Endodontic microsurgery. Part one: diagnosis, patient selection and prognoses

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Key points

- Reviews the indications and contraindications for endodontic microsurgery.
- Identifies key factors to consider when planning endodontic microsurgery.
- Discusses the factors associated with success, and the success rates of endodontic microsurgery.

Abstract

Historically, surgical endodontics has been viewed as a treatment of last resort, mainly due to poor outcomes as a result of limitations in materials and techniques. Contemporary techniques, modern materials and better visualisation have all led to an improvement in success rates, making endodontic microsurgery a valuable treatment option to certain patients. Such advances, however, are no substitute for skill in endodontic diagnosis and treatment planning, which can often prove challenging. A variety of tools are available to test for fractures and assess both periodontal and pulpal health. More advanced techniques such as cone beam computed tomography are often invaluable in pre-surgical assessment and diagnosis. Once an accurate diagnosis has been established, a favourable prognosis is explicitly linked to careful patient selection. Orthograde treatment, or retreatment, remains the gold standard for the majority of endodontic problems. However, there are a number of indications for surgery where orthograde treatment is either impossible, or less likely to be successful. It is paramount for any clinician undertaking endodontic surgery to have a detailed understanding of the local and systemic factors associated with successful treatment. Whilst there are few absolute medical contraindications, there are a number of conditions which may influence patient management and make treatment more challenging.

Introduction

Endodontic surgery has often been viewed as a treatment of last resort. Historically, the technique has been flawed due to limitations with instruments and materials alongside challenges in access and visualisation. The surgery has been considered brutal and, most importantly, it has been associated with poor outcomes. Modern techniques overcome these obstacles and this is borne out by ever increasing success rate data.[1] These papers seek to review these changes and inform practitioners on the current guidance for diagnosis, patient selection and treatment regimen.

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Refereed Paper.
Accepted 4 April 2019
DOI: 10.1038/s41415-019-0415-3

History

The patient's complaint

It is often possible to determine an accurate differential diagnosis derived from the history before even examining the patient. Pulpal, periodontal and periapical pain all have characteristic descriptive features, but it is necessary to also consider more uncommon causes of discomfort which can sometimes mimic dental pain such as neuropathic, sinusitic or idiopathic pain. Though superficially these can be hard to diagnose, there are often signs and symptoms that do not align with odontogenic pain.[2,3]

Medical history

Though there are no medical contraindications to root canal treatment and few absolute contraindications to endodontic surgery, a detailed medical history is required as there are a number of conditions which may influence patient management. The American Society of Anesthesiologist's (ASA) classification of physical states (Table 1) is a simple tool for determining the physical health of a patient. In general, patients in ASA classes I and II could be safely managed in primary care. An assessment of the suitability of ASA Class III patients to undergo endodontic surgery would need to be made on an individual basis, with input from general or specialist medical colleagues if necessary. Those in Class IV would be considered unsuitable for elective endodontic surgery and any non-urgent dental treatment should be postponed until a time when the patient's general physical state has improved.

Bleeding risk

Bleeding is a risk during any surgery where an incision is made and there is a range of conditions and medications which can potentiate this bleeding risk (Table 2). It is important to note that whilst general guidance is available, none of the major guidelines reference endodontic surgery in their descriptors of what constitutes dental treatment.[5,6]

Table 1 A summary of the American Society of Anesthesiologist's classification of physical states[4]

ASA Class	Definition	Examples
I	A normal healthy patient	Non-smoker, normal weight, minimal alcohol use
II	Mild systemic disease	Tobacco use, moderate alcohol intake, pregnancy, obesity, well controlled chronic diseases such as asthma/diabetes/ hypertension
III	Severe systemic disease	COPD, morbid obesity, hepatitis, excessive alcohol intake, >3 month history of MI/CVA/TIA, poorly controlled chronic diseases such as asthma/diabetes/hypertension
IV	Severe systemic disease that is a constant threat to life	Recent (<3 month) history of MI/CVA/TIA
V	Moribund	Massive trauma, multiple organ failure, ruptured abdominal/thoracic aneurism
VI	Brain dead (organs to be removed for donor purposes)	

