A powerful practice-builder

Michael Sultan discusses CPD in dentistry

CPD is a vital part of modern dentistry. Given the importance of CPD to both my work as an endodontist and as an employer, I was interested to read over the GDC’s latest study exploring what registrants, stakeholders and providers think about mandatory CPD in dentistry. The survey, which can be found in full on the GDC website, received more than 6,000 responses in total – the results of which were then analysed and compiled into a substantial and rather enlightening report.

Among the many findings of the study, the report found that 65 per cent of all registrants generally do CPD outside of working hours. It is perhaps unsurprising then, that the report also found that online learning is generally preferred over half of all GDC registrants.

The report also found that online learning is generally the preferred learning style of over half of all GDC registrants. From my own perspective, one of the key findings of the study revolves around the thorny issue of cost. According to the report: “cost of CPD was an important factor for dental nurses because of their low wages and the fact that some employers paid only for a part of or none of the CPD their nurses were required to do.”

When I read this, I was quite frankly shocked that some practices don’t cover these costs. At EndoCare it is our policy to arrange and pay for all necessary staff CPD. The reason for this is that CPD is just so vital in allowing us to provide the very best levels of patient care. In my experience it can also be a powerful motivator, and helps add to staff satisfaction, making for a far more positive working environment.

First, there is the obvious function that it allows our team members to complete their compulsory CPD requirement. Secondly, and just as importantly, it helps us to build up a far better team spirit. Anything we do together as a team helps produce a better atmosphere and ultimately a better practice. It’s short-sighted then to say to nurses “you’re on your own, you have to pay for it yourself”, as if anything, compulsory training sessions such as CPR are an excellent excuse to get together – normally followed by food and wine!

In my opinion it is our duty to train our nurses, and it’s unfair to expect them to pay for it. As a profession we often get too caught up in our own little “bubbles” and forget to look at the bigger picture as a result. We should remember that people don’t just come to work for the money (if they do then we shouldn’t employ them); people come for a sense of worth, for education, for purpose. From a financial sense, it seems only fair that we pay for our nurses’ CPD, but from a wider perspective as well these sorts of things give our employ- ees something tangible they can take away from their job. They give our staff an extra reason to come into work every day.

With a happy, highly motivated, highly trained workforce, the practice can only benefit as a result.

About the author

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Endodontic retreatment

Dr Brett E Gilbert discusses how to achieve success the second time around

Root-canal treatment has been shown to have a success rate of 92 per cent. However, as research methodologies move towards higher levels of substantiation, clinicians must rely on the best current evidence available to gain insight into the expected outcomes of their treatment. The highest level and best current evidence we have on the clinical success of endodontic treatment comes from a meta-analysis of the literature.

A meta-analysis done in 2007 by Ng et al. provides a thorough review of endodontic success rates from a variety of classical outcome studies. They found a weighted pooled success rate of 68 to 85 per cent, with at least one year of follow-up.1 This view considers the strictest of criteria for determining that a tooth has healed, and includes many studies that were completed prior to the clinical use of dental operating microscopes and other advanced armamentaria.

When considering treatment for a tooth that has not healed successfully with root-canal therapy, there are significant challenges to address to be able to attain complete healing of the diseased tooth. The armamentarium and techniques available today allow us the ability to disinfect the root-canal system properly after initial treatment has led to post-treatment disease.

The success rate of retreatment has been shown to be in the range of 80 per cent healing. Phases III and IV of the Toronto Study showed such a healing rate four to six years after non-surgical retreatment.1 In a systematic review by Torabinejad et al. comparing non-surgical retreatment to endodontic surgery, it was demonstrated that non-surgical retreatment had a success rate of 85 per cent versus 71.8 per cent for endodontic surgery after four to six years.4

The presence of pretreatment apical periodontitis is one factor that has been shown to decrease the success rate. Without apical periodontitis, a ten-year success rate of 92 to 98 per cent has been shown for both initial and retreatment root-canal therapy. With the preoperative presence of apical periodontitis, there is a decrease in the success rate to 74 to 86 per cent over the 10 years.5 From this, it is evident that endodontic healing is attainable through retreatment procedures, allowing us to maintain our patients’ natural teeth (Figs. 1a–c). Although the alternative clinical treatment option of implant placement can provide an effective method for replacing a missing tooth, healthy maintenance of the natural tooth should remain the overall goal.

