Enhanced CPD DO C

Robert Smith

Graeme Bryce, Geoffrey St George, Poonam Kalsi

Endodontic Surgery. Part 2: Surgical Root Canal Re-treatment

Abstract: Surgical root canal re-treatment (SRCReT), or root-end surgery, is the most commonly undertaken surgical endodontic technique. Approaches to SRCReT differ, with a variety of different protocols described and varied success rates reported. In the second part of this two-part series, the current scientific literature is examined and clinical examples are given to offer guidance for the optimal protocol for SRCReT.

CPD/Clinical Relevance: SRCReT is a procedure which may facilitate the treatment of disease of endodontic origin which is not amenable to management with orthograde non-surgical root canal treatment.

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In Part 1 of this series, a general overview of endodontic surgery was discussed. The second article evaluates the optimal way to perform SRCReT, the commonest endodontic surgical procedure, which is a long-established method of treatment for apical periodontitis when conventional root canal treatment (RCT) has failed and non-surgical root canal re-treatment (NSRCReT) is impractical.[1] As discussed in Part 1, SRCReT success rates are reported to range between 37% to over 90%[1–5] with a number of general and local factors responsible for this wide variation. A strict surgical protocol improves the prognosis of treatment.[4,6] Guidelines for the provision of SRCReT (American Association of Endodontists, British Endodontic Society Quality Guidelines, Royal College of Surgeons of England) are generic and do not adequately detail or illustrate their proposed approaches. This article uses published scientific literature to produce a protocol for SRCReT, with inferences drawn that can be applied to other endodontic surgical techniques.

Surgical root canal re-treatment

Surgical procedures can generally be broken down into three phases: pre-operative; intra-operative; and post-operative procedures. The pre-operative phase for SRCReT should include a thorough history, clinical and radiographic assessment, diagnoses, treatment planning, consent, prescription of prophylactic drugs, the disinfection of the operative site and local anaesthesia. The intra-operative phase includes magnification and visualization, soft tissue management, osteotomy, haemostasis, root-end resection, root canal root-end preparation, obturation of the prepared root-end, curettage, regenerative procedures and wound closure. The post-operative phase includes pain control, post-operative instructions, pre-emptive management of possible complications, suture removal and review.

Robert Smith, BDS, MSc, MFDS RCS, MFDTEd, Enhanced Practitioner, Defence Primary Healthcare (Dental), Defence Centre for Rehabilitative Dentistry. **Graeme Bryce**, BDS, MSc, MEndoRCS, MRD RCPSG, FDS (Rest Dent), FFDT, Consultant in Restorative Dentistry, Defence Primary Healthcare (Dental), Defence Centre for Rehabilitative Dentistry. **Geoffrey St George**, BDS, DGDP (UK), MSc, FDS RCS, FDS (Rest Dent), Consultant in Restorative Dentistry, Royal National ENT and Eastman Dental Hospitals, University College Hospitals NHS Trust, 47-49 Huntley Street, London, WC1E 6DG. **Poonam Kalsi**, BDS (Hons), MSc, MJDF RCS, FDS (Rest Dent), Consultant in Restorative Dentistry, Guy's and St Thomas' NHS Foundation Trust.
email: graemebryce001@hotmail.com

Pre-operative phase

History

This should include routine history, such as medical, and more specific aspects, such as the history of treatment to the tooth, previous trauma, pain history and decementation of restorations, for instance, post crowns, which may indicate poor restorative prognosis or root fracture.

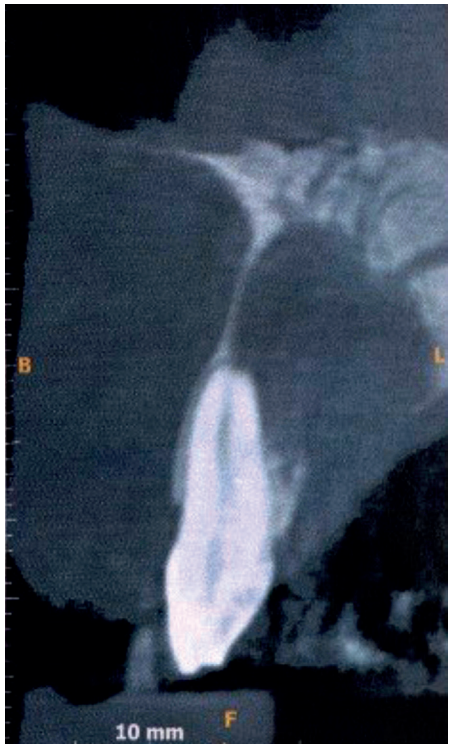


Figure 1. CBCT view of radicular cyst encroaching on the incisive nerve foramen.