Table 2 Summary of the management of common bleeding risks

Potential bleeding risk	Management with regard to endodontic surgery
Dual antiplatelet therapy; for example, aspirin and clopidogrel	Consult cardiologist
New oral anticoagulants (NOACs); for example, dabigatran, rivaroxiban, apixaban	Dentist to advise patient to alter dose For drugs taken twice daily (for example, apixaban/ dabigatran; omit morning dose) For drugs taken once daily (for example, rivaroxaban); delay dose until four hours post-operatively
Injectable anticoagulants; for example, dalteparin, enoxaparin, tinzaparin	Consult with patient's medical hospital consultant
Vitamin K antagonists; for example, warfarin	Check INR within 72 hours of treatment. If INR >4 then treatment should be postponed until INR is stable
Combination medication	Liaise with GP/hospital consultant
Inherited/acquired bleeding disorders; for example, haemophilia, von Willebrands disease	Liaise with haematologist

Fig. 1 The sinus track is clear evidence of endodontic disease

Fig. 2 This is a slightly more challenging presentation: there is a sinus disto-apically to the 11, a draining pocket on the mid buccal of the 11 and 21. Further investigation is clearly required

Osseous conditions

Any conditions that affect bony healing should be identified. Principally, these include patients who have a history of radiotherapy and those taking bisphosphonates. There is no official guidance in relation to endodontics, however it would be wise to consider orthograde re-root treatment if possible in such patients, and it has been suggested that surgical endodontics should be contraindicated.[7] If orthograde treatment is not possible one must then discuss the risks inherent with both extraction or surgical endodontic treatment. In such cases there may not be a 'right' answer but endodontic microsurgery may well be less invasive than exodontia in some cases. Close liaison with the necessary medical support is essential if there is any doubt about exposure status and risk of bone necrosis.

Steroid cover

There have been reported cases of adrenal crises precipitated by dental treatment in patients taking steroid medications[8] and there has been debate surrounding the need for steroid cover in such patients. It is recommended that in patients who are taking steroid medication, additional cover should be provided based on the level of physiological stress caused by a procedure. For minor oral surgical procedures, such as surgical endodontics, it is recommended that the patient takes their morning dose of steroid as usual, followed by a double dose of their next dose an hour before the procedure, and that they continue with double doses at their usual intervals for 24 hours.[9]

Cardiovascular disease

There is no contraindication to surgical endodontic treatment, if cardiovascular disease is well controlled. In patients who have had a recent myocardial infarction or who are found to be severely hypertensive, elective surgical treatment should be delayed until their condition has stabilised. A number of cardiac diseases can predispose to infective endocarditis following endodontic surgery. Current guidance stipulates that antibiotic prophylaxis is not recommended routinely for patients undergoing dental surgery.[10] However, apical surgery can be considered a high-risk procedure and, in high-risk patients, a single dose of antibiotic prophylaxis could be considered.[11] The most recent implementation advice with regards to the NICE guidelines suggests that in patients with certain conditions such as prosthetic valves, previous endocarditis or congenital heart disease, antibiotic prophylaxis should be considered through liaison with their cardiologist.[12] It is also suggested that there should be a discussion of the signs and symptoms of infective endocarditis and the risks and benefits of antibiotic prophylaxis with all 'at risk' patients.

Mental capacity

Patients with reduced capacity to consent are not contraindicated to either surgery or

orthograde root canal treatment, but complex treatment on such patients can be demanding if not impossible. A best interests decision, made in conjunction with next of kin, carers and if need be an independent mental capacity advocate, could include surgical endodontics if clinically appropriate. Key factors to consider must be the complexity of the treatment, the patient's ability to undergo care and the necessary IV or GA adjuncts required to facilitate such care.

Examination

Extra-oral examination will identify the presence of swellings, sinuses or lymphadenopathy within the neck or face. These may all support the diagnosis of persistent endodontic disease (Figs 1 and 2). Intra-oral examination should assess the patient's oral hygiene and occlusion. Details of any periodontal disease, caries or tooth surface loss should also be recorded. When assessing previously endodontically treated teeth, particular attention should be paid to the following:

- The presence of sinus tracts in buccal or palatal soft tissues
- Tenderness within the buccal sulcus
- Mobility
- Tenderness to percussion
- Isolated deep pocketing suggestive of root fracture
- Expansion of the alveolar bone
- The quality of coronal restoration
- The periodontal status of the tooth.

Table 3 discusses some of the factors at a tooth level which may influence patient management (Fig. 3).