Post-treatment disease is, inevitably, a result of bacteria and the host response of the patient to the bacteria. These supporting substrate for intra-radicular bacteria and restorative failure. Intra-radicular bacteria are the primary aetiology of post-treatment disease and eradication of these bacteria is the primary goal of retreatment procedures. The intra-radicular bacteria present in the previously treated tooth are persistent and resistant removal methods. Bacteria are able to hide and survive in canal ramifications, deltas, irregularities (lips) and dentinal tubules.6

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The bacteria present in the initial infection of a root canal differ markedly from the bacteria infecting a previously treated tooth. Post-treatment flora is polymicrobial with equal numbers of Gram-negative and -positive bacteria. Post-treatment bacteria are predominantly Gram-positive7 and they have been shown to be able to survive in harsh environments and to be resistant to many treatment methods.

There are high numbers of Enterococcus species,8 Enterococcus faecalis, for exam-
ple, has been shown to be a common isolate in 27 to 77 per cent of teeth with post-treatment disease. A contaminated canal space may result from incomplete cleansing initially or subsequent leakage into root-canal spaces following root-canal treatment. Once present inside the canals, E. faecalis has a variety of characteristics that allow it to evade our best efforts to eradicate it from the root-canal system, including the ability to invade dentinal tubules and adhere to collagen. It is also resistant to calcium hydroxide application inside the canal system, which is an inter-appointment treatment technique used to help remove micro-organisms and their by-products, such as lipopolysaccharides, from the canal space. E. faecalis’s resistance of calcium hydroxide action arises from its ability to pump hydrogen ions from a proton pump. The hydrogen combines with the hydroxyl ions of calcium hydroxide and neutralises the high pH value.

E. faecalis is also able to resist calcium hydroxide by being part of a biofilm. The protection of bacteria within a biofilm matrix prevents the contact of the bacteria with irrigants and medicaments, and allows communication between bacteria to aid in survival capabilities. The presence of E. faecalis is well documented; however, its role in post-treatment disease has yet to be proven definitively. Its survival mechanisms, however, shine a light on the persistent capabilities of these bacteria, and our clinical techniques must be focused on the challenge of eliminating them.

Iatrogenic issues encountered during the initial root-canal treatment may be the cause of intra-canal bacterial infection. These issues may include perforation, incomplete cleansing and shaping,
inadequate canal enlargement, missed canals, ledging, canal transportation, overinstrumentation, as well as obstruction of the canal by debris or separation of instruments. Failure to use or using too small a volume of an appropriate irrigant solution, such as sodium hypochlorite, is an iatrogenic error.

Full-strength six per cent sodium hypochlorite been shown to be highly antimicrobial and able to dissolve tissue and disrupt bacterial biofilm.²⁶ These qualities in an irrigant are ideal for the debridement of residual bacteria and tissue debris. The use of a rubber dam to isolate the treatment field is the standard of care for endodontic treatment. Failure to use a rubber dam may be a fundamental contributor to post-treatment disease. The following case illustrates the ability to overcome prior or incomplete treatment to achieve successful healing (Figs 3a–c).

Clinical example

Restorative failure is a common cause of post-treatment disease. Failure to place an effective permanent access restoration in a timely manner can allow for bacterial entry into the root-canal system by coronal leakage. Submarginal leakage on a crowned tooth can also allow bacterial entry to occur.

Decay in a previously treated tooth is another source of bacterial contamination. Structural damage to a tooth by trauma, cracking or fracture may provide an entry point for bacterial contamination of the canals. Our patients are responsible for their own oral health and must commit to effective oral hygiene practices. The use of a dental operating microscope and ultrasonic instruments allows clinicians to uncover all existing canal anatomy properly to ensure that they are able to cleanse the root-canal system completely. The following clinical case (Figs 4a & b) illustrates the extent of the canal space left untreated in the initial root-canal therapy by not opening the mesiodistal canal adequately and not locating and cleansing the hidden second mesiobuccal canal up to 3mm in front of the pulp chamber and activate it as it is carried down to the apical end of the root canal. The IrriSafe tip from Satelec (Acrotec; Fig. 7) is a non-cutting ultrasonic file that is placed into each canal and is moved up and down in the canal for three cycles of 20 seconds. Passive ultrasonic irrigation has been shown to irrigate lateral canals better at 4.5 and 2mm from the working length of canals as compared with needle irrigation alone.²⁶ It has been demonstrated that passive ultrasonic irrigation can remove dentin debris in a canal up to 5mm in front of where the tip extends apically in straight or curved canals.²⁶ This evidence shows that an effective flow of irrigation can assist in the cleaning of teeth in which canal alterations occurred during the initial root-canal treatment.

