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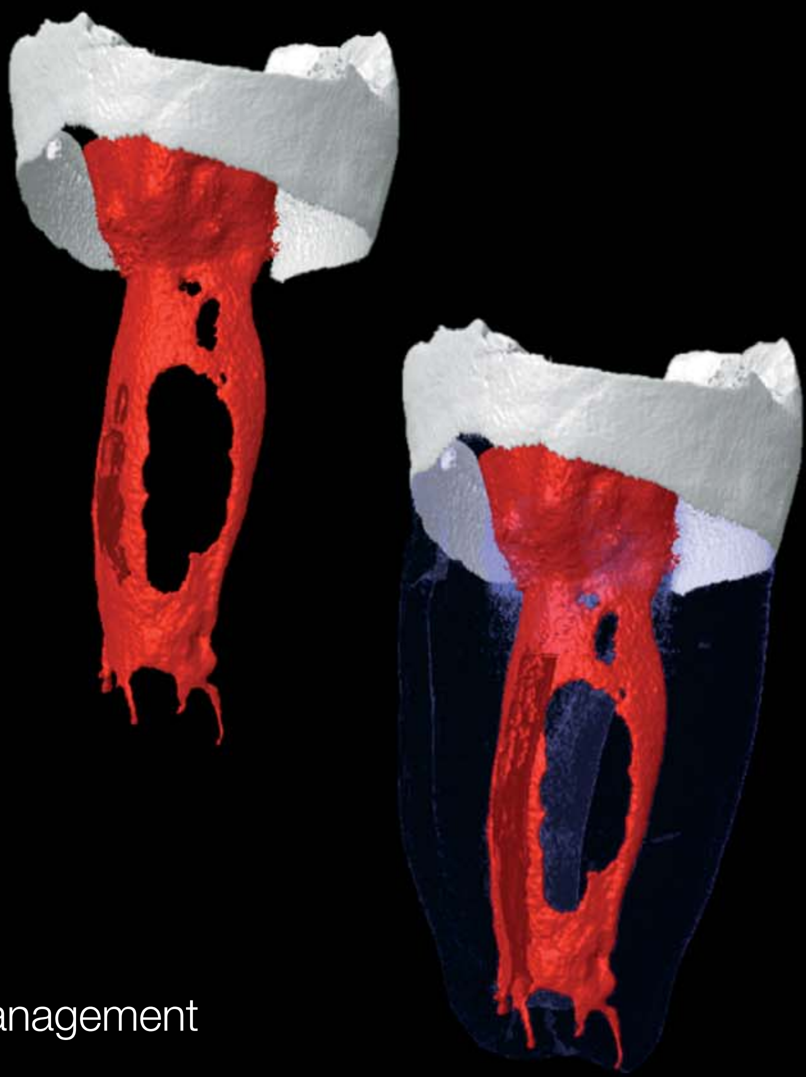

| **case report**
Large periapical lesion management

| **special**
The antibacterial effects of lasers in endodontics

| **research**
Ability of four irrigating solutions to remove debris after root-canal instrumentation

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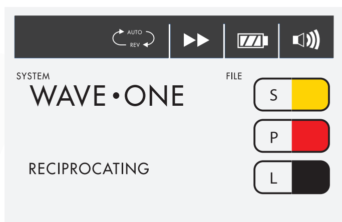

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Dear Reader,

Prof Michael A. Baumann

_Ten years ago, in January 2002, the German Society of Endodontology (DGEndo) was founded. Full of enthusiasm, the 13 founding members pursued their goal of shaking up the endodontic world. In no time, a statute had been written, a home page and logo designed and the first annual meeting planned. Today, there are more than 1,000 registered members and the enthusiasm is still tangible. In light of this development, the German Society for Conservative Dentistry (DGZ) and the DGEndo decided to join forces and formed the German Society of Endodontology and Traumatology (DGET). The first annual meeting was held in Bonn last year—a great start for a successful merger.

What began ten years ago with the use of modern technology has rapidly developed in recent years. Literature research on iPads during a presentation, lectures on mobile phones, apps and videos on YouTube are now available to many. This globalisation is also reflected in the representation of nationalities from all over the world amongst speakers at conferences and in the instant availability of the latest information and news.

Last year, a child born in Manila was symbolically named the world's seven billionth baby by the UN. Never before had that many people simultaneously lived on earth. According to the BBC, about 77 billion people have lived on our planet since the beginning of human history.[1] Thanks to the Internet, social networks and search engines, we now have virtually unlimited and rapid access to the knowledge mankind has accumulated thus far. In this context, endodontics has also experienced an explosion of factual knowledge and technological development in recent years. Furthermore, medicine, biology, chemistry, physics and engineering have become intermeshed in technology that offers never-before-seen speed and perfection. Today, in addition to the more technically oriented innovations, such as NiTi, reciprocating one-file systems or the technologically fascinating self-adjusting file, as well as an immense variety of new irrigation concepts, more biologically oriented ideas are taking shape.

In the April 2007 issue of the *Journal of Endodontics*, Kenneth M. Hargreaves called on researchers around the world to combine the available knowledge and to join efforts in the field of tissue regeneration in endodontics.[2] The collected ideas ranged from the revascularisation of the root canal to stem-cell therapy, pulp implants, 3-D polymer scaffolds, injectable 3-D cell printing and gene therapy. Today, some of these ideas have already found their way into our practices, such as triple antibiotic paste (metronidazole, ciprofloxacin, minocycline). Teeth with incomplete root growth and necrosis of the pulp treated with this paste show good development of the dentine–pulp complex in the form of good root development.[3]

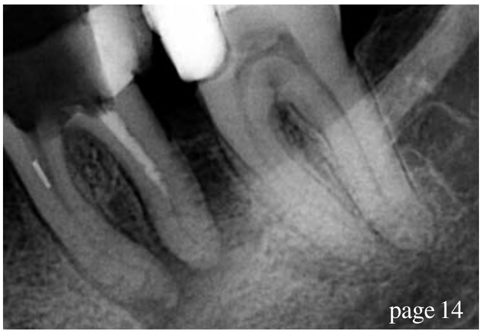
Back in 2005, we succeeded in creating artificial dental and bone tissue in the laboratory.[4] Researchers[5–8] have been working on creating human teeth in test tubes for many years. Today, the daily press even reports about such news and, thus, endodontic topics have been made available to the whole world. Even though we only cover one of many sectors, these prospects hold significant implications for both specialists and patients, and keep us moving forward with enthusiasm and scientific curiosity.

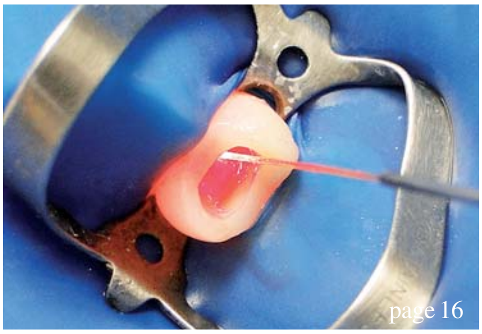
Yours faithfully,

Prof Michael A. Baumann
University of Cologne, Germany

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


page 6


page 14


page 16

editorial

case report

special

feature

research

The Endospot

industry news

meetings

about the publisher

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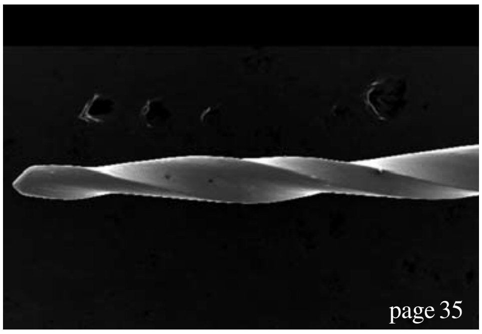
page 34


page 35

page 36

Large periapical lesion management

Decompression combined with root-canal treatment

Author_ Dr Nuria Campo, Spain

Fig. 1_Buccal abscess.