Indications for SRCReT	Contraindications for SRCReT
Signs and symptoms (including radiographic findings) that indicate a diagnosis of apical periodontitis associated with a root canal that is not negotiable (the obstruction cannot be bypassed, or removal poses too great a risk to the root)	Systemic illness contraindicating the undertaking of minor surgical procedures. Patient physically or psychologically unable to tolerate treatment
Extruded root filling material with radiographic findings and/or signs and symptoms of apical periodontitis	Local anatomical factors, such as: unusual bony anatomy; root ends lying in close proximity to the nasal cavity, maxillary sinus and neurovascular bundles; posterior teeth with inaccessible root ends, dental implants in close proximity to the surgical site
The emergence, or persistence, of disease following root canal treatment where further orthograde root canal re-treatment is contraindicated (suspected aberrant apical anatomy or teeth with well-fitting restorations)	Teeth with a hopeless restorative prognosis, for instance, a vertically root-fractured tooth

Table 1. Indications and contraindications for SRCReT.

Clinical assessment

A consultation should include a thorough clinical examination and special tests, as per best practice guidelines.[7]

Radiographic assessment

Both digital and wet film parallel long-cone peri-apical radiographic images can be used for pre-operative assessment,[8,9] although the effective dose is lower for digital radiographs.[10] The taking of two angled peri-apical views provides greater information of the surgical site than a single view.[11] 3D imaging using a small volume cone beam computerized tomography (CBCT) has also been shown to be useful in SRCReT because it can be more effective than peri-apical radiography in diagnosing apical lesions,[12] assessing adjacent anatomical structures and planning extensive surgery (Figure 1). However, a balance must be struck between radiation dose limitation and obtaining sufficient information for diagnosis and treatment planning.[13]

Diagnosis and treatment planning

A diagnosis must be made and explained to the patient to justify intervention/non-intervention. Indications and contra-indications for SRCReT are well established[7] and are listed in Table 1.

Consent

The consent process should provide the patient with a detailed explanation of the surgical procedure, the advantages/disadvantages and risks of the proposed treatment and alternative treatment options. Common risks include bleeding, swelling, pain, gingival recession, scarring of mucosa, a transient increase in mobility of teeth, failure of treatment, and devascularization of adjacent roots contained within the lesion.

Use of prophylactic medications

No correlation has been found between prophylactic antibiotic provision and healing following SRCReT,[14] or elimination of post-operative wound healing complications.[15,16] The routine prescription of antibiotics cannot therefore be recommended. Single pre-operative doses of a non-steroidal anti-inflammatory drug (NSAID) have been shown to be effective at reducing post-operative pain for general surgical procedures[17,18] and prophylactic steroids have been shown to reduce post-extraction pain.[19] For SRCReT, a pre-operative dose of 8 mg dexamethasone followed by two single 4-mg doses on the first and second days post-operatively has been found to reduce post-operative pain.[20] However, presently, there is insufficient evidence to support the use of single-dose steroids over their NSAID counterparts. Given the availability and well-tolerated nature of NSAIDs, a single pre-operative dose of 400 mg ibuprofen[21] or 1000 mg paracetamol is advised as part of any pre-operative protocol.[22]

Disinfection of the intra-oral operative site

Pre-operative rinsing with chlorhexidine gluconate may inhibit the growth of bacteria in saliva for up to 4 hours post-operatively[23] and reduce the bacterial load around apicectomy sites by up to 94%.[24] Patients should rinse pre-operatively for 1 minute, using 10 ml of a 0.2% chlorhexidine gluconate-containing mouthwash. The application of chlorhexidine gluconate-dampened gauze to the relevant oral tissues should also be considered.[24]

Local anaesthesia

The use of local anaesthetic containing a vasoconstrictor improves both intra-operative haemostatic control as well as the depth and the duration of anaesthesia.[25] There is insufficient evidence to support the superiority of any particular local anaesthetic. However, improved control of intra-operative bleeding is achieved with increased adrenaline concentration.[26,27] Commercially available 2% lidocaine with 1:80,000 adrenaline can be recommended[28] although alternatives exist, including

formulations of articaine, prilocaine and mepivacaine. The long-acting local anaesthetic bupivacaine, when combined with 1:200,000 adrenaline, is an effective local anaesthetic. It has the additional benefit of a long duration, which reduces post-operative pain, but at the expense of an increase in the amount of intra-operative bleeding.[29]

Intra-operative phase

Magnification and visualization

Microsurgical techniques, undertaken with high magnification, offer a number of advantages, including improved detection of root canal features, such as cracks and accessory anatomy.[30] The use of operating microscopes, combined with microsurgical instruments, can improve SRCReT outcomes.[31,32] An operating microscope or, at the very least, magnifying loupes with a direct light source should be employed for SRCReT.

