Dental

An evidence-based surgical protocol for the provision of surgical retrograde root canal treatment: Part 1

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Introduction
It is well established that intra-root canal bacterial infection is the primary causative factor in apical periodontitis (1,2,3). A surgical retrograde root canal re-treatment (SRRCR) approach to root canals with persistent apical periodontitis is an accepted treatment method when conventional non-surgical orthograde root canal treatment (NSORCT) has failed or when it is impractical to adopt a non-surgical orthograde root canal retreatment (NSORCReTx) approach (4,5,6). Success rates within SRRCR vary from 37% to over 90% (6,7,8). The disparity between these studies can be partially explained by: the differences in sample size, recall periods employed, recall rates of participants and the stringency of the method used to evaluate the success of the treatment. Localized factors have also been shown to influence outcome and these include: case selection (i.e. diagnosis and identification of exacerbating factors such as root fracture), the tooth type, number of teeth involved and location within the dental arch. The extent of the bone loss resulting from the apical periodontitis, the quality of the coronal seal, the root filling and the surgical technique employed have also been found to influence success rates (4,9). In particular, it has been demonstrated that a strict surgical protocol is related to improving the prognosis of treatment (10,11). Although guidelines for the provision of surgical endodontics are available (American Association of Endodontists, British Endodontic Society Quality Guidelines, Royal College of Surgeons of England), these tend to be fairly generic and lack specificity or detail within their published protocols. The aim of this paper was to examine the published scientific literature base to determine an evidence-based protocol for the provision of SRRCR.

Materials and Methods
The phases of the proposed surgical protocol were identified as pre-, intra- and post-operative. The examination of the pre-operative phase included the clinical assessment (including radiographic assessment), indications for providing SRRCR, treatment planning, the use of prophylactic medications, the disinfection of the intra-oral operative site and local anaesthesia. The intra-operative phase assessed: magnification and visualization, soft tissue management, alveolar bone removal, intra-operative haemastasis, root end resection, retro-preparation of the root canal space, disinfection of the retro-prepared cavity, obturation of the retro-prepared cavity, curettage, regenerative procedures and wound closure. The post-operative management assessed the requirement for medicaments, immediate oral hygiene regime, suture removal and review.

A single operator conducted a literature search using key words relevant to the afore-described components of the operative phases. Sought abstracts were initially screened and, if deemed relevant, the entirety of the article was subjected to scrutiny. The relevance to the proposed protocol was established and key findings were collated for comparison with corresponding articles. This paper was not intended to act as a systematic review of all the literature but was aimed at developing a surgical protocol based on high quality evidence. When insufficient evidence of high quality was available, evidence from other surgical fields was correlated and used to determine appropriate inclusion or rejection of key findings into the surgical protocol.

Results
Pre-operative Phase
Clinical assessment. It was established that a standard consultation process would suffice for the provision of retrograde surgical root canal treatment procedures. The consultation would include the taking of a thorough patient history (including medical history), full clinical examination, provision of a diagnosis and treatment plan, as per accepted good practice guidelines (12).

Radiographic assessment. Although there is an ongoing trend for digitization of radiography within the dental profession, in-vitro and clinically based comparative studies suggest that there is little difference in diagnostic yield when digital images are compared to their wet film counterparts (13,14). In the absence of digital radiography equipment, wet film was adopted as standard. It has been demonstrated that two periapical views deliver increased perception into the surgical site than a single view and it
was determined that a minimum of two parallel-technique periapical views, with periapical film holders, were to be taken pre-operatively(15). In terms of additional imaging of the surgical site, CT was shown to be more effective than periapical radiography in diagnosing both apical lesions and identifying the mandibular canal, in a group of 50 patients treatment planned for periapical surgery(16). However, the use of CT involves subjecting the patient to an increased radiation dose and it has been argued that the routine use of such imaging must be justifiable(17). This protocol did not adopt the prescription of CT scans for routine surgical retrograde root canal re-treatment procedures but would be requested when specific complications arose (e.g. operating within the mental nerve region).