Failure to use or using too small a volume of an appropriate irrigant solution, such as sodium hypochlorite, is an iatrogenic error.

Endodontic ultrasonic tips are highly efficient at removing core build-up material, paste fills, posts and silver-point fillings, as demonstrated in Figure 5. These instruments allow clinicians to conserve root dentine by providing excellent visibility under a dental operating microscope, thereby greatly improving the ability to retreat canals (Figs 6a–c). A heat source such as a System B tip (Axis, SybronEndo) is efficient for the removal of gutta-percha and resin materials from the coronal third. Hand and rotary files can remove root fillings and shape canals to appropriate working lengths. Current NiTi rotary files are highly flexible and resistant to separation and allow us to mechanically enlarge the apical third of root canals safely and efficiently without alteration of the natural canal morphology, which allows effective irrigation to reach the complex anatomy where bacteria are able to hide and resist debridement.

Once the canals have been located and instrumented, the ability to irrigate becomes essential to successful treatment. The irrigant solutions target the bacteria we are trying to eliminate. While sodium hypochlorite is a potent and proven antimicrobial and tissue dissolver,²² two per cent chlorhexidine has been shown to prevent the adhesion of E. faecalis to dentine.²³ EDTA 17 per cent is often used as an effective smear-layer removal agent.²⁴ Therefore, mechanical debridement and canal instrumentation provide a pathway for copious chemical irrigation deep into the canal.

Passive ultrasonic irrigation allows clinicians to place an irrigant solution into the pulp chamber and activate it as it is carried down to the apical end of the root canal. The IrriSafe tip from Satelec (Acrotec; Fig. 7) is a non-cutting ultrasonic file that is placed into each canal and is moved up and down in the canal for three cycles of 20 seconds. Passive ultrasonic irrigation has been shown to irrigate lateral canals better at 4.5 and 2mm from the working length of canals as compared with needle irrigation alone.²⁶ It has been demonstrated that passive ultrasonic irrigation can remove dentin debris in a canal up to 5mm in front of where the tip extends apically in straight or curved canals.²⁶ This evidence shows that an effective flow of irrigation can assist in the cleaning of teeth in which canal alterations occurred during the initial root-canal treatment.

The following silver-point case (Figs 8a–c), with a large distal post and apical transportation in the mesial root, demonstrates the successful healing of post-treatment disease when proper disinfection has been accomplished. This case illustrates the reason that retreatment is the primary treatment option for post-treatment disease.

Once debridement and disinfection have been completed, appropriate
Obturation methods are used to seal the canal spaces. The warm vertical technique using gutta-percha or resin with an appropriate sealing agent provides a thorough seal of the well-cleansed and shaped canal spaces. The final restoration must provide a proper seal of the pulp chamber to prevent coronal micro-leakage.

Current evidence has demonstrated that we can retreat previously endodontically treated teeth properly and successfully. The literature has also shown that specific bacteria, such as E. faecalis, are able to survive inside a previously filled canal. The use of a dental operating microscope, ultrasonic instruments, irrigants, rotary NiTi files and appropriate obturation materials increases our ability to attain healing after retreatment. As we continue to strive to maintain healthy natural teeth for our patients, endodontic retreatment should be the primary option for patients with post-treatment disease.

A complete list of references is available from the publisher.

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"Current evidence has demonstrated that we can retreat previously endodontically treated teeth properly and successfully"
Large periapical lesion management

Dr Nuria Campo discusses decompression combined with root-canal treatment

Most periapical lesions occur as direct sequelae of chronic apical periodontitis, usually after pulpal necrosis of a tooth. The affected tooth is non-responsive to thermal and electrical pulp tests. Periapical lesions often develop slowly and do not become very large. Patients do not experience pain unless there is acute inflammatory exacerbation. These lesions are often diagnosed during routine radiographic exams. Some periapical lesions become large and, in cases of large radiolucencies, they may be diagnosed in the absence of any patient complaint.

Sometimes, symptoms such as mild sensitivity, swelling, tooth mobility and displacement may be observed in these cases.