_**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 solid 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]

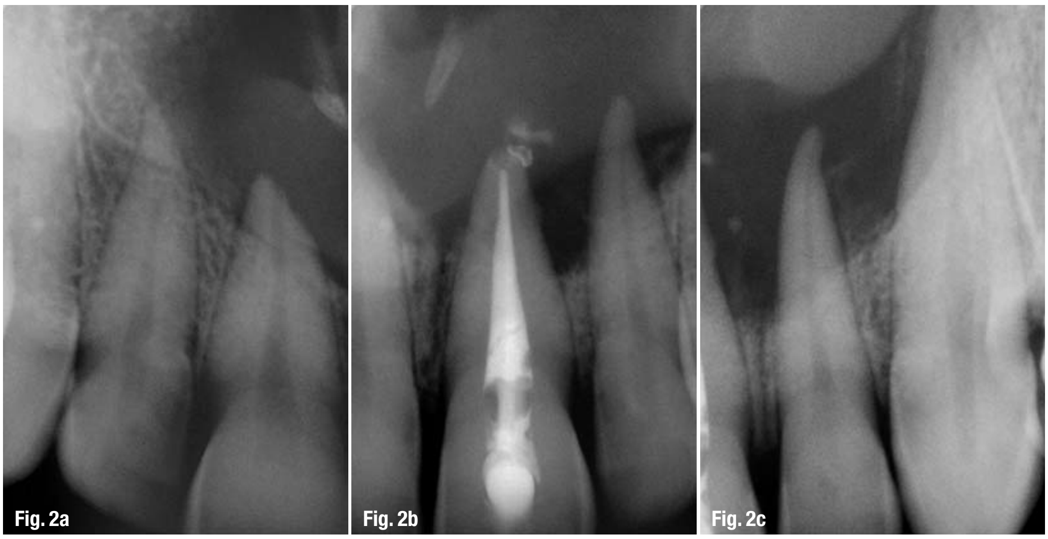


Fig. 2a_Mesio-radial periapical radiograph. Fig. 2b_Ortho-radial periapical radiograph. Fig. 2c_Disto-radial periapical radiograph.

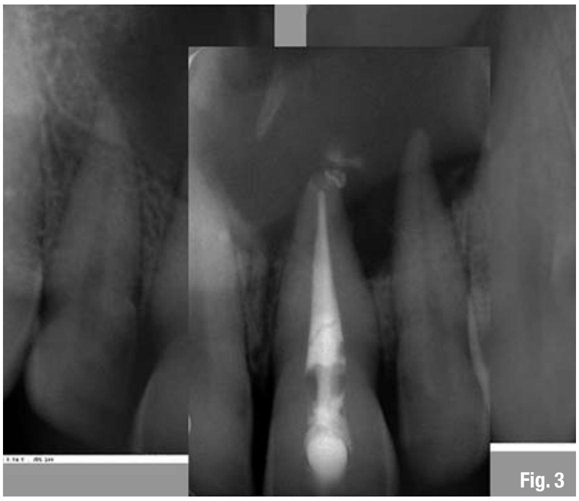


Fig. 3


Fig. 4

Fig. 3_Periapical's composition showing the full extension of the lesion.

Fig. 4_Initial panoramic radiograph.

According to Nair's[3] research, based on serial sectioning and strict histopathological criteria, the prevalence of pocket cysts to be 6%, whereas that of true cysts is 9%. Previous studies without serial sectioning that reported ranges from 6 to 55% 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, Papanicolaou 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 evidence[1] 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 semi-solid 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 heal after non-surgical root-canal treatment (NSRCT), but there is no consent regarding this in the case of periapical cysts. In Nair's opinion, based on indirect clinical evidence, it appears that pocket cysts 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 ($Ca(OH)_2$).

Fig. 5_Previous root-canal filling (gutta-percha with a plastic carrier).

Fig. 6_$Ca(OH)_2$ root dressing.

Fig. 7_Remains of buccal encapsulated tissue.


Fig. 5

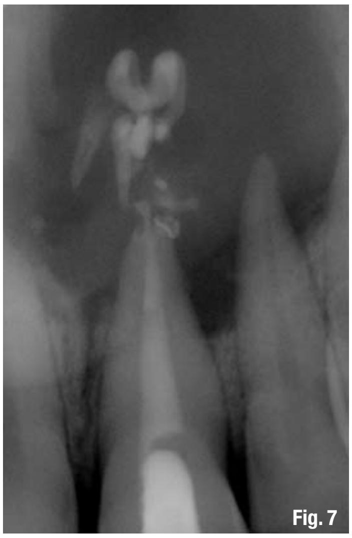


Fig. 7


Fig. 6

Fig. 8

Fig. 8_Modified print tip used as cannula.

_Case report

A healthy 39-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 extent 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 % sodium hypochlorite. A vestibular incision was made and a 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 3 ml of 0.12 % chlorhexidine on a daily basis for four weeks (Fig. 10), consistent with the protocol described by Brøndum and Jensen.[5]

3. 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.

4. 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.

Fig. 9

Fig. 10

Fig. 9_Sutured plastic cannula.
Fig. 10_Flat-tipped needle with Luer-Lok syringe for irrigation.

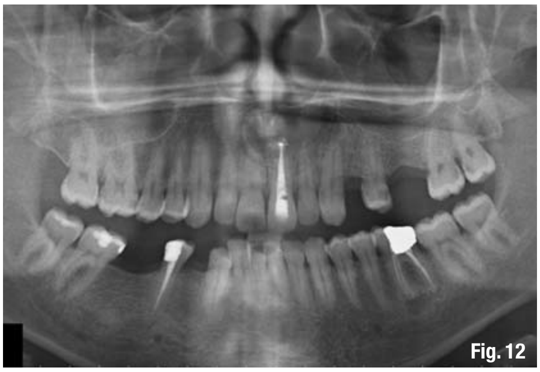


Fig. 11a_After five months of interim medication, healing appeared to be underway.

Fig. 11b_Root-canal filling and coronal sealing.

Fig. 11c_Eight-month recall periapical radiograph.

Fig. 12_Eight-month recall panoramic radiograph.

_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. This could last for between 15 days and one month. At each visit, debridement, drying and closing of the access cavity are mandatory. Another method of drainage is decompression with a tube 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. Çaliskan[6] reported 74 % complete healing and 9.5 % incomplete healing in an *in vivo* study of anterior teeth with large periapical lesions ranging from 7 to 18 mm. The treatment combined long-term canal drainage with $Ca(OH)_2$ dressing and non-surgical RCT. Several case reports[7–9] 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.[6] 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. nasopalatal 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._

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

_about the author roots

Dr Nuria Campo received her degree from the University of Barcelona in 1997. She is a self-trained endodontist. Dr Campo co-organised the Roots Summit IX in Barcelona.

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Intentional replantation: A viable treatment option for specific endodontic conditions

Authors_ Prof Naseem Shah, Dr Ajay Logani & Dr Abhinav Kumar, India

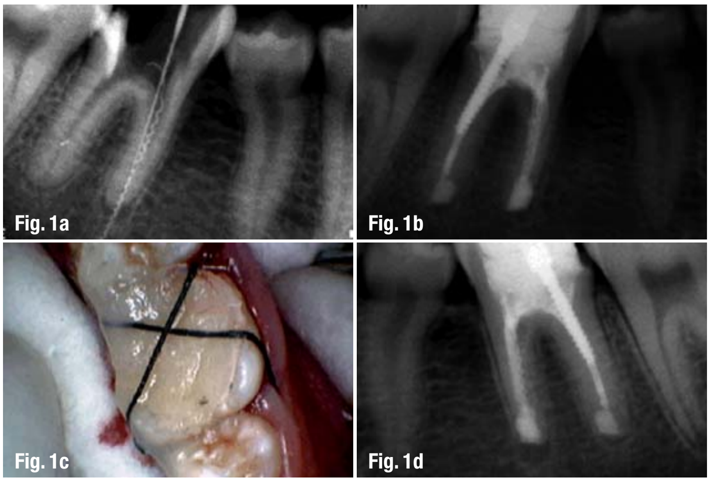

Fig. 1a_Tooth #46 with a fractured Lentulo spiral pushed past the apical foramen in the mesiolingual canal.
Fig. 1b_Tooth replanted after removal of the fractured instrument (apicoectomy and retrograde MTA obturation).
Fig. 1c_Clinical photograph showing stabilisation of the replanted tooth with sling sutures.
Fig. 1d_Six-month follow-up.