Soft tissue management

A number of muco-periosteal flap designs have been advocated for use in SRCReT and these include semi-lunar, submarginal, as well as different types of full-thickness flaps that employ either intrasulcular or papilla-based incisions. These have been combined with vertical relieving incisions to allow better access to the surgical site.[33,34] Flap designs that use an intrasulcular or papilla-based incision, combined with appropriate relieving incisions are preferred over a semi-lunar approach because there is improved visualization, reduced intra-operative bleeding, the incision line does not encroach upon the osteotomy site, and there is reduced post-operative scarring.[34] To facilitate adequate visualization and management of the surgical site, the flap should be extended at least one tooth either side of the estimated extent of the peri-radicular lesion. Greater debate surrounds the optimal method of incision at the gingival margin. Papilla-based incisions are better at preserving the vertical height of the papillae when compared to their intra-sulcular counterparts[35] because of reduced vascular and connective tissue damage to the most coronal part of the papilla. Closer adaptation of the flap margin to the adjacent fixed tissue, which facilitates primary healing, is also easier to achieve. However, this incision may impair the visualization of the proximal marginal aspects of the root and this should be taken into consideration when planning the flap design. When maintenance of papillae height is essential for aesthetic reasons, a papilla-based incision is advocated. A full thickness intra-sulcular incision would be the preferred approach when full visualization of a tooth/alveolar bone is essential (to rule out the presence of a crack or perforation). Either a 15C or micro-surgical blade is sufficiently small to make precise incisions (Figure 2). Retraction should commence at the base of the relieving incision, rotating a periosteal elevator (such as a Buser) against the bone and advancing the instrument in small movements to ensure separation of the periosteum from the bone. The flap should be kept moist throughout the procedure using sterile saline.

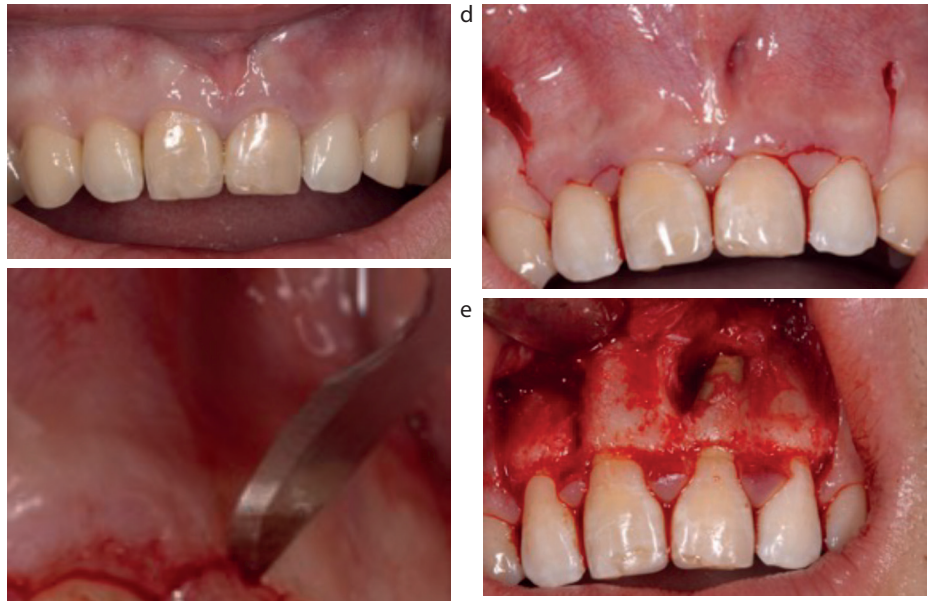


Figure 2. Papillae preservation incision for SRCReT UR1 UL1. **(a)** Pre-operative. **(b)** Primary 1.5-mm deep split-thickness incision, angled at 90° to the surface of the gingivae and meeting the papillae gingival margins at 90°. **(c)** Secondary full-thickness incision, retracing the original incision at a much steeper angle and contacting bone using a 15c blade to **(d)** connect the initial incisions and **(e)** for the vertical relieving incision and elevation of rectangular-shaped flap.