Table 3 Factors to be considered before performing endodontic surgery

Factor to consider	Clinical or radiological signs
Quality of coronal restoration (Fig. 3a)	Leaking margins Lack of cuspal coverage
Quality of endodontic restoration (Fig. 3b)	Poorly condensed Presence of voids Absence of orthograde filling material More than 2 mm short of radiographic apex
Periodontal health (Fig. 3c)	Mobility Bleeding on probing Pathological pocketing Perio-endo lesions Vertical or horizontal bone loss
Caries (Fig. 3d)	Stickiness on probing crown margins (secondary caries in extra-coronal restorations can be difficult to diagnose radiographically)
Root fractures (Fig. 3e)	Localised, deep areas of pocketing Mobility of a post crown A history of de-bonding of post crowns
Tooth morphology (Fig. 3f)	Poor crown root ratio

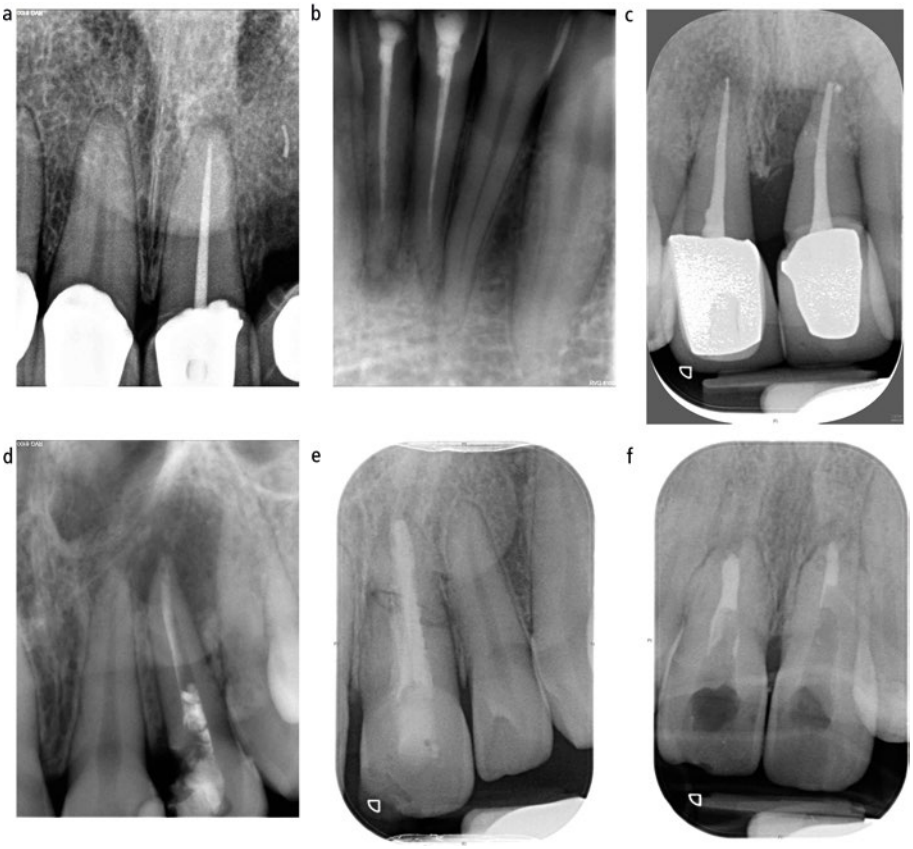

Fig. 3 a) The compromised coronal margins may explain persistent intra-radicular infection on an otherwise well shaped and filled 21. This presentation would support strip-down, retreatment and replacement of the restorations over surgery; b) the poor shape, length and obturation of these lower incisors should always point towards retreatment over surgery; c) the lesion on this 21 is on the mesio-apical aspect and associated with a vertical defect suggesting the pathology is periodontal in nature not endodontic and caution should be exercised if proposing surgery; d) without addressing the coronal seal on the 22 any kind of treatment is unlikely to be successful; e) the pathology of 21 originates from the fracture line not the apex. Amputation of the apical portion and retrograde root filling may be possible but would render this tooth mobile; f) 'when you ain't got nothing, you got nothing to lose' sang Dylan, but in this case there is everything to lose! Apical surgery would leave no root left

Further investigations

Assessing periodontal health

A basic periodontal examination must be performed and it is essential to assess the tooth or teeth under suspicion in more detail. Horizontal pattern bone loss may contraindicate surgery, and when severe may contraindicate any form of treatment especially when the diagnosis of a perio-endo lesion is suspected. Deep isolated pockets may represent draining sinuses for endodontic lesions. However, they are also pathognomonic of root fractures, which often contraindicate any further endodontic treatment, be it surgical or non-surgical.