**Treatment Planning.** Indications and contra-indications for surgical retrograde root canal treatment were identified from previously published accepted guidelines(12). These were implemented into the treatment-planning phase of the protocol as follows:

Indications for apicectomy:

- a. Radiological findings of apical periodontitis and/or symptoms associated with an obstructed canal (the obstruction proved to be immovable or involved too great risk to the root to remove).
- b. Extruded material with clinical or radiological signs/symptoms of apical periodontitis.
- c. Persisting or emerging disease following orthograde root canal treatment when orthograde root canal re-treatment is inappropriate.

Contra-indications for apicectomy:

- d. Severe systemic disease or patient unable to tolerate treatments.
- e. Local anatomical factors such as unusual bone configuration, position of neurovascular bundle or inaccessible root end.
- f. Unrestorable, non-functional or severely-compromised (e.g. vertically root fractured) tooth.

Informed written consent from the patient would be gained following detailed explanation of the surgical process, the advantages/disadvantages of the proposed treatment as opposed to alternative treatment options.

**The use of prophylactic medications.** The use of prophylactic medications to address systemic disease was not considered as it was considered that any undertaken surgical procedure would comply with the 2008 National Institute for Clinical Excellence Guidelines. Indications for prophylactic medicaments included the management of post-operative inflammation, pain and complications with healing.

The examination of prophylactic medications for reducing the risk of complications with healing was focused around the prescription of antibiotics. A recent randomized control trial concluded that the prophylactic prescription of clindamycin had no impact in reducing the number of post-operative wound healing complications(18). In addition, a longitudinal study of 194 patients similarly did not find a correlation between antibiotic provision and healing post apical surgery(19). These findings were supported by multiple papers, within other dental surgical disciplines, that failed to correlate antibiotic prophylaxis with improved healing(20).

Extensive literature was found examining the use of both steroids and non-steroidal anti-inflammatory (NSAIDs) prophylactic medication for the reduction of post-operative pain and inflammation following orthograde root canal treatment. Within the discipline of endodontic surgery, one randomized trial reported a reduction in post-operative pain(21) and this finding was in keeping with trials that concluded that the prophylactic prescription of steroids can reduce the incidence of pain post extraction of wisdom teeth(22). The efficacy of NSAIDs, when provided as a single pre-operative dose, at reducing post-operative pain is well documented within general surgical procedures(23).

However, it was unclear from the literature whether the provision of either prophylactic steroids or NSAIDs reduced post-operative pain and inflammation over and above a prescribed post-operative pain regime. Subsequently, it was determined that prescribed medicaments would be provided on-site for taking post-operatively and a prophylactic regime was not adopted into the surgical protocol.

**The disinfection of the intra-oral operative site.** Bacterial sampling studies indicate that the use of a pre-operative rinse of chlorhexidine gluconate can reduce bacterial saliva counts for up to 4 hours post-operatively(24). These findings correlate with a study that concluded that recoverable bacterial counts from apicectomy sites were reduced by up to 94% immediately after application(25). It was determined that the protocol would adopt a 1-minute intra-oral rinse of 30 ml of Corsodyl® (Glaxosmithkline, Brentford, UK).

**Local anaesthesia.** It was well established that the use of a vasoconstrictor within a local anaesthetic improved both intra-operative haemostatic control and duration of anaesthesia(26). With regards to the depth of local anaesthesia obtained, there is inconclusive evidence to suggest that there is any one optimal agent or concentration. However, studies have concluded that intra-operative blood loss is reduced when the concentration of adrenaline is increased(27) and this was supported by a well-constructed review article(28). A systematic review of the literature(29) recommended that a minimum concentration of 1:80000 adrenaline is utilized during periapicular surgery; subsequently the protocol adopted the use of 2.2ml 2% lignocaine 1:80000 adrenaline cartridges (Xylocaine®,
Dentsply-Maillefer, Weybridge, UK) for both infiltration and nerve block injections.