Alveolar bone removal

The amount of bone removal to facilitate access for curettage, root resection and root-end preparation depends on the size of the peri-apical lesion. Larger lesions are more likely to have incurred buccal cortical plate erosion, helping to assist with the identification of the root-end. With smaller lesions, direct measurements from radiographs and careful orientation are needed to locate the site to start the osteotomy preparation. Prospective studies with good outcomes have employed rear-venting high-speed handpieces (that avoid contamination of the surgical site with handpiece oil and the theoretical possibility of surgical emphysema), and use of round tungsten carbide burs for the osteotomy phase of the treatment.[6] A contra-angle

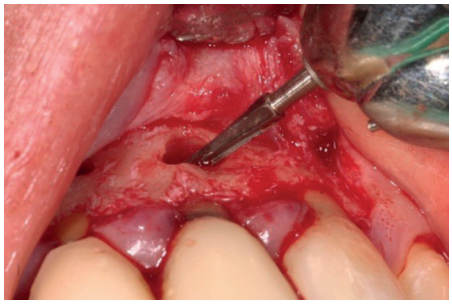
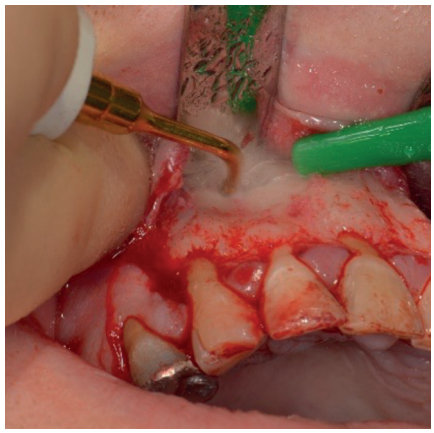


Figure 3. Use of a rear-venting high speed handpiece with tungsten carbide bur for creation of the alveolar window and apical root resection.

a



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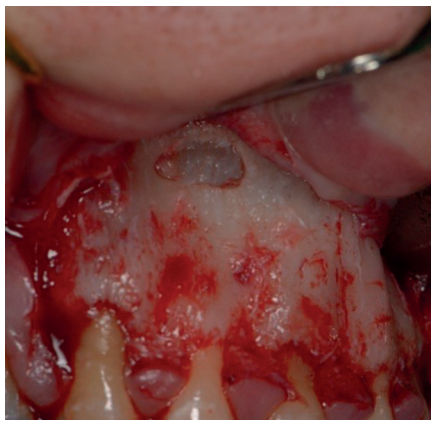
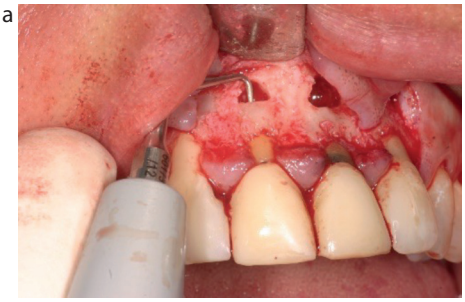


Figure 4. Use of a piezoelectrical surgical unit for **(a)** precise bone removal and **(b)** creation of an alveolar window.

rear-venting high speed surgical handpiece with a surgical Lindemann bone bur (or rose head bur), cooled with saline, facilitates good visualization for precise removal of alveolar bone (Figure 3). Alternatively, surgical motors or piezoelectric surgical units (eg Mectron, Carrasco, Italy) can create the alveolar window, while also offering the flexibility to resect and retro-prepare the root-end (Figure 4). Initial preparation of the bony window should be conservative, because access will be increased following root resection, with evaluation and further enlargement carried out if required.

a



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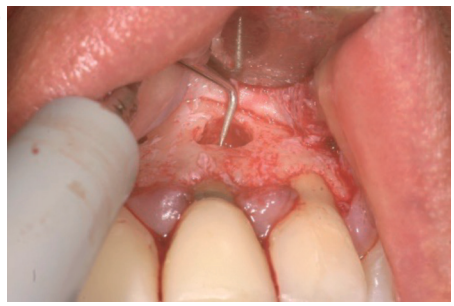

Figure 5. Retro-preparation of the root-end cavity with **(a)** 3-mm and **(b)** 6-mm ultrasonic tips.

Minimizing the osteotomy site reduces soft tissue invasion of the bony cavity, which may impair bone healing.

Curettage of the lesion

Different instruments may be used to fully access and curette the irregular walls of the bony crypt. Suitable instruments include Lucas surgical curettes, periodontal curettes and spoon excavators. A systematic approach to curettage should be undertaken, with scraping and soft tissue removal carried out in a uniform direction from one wall of the lesion to the other. Further curettage may be accomplished once the root tip is removed and access is improved. As with any excisional procedure, a specimen sample of the lesion should, if possible, be sent for histopathological examination to confirm the diagnosis. Healing occurs if the bulk of an inflammatory lesion is removed, even in the presence of residual soft tissue tags.[36]