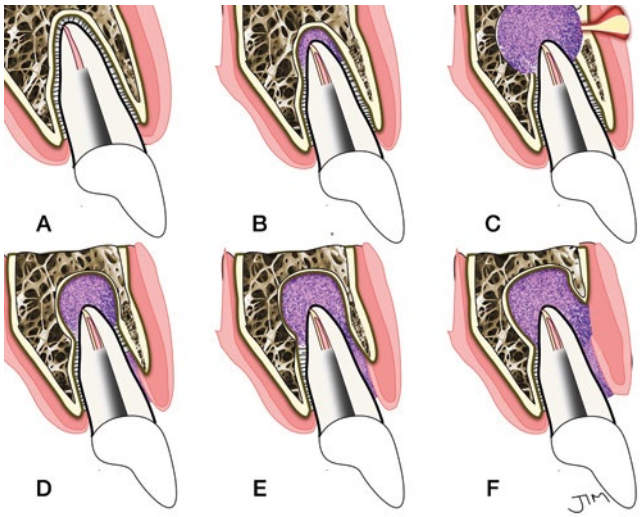

Fig. 4 Classification of differing endodontic conditions: a) no apical disease; b) small endodontic lesion; c) larger lesion half root length; d) class B lesion with periodontal bone loss; e) class B lesion with periodontal communication; f) class E with total buccal fenestration

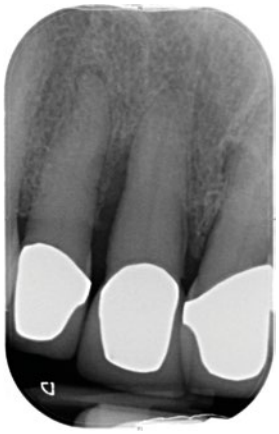

Fig. 5 The radiograph of the patient seen in Figure 2 reveals an endodontic lesion associated with the 12 and a deep vertical periodontal defect associated with the 11. This patient's management strategy will require input from both disciplines

Kim has suggested a classification for assessing the perio-endo status of a tooth (Fig. 4). Classifications A–C represent favourable conditions for endodontic surgery. Classifications D–F represent progressive periodontal involvement. A classification D reflects the coexistence of both periodontal and endodontic lesions. Classification E, the presence of a combined perio-endo lesion and F, a perio-endo lesion with loss of buccal plate. Kim suggests that cases D–F carry uncertain outcomes and may be contraindications to treatment. This may be too simplistic. Firstly, the true nature of any defect may not be fully understood until surgical exposure, at which time it is often reasonable to continue with planned therapy accepting a compromised outcome. Secondly, the biology of a primary endo secondary periodontal lesion may have greater potential to heal than a primary perio secondary endodontic lesion; this distinction should be recognised rather than contraindicating all perio-endo lesions.

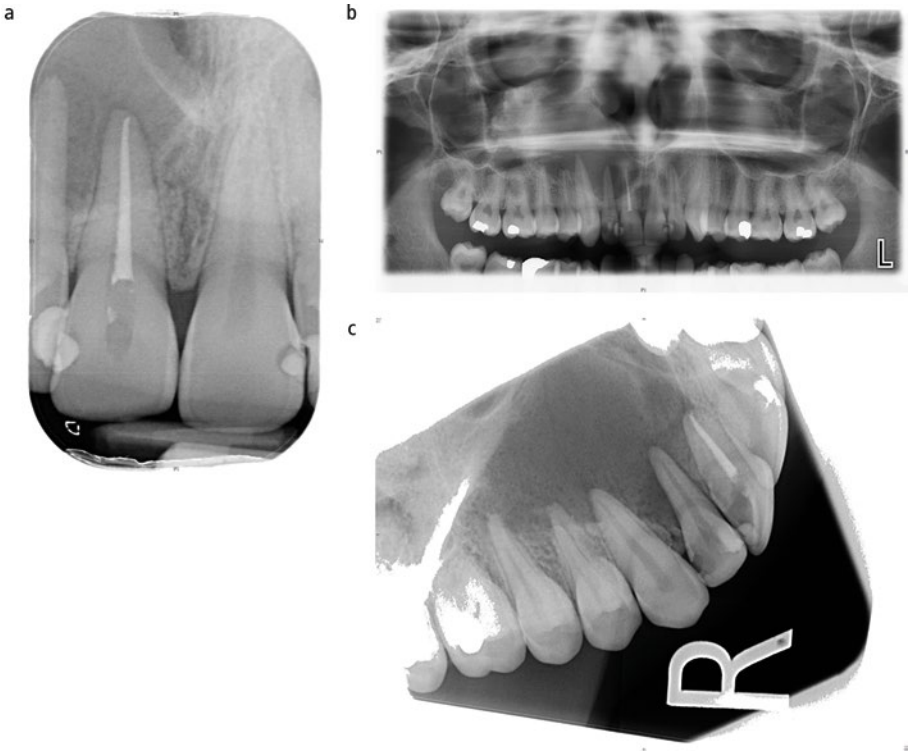

Fig. 6 The periapical radiographs show a lesion associated with the 11 but the full extent of the lesion is not evident and further views were deemed necessary. The lesion is far more expansive than originally thought and the decision was made to refer this patient to an oral surgeon following CBCT