_***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.[1] Any tooth that can be atraumatically removed in one piece is a potential candidate for intentional replantation. However, specific indications include:[1–3]

_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-radicular surgical endodontic procedures;
_root-canal obstructions; and
_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:[1–2]

_long, curved roots;
_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; and
_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 to 5 mm beyond the apex of the mesiolingual 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 mesiolingual 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. Since 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 overextended Lentulo spiral. Thereafter, we performed a 3 mm Class I root-end preparation with an ultrasonic tip, at the apical end of all three canals. A retrograde filling was done with mineral trioxide aggregate (MTA). The extraction socket was then irrigated with normal saline and gently suctioned to remove blood clots. The socket was filled with tricalcium phosphate in order for the tooth to be 2 to 3 mm 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 it 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 to 3 mm 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 3 to 4 mm of the socket and reinserted the tooth with a 180° rotation to bring the deep fracture line into 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 inter-dental area and endodontic treatment was completed one week later. The apical 4 to 5 mm of the root were sealed with MTA, and the rest of the root canal was back-filled with thermo-plasticised gutta-percha. The patient was re-evaluated after seven days.

_Discussion

Intentional replantation in dentistry has been performed for more than ten centuries and was used extensively to manage odontalgia.[4] In 1561, Pare recommended its use when a healthy instead of a diseased tooth was mistakenly extracted![5] In 1712, Pierre Fauchard[6] 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[7] presented the treatise on the replantation of teeth and emphasised the importance of peri-cemental tissues for treatment success. Later, Fredel[8] in 1887 and Scheff[9] 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

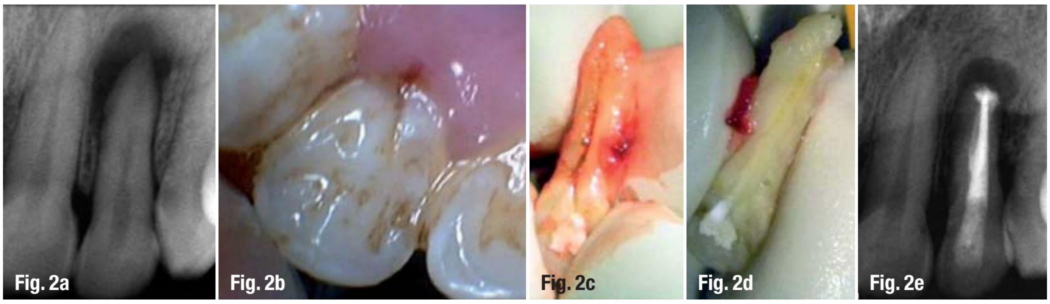

Fig. 2a_Clinical photograph of tooth #12 showing the PGG.
Fig. 2b_Intra-oral peri-apical radiograph showing the peri-apical lesion.
Fig. 2c_Tooth extracted, PGG prepared with ultrasonics.
Fig. 2d_PGG sealed with GIC.
Fig. 2e_Intra-oral X-ray showing obturated canal. The sealed PGG is superimposed on the root-canal obturation.

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.[1] 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 antioxidant activity, the solution keeps the periodontal ligament moist and reduces the likelihood of surface resorption.[2]

We generally use ultrasonic 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.[3] 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.[10]

A palato-gingival groove is a developmental anomaly that represents an infolding of enamel and Hertwig's epithelial root sheath.[11] PGG can vary in depth, length and complexity, causing varying degrees 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.[12]

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.[13] 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[14], hydroxyapatite and platelet-rich plasma,[15] 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.

We would like to acknowledge the assistance of Dr Akanksha Gupta and Dr Nikhil Sinha._

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

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When flexibility and strength are key

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Fig. 2


Fig. 3

_**Root-canal retreatment** is a very common procedure that endodontists and general practitioners are faced with on almost a daily basis. The biggest challenge here is to re-establish the initial pathway of the canal and its original exit or apex. During the past decade, several techniques required that gutta-percha be used to fill the root canals. Sometimes and for many reasons, such as leakage or short preparation and/or obturation, the gutta-percha needs to be removed and the canal renegotiated.

Generally, NiTi rotary files were used in such cases in order to facilitate and expedite our task. However, the files used to accomplish this task faced additional challenges, that is, the debris coming from the previous obturation and the density of the obturation material. The first difficulty is piercing the mass of the obturation material. Here, our choice of file should focus on a strong tip that can take the pressure and engage the mass of the gutta-percha, break it down and push it back into the access cavity. The second challenge is to select an instrument that can enter the root-canal structure and engage the obturation material, pushing it out coronally, while offering enough flexibility to go around curves and shape the root-canal surface safely.

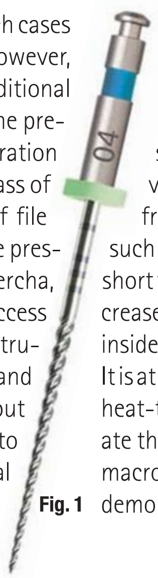

Fig. 1

Today, thanks to heat treatment that has changed the world of rotary NiTi files, allowing us to modify the crystalline structure of the metal, we have been able to obtain several types of the alloy to give us different files, from the Twisted File to the latest modification of the K3 system, the K3XF (SybronEndo; Fig. 1). The K3 system files are known to be robust yet very safe. The slight modification in their structure gives these files much-needed flexibility, while preserving their very high safety levels.

The clinical applications are very simple. My favourite sequence of the K3 system is the G-pack, which allows me to do crown-down using the taper of the files and keeping the tip stable at ISO 0.25. This sequence allows for a very nice start, removing the obturation material from the coronal third with relatively short files, such as orifice openers, and doing so in a relatively short time. The deeper we go, the more we need to decrease the taper, especially when curves are present inside the canals and smaller taper files are needed. It is at this particular moment that the flexibility of the heat-treated alloy gives the files the ability to negotiate the curves without any distortion of the canal or macro-damage to the file structure (as has been demonstrated in research and clinically).


Fig. 4


Fig. 5

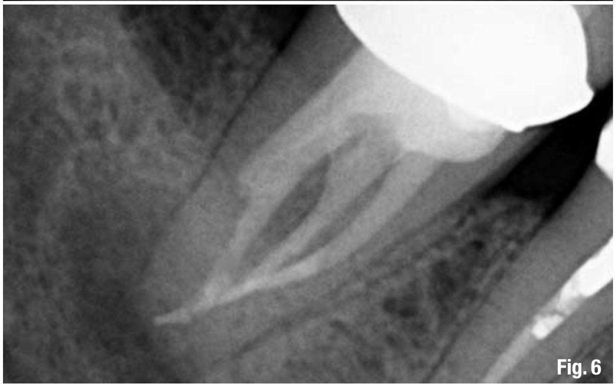
Fig. 6

_Clinical cases

The first clinical case could be described as a very bad day in a dental office. Two files had been trapped and separated in the mesial canals and the patient was referred to the clinic but had to drive for more than two hours to get to our clinic. When I first saw the X-rays (Fig. 2), I remembered a very similar case from several years ago with practically the same location of file separation. The separated files in the mesial canals were clearly visible. It was also noticeable that the distal canal had not been treated to full length. Ultrasonic tips and the use of an operating microscope allowed me to retrieve the separated files and it was then time to reshape the canals and retreat the distal canal (Fig. 3). Owing to the combination of requirements for the treatment of this case—shaping and retreatment in one tooth—my instruments of choice were K3XF files. I started with 25.08, followed by 26.06 and concluded crown-down with 25.04. This gave access to the apical part, which was enlarged to 35.04 in the mesial and distal canals in order to prepare the apical portion of the root-canal system. The speed of the micromotor for the shaping procedure was 500 rpm and a sequence of push-and-pull movements—four to five strokes per canal—with each file was used in order to reach full working length. Figure 4 shows the obturation of the canals, which was performed with RealSeal (SybronEndo) after both separated files had been removed and the root-canal system reshaped.

The second case came as another referral. The patient was suffering from pain in her lower molar and was sent to the office in order to check the case and give the necessary treatment. The preoperative X-ray (Fig. 5) showed an apical lesion with an incomplete root-canal treatment. Because diagnostics found no sign of a root-canal crack, retreatment was my choice. However, we had to overcome two obstacles: the crown placed on the tooth and the fibre post inside the distal canal. I decided to go through the crown without removing it in order not to place any tension on the distal canal. When analysing the anatomy, it appeared that the roots were fused. In such cases, avoiding any tension is recommended in order to avoid any cracks.