Root-end resection

Resection of the apical 3 mm of the root tip removes the majority of accessory anatomy[37,38] and facilitates access for both further curettage and retro-preparation of the root canal space.[39] The resection angle should be at 90 degrees to the long axis of the root as this reduces the number of exposed (and potentially) infected dentinal tubules[40] that result when a traditional bevelled resection is employed. A surgical high-speed handpiece, using either a diamond or tungsten carbide bur[40,41] can achieve this angle of resection (Figure 3).[4,6,42] Methylene blue dye (Vista-Blue, Vista Dental Products, Racine, USA) can be used to stain the resected root surface to aid the identification of cracks, unfilled canals and also help differentiate the root from adjacent alveolar bone.[42] Cracks can initiate and propagate in an apico-coronal direction or corono-apical direction. Where a crack communicates with the oral cavity, the chance of re-infection of root canal space is high, and failure of the SRCReT is likely, in which case arrangements to extract the tooth +/- subsequent bone grafting +/- prosthetic replacement should be made. However, in cases where the crack is within the apical half of the tooth, it may be possible to resect away the cracked portion of the root. Where further root resection is undertaken consideration needs to be given to the effect of further reducing the crown–root ratio, and the effect of this on the restorative prognosis for the tooth.

Intra-operative haemostasis

Multiple materials have been tested to control intra-operative haemostasis, including mechanical agents (bone wax, calcium sulphate), absorbable haemostatic agents (Surgicel, Ethicon Inc, San Lorenzo, Puerto Rico), chemical agents (aluminium sulphate, ferric sulphate, adrenaline-soaked pellets) and collagenous based materials such as Avitene (Davol Inc, Warwick, USA) (bovine collagen fibrils).[28] Consideration should be given to the prolonged inflammation that these agents may initiate within the surgical site.[28,43–45] Adrenaline (local anaesthetic) soaked sterile cotton pellets offer a readily available and safe means of controlling bleeding, though any stray fragments of cotton fibre in the surgical site must be sought and removed under the operating microscope prior to surgical closure.

Root-end preparation

Ultrasonic tips are smaller than conventional rotary handpieces and offer better visualization of the root-end, providing an effective method of removing root filling materials and preparing the apical 3mm of the canal space.[32,46,47] Although no conclusive evidence supports any particular ultrasonic regimen a low-power setting, combined with a diamond-tipped instrument, may help to avoid

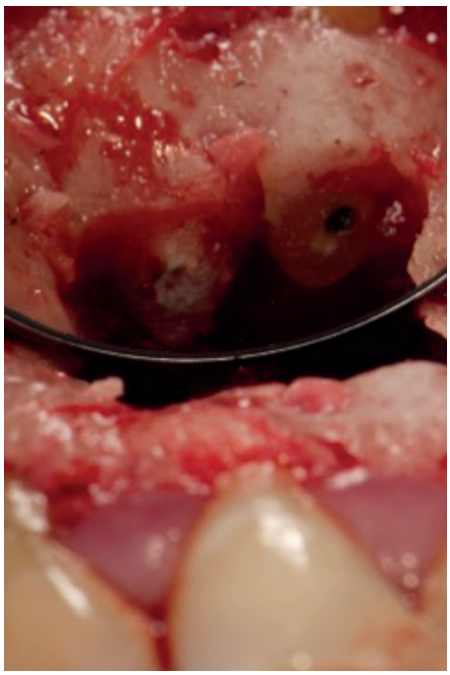

Figure 6. View of the resected and retro-prepared root canals.

crazing of the root-end surface.[48,49] Longer-length ultrasonic file tips allow deeper preparation of the root canal space (Figure 5), although little is known about the influence of this on outcome. Following preparation, the root-end cavity should be carefully re-examined for the presence of residual debris, damage and cracks (Figure 6) then rinsed with sterile saline and dried with paper points.

Cavity obturation

A host of materials have been employed with SRCReT obturation and include amalgam, gutta percha, zinc oxide–eugenol-based materials such as Super EBA (Bosworth Company, Myerstown, USA) and IRM (Dentsply Caulk, Milford, USA),[50] composite, glass ionomer and mineral trioxide aggregate (MTA). Amalgam has been negatively associated with outcome and should be avoided,[51] while high success rates have been associated with IRM, EBA and MTA.[50,52] Favourable properties of MTA include its reduced peri-radicular inflammatory response and the cementum deposition that occurs over its surface.[53,54] More recently, tricalcium silicate cements (Biodentine (Septodont, Saint-Maur-des-Fossés, France) and putties have been advocated for use in endodontic surgery due to having a similar biocompatibility as MTA,[55] but with improved handling qualities. Either MTA or