Testing for fractures

Previously root treated teeth are usually heavily restored and fractures are not uncommon. Diagnosis of cracked teeth can be difficult but is important, as the presence of a fracture may rule out any further complex treatment. The use of the Fract-finders or a Tooth Sleuth on an individual cusp can often recreate the vague, painful symptoms caused by cracked teeth. Visualisation under magnification and good illumination is essential. Fibre-optic lights or disclosing solutions can also be used to highlight fracture lines within teeth. If, radiographically, a lesion is not centred on the apex but rather the lateral aspect of the root, this may suggest a fracture.

Assessing pulpal health

By definition, a tooth that is suspected to need either retreatment or surgery will be non-vital. It is, however, sensible to test adjacent teeth to build the case that pathology stems from the suspected tooth and ensure that the adjacent teeth are healthy. A variety of tools are available, but cold testing with a suitably cold medium consistently appears to be the most reliable. Propane-butane mixes reach temperatures of 50 degrees Celsius and should be considered the gold standard, not ethyl chloride.[13,14,15]

Fig. 7 The 24 had been root canal treated but failed with persistent disease: a) the PA suggests unfilled canal apically supporting the need for re-treatment over surgery but something looked suspicious and it was felt CBCT may help elucidate the anatomy; b) the sagittal CBCT view supported the original position but the coronal view; c) reveals a very unusual anatomical configuration with an open apex exiting buccally; d) reconstruction reveals the perverse anatomy not predictably accessible to conventional retreatment; e) shows the post-operative image following microsurgery

Radiology

The standard imaging required prior to surgical endodontic treatment are plain film intra-oral radiographs. These can provide detailed information regarding the diagnosis of periapical lesions and should include at least 3 mm of tissue beyond the apex (Fig. 5).[16] The principles of parallax can be used assess multi-rooted teeth and gutta percha points may be placed down sinus tracts to identify the origin. Extra-oral panoramic radiographs can also be of use for larger lesions, however superimposition of structures can sometimes make diagnosis difficult (Fig. 6).

Increasingly, cone beam computed tomography (CBCT) has been used to provide detailed radiographic examination and can be particularly useful in planning surgical endodontic treatment. Its use, however, should not be routine, but reserved for cases in which conventional radiography has not provided sufficient information to make an accurate diagnosis or pre-surgical assessment for anatomical variances and proximity to key structures. CBCT provides better assessment of the relationship of lesions to anatomical structures such as the maxillary antrum and mental nerve, when compared to conventional radiography;[17] such information can be invaluable when planning a surgical approach. CBCT can also provide greater information with regards to complications such as root fracture[18] and root resorption.[19] Guidelines in the UK state that CBCT may be indicated in selected surgical cases, but that selection should be made on an assessment of potential complicating factors (Fig. 7).[20]

Establishing the correct diagnosis is key in determining the most appropriate primary treatment strategy (Table 4). If there is doubt about the correct diagnosis, referral to local ENT, maxillofacial surgery or facial pain services for a second opinion and possible management strategy is wise before undertaking any dental treatment.

Table 4 Appropriate treatment strategies for different causes of endodontic disease

Aetiology of disease	Considerations	Primary treatment strategy
Persistent intraradicular infection	Missed anatomy, inadequate shaping, cleaning and/or obturation, failed coronal seal, root fracture, iatrogenic damage	Non-surgical retreatment
Foreign body response	Overfill and overextension of obturation materials	Surgical endodontics
Extraradicular infection	Biofilm development on the external root surface	Surgical endodontics
Cyst	Multiple theories of cystic development	Surgical endodontics

Indications for re-root canal treatment

When undertaken to a high standard, endodontic treatment is associated with success rates in excess of 80% and survival rates over 90%.[21,22] Primary treatment can, however, fail for a number of reasons. Ultimately, this may be due to persistent intraradicular infection, extraradicular infection, foreign body response to extruded materials, or the development of a cyst.[23] It is essential to reflect upon the possible reason for persistent disease, as this will dictate the most appropriate treatment strategy. The most common cause remains the persistence of bacteria within the root canal system.[24] This may be due to a complex myriad of factors but the clinician should be aware of the most likely causes.