Large periapical lesions are often associated with anterior maxillary teeth, probably due to traumatic injuries. These lesions could be classified as granulomas, pocket cysts (also called bay cysts) and true cysts. Granulomas are usually composed of soft tissue, while cysts have a semi-solid or liquefied central area usually surrounded by epithelium.1 Pocket cysts have an epithelial lining that is connected with the root canal, and true cysts are completely lined with epithelium and not connected with the root canal.2

According to Nair’s3 research, based on serial sectioning and strict histopathological criteria, the prevalence of pocket cysts to be six per cent, whereas that of true cysts is nine per cent. Previous studies without serial sectioning that reported ranges from six to 55 per cent are proven to contain a great margin of error. The differential diagnosis of large periapical lesions is still a controversial topic. Periapical radiographs, contrast media, Papamirouloou smears and albumin tests have proven to be inaccurate in establishing a preoperative diagnosis. Only once the post-operative biopsy has been taken, can a diagnosis be established.

There is evidence1 that CBCT scans may provide a more accurate diagnosis than biopsy. To obtain an accurate reading, the entire lucency must be scanned for the most lucent or least dense areas. If the least dense area of the CBCT scan shows positive grey-scale values identified as solid tissues, diagnosis will be consistent with granuloma. If it shows negative grey-scale values identifying a semisolid or fluid-filled central area, diagnosis will be consistent with a pocket or a true cyst. Real-time ultrasound imaging and ultrasound recently demonstrated that they are capable of establishing differential diagnosis as well.4

There is widespread agreement that most granulomas may heal after non-surgical endodontics. He asserts that a pocket cyst is sustained by the microbes within the canal system, but that a true cyst is self-sustaining and will remain after the micro-organisms have been removed from the root-canal system. The new preoperative diagnostic techniques will be helpful in the treatment decision process.

The following case report describes the management of a particularly large maxillary periapical lesion (involving four anterior teeth) by decompression with tubing, followed by NSRCT using interim long-term calcium hydroxide (Ca(OH)2).

Case report
A healthy 50-year-old male patient with recurrent palatal swelling and buccal abscesses was referred to our practice (Fig 1). He had had these symptoms for the last two to three years owing to trauma sustained while working with machinery. An RCT on tooth #9 had been performed following the incident. One year later, the tooth presented with apparent brown discolouration according to the patient.

At the initial examination, tooth #9 was found to be non-vital (non-responsive to cold or electrical stimuli), and teeth #7, 8, 10 and 11 had a cold pulpal response within normal limits. Radiographs revealed a large cyst-like periapical lesion that appeared to be centred above the left upper central incisor (Figs 2 & 3). A panoramic radiograph (Fig 4) confirmed the full ex-
tent of the lesion, which appeared to involve the floor of the nasal sinus. The history of repeated palatal and buccal abscesses suggested a through and through osseous defect. The diagnosis was apical periodontitis in tooth #9.

The following treatment options were considered:

- decompression combined with RCT; and
- surgical removal of the lesion with RCT on tooth #9 and possibly teeth #8, 10 and even 7 and 11 owing to the great risk of damaging nervous and vascular supply during surgery.

The patient preferred the most conservative approach and treatment was performed in four appointments over five months.

Management sequence

1 During the first visit, the previous root-canal filling (gutta-percha with a plastic carrier) was removed (Fig 5). There was a lot of gutta-percha in the pulpal camera. This and remains of necrotic pulpal tissue could have been the cause of the brown staining of the tooth. Persistent purulent content from the canal was noted. A Ca(OH)2 paste (Ultracal XS, Ultradent) was placed in the root canal as interim medication (Fig 6). Once the buccal encapsulated tissue was removed (Fig 7), copious drainage was also obtained from the buccal abscess.

2 After one month, Ca(OH)2 was replaced because the canal could not be dried even after shaping and cleaning with copious amounts of 5.25 per cent sodium hypochlorite. A vestibular incision was made and a

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There is widespread agreement that most granulomas heal after non-surgical root-canal treatment (NSRCT), but there is no consent regarding this in the case of periapical cysts.
plastic cannula was inserted into the lesion, obtaining purulent drainage. Thereafter, the cannula was prepared and sutured to the mucosa (Figs 8 & 9), and the patient was instructed to irrigate through the lumen of the cannula with 3ml of 0.12 per cent chlorhexidine on a daily basis for four weeks (Fig 10), consistent with the protocol described by Brøndum and Jensen.5

Two months after the last visit, complete drying of the canal space was achieved but, owing to the extent of the lesion, it was decided to replace and maintain the Ca(OH)2 for two months in order to determine whether this would effect healing as evidenced in the pattern of the lesion.

