, Kettering JD, Pitt Ford TR. Bacterial leakage of mineral trioxide aggregate as a root-end filling material. *J Endod.* 1995d; 21:109-12.

von Arx T, Walker WA. Microsurgical instruments for root-end cavity preparation following apicoectomy: a literature review. *Endod Dent Traumatol* 2000; 16: 47-62

Wada M, Takase T, Nakanuma K, Arisue K, Nagahama F, Yamazaki M. Clinical study of refractory apical periodontitis treated by apicectomy. Part 1. Root canal morphology of resected apex. *Int Endod J* 1998;31:53-6.

Waplington M, Lumley PJ, Walmsley AD. Incidence of root canal alteration after ultrasonic retrograde cavity preparation. *Oral Surg, Oral Med, Oral Pathol Oral Radiol Endod* 1997;83:387-92.

Witherspoon DE, Gutmann JL Haemostasis in periradicular surgery. *Int Endod J* 1996; 29: 135-149.

Worrall SF. Are postoperative review appointments necessary following uncomplicated minor oral surgery? *Br J Oral Maxillofac Surg* 1996;34:495-9.

Zetterqvist L, Hall G, Holmlund A. Apicectomy: a comparative clinical study of amalgam and glass ionomer cement as apical sealants. *Oral Surg Oral Med Oral Pathol* 1991;71:489-91.