Inadequate primary root canal treatment resulting in bacterial persistence similar to a primary disease

Principally, this could be due to poor technique with inadequate shaping and cleaning or reflect some of the challenges all endodontic treatments pose: complex micro- and macro-anatomy and the complex biofilm. If suspected, in these circumstances, retreatment should be considered the most sensible option. If there is considerable iatrogenic damage to a tooth, the consent process should make the patient aware of the challenges in overcoming such problems.[25]

High-quality primary root canal treatment with persistent primary disease

Unless there is missed anatomy, the bacterial species in these cases may be more limited and more virulent.[25] Retreatment may be more challenging and consideration must be given to the limitations of instrumentation and cleaning within complex anatomy. Nonetheless, retreatment should be considered the first option unless there is confidence that the primary treatment cannot be improved upon.

Other possible aetiological factors

Irrespective of the quality of the root canal treatment, there are several factors that may result in failure if not diagnosed. These include fractures, perforations, and failure of the coronal restoration and seal. In the case of fractures, it is unlikely that retreatment or surgery will result in success. Where the coronal seal is compromised one should be optimistic about the likelihood of success.

Fig. 8 An attempt was made to relocate the canal apical to the ledge on the mesiobuccal root of this 16 but failed. Such iatrogenic damage may be only managed surgically

Perforations present more challenges but ultimately success may be related to the size, duration and site of the perforation.[26]

Non-surgical retreatment is associated with success rates of over 80% when undertaken to a high standard, with survival rates of up to 95%[22,27] there is some evidence that it may offer a better prognosis than apical surgery alone.[28] Furthermore the presence of an existing root filling and adequate coronal seal are prognostic indicators in surgical endodontics.[29,30] As such, the possibility of orthograde retreatment should always be considered before surgery or extraction.

Indications for endodontic surgery

Iatrogenic or developmental anomalies which prevent orthograde treatment

Factors that may prevent the clinician accessing apical anatomy and thus thoroughly decontaminating include: ledging, fractured instruments, restoration with posts, and heavily sclerosed canals. It is important to note that the above are not absolute indications for surgery, as there are many techniques for retrieving fractured instruments[31] and removing posts from canals.[32] A clinician with specialist skill and access to a microscope may be able to resolve such problems without resorting to a surgical approach (Figs 8 and 9).

Failure of orthograde treatment when retreatment is unlikely to be successful

If the original treatment has been undertaken to a high standard and there is confidence that it cannot be improved, then surgery becomes the treatment of choice. Often the judgement about the quality of a root canal treatment is based upon a two-dimensional radiograph, with only proxy information to the techniques and skill of the original treating clinician. Unless one actually performed the original treatment and can objectively vouch for the technical merits of the protocol, it is impossible to know how well the canals are shaped, cleaned and obturated, and under what conditions the care was provided. As such, even if the original treatment appears high-quality there may be a possibility to improve the care provided (Fig. 10).

Fig. 9 There are separated instruments in the buccal roots of this three-rooted upper premolar. Successful retreatment would be impossible

Fig. 10 The 21 has been root canal treated by a clinician with skill. Though there is some potential to improve on the shaping, this may only offer marginal gains and surgery was planned

Failure of orthograde treatment when coronal disassembly would jeopardise the prognosis of the tooth or prove too costly or time consuming.

If the collateral damage incurred in disassembly would render the tooth unrestorable or begin to incur costs that start to parallel other prosthetic modalities, an honest conversation should be held with the patient to explore the surgical endodontics or alternatives to endodontic therapy (Fig. 11).

Biopsy

There are occasions when the diagnosis of an apical lesion is not clear from the clinical history and radiographic investigations. In such cases, a surgical approach may be indicated so that a specimen can be obtained for histopathological analysis.

Surgical exploration

In cases where there is a suspected fracture or perforation, the diagnosis may remain unclear despite CBCT imaging. Surgical exploration in these cases can be invaluable (Fig. 12).

Retrieval of displaced materials or instruments

Foreign body reactions or biofilm development around extruded materials/instruments contributes to non-healing lesions.[33,34] If these cannot be retrieved via the canal system surgery may be the only option available.

Fig. 11 Though it is technically possible to dismantle many teeth this is the classic scenario supporting a surgical approach

Patient factors precluding lengthy retreatment

These could include patients with trismus, patients who cannot tolerate rubber dam, or simply patients who, through conditions of chronic pain, cannot remain seated comfortably for the two hours plus required to undertake retreatment. In these cases, though not the first line choice, surgical treatment may be the most pragmatic option.

Contraindications to endodontic surgery

Internal factors

Inadequate surgical skill, training or support.