Two months later, healing appeared to be underway (Fig 11a) and the canal was dry. The root-canal filling was performed with gutta-percha and AH Plus (DENTSPLY DeTrey) and composite were placed to seal the access (Fig 11b). The patient was recalled at eight months and was asymptomatic and there was no swelling or abscess at either the palatal or buccal surfaces. Normal pulpal responses have been maintained in teeth #7 to 11 since.

Healing of the lesion still appeared to be in progress, owing to the reduction in the size of the lesion. The trabecular pattern at the borders of the lesion had been restored (Fig. 11c) and the periodontal ligament around tooth #9 was almost fully recovered (Fig. 12). We plan to recall this patient on a yearly basis until the lesion is fully healed.

Discussion

The management of large periapical lesions is the subject of prolonged debate. The treatment options range from RCT or NSRCT with long-term Ca(OH)2 therapy to various surgical interventions, including marsupialisation, decompression with a tube and surgical removal of the lesion. These treatment options can also be combined.

Long-term drainage is important in the conservative management of these large lesions. One method is to drain through the canal on a daily basis until the canal becomes dry.

‘Long-term drainage is important in the conservative management of these large lesions. One method is to drain through the canal on a daily basis until the canal becomes dry’
from the apical focus. There is no standard protocol for the length of time for which the tube should be left in. Some clinical cases, however, have reported five-week to 14-month periods, with periodical reshaping if necessary.

The literature offers evidence that the majority of these cyst-like lesions heal after conventional RCT over multiple appointments. Çaliskan6 reported 74 per cent complete healing and 9.5 per cent incomplete healing in an in vivo study of anterior teeth with large periapical lesions ranging from seven to 18 mm. The treatment combined long-term canal drainage with Ca(OH)$_2$ dressing and non-surgical RCT. Several case reports7–9 have demonstrated that long-term decompression involving a tube combined with interim Ca(OH)$_2$ dressing and RCT is also successful.

Decompression is favoured because fewer visits are necessary compared with root-canal drainage. Furthermore, it is much more conservative, especially in comparison with surgical removal of the lesion with the risk of damaging the nervous and vascular supply of adjacent teeth and other anatomical structures, such as the nose and maxillary sinus floor. Even if surgical removal is still necessary later, the lesion will predictably have shrunk in size by such time and present less difficulty and less risk of damage to other teeth or vital structures.

With complete informed consent, the patient may prefer more immediate therapy and select surgical enucleation without delay in conjunction with the conventional endodontic therapy of the responsible tooth and usually the adjacent ones involved in the lesion. It is important to remember that microbes initially caused the lesion and continue to maintain the immune response and thus the apical periodontitis.

The length of time required for healing in these cases ranges from eight to 14 months.8 Follow-up on the process of healing should be done every six months for four years.

There are also large periapical lesions of non-dental origin, such as non-dental cysts (e.g. naso-palatal cyst) and neoplastic entities. If there are doubts regarding the dental origin of the periapical lesion, the first choice of treatment is the surgical approach.

This case has illustrated the healing of a large periapical lesion with a minimally invasive approach. However, every case requires an individual approach depending on the patient’s cooperation, preferences, availability and proximity to the surgery, as well as the dentist’s professional training and technical skills.

‘Decompression is favoured because fewer visits are necessary compared with root-canal drainage. Furthermore, it is much more conservative’

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Editorial note: A complete list of references is available from the publisher.

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Intentional replantation: A viable treatment option for specific endodontic conditions

Prof Naseem Shah, Dr Ajay Logani & Dr Abhinav Kumar

Intentional replantation is defined as the purposeful extraction of a tooth in order to repair a defect or cause of treatment failure and thereafter the return of the tooth to its original socket. Any tooth that can beatraumatically removed in one piece is a potential candidate for intentional replantation.

However, specific indications include:1-5

• all other endodontic non-surgical and surgical treatments have failed or are deemed impossible to perform
• limited mouth opening that prevents the performance of non-surgical or peri-apical surgical endodontic procedures
• root-canal obstructions
• restorative or perforation root defects that exist in areas that are not accessible via the usual surgical approach without excessive loss of root length or alveolar bone

Contraindications may include:1,4

• advanced periodontal diseases that have resulted in poor periodontal support and tooth mobility
• multi-rooted teeth with diverging roots that make extraction and reimplantation impossible
• teeth with non-restorable caries

In order to provide the best long-term prognosis for a tooth that is to be replanted intentionally, the tooth must be kept out of the socket for the shortest period possible, and the extraction of the tooth should be atraumatic to minimise damage to the cementum and the periodontal ligament.