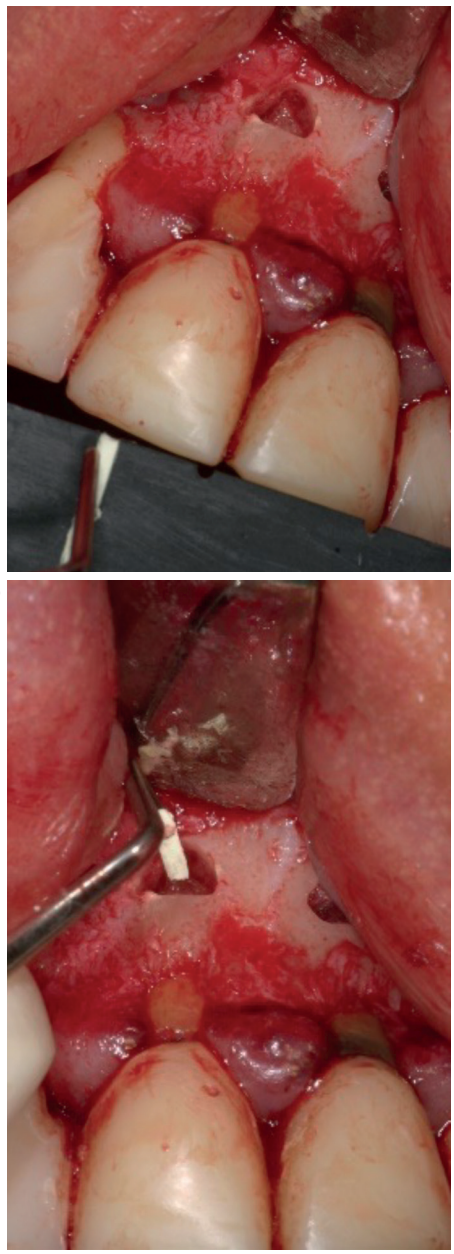

Figure 7. (a, b) Obturation of the root-end cavity using an MTA block, Lee carver and MTA plugger.

tricalcium silicate cements can be placed into the prepared canal space using a Lee Carver and MTA block (Hartzell and Son, Concord, USA) (Figure 7) or specifically designed micro-apical placement (MAP) system (Dentsply Maillefer, Ballaigues, Switzerland) (Figure 8). The adequacy of the preparation and elimination of root-filling materials from the cavity can be confirmed through use of an operating microscope and micro-surgical mirror. A radiograph should be taken post-obturation, prior to suturing, to ensure adequate filling of the root-end cavity (Figure 9).

Figure 8. Dentsply MAP MTA Gun system.

Regenerative procedures

Multiple materials have been advocated for guided bone regeneration (GBR) that include: alloplastic materials (calcium sulphate, Bioglass and non-resorbable membranes (ePTFE)), xenograft materials (denatured bovine bone and porcine-derived resorbable collagenous membrane) and allograft materials (donor human bone and collagen membranes). GBR has not been demonstrated to influence longer-term outcomes within small lesions/osteotomy sites and cannot be justified for routine SRCReT.[56,57] In large lesions, or those where bilateral labial and palatal cortical plate perforation has occurred, the healed lesion often contains fibrous tissue that may confuse future radiographic assessment for healing. For lesions extending over 10mm in diameter[58] the use of a bovine bone scaffold (eg Bio-Oss, Geistlich, Wolhusen, Switzerland, or Cerabone, Botiss Biomaterials GmbH, Berlin, Germany), mixed with blood from the wound site and loosely packed into the cavity space and covered by a porcine-derived resorbable membrane (eg Bio-Gide, Geistlich, Wolhusen, Switzerland, or Jason Membrane, Botiss Biomaterials GmbH, Berlin, Germany) has been associated with high success rates (Figure 10).[59] Within through and through lesions, membranes may be employed on both the palatal and buccal aspects to sandwich the xenograft bone within the cavity. It should be noted that a horizonal periosteal relieving incision may be required to ensure tension-free repositioning of the flap.

Wound closure

Absorbable (Polycaprone, Polygalactin), non-absorbable single-strand (polypropylene, polyamide) as well as braided threads (silk) have been advocated for dental microsurgical procedures.[60] The number and type of sutures required should be governed by flap design. In general, interrupted sutures are normally placed 2 mm apart, though this will depend on suture size. A sufficient number of sutures need to be placed to approximate the edges of all of the incisions. The original concept