Medical or psychological factors precluding surgery

Factors such as dental anxiety, the patient's ability to maintain complex restorations and even an individual preference towards particular treatment options can all rule out the provision of surgery. As discussed earlier, the patient's capacity to consent and any relevant medical history can contraindicate surgical treatment.

Dental factors

Unstable oral disease

Endodontic surgery is complex and should be avoided in patients with unstable dentitions. Ownership of oral health and control of primary disease is an essential prerequisite for all advanced care (Fig. 13).

Unusual root configuration

Roots should be assessed for access and surgery avoided where the root is unlikely to be prepared adequately. Lower incisors, lingual canals on lower posterior teeth, and palatal roots of upper teeth can be particularly difficult to access. Long roots or limited mouth opening can further complicate procedures.

Proximity to vital structures

The inferior dental, mental and lingual nerves, the maxillary sinuses and the roots of adjacent teeth may be in close proximity to apical lesions. Potential damage involving these structures should be included in the consent and planning process, and surgery avoided if the risk is deemed too high.

Compromised periodontal status

If the apical amputation renders the tooth without sufficient periodontal support, surgery must be avoided.

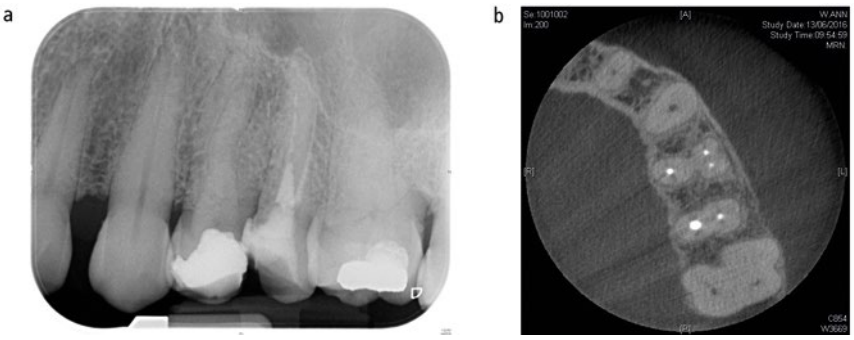

Fig. 12 Though the quality of the original treatment was sub-optimal the apical anatomy and nature of the lesion seemed unusual suggesting a more complex scenario furthermore adequately obturating the open apex beyond the curvature of the canal would be very challenging so exploration and retrograde approach was proposed

Compromised restorative status

If the coronal restoration is so mutilated that restoration is impossible, then surgery is futile.

Success in surgical endodontics

Success is usually measured on the basis of radiographic examination and the presence of symptoms (Table 5):

- Success/favourable outcomes: the outcome can be classed as successful or favourable if there is complete radiographic healing and an absence of symptoms
- Failure/unfavourable outcomes: an unsuccessful outcome is seen where there is no evidence of bony healing and clinical signs or symptoms suggest that endodontic disease is progressing
- Uncertain outcomes: if a periapical lesion remains but is asymptomatic, this could be regarded as an uncertain outcome. It may be that there is scar tissue apically rather than regeneration of periodontal ligament, therefore showing incomplete radiographic healing whilst the patient remains asymptomatic.

It is essential to recognise that these are proxy indicators of a cellular process apically rather than a definitive indication of healing. Whilst good bony healing is generally a sign of success, it is impossible to say without histopathalogical examination whether a lesion which appears to have healed with scar tissue remains inflamed.[35] Nonetheless, it has been shown that certain radiographic features do correlate with histology indicative of success or failure of surgical endodontic treatment (Table 5); in reality, a more pragmatic approach is often needed in defining success.

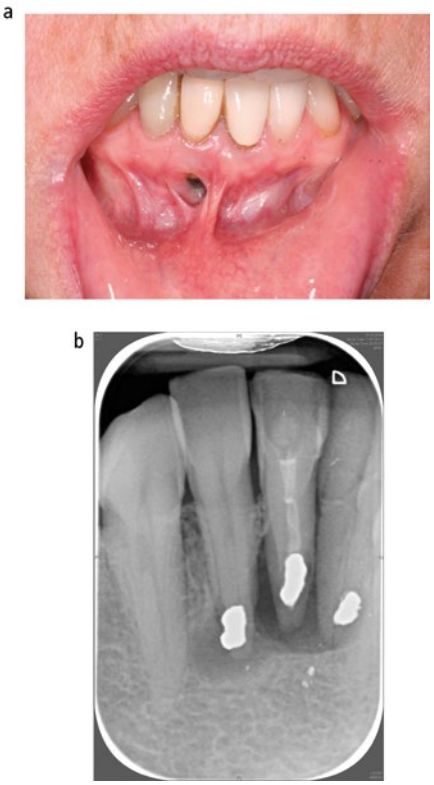

Fig. 13 This patient was referred for re-apical surgery of the lower anteriors. The 41 apex is exposed to the oral environment and the radiographs show the lesion to extend coronally into the coronal third of the root. This would not make for a favourable apicectomy