Under the microscope and through the crown, I managed to remove the filling surrounding the post. With the use of the ultrasonic WHAT, I managed to remove the fibre post itself together with the previous filling from the access cavity. Using the K3XF after removal of the fibre post was a great help in reshaping the root-canal system, which appeared very convergent. The files displayed no sign of metal fatigue and the 25.06 was taken deeper into the canal compared with the standard K3 files. The extra flexibility and strength of the K3XF allowed me to perform crown-down and final apical shaping. Obturation of the root-canal system was performed with the Elements Obturation Unit (SybronEndo) and RealSeal material. The post-operative X-ray (Fig. 6) shows that the merging canals had been cleaned, shaped and filled; and the same had been done for the fibre-post space.

_Conclusion

In the two clinical cases presented here—both rather a challenge for root-canal retreatments—the final results were an endodontic success. This lends support to the fact that each challenge needs to be treated separately without fear or tremor from the initial preoperative X-rays. Our fear shall control neither our judgment nor our choices!

I would like to thank Yulia Vorobyeva, interpreter and translator, for her help with this article._

_contact roots

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The antibacterial effects of lasers in endodontics

Author_ Dr Selma Cristina Cury Camargo, Brazil

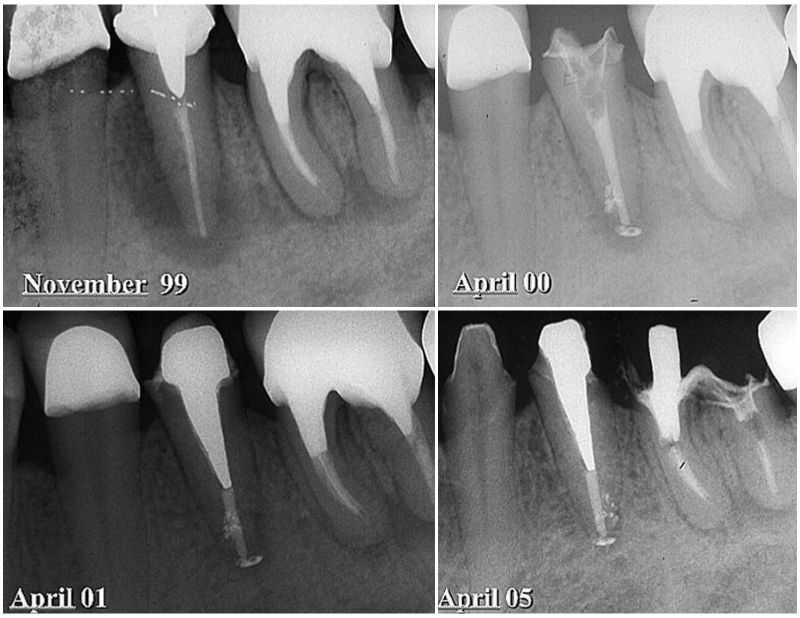


Fig. 1

Fig. 1_Success in endodontic treatment: apical radiolucency repair.

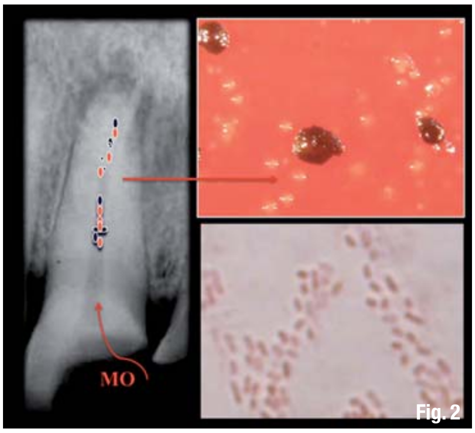
_Endodontic infection

Endodontic treatment can attain success rates of between 85 and 97 %.[1] Adequate treatment protocols, knowledge and infection control are essential to achieving such rates (Figs. 1a–d).[2] It is well known that apical periodontitis is caused by the communication of root-canal micro-organisms and their by-products to the surrounding periodontal structures. Exposure of dental pulp directly to the oral cavity or via accessory canals, open dentinal tubules or periodontal pockets is the most probable route of the endodontic infection.[2,3]

Clinically, apical periodontitis is not evident as long as the necrotic tissue is not infected with micro-organisms.[4–6] There are up to 40 isolated species of bacteria present in the root canal. Cocci, rods, filaments, spirochaetes, anaerobic and facultative anaerobic are frequently identified in primary infection. Fungus can also be isolated.[2,7] Endodontic microbiota can be found suspended in the main root canal, attached to the canal walls and deep in the dentinal tubules at a depth of up to 300 μm (Figs. 2a–c). The absence of cementum dramatically increases bacterial penetration into dentinal tubules.[8–11]

It has been shown that bacteria can also been found outside the root-canal system, located at the apical cementum and as an external biofilm on the apex.[12–15] Following conventional endodontic treatment, 15 to 20 % of non-vital teeth with apical periodontitis fail.[16–18] The presence of bacteria after the decontamination phase or the inability to seal root canals after treatment are reasons for failure.[2] The remaining contamination in endodontically treated teeth continues the infectious disease process in the periapical tissue.

Retreatments are the first choice for failed root canals. The microbiota found in persistent infections differ from that in primary infection (Figs. 3a–c). Facultative anaerobic Gram-positive (G+) and -negative (G-) micro-organisms and fungi are common.[19–21] Special attention is given to *Enterococcus faecalis*, a resistant facultative anaerobic G+ cocci, identified in a much higher incidence in failed root canals.[22–25] The importance of bacterial control plays a significant role in endodontic success. Adequate and effective disinfection of the root-canal system is necessary.



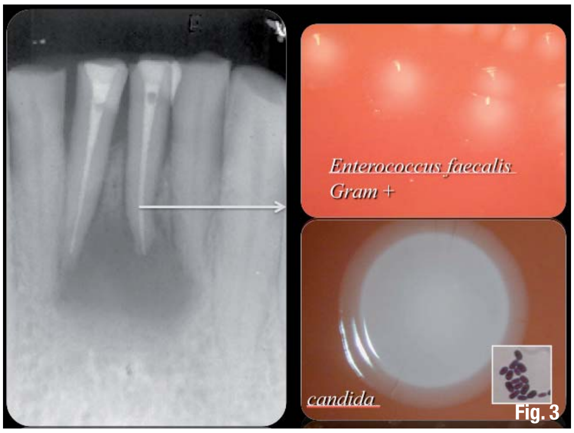


Fig. 2_Primary infection: black pigmented strains and G- rods.
Fig. 3_Persistent infection.

_Endodontic therapy

The bacterial flora of the root canal must be actively eliminated through a combination of debridement and antimicrobial chemical treatment. Mechanical instrumentation eliminates more than 90 % of the microbial amount.[26] An important point to note is the adequate shaping of the root canal. Evaluating the antibacterial efficacy of mechanical preparation itself, Dalton et al.[27] conclude that instrumentation to an apical size of #25 resulted in 20 % of canals free of cultivable bacteria. When shaped to a size of #35, 60 % showed negative results.

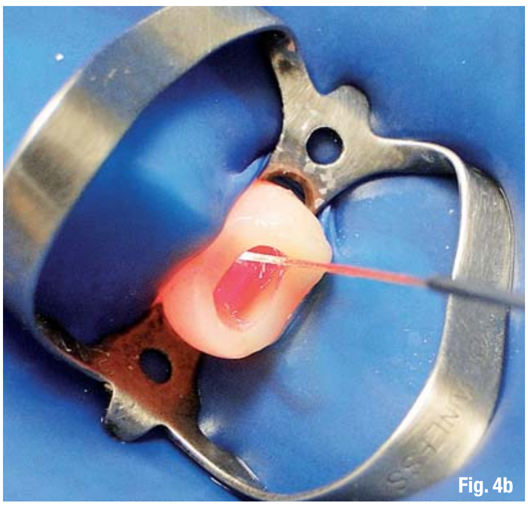
Irrigating solution has been used with mechanical instrumentation to facilitate an instrument's cutting efficiency, remove debris and the smear layer, dissolute organic matter, clean inaccessible areas and act against micro-organisms. Sodium hypochlorite is the most common irrigant used in endodontics.[28] It has an excellent cleansing ability, dissolves necrotic tissue, has a potential antibacterial effect and, depending on the concentration, is well tolerated by biological tissues. When accompanied by mechanical instrumentation, it reduces the number of infected canals by 40 to 50 %.