Intra-operative Phase
Magnification and visualization. A systematic review of the literature found that the use of magnification had no conclusive impact on apicectomy outcome(30) and this was supported by a 4 year retrospective study that found no significant difference between the use of surgical loupses and an operating microscope(31). However, both single-operator studies(32) and a meta-analysis(33) have reported that high levels of success were associated with the use of operating microscopes with microsurgical instruments. In addition, these findings were supported by a literature review(34) that stated that the use of an operating microscope, in combination with microsurgical instruments, was likely to aid with both the visualization of root surface features (cracks, accessory anatomy) and the provision of treatment. Subsequently, the use of an operating microscope (Global®, DP Medical Systems, Chessington, Surrey) with microsurgical instruments (Hu-Friedy®, Rotterdam, Netherlands) was adopted into the surgical protocol.

Soft tissue management. Multiple methods of flap mobilization have been discussed including; semi-lunar, sub-marginal, papilla-based, intra-sulcular and relieving incisions via vertical or horizontal orientation. It is generally accepted that a vertical relieving incision is preferred over horizontal orientation or a semi-lunar approach as it increases visualization of the surgical area, reduces intra-operative blood loss and reduces post-operative scarring(4,35). Additionally, the evidence base supported the extension of the flap by one tooth either side of the estimated extent of the periradicular lesion to enable adequate visualization and management of the surgical site. However, there is conflicting evidence concerning the incision method at the gingival margin of the tooth. Clinical based-studies, with longer-term follow-up, have claimed that full thickness intra-sulcular incisions can lead to increased loss of vertical height of the papilla, when compared to papilla-based incisions(36,37). In contrast, Del Fabbro(38), with a small study of 40 surgical cases using a visual analogue pain scale technique, found that increased post-operative pain was encountered following papilla-based incisions.

It was determined that both the intra-sulcular and papilla-based incision methods would be adopted into the surgical protocol; their use being selected on an individual case basis. When maintenance of papilla height was essential (for instance, the maintenance of an aesthetic gingival profile around a crown), a papilla-based incision would be chosen. When it was deemed that full visualization of the tooth/ alveolar bone being treated was essential (for instance, to rule out the presence of crack or perforation), a full thickness intra-sulcular incision would be chosen. A 15C surgical blade (Swann-Morton, Sheffield, England) was chosen for implementation of both incision methods.

Alveolar bone removal. Factors assessed within removal of alveolar bone included: the type of surgical handpiece used, the type of surgical bur and the type of irrigant. Prospective studies with good outcomes have employed high-speed handpieces with round tungsten carbide burs for the osteotomy phase of the treatment(11). However, it was unclear as to the significance of the use of any one type of surgical handpiece with improved outcome. In the absence of conclusive evidence the author, who had previous experience of all forms investigated, opted to adopt a contra-angle high speed surgical handpiece with a surgical Lindemann bone bur with sterile saline irrigation.

Intra-operative haemastasis. Multiple materials have been tested for the control of intra-operative haemastasis and include mechanical agents (Bone Wax, calcium sulphate), absorbable haemostatic agents (Surgicel®), chemical agents (aluminium sulphate, ferric sulphate, adrenaline-soaked pellets) and collagenous based materials such as Avitene® (bovine collagen fibrils)(29). Although many of these agents are efficient haemostats, their use can lead to prolonged inflammation of the surgical site (29, 39, 40, 41). The least contentious haemostatic agent was adrenaline-soaked cotton pellets and it was decided to adopt this process into the surgical protocol.

The root end resection. It was generally accepted that approximately 3mm of apical root resection is required to remove the majority of accessory anatomy(42, 43, 44) to provide access for curettage and retro-preparation of the root canal space(45). It has been proposed that the angle of resection should be at 90 degrees to the long axis of the tooth and that a traditional beveled resection should be avoided to reduce the number of exposed (and potentially) infected dentinal tubules(44). In general, the literature supported the use of a surgical high-speed handpiece with either diamond or tungsten carbide bur(4, 44, 46) to resect at least 3 mm of apical root with a resection angle at 90 degrees to the root axis(10,11,47). A high-speed handpiece with a fissure tungsten carbide bur, using sterile saline irrigation, were adopted into the surgical protocol. Methylene blue dye (Methylene blue®, BDH Laboratory Supplies) was implemented to assist with the identification of the cut root surface in relation to alveolar bone (Kim).