To determine long-term success, it is necessary to follow-up the patient clinically and radiographically at regular intervals.[16] It has been suggested that, in the short-term, surgical treatment caries a greater success

Table 5 Radiographic and clinical features of endodontic success

Outcome of surgical treatment	Radiographic features	Clinical signs/symptoms
Successful	Resolution of apical radiolucency Intact periodontal space of normal width Intact lamina dura	Asymptomatic
Incomplete	Decreased but incompletely resolved radiolucency Radiolucency with irregular outline Asymmetry of radiolucency around the apex Course bone structure peripheral to the lamina dura Radiolucencies with angular extensions into the periodontal space	Asymptomatic
Uncertain	As with incomplete	Mild discomfort Sensation of pressure from the tooth
Unsuccessful	Periodontal membrane of more than twice normal width Circular or semi-circular radiolucencies Radiolucencies with funnel shaped extensions into the periodontal space	Tenderness to percussion Presence of a sinus tract Abscess formation Tenderness within the buccal sulcus Acute pain

Fig. 14 a) The 12 had been retreated but with no evidence of healing; b) 12 immediately following apicectomy; c) evidence of healing at 6 months; d) complete healing at 12 months

rate than non-surgical treatment, which then levels out between the two treatments in the medium to long-term, most likely due to the persistence of an intraradicular infection.[36] Molven *et al.* demonstrated that the majority of lesions managed with apical surgery classified as having incomplete radiographic healing, remained asymptomatic during 8–12 years of observation.[37] It has also been shown that, of cases considered to have healed successfully after one year, 91% remain healed and symptom free at seven years of follow-up (Fig. 14).[38] For these reasons, patients who have undergone endodontic surgery tend to be followed up clinically and radiographically for one year.

With the advancement of techniques, instruments and materials, success rates have been increasing. Endodontic microsurgery has been defined as the use of an operating microscope or an endoscope with high-power magnification together with microsurgical instruments, ultrasonic root-end preparation, and more biocompatible filling materials such as IRM, SuperEBA or MTA.[1] Recent meta-analyses of these trends suggest a cumulative success rate of 89–93.5% for endodontic microsurgery.[1,39,40,41] From these meta-analyses, several factors have been associated with success.

Treatment-related factors

The outcomes of up-to-date endodontic microsurgery, using ultrasonic instruments, magnification and modern root end filling materials, have been compared to those of traditional endodontic surgery which utilises a bur to prepare the root end before filling with amalgam. The use of modern techniques appears to increase the success rate from 59% to 93.5%.[1] A further study compared endodontic microsurgery to the use of modern techniques without a microscope. Without the use of higher magnification, the success rate fell from 94% to 88% (Table 6).[40]

Tooth-related factors

Numerous studies have looked for correlations between tooth-related factors and the success of surgical treatment.[42,43,44,45,46] The following factors were identified as having a greater chance of success: periapical lesions <5 mm in size, an absence of pre-operative pain, good radiographic density of the root end filling, and pre-operative probing depths of <3 mm. Maxillary teeth generally had a greater success rate than mandibular teeth, and teeth treated surgically for the second time had a significantly worse prognosis.[47]

Conclusion

Non-surgical retreatment should always be considered in the first instance when a patient presents with persistent periapical disease. There are certain cases where surgical endodontics may be a more appropriate, if not the only available modality, but careful

Table 6 Pooled success rates associated with microsurgery compared to contemporary apical surgical techniques

Type of surgery	Success rate
de Lange 2007	81%
von Arx 2003	75%
Zuolo 2000	91%
Maddalone 2003	93%
Lindeboom 2003	89%
Taschieri 2006	91%
Contemporary Root-End Surgery	**88%**
Rubinstein 1999	97%
von Arx 2003	89%
Taschieri 2008	91%
Christiansen 2009	100%
Fillipi 2006	93%
Taschieri 2005	93%
Chong 2003	90%
Kim 2008	95%
Endodontic microsurgery	**94%**

assessment of both the patient and the tooth is required to ensure that such treatment is appropriate. When indicated, the use of a microsurgical technique will give the greatest opportunity for a successful outcome, with success rates over 90%. Paper two in this series will review techniques, instruments and materials that may contribute to these higher success rates.

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