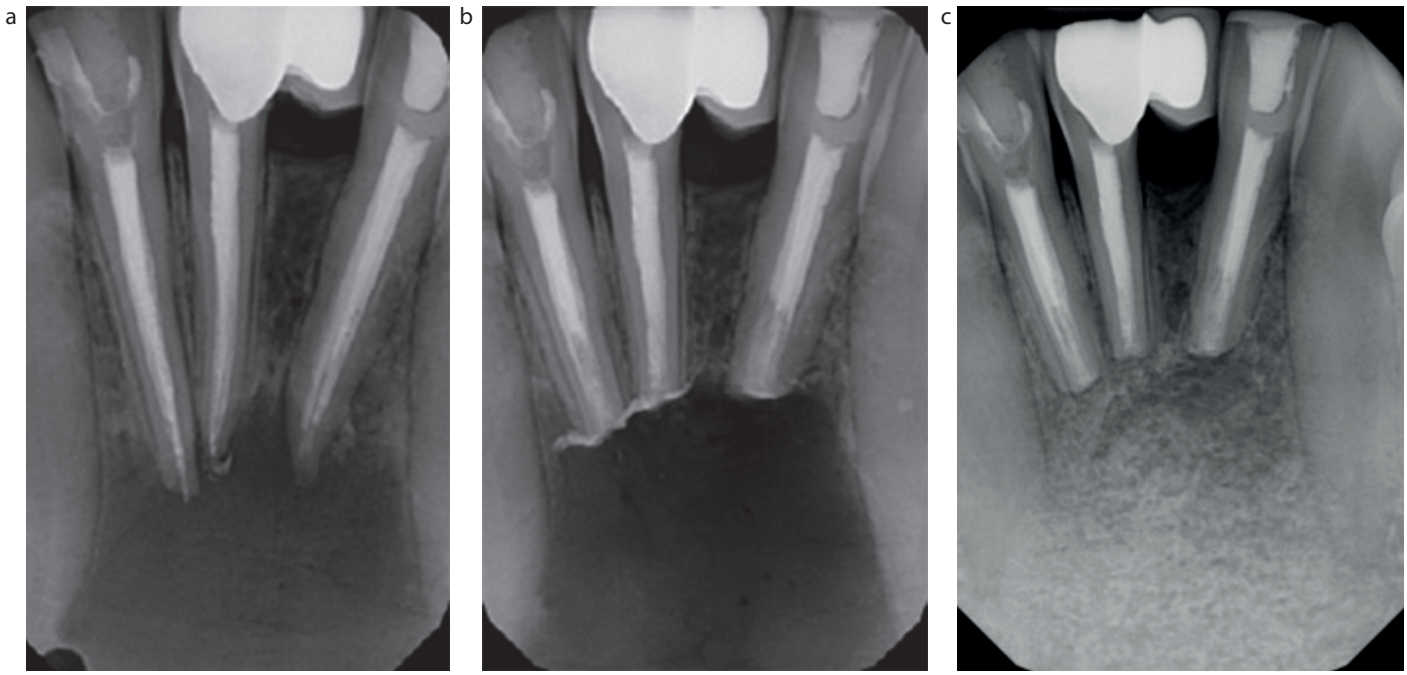

Figure 9. Peri-apical radiographs of SRCReT. **(a)** Pre-operative; **(b)** post-operative; and **(c)** at follow-up, revealing bony healing.

by Harrison[61] of closing relieving incisors with a single interrupted suture has now been superseded by approaches that aim to reduce scarring and recession by using multiple sutures.[14] These sutures should be orientated obliquely from the flap to the mucosa to reduce tissue contraction. Fine, non-absorbable sutures (5.0 or 6.0), as employed within plastic surgery,[62] provide optimal mucosal healing when placed using a single interrupted suture technique (Figure 11),[60] although other techniques are also appropriate. Following closure, the wound should then be compressed, to eliminate excess blood and help produce close adaptation of the flap to the bone, for 5 minutes with a sterile surgical gauze, soaked with saline.

Post-operative management

Pain management

NSAIDs and non-opioids are effective in managing pain following dental surgery.[63–65] Providing the patient with ibuprofen (400 mg, three times daily) and paracetamol (1000 mg, four times daily), should provide effective post-operative pain relief.

Management of complications

Although early-presenting complications with SRCReT procedures are rare, the clinician should be aware of problems such as post-operative bleeding, swelling and flap breakdown. The management of swelling is best managed with NSAIDs[66] and steroids[3] or via adjuncts such as cold compresses (20 minutes on 20 minutes off for no more than 4 hours).[67] Tooth brushing should be continued as normal but the patient advised to avoid brushing the teeth associated with the surgical site. For plaque control, patients should use a mouthwash containing chlorhexidine gluconate,[68,69] although not until 30-minutes after tooth brushing to prevent any neutralizing effect from sodium lauryl sulphate.[70] Patients should avoid vigorous rinsing, which could undermine the flap, instead patients should be advised to allow the mouthwash to bathe the area for 1-minute, twice daily until sutures are removed.