Root-end preparation. The general consensus was that ultrasonic tips should be used to extend the retro-preparation by approximately 3mm into the root canal(48, 49). The literature supported the use of ultrasonics to remove root filling materials from the apical aspect of the root canal and prepare a retro-cavity space(50,51,52). No conclusive evidence was found that detailed the effectiveness of a particular ultrasonic regime. However, it has been suggested that the handpiece should be set at a
low power setting and a diamond-tipped instrument should be employed to avoid crazing of the root end surface(52,53).

The protocol adopted the use of a 3mm ultrasonic diamond KiS1D® tip (Spartan USA), with a Satelec P5® (Merignac, France) ultrasonic unit at a low power setting, to prepare the cavity space. Corsodyl® was used to disinfect the cavity space due to its established anti-microbial properties (Aziz et al), low toxicity and availability. A 3ml luer-lock endodontic syringe, with 3mm of the tip bent at a retro-inclined angle, was used to deliver the Corsodyl® solution to the full extent of the prepared space.

Curettage. Evidence suggests that, as long as the body of the inflammatory lesion is excised, not all tissue tags have to be removed during curettage for healing to occur(54). It was established a specimen sample of each lesion would be sent for histopathological examination.

Cavity obturation. Multiple materials have been used for obturcation of retro-prepared cavities and include; amalgam, gutta percha, zinc-oxide eugenol based materials (Super EBA, IRM, composite, glass ionomer(55) and, more recently, mineral trioxide aggregate (MTA). A systematic review of the literature(56) found that the quality of evidence was poor within this field but concluded that amalgam was negatively associated with outcome. IRM and EBA have been associated with high rates of success(55) as has MTA(57). It has been reported that, in contrast to other materials, MTA does not initiate a periradicular inflammatory response and that cementum deposition occurs over its surface (58,59,60). MTA (Pro-Root® MTA, Dentsply-Maillefer, Weybridge, UK) was adopted into the protocol due to high success rate and excellent biocompatibility. The material was to be applied using a Lee® MTA block (Hartzell&Son, USA).

Regenerative procedures. Regenerative techniques can be adopted to either accelerate periradicular healing(61) or to improve healing outcome in compromised patients(62). Multiple materials have been advocated for guided bone regeneration and include; calcium sulphate, alloplastic materials (Bioglass®, denatured bovine bone (Bio-oss®), resorbable collagenous membrane (Bioguide®) and non-resorbable membranes (ePTFE). By filling or covering the bone cavity with many of these materials, it has been shown that successful regeneration of large lesions, or in situations where both cortical components are affected, can be achieved(63,64). However, multiple trials (65,66,67,68) have found that the use of such materials does not influence the longer-term outcome and cannot be justified for uncomplicated apicectomies(62). However, it is advocated that for lesions that extend over 10 mm in diameter or that have perforated both the labial and palatal alveolar cortical plates (through and through), then regenerative procedures should be implemented (62,68). When the afore-described conditions were encountered, xenogenic bovine bone (Biooss®, Geistlich, Wolhusen, Switzerland) and porcine-derived resorbable membranes (BioGuide®, Geistlich, Wolhusen, Switzerland) were chosen due to their osteogenic potential and high success rates(68).

Wound Closure. Both resorbable (Polycaprone) and non-resorbable (Polypropylene, polyamide) threads have been advocated for use within dental microsurgical procedures(69). The role of suture type or method in influencing either apical healing or soft tissue aesthetics was unclear with little evidence of quality found. In general, it was accepted that the use of small non-resorbable sutures provided optimal mucosal healing(69) and this was in keeping with findings from within the plastic surgery literature(70). 6.0 Ethilon (Ethicon, Johnson & Johnson Int'l) single interrupted sutures were established as the wound closure method of choice(71, 72). Sterile surgical gauze, dampened with Corsodyl®, was to be applied as a compress to the wound site for a period of 5 minutes to assist with haemostasis.