The periodontal ligament attached to the root surface should be kept moist in saline, Hank's Buffered Salt Solution (HBSS), Viaspan or Doxycycline solution for the entire time the tooth is outside the socket.

We have documented three clinical cases to exemplify the potential of intentional replantation as a viable treatment option in select endodontic cases.

Case I

A 14-year-old male patient presented with a separated Lentulo spiral extending 4-5mm beyond the apex of the mesiobuccal root canal of tooth #46 (Figs. 1a-d). The tooth was badly broken and the instrument tightly screwed into the root canal. All efforts to remove the spiral were futile, and we were concerned that it would fracture at the apex.

Apical surgery was ruled out because accessibility to the mesiobuccal root would have been limited. We decided to replant the tooth intentionally and discussed this treatment option with the patient, who agreed to our proposal.

The tooth was badly broken, we planned to reinforce its core with a post in the distal canal prior to extraction.

Once we had obtained adequate anaesthesia, the tooth was extracted atraumatically with an extraction forceps. We did not use surgical elevators and took care that the beaks did not go beyond the cemento-enamel junction (CEJ), as this may have damaged the cementum and the periodontal ligament.

Following extraction, we kept the tooth moist by immersing it in Viaspan. With the beaks of the forceps, we held the tooth by its crown and cut the clot. The socket was filled with tricalcium phosphate in order for the tooth to be 2-5mm higher than before. This helped in planning a good post-endodontic restoration.

The tooth was carefully reinserted into its socket and brought into occlusion with digital manipulation and patient bite force. The tooth was stabilised in its socket with a sling suture. The patient was re-evaluated after seven days, and the sutures were removed.

Case II

A 22-year-old male patient presented with a history of trauma to his maxillary anterior region. Clinical examination revealed an Ellis Class III fracture of tooth #12, with the fracture line extending to the root palatally. Once the mobile fragment had been extracted, we realised that the fracture line extended 2-5mm sub-crestally. In order to bring the apical end of the fracture line to a supra-crestal position, we considered two options: orthodontic extrusion and intentional replantation. The patient did not accept orthodontics as an option owing to the extended treatment time required.

Once the tooth had been atraumatically extracted, it was kept moist in Viaspan,
We inserted tricalcium phosphate in the apical 5-4mm of the socket and reinserted the tooth with a 180° rotation to bring the deep fracture line to a more accessible labial side. The tooth was then splinted with fibre reinforced composite for a period of three weeks.

The root-canal treatment was completed at a later date, and the facial surface was built up with composite. We decided not to proceed with the crown immediately after stabilisation to prevent loading of the tooth. The patient was recalled periodically for follow-up.

Case III
A 23-year-old female patient presented with pain in her upper right anterior tooth. There was no history of trauma, and clinical examination revealed a deep palato-gingival groove (PGG) with respect to tooth #12 (Figs 2a–e). The intra-oral peri-apical radiograph revealed a peri-apical radiolucency. We decided to extract the tooth, seal the groove and then replant the tooth. After adequate anaesthesia had been obtained, the tooth was extracted with all the necessary precautions and immersed in Viaspan. With help of the forceps, it was then held by its crown. The PGG was debrided with the tip of the ultrasonic scaler and sealed with glass-ionomer cement (GIC). The socket was then gently curetted and the tooth reinserted. Sutures were placed in the minter-dental area and endodontic treatment was completed one week later. The apical 4-5mm of the root were sealed with MTA, and the rest of the root canal was back-filled with thermoplasticised gutta-percha. The patient was re-evaluated after seven days.

Discussion
Intentional replantation in dentistry has been performed for more than 10 centuries and was used extensively to manage odontalgia. In 1561, Pare recommended its use when a healthy instead of a diseased tooth was mistakenly extracted! In 1712, Pierre Fauchard® replanted a tooth and reported it to be stable on follow-up. Several steps in the replantation were debated, for instance the need for amputation of root apices, immediate or delayed replantation, root-canal obturation before or after replantation, removal or preservation of periodontal ligament cells and the goal of ultimate healing—bony ankylosis or ligament repair.