Suture removal

There has been no universal agreement on the optimum time to remove sutures. Research into the healing of incisional wounds using an animal model demonstrated epithelial bridging at 48–72 hours, which some authors have used to support removal of sutures within this early time frame.[61] However, observations from clinical outcomes using microsurgical techniques have supported the benefits of delaying suture removal by up to 10 days.[14] The time to suture removal should balance the benefits of mechanical stabilization of the wound provided by sutures against the

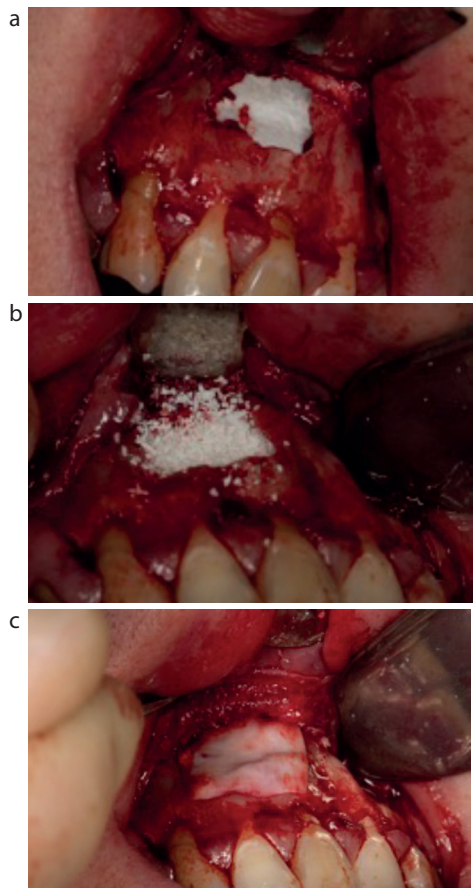

Figure 10. Grafting of an apical defect with perforation of both the palatal and buccal plates. **(a)** A membrane (Bio-Gide, Geitschlich) is placed onto the palatal wall of the defect, **(b)** with filling of the cavity space with bovine particulate bone (Bio-Oss, Geitschlich) and **(c)** placement of a second membrane layer over the buccal/labial cavity defect.

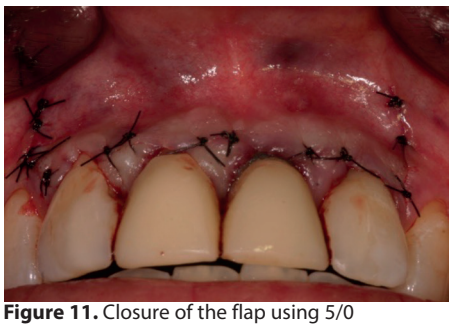

Figure 11. Closure of the flap using 5/0 monofilament non-absorbable Ethicon sutures.

inflammation that occurs around sutures, which can impede healing.[71] The authors recommend removal of sutures between 7–10 days. Following suture removal, surgical soft-bristled brushes can be provided to facilitate brushing of the surgical site for a further 14 days, reducing the risk of gingival trauma and recession.[72]

Review

The outcome for the majority of cases may be determined at one-year post-operative review.[6] Strict assessment criteria are available[4] and are determined as follows: success (absence of clinical signs/symptoms + radiographic resolution of peri-apical lesion; uncertain (absence of clinical signs/symptoms but with incomplete radiographic resolution of peri-apical lesion) and failure (signs/symptoms + no resolution or expansion of peri-apical lesion). Indication of treatment failure may result from both patient reported factors (such as pain and swelling or discharge from the surgical site), clinical signs of failure (such as pain initiated by examination of the surgical site, erythema, the presence of a sinus tract or swelling) and radiographic examination (continued presence or increased size of peri-apical area). Aiming to capture the same film angulation, as taken in the pre-operative view, reduces the risk of false conclusions regarding the reduction or increase of the size of the peri-apical radiolucency. Treatment success may be determined if there is an absence of symptoms or signs and infill of the radiographic bony lesion. An uncertain outcome may be an absence of signs or symptoms and a radiographic bony defect that decreases in size but fails to completely resolve.

Summary

Evaluating the approaches adopted for surgical root canal retreatment within the endodontic literature facilitates decision-making when constructing a surgical protocol for achieving optimal treatment outcome. By adopting best-practice techniques (as derived from the discipline's current evidence base), high success rates should be achieved with endodontic surgery.

Compliance with Ethical Standards
Conflict of Interest: The authors declare that they have no conflict of interest.
Informed Consent: Informed consent was obtained from all individual participants included in the article.

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