Other irrigating solutions are also used during endodontic preparation. EDTA, a chelating agent used primarily to remove the smear layer and facilitate the removal of debris from the canal, has no antibacterial effect.[29] Chlorhexidine gluconate has a strong antibacterial effect on an extensive number of bacterial species, even the resistant *E. faecalis*, but it does not break down proteins and necrotic tissue as sodium hypochlorite does.[30]

As mechanical instrumentation and irrigating solutions are not able to eliminate bacteria from the canal system totally—a requirement for root-canal filling—additional substances and medicaments have been tested in order to address the gap in standard endodontic protocols. The principal goal of dressing the root canal between appointments is to ensure safe antibacterial action with long-lasting effects.[31] A great number of medicaments have been used as dressing material, such as formocresol, camphorated parachlorophenol, eugenol, iodine-potassium iodide, antibiotics, calcium hydroxide and chlorhexidine.

Calcium hydroxide has been used in endodontic therapy since 1920.[31] With a high pH at saturation (pH above 11), it induces mineralisation, reduces bacteria

Figs. 4a & b_Nd:YAG laser intra-canal irradiation.
Fig. 5_Nd:YAG laser irradiation, deep penetration.



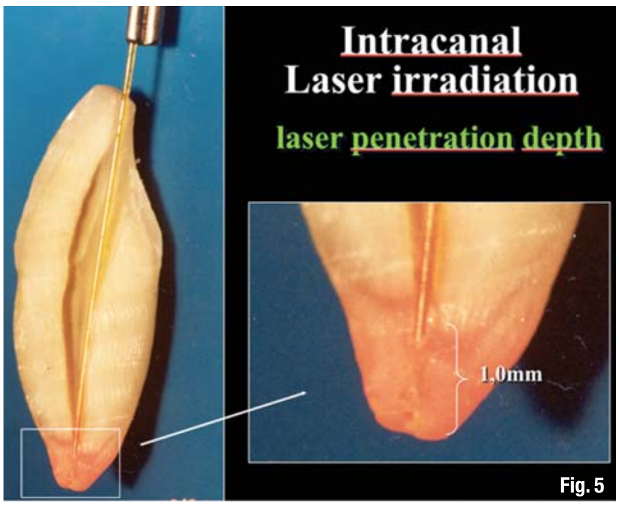


Fig. 6a

Figs. 6a & b_Diode 980 nm intra-canal irradiation.

and dissolves tissue. For extended antibacterial effectiveness, the pH must be kept high in the canal and in the dentine as well. Sustaining the pH depends on the diffusion through dentinal tubules.[32]

Although most micro-organisms are destroyed at pH of 9.5, a few can survive a pH of 11 or higher, such as *E. faecalis* and *Candida*.[21] Because of the resistance of some micro-organisms to conventional treatment protocols—and the direct relation between the presence of viable bacteria in the canal system and the reduced rate of treatment success—additional effort has to be made to control canal system infection.

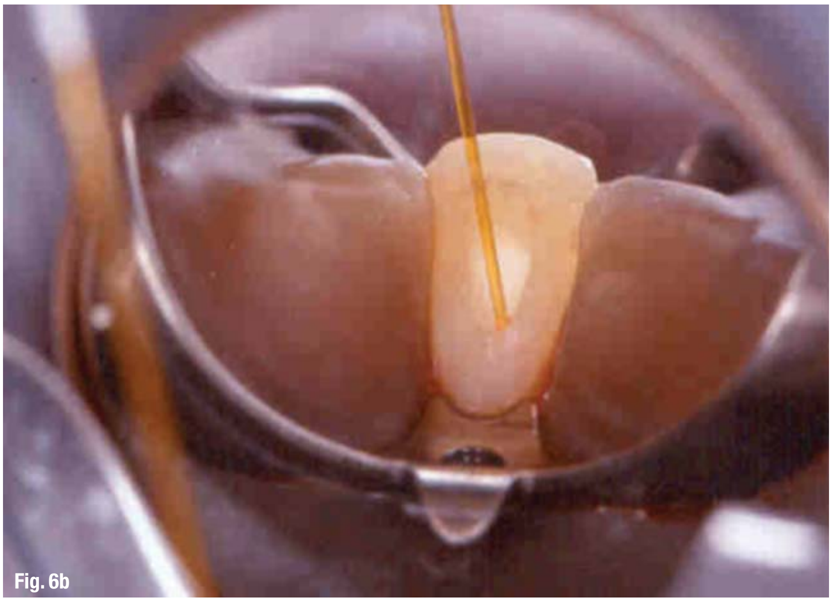


Fig. 6b

_Lasers in endodontics

Lasers were introduced to endodontics as a complementary therapy to conventional antibacterial treatment. The antibacterial action of Nd:YAG, diodes, Er:YAG and photoactivated disinfection (PAD) have been explored by a number of investigators. In the following section, each laser is evaluated with the aim of selecting an adequate protocol with a high probability of success in teeth with apical periodontitis.

Nd:YAG laser

The Nd:YAG laser was one of the first lasers tested in endodontics. It is a solid-state laser. The active medium is usually yttrium aluminium garnet ($Y_3Al_5O_{12}$), where some Y^{3+} ions are replaced by Nd^{3+}ions. It is a four-level energy system operating in a continuous wave or pulsed mode. It emits a 1,064 nm infra-red wavelength. Thus, this laser needs a guide light for clinical application. Flexible fibres with a diameter between 200 and 400 µm are used as delivery systems. The laser can be used on intra-canal surfaces, in contact mode (Figs. 4a & b).

The typical morphology of root-canal walls treated with the Nd:YAG laser shows melted dentine with a globular and glassy appearance, and few areas are covered by a smear layer. Some areas show dentinal tubules sealed by fusion of the dentine and deposits of mineral components.[33,34] This morphological modification reduces dentine permeability significantly.[35,36] However, because the emission of the laser beam from the optical fibre is directed along the root canal, not laterally, not all root-canal walls are irradiated, which gives more effective action at the apical areas of the root.[37] Undesirable morphological changes, such as carbonisation and cracks, are seen only when high energy parameters are used.

One of the major problems regarding intra-canal laser irradiation is the temperature increase at the external surface of the root. Laser light exerts a thermal effect when it reaches tissue. The heat is directly associated with the energy used, time and irradiation mode. An increase in temperature levels above 10 °C per minute can cause damage to periodontal tissues, such as necrosis and anchylosis.

Lan[38] evaluated *in vitro* the temperature increase on the external surface of the root after irradiation with a Nd:YAG laser under the following energy parameters: 50, 80 and 100 mJ at 10, 20 and 30 pulses per second. The increase of temperature was less than 10 °C. The same results were obtained by Bachman et al.[39], Kimura et al.[40] and Gutknecht et al.[41] In contrast to the external surface, the intra-canal temperature rises dramatically at the apical area, promoting effective action against bacterial contamination. For the Nd:YAG laser, 1.5 W and 15 Hz, are safe energy parameters for temperature and morphological changes.[33,41]

The primary use of the Nd:YAG laser in endodontics is focused on elimination of micro-organisms in the root-canal system. Rooney et al.[42] evaluated the antibacterial effect of Nd:YAG lasers *in vitro*. Bacterial reduction was obtained considering energy parameters. The researchers developed different *in vitro* models simulating the organisms expected in non-vital, contaminated teeth. Nd:YAG irradiation was effective for *Bacillus stearothermophilus*,[43,44] *Streptococcus faecalis*, *Escherichia coli*,[45] *Streptococcus mutans*,[46] *Streptococcus sanguis*, *Prevotella intermedia*[47] and a specific micro-organism resistant to conventional endodontic treatment, *E. faecalis*.[48–50] Nd:YAG has an antibacterial effect in dentine at a depth of 1,000 µm (Fig. 5).[50]

Histological models were also developed in order to evaluate periapical tissue response after intracanal Nd:YAG laser irradiation. Suda et al.[51] demonstrated in dog models that Nd:YAG irradiation at 100 mJ/30 pulses per second for 30 seconds was safe to surrounding root tissues. Maresca et al.,[52] using human teeth indicated for apical surgery, corroborated Suda et al.'s[51] and Ianamoto et al.'s[53] results. Koba et al.[54] analysed histopathological inflammatory response after Nd:YAG irradiation in dogs at 1 and 2 W. Results showed significant inflammatory reduction at four and eight weeks compared with the non-irradiated group.

Clinical reports published in the literature confirm the benefits of intra-canal Nd:YAG irradiation. In 1993, Eduardo et al.[55] published a successful clinical case that combined conventional endodontic treatment with Nd:YAG irradiation for retreatment, apical periodontitis, acute abscess and perforation. Clinical and radiographic follow-up showed complete healing after six months.