Post-operative Management
Pain management. The use of NSAIDs and non- opioids in the management of pain following dental surgeries is well documented with multiple trials of high quality(73,74,75). A meta-analysis found that ibuprofen was more effective in controlling post-operative pain than the combination of paracetamol and codeine(73). However, a Cochrane systematic review(23) found paracetamol with codeine to be effective in controlling post-operative pain. The protocol adopted the prescription of ibuprofen (400mg TDS) with codeine-paracetamol (8/500 2-QDS) to be taken to supplement pain relief, if required; both these medicaments were provided at the time of surgery to facilitate early pain management post-operatively.

Complications management. The literature did not support the use of antibiotics for either reducing the risk of post-operative complications or increasing the outcome of apical healing(18,19). Antibiotics were not routinely prescribed as part of the operating protocol. The efficacy of chlorhexidine in plaque maintenance following surgery is well established(76,77) and patients were provided with 1x 300 ml bottle of Corsodyl® mouthwash to be used three times daily until suture removal. Patients were advised to maintain tooth brushing but to avoid brushing of the gingival tissues until suture removal.

Suture Removal. Various timings for post-operative suture removal have been reported and range from 3-4 days(11,45) to 10 days(19). No one particular regime was determined as influencing healing outcome and the protocol adopted a 7 – 10 days suture removal.

Review
Review of patients was deemed important to assess the outcome of the surgical intervention. Strict criteria for
The available outcome evidence for SRRCR suggests that, whilst this approach offers similar success rates as non-surgical orthograde root canal re-treatment at one-year review, longer term review finds increased failure rate associated with the surgical approach(38,61). There are many proposed theories that attempt to explain this increased longer-term failure and include: secondary leakage of the coronal restoration, failure of the orthograde root filling, failure to adequately disinfect the root canal and poor sealing of the retrograde filling. A likely possibility for the increased failure rate is that the majority of studies employ a retrograde re-preparation technique that extends only 3mm into the root canal space, leaving the majority of the intra-canal bacterial infection undisturbed. The delayed increased failure rate could be the result of the recontamination of the apical root portion from this undisturbed bacterial infection. The advocacy of retro-preparation extending 3mm into the canal space is a result of traditional ultrasonic retro-tip lengths (a length that was established from the maximal depth that could be achieved when slow-speed handpiece burs were historically employed) and the maximal depth that the cavity could be predictably obturated. More recently, ultrasonic file tips have been introduced that allow retro-preparation up to a depth of 9mm, enabling preparation of most of the root canal space. Presently little is known about the influence of retro-cavity preparation depth but, as these techniques are introduced, it will be interesting to witness how this factor influences long-term outcome of SRRCR.

The prevalence of apical periodontitis is approximately 30-40% within 35-40 year olds population groups(81,82,83). The prevalence of apical periodontitis has been found to be associated with both general factors (increased with age, social deprivation category) and local factors (number of root filled teeth and quality of root canal filling). It is unclear what the prevalence of apical periodontitis is within our military population but, given that we treat a relatively young, dentally-supported cohort of individuals, it would be hoped that this rate is below general population studies. The use of COGNOS, within DMICP, to review the quantities of root canal treatments performed on military patients found that approximately 4500 root canal treatments were performed between the period of 2009-11( ). When NSORCT is performed within controlled clinical environments, a success rate of approximately 80% and survival rate of over 90% can be expected(84,85,86). However, cross-sectional studies indicate that these high success rates are not mirrored within the general population where estimated success rates are approximately 65%(81). Again, there is no current evidence available to determine the outcome of NSORCT within the military but it can be expected that a proportion of these treatments will fail and will require either NSORCrEiT or SRRCR. By establishing a strict operating protocol for SRRCR, it is hoped that high success rates, at least equivocal to those achieved in controlled studies, can be achieved.
References


45. Gutmann JL, Pitt Ford TR. Management of the resected root end: a

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