It was in 1881 that Thompson presented the treatise on the replantation of teeth and emphasised the importance of peri-cemental tissues for treatment success. Later, Fredel® in 1887 and Scheff® in 1890 addressed the role of periodontal ligament cells with regard to external root resorption after replantation.

As the replantation technique became increasingly refined, it was used as an easy alternative for failing root-canal treatment and hence evoked sharp criticism for the technique of replantation per se.

There are many reasons for an adverse outcome of a replantation: the tooth can fracture during extraction and may be completely lost; peri-cemental tissues can be damaged, reducing the likelihood of reattachment; infection; external root resorption; and ankylosis. Therefore, it is extremely important to understand that intentional replantation should be the last choice, selected only when all the other options of treatment (non-surgical and surgical) have been exhausted. Replantation can be a treatment of choice in cases in which...
a surgical approach can be difficult, for example on the lingual root of a mandibular molar, or in cases in which a surgical approach would be very invasive, such as the removal of thick bone from the buccal aspect of a second mandibular molar.

Intentional replantation has a better prognosis when the extra-oral time is kept as short as possible and trauma to the periodontal ligament and cementum is minimised. It is advisable to perform routine endodontic treatment intra-orally before the tooth is extracted to minimise the extra-oral time. It is also suggested that a team of two dentists work in tandem to prevent prolonged treatment time, thus improving the chances of success. The use of elevators should be avoided, and the beaks of the extraction forceps should not go beyond the CEJ. The cortical bone integrity should be maintained, and the tooth should be extracted as atraumatically as possible.

The medium in which the tooth is kept moist plays an important role. Saline, HBSS, milk, Viaspan, to name a few, are widely used. Viaspan is used for organ transplantation and preservation. Owing to its anti-oxidant activity, the solution keeps the periodontal ligament moist and reduces the likelihood of surface resorption.

We generally use ultrasound tips to prepare the root-end and the debridement of the PGG. It conserves the tooth structure and produces significantly less smear layer compared with burs. Commonly used root-end filling materials are amalgam, Intermediate Restorative Material (IRM), Super EBA, GIC, DiaKet, composite and MTA. The sealing ability and marginal adaptation of MTA have been proven to be superior and not adversely affected by blood contamination. In addition, MTA promotes deposition of new cementum and stimulates osteoblastic adherence to the retro-filled surface.

In two of our cases, tricalcium phosphate was placed in the apical few millimetres of the socket. This was done in order to bring the defect supragingivally so that the integrity, aesthetics and prognosis of the case were improved. Tricalcium phosphate is an osteo-conductive material that acts as scaffold for bone growth and is gradually degraded and replaced by bone.

A palato-gingival groove is a developmental anomaly that represents an infolding of enamel and Hertwig's epithelial root sheath. PGG can vary in depth, length and complexity, can occur around one or more of periodontal defects. Mild grooves terminate at the CEJ, whereas moderate grooves continue apically along the root surface. A treatment option for a PGG terminating close to CEJ is to expose the groove surgically and to seal it thereafter. As presented, the groove extended beyond the apex in Case III. Here, the defect was sealed extra-orally and the tooth replanted. GIC was used to seal the PGG, as it chemically adheres to the tooth structure and has a good sealing ability and antibacterial effect.

After replantation, the tooth was splinted for ten days. The splint enabled physiological movement of the tooth to prevent ankylosis. Endodontic treatment was completed one week after replantation in order to prevent inflammatory resorption and ankylosis and to allow splicing of periodontal fibres, which limits the seepage of potentially harmful root-filling materials into the traumatised periodontal ligament. Final restoration of the tooth was delayed to avoid loading and to ensure that proper healing of periodontal ligament took place.

In recent years, several bio-modulators, such as enamel matrix protein 1, hydroxyapatite and platelet rich plasma, have been used in intentional replantation cases to improve the success rates. Guided tissue-regeneration techniques can also be employed along with these supplements to further improve the likelihood of success.

We conclude that intentional replantation is a viable treatment option in carefully selected cases in which all other treatment options have been exhausted.

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• Editorial note: A complete list of references is available from the publisher.

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**Fig 2b** Intra-oral peri-apical radiograph showing the peri-apical lesion

**Fig 2c** Tooth extracted, PGG prepared with ultrasonics

**Fig 2d** PGG sealed with GIC

**Fig 2e** Intra-oral X-ray showing obturated canal. The sealed PGG is superimposed on the root-canal obturation