Similar results were shown by Camargo et al.[56] Gutknecht et al.[57] reported a significant improvement in healing of laser-treated infected canals, when compared with non-irradiated cases.

Camargo et al.[58] compared *in vivo* the antibacterial effects of conventional endodontic treatment and the conventional protocol associated with the Nd:YAG laser. Asymptomatic teeth with apical radiolucency and necrotic pulps were selected and divided into two groups: conventional treatment and laser irradiated. Microbiological samples were taken before canal instrumentation, after canal preparation and/or laser irradiation and one week after treatment. The results showed a significant antibacterial effect in the laser group compared with conventional treatment. When no other bactericidal agent was used, it was assumed that the Nd:YAG laser played a specific role in bacterial reduction for endodontic treatment in patients.

Fig. 7_Er:YAG laser.

Diodes

The diode laser is a solid-state semiconductor laser that uses a combination of gallium, arsenide, aluminium and/or indium as the active medium. The available wavelength for dental use ranges between 800 and 1,064 nm and emits in continuous wave and gated pulsed mode using an optical fibre as the delivery system (Figs. 6a & b). Diode lasers have gained increasing importance in dentistry owing to their compactness and affordable cost. A combination of smear layer removal, bacterial reduction and reduced apical leakage are advantages of this laser and make it viable for endodontic treatment. The principal laser action is photo-thermal.

The thermal effect on tissue depends on the irradiation mode and settings. Wang et al.[59] irradiated root canals *in vitro* and demonstrated a maximum temperature increase of 8.1 °C using 5 W for seven

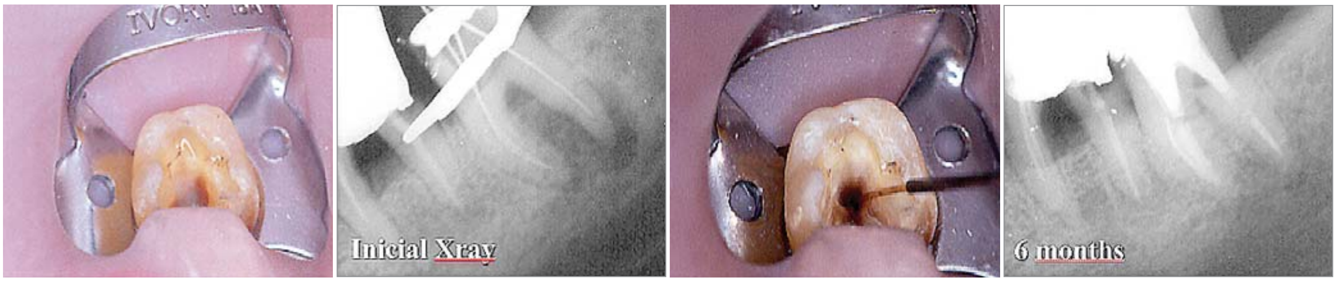


Fig. 8

Fig. 8_Therapeutic plan.

seconds. Similar results were obtained by Da Costa Ribeiro.[60] Gutknecht et al.[61] evaluated intra-canal diode irradiation with an output of 1.5 W and observed a temperature increase of 7 °C in the external surface of the root using a 980 nm diode laser at a power setting of 2.5 W at a continuous and chopped mode, and found that the temperature increase never exceeded 47 °C, which is considered safe for periodontal structures.[41]

Clean intra-canal dentinal surfaces with sealed dentinal tubules, indicating melting and recrystallisation, were morphological changes observed at the apical portion of the root after intra-canal diode irradiation.[62] In general, near infra-red wavelengths, such as 1,064 and 980 nm, promote fusion and recrystallisation on the dentinal surface, sealing dentinal tubules.

The apparent consensus is that diode laser irradiation has a potential antibacterial effect. In most cases, the effect is directly related to the amount of energy delivered. In a comparative study by Gutknecht et al.,[63] an 810 nm diode was able to reduce bacterial contamination by up to 88.38 % with a distal output of 0.6 W in continuous wave mode. A 980 nm diode laser has an efficient antibacterial effect of an average of between 77 to 97 % in root canals contaminated with *E. faecalis*. Energy outputs of 1.7, 2.3 and 2.8 W were tested. Efficiency was directly related to the amount of energy and dentine thickness.[64]

Fig. 9_Intra-canal laser irradiation, molar.

Fig. 9

Er:YAG laser

Er:YAG lasers are solid-state lasers with a lasing medium of erbium-doped yttrium aluminium garnet ($Er:Y_3Al_5O_{12}$). Er:YAG lasers typically emit light with a wavelength of 2,940 nm, which is infra-red light. Unlike Nd:YAG lasers, the output of an Er:YAG laser is strongly absorbed by water because of atomic resonances. The Er:YAG wavelength is well absorbed by hard dental tissue. This laser was approved for dental procedures in 1997. Smear layer removal, canal preparation and apicoectomy are indications for endodontic use (Fig. 7).

The morphology of a dentinal surface irradiated with an Er:YAG laser is characterised by clean areas showing open dentinal tubules, free of a smear layer, in a globular surface. Bacterial reduction using the Er:YAG was observed by Moritz et al.[65]

Stabholz et al.[37] describe a new endodontic tip that can be used with an Er:YAG laser system. The tip allows lateral emission of the radiation rather than direct emission through a single opening at the far end. It emits through a spiral tip located along the length of the tip. In examining the efficacy of the spiral tip in removing the smear layer, Stabholz et al.[66] found clean intra-canal dentinal walls free of a smear layer and debris under SEM evaluation.

Photoactivated disinfection

PAD is another method of disinfection in endodontics and is based on the principle that photoactivated substances, which are activated by light of a particular wavelength, bind to target cells. Free radicals are formed, producing a toxic effect to bacteria.

Toluidine blue and methylene blue are examples of photoactivated substances. Toluidine blue is able to kill most oral bacteria. In *in vitro* studies, PAD has an effective action against photosensitive bacteria such as *E. faecalis*, *Fusobacterium nucleatum*, *P. intermedia*, *Peptostreptococcus micros* and *Actinomycetemcomitans*.[67,68] On the other hand, Souza et al.,[69] evaluating PAD antibacterial effects as a supplement to instrumentation/irrigation of canals infected with *E. faecalis*, did not prove a significant effect regarding intra-canal disinfection. Further adjustments to the PAD protocols and comparative research models may be required before recommendations can be made regarding clinical usage.

_Discussion and conclusion

There are good reasons to focus the treatment of non-vital contaminated teeth on the destruction of bacteria in the root canal. The possibility of a favourable treatment outcome is significantly higher if the canal is free from bacteria when it is obturated. If, on the other hand, bacteria persist at the time of root filling, there is a higher risk of treatment failure. Therefore, the prime objective of treatment is to achieve complete elimination of all bacteria from the root-canal system.[2,31]

Today, the potential antibacterial effect of laser irradiation associated with the bio-stimulation action and accelerated healing process is well known. Research has supported the improvement of endodontic protocol. Laser therapy in endodontic treatment offers benefits to conventional treatment, such as minimal apical leakage, effective action against resistant micro-organisms and external apical biofilm, and an increase in periapical tissue repair. For this reason, laser procedures have been incorporated into conventional therapeutic concepts to improve endodontic therapy (Figs. 8a–d).

Clinical studies have proven the benefits of an endodontic laser protocol in apical periodontitis treatment. For endodontic treatment, the protocol entails standard treatment strategies for cleaning and shaping the root canal to a minimum of #35, irrigating solutions with antibacterial properties and intra-canal laser irradiation using controlled energy parameters. Ideal sealing of the root canal and adequate coronal restoration are needed for an optimal result.

In practice, little additional time is required for laser treatment. Irradiation is simple when flexible optical fibres of 200 µm in diameter are used. The fibre can easily reach the apical third of the root canal, even in curved molars (Fig. 9). The released laser energy has an effect in dentine layers and beyond the apex in the periapical region. The laser's effect extends to inaccessible areas, such as external biofilm at the root apex.

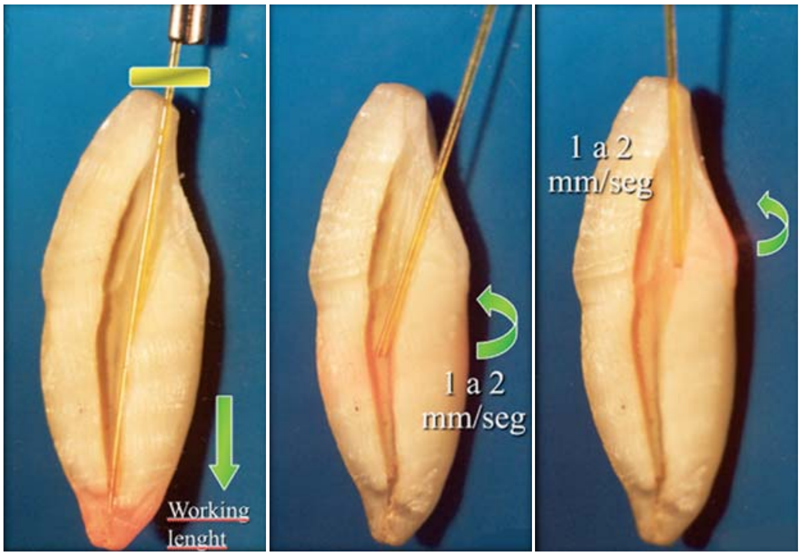


Fig. 10

Fig. 10_Intra-canal laser irradiation, technique.

The irradiation technique must adhere to the following basic principles. A humid root canal is required and rotary movements from the coronal portion to the apex should be carried out, as well as scanning the root canal walls in contact mode (Figs. 10a–c). The power settings and irradiation mode depend on one's choice of a specific wavelength.

Nd:YAG, diodes of different wavelengths, Er:YAG, and low-power lasers can be used for different procedures with acceptable results. Laser technology in dentistry is a reality. The development of specific delivery systems and the evolution of lasers combined with a better understanding of laser–tissue interaction increase the opportunities and indications in the endodontic field._

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

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Dental professionals on front line in fight against diabetes

An interview with Dr Maria Emanuel Ryan, periodontist and Professor of Oral Biology and Pathology at Stony Brook University, USA

_An as-yet unceasing increase in the number of people with diabetes or prediabetes in the USA and across the globe makes it not so much a question of if, but when more dental professionals will need to become highly skilled in treating such patients. There are 26 million people with diabetes in the USA, and 95 per cent of them have a form of periodontal disease, compared with 50 per cent of the general population.

Of those 26 million, more than 7 million are unaware of their diabetes.

Just as significant, 79 million people are estimated to have prediabetes, with as many as half unaware of it. A growing body of research suggests that the association between oral health and diabetes is bidirectional, placing dental professionals in the position of not just being able to help patients with diabetes control the illness, but also perhaps being able to help those with prediabetes avoid full onset.

In recognition of this link between oral health and diabetes, Colgate Total is donating US$100,000 and joining forces with the American Diabetes Association's campaign to *Stop Diabetes* by encouraging people to learn more about oral health care and *Raise Their Hand to Stop Diabetes.*

Central to the campaign's focus is educating people on the importance of dental visits, as well as helping dental professionals, who are seeing growing numbers of patients with diabetes. Colgate's involvement also stems from its interest in promoting the use of antibacterial toothpastes such as Colgate Total to support gum health.

Also helping with the effort is Dr Maria Emanuel Ryan, a periodontist and Professor of Oral Biology and Pathology at Stony Brook University, New York. Ryan, a globally known expert on the link between oral health and diabetes, recently spoke with roots.

_roots: *What size patient base are we talking about in terms of the need for achieving greater awareness?*

Dr Maria Emanuel Ryan: Some of the talks I have given have been at the Centers for Disease Control and Prevention (CDC). They have an interest in this

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area because to them diabetes is an epidemic. Each year, we have 1.9 million new cases diagnosed in people 20 years of age and older. If the population of people with diabetes keeps growing at this rate, in the very near future it will be about one in three, which is a very significant number.

_What can dental professionals do to help identify patients who have diabetes or prediabetes but have not been diagnosed?

Certainly we can screen for diabetes. And this is being recommended by the CDC. One way is by risk assessment: knowing a patient's family history, looking at obesity as a risk factor, looking to determine whether the patient is in one of the populations in which risk factors may be higher (African-Americans, Pacific Islanders, Native Americans, Latinos and Hispanics), asking about gestational diabetes. Most patients with diabetes are type II patients, who tend to be older than 45 years of age. Risk factors such as hypertension and dyslipidaemia are also important to consider. Of course, there are the classic signs and symptoms: thirst, frequent urination, infections, numbness in extremities, leg cramps, vision problems. Unfortunately, with type II diabetes, there are many people who are unaware they have it. That's why the CDC is looking to oral health-care professionals for help. If a person has any of the risk factors, signs or symptoms, dental professionals can refer to the physician for additional screening, or obtain a random blood glucose level or even a fasting blood glucose level and then refer appropriate patients to the physician for diagnosis.

_What do dentists need to be aware of with their patients who have diabetes or prediabetes?

If patients are poorly controlled, then you may need to be very cautious in what procedures you might be doing because the patients' wound healing may be affected. You need to know whether they have any other long-term complications of diabetes. You need to work closely with the patients' physician and other health-care professionals. Many patients with diabetes, especially those who have a physician working very hard to tightly control their diabetes and whose blood glucose levels tend to run low, may have a higher risk for hypoglycaemic events. Ask patients whether that is common for them because the more hypoglycaemic events patients have had, the more likely they are to have more—and the more likely they are to develop hypoglycaemia unawareness. That's when they don't get any of the classic signs: getting dizzy, feeling like they are going to pass out or getting confused. Some patients don't get those signs and symptoms; they can just suddenly become unconscious or have seizures.

_What can the dental professional do to confirm whether patients with diabetes have well-controlled blood sugar prior to treatment?

You can actively take the blood glucose level by doing either a random screening for blood glucose or even a fasting for blood glucose. If the level is greater than 126, the patient can be referred to a physician for further treatment. Another way to screen is the haemoglobin A1C test, a long-term marker of control that lets you know how well controlled someone with diabetes has been over the past two to three months. It used to be that only a centralised laboratory could do this, but now there are point-of-care tests. The only way you can help predict a hypoglycaemic event in your patient is to check blood glucose levels. Patients on insulin are at the highest risk of having a hypoglycaemic event at the time of peak activity of the insulin that has been administered, which is not when you want to be treating them. You also need to know what oral medications they may be taking because some may have a higher risk than others of causing hypoglycaemia.

_Research indicates that serious periodontal disease may affect blood glucose control and contribute to the progression of diabetes. Why is this?

In fact, the impact of periodontal disease may even be evident before someone develops diabetes. Recent research suggests that patients who have untreated periodontal disease, when followed for over 20 years, may be twice as likely to develop diabetes. Periodontitis is driven by infection and inflammation; and infection and inflammation can drive insulin resistance. Insulin resistance can lead to the development of diabetes and prevent good control of diabetes. By reducing infection and inflammation, you may actually prevent development of diabetes, and certainly you can make it easier to control diabetes. Some recent papers have suggested that if you don't treat the periodontal disease, not only is it more difficult to control diabetes, but people with diabetes are then also at higher risk for long-term complications such as cardiovascular disease and kidney disease, thereby increasing the risk for mortality.

_Are people with diabetes and prediabetes at risk for other dental problems?

If patients are not well controlled, they also tend to get more cavities or caries. They have a higher risk of developing oral yeast infections such as candidiasis. They may have enlarged parotid glands, which can lead to dry mouth. And because of the yeast infections in a dry mouth, they could report burning mouth or dry tongue. Dry mouth due to salivary gland dysfunction will drive periodontal disease and caries formation. Poorly controlled patients are also at greater risk for abscess formation. Gingival crevicular fluid is a serum transudate, so if your blood sugar levels are high, you have more glucose coming out of those pockets around the teeth. Your mouth has more glucose in it, so your teeth are bathing in glucose, increasing the risk for developing cavities. Working to improve home care with patients is of great help because such patients need to keep levels of bacteria as low as possible in the mouth. They can use antibacterial toothpaste or rinses. One of the toothpastes that's very effective at reducing the levels of bacteria for 12 hours is Colgate Total. I recommend that to many of my patients with diabetes. And, of course, we need to provide adequate care in the office. The treatment of infection and inflammation, providing periodontal therapy whether it's surgical or non-surgical, absolutely needs to be provided and should never be considered an optional or elective procedure.

_Are insurance organisations responding to the growing evidence of the connection between oral health and diabetes?

Some dental insurance companies are reimbursing dentists for screening, not only for diabetes but also for hypertension by checking blood pressure and for obesity by determining body mass index. Some dental insurance companies have begun to create expanded plans that begin to better address the oral health-care needs of patients with diabetes. This may help with access. Some patients—especially those without dental insurance—complain that if they go to the podiatrist, it's covered by their medical insurance, but if they're going to the dentist, it isn't covered by medical in most cases. This may be changing.

_Are there dental professionals specialising in the treatment of people with diabetes? If so, how does one develop such a specialty?

When your comfort level goes up, you will see more and more of these patients (by referral). Patients say, "You know, Dr Ryan asks me questions that other dentists never asked me about my diabetes. And she seems to base her treatment plan around the answer to those questions." If you're comfortable talking to physicians about this, you begin to get more referrals from physicians who are treating and educating these patients. I often speak on panels with other health-care providers at local meetings organised by the American Diabetes Association, initiators of the *Stop Diabetes* campaign. And because the folks from Colgate recognised the importance of oral health in this, they have supported this campaign, which I think is very important. When I speak as part of a diabetes-education health-care team, patients are already aware of what the podiatrist has to say, of what the ophthalmologist may be saying about their eyes and the cardiologist about cardiovascular disease. But when I start talking about the dental considerations, so many of them say to me, "I have never heard this before. No one's ever discussed this with me." It's important for all of us in the profession to share this knowledge not only with our patients but also with each other.

_Are there established, approved protocols for dental professionals to follow when treating patients who have diabetes or prediabetes?

No, but maybe we will be going in that direction. There has been a substantial effort by the American Dental Association to improve on continuing education in this area. There are efforts throughout the profession to improve on the transfer of knowledge from the published research to the practising clinician. In the future, there may be programmes through which people may become certified to manage higher-risk patients, such as those with diabetes or cardiovascular disease. There has been great interest by all members of the profession. Not just dentists, but hygienists and dental assistants are interested in how to better manage these patients. You're beginning to see practices develop protocols that are tailored to the provision of care to people with diabetes._

Editorial note: This interview was prepared by Robert Selleck, Dental Tribune America.

_about the interviewee roots

Dr Maria Emanuel Ryan is a tenured full professor in the Department of Oral Biology and Pathology at Stony Brook University's School of Dental Medicine and a member of the medical staff at University Hospital at the Stony Brook University Medical Center. She has published more than 75 scholarly works and speaks frequently on emerging therapies, connections between oral and systemic health and the need for early detection of periodontal disease and oral cancer.

Ability of four irrigating solutions to remove debris after root-canal instrumentation

Authors_ Dr Jorge Paredes-Vieyra, Dr Francisco Javier Jiménez Enríquez & Dr Carlos Cuevas Lasso, USA & Mexico

_The cleaning and shaping of the root-canal system are considered key requirements for a successful root-canal treatment (RCT). However, limitations in the overall quality of preparations obtained by manual and automated root-canal instrumentation have been reported by numerous researchers.[1,2] Many studies have concluded that neither hand instrumentation nor rotary preparation sufficiently clean the root canal, especially the apical region of curved canals.

Group (*n*=20)	Irrigating solutions during root-canal preparation
A	17 % EDTA (Roth International)
B	2.5 % NaOCl
C	2.5 % MTAD (BioPure MTAD, DENTSPLY Tulsa)
D	2 % chlorhexidine

Table I_Solutions used during root-canal preparation.

Cleaning and shaping can be easily accomplished in straight canals. However, many canals have moderate, severe or abrupt curvatures that make them susceptible to procedural accidents, such all as ledges, zips, perforations and apical blockages.[3–5]

The removal of pulp tissue, debris, the smear layer and bacteria from the root-canal space prior to obturation is one of the primary aims of RCT. The degree of difficulty experienced during the cleaning and shaping procedure is affected by the canal curvature, access to the canal space, canal length and canal diameter.[6,7] There can be no doubt that micro-organisms that either remain in the root-canal space after treatment or recolonise the filled canal system are the main cause of endodontic failure.[8]

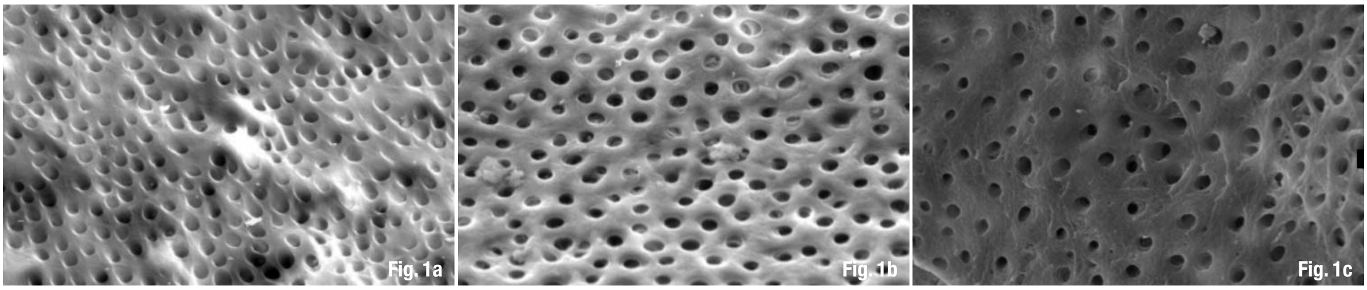
While irrigants, such as sodium hypochlorite (NaOCl), are helpful in dissolving organic debris,[9] thorough instrumentation is a necessity. The efficiency of cleaning the endodontic space depends on both instrumentation and irrigation. Irrigation plays a main role in successful debridement and disinfection. The most widely used irrigant for RCT is NaOCl at concentrations of 0.5 to 5.25 %. The tissue-dissolving capacity and microbicidal activity of NaOCl make it an excellent irrigating solution.[9]

Of all the currently used substances, NaOCl appears to be the most ideal, as it fulfils more of the requirements for endodontic irrigant than any other known compound. Hypochlorite has the unique capacity to dissolve necrotic tissue[10] and the organic components of the smear layer. Inactivation of endotoxins by hypochlorite has been reported;[11,12] the effect, however, is minor compared with that of a calcium hydroxide dressing.[13]

Acid solutions have been recommended for removing the smear layer, including: EDTA, most active at a concentration of 15 to 17 %, and a pH of 7 to 8;[10] citric acid solutions, used at concentrations of 10, 25 and 50 %.[14,15] In addition, calcification hindering mechanical preparation is frequently encountered in the canal system.

Demineralising agents such as EDTA show high efficiency in removing the smear layer.[16,17] In addition to their cleaning ability, chelators may detach biofilms adhering to root-canal walls. This may explain why an EDTA irrigant has proven to be highly superior to saline in reducing intra-canal microbiota,[18] despite the fact that its antiseptic capacity is relatively limited.[19] Antiseptics such as quaternary ammonium compounds (EDTAC)[20] or tetracycline antibiotics (MTAD)[21] have been added to EDTA and citric acid irrigants, respectively, to increase their antimicrobial capacity. The clinical value of this, however, is questionable.

EDTAC shows similar efficacy to EDTA regarding smear layer removal, but it is more caustic.[21] As for MTAD, resistance to tetracycline is not uncommon in bacteria isolated from root canals.[21] Generally speaking, the use of antibiotics instead of biocides such as hypochlorite or chlorhexidine appears unwarranted, as the former were developed for systemic use rather than local wound debridement, and have a far narrower spectrum than the latter.[22]



Figs. 1a–l_Typical SEM photomicrographs showing the cervical, middle and apical thirds of the root-canal dentine surface for 17 % EDTA (a–c), MTAD (d–f), 2.5 % NaOCl (g–i) and 2 % chlorhexidine (j–l; 1,000–5,000x).

MTAD was used to remove the smear layer[21] on coronal leakage of obturated root canals using a dye leakage test.[23]

Chlorhexidine is a strong base and is most stable in the form of its salts. The original salts were chlorhexidine acetate and hydrochloride, both of which are relatively poorly soluble in water.[24] Hence, they were replaced by chlorhexidine digluconate. Chlorhexidine is a potent antiseptic widely used for chemical plaque control in the oral cavity.[25,26] Aqueous solutions of 0.1 to 0.2 % are recommended for such purpose, and 2 % is the concentration of root-canal irrigating solutions usually found in the endodontic literature.[27]

The purpose of the present study was to evaluate the ability of 17 % EDTA, 2.5 % NaOCl, MTAD and 2 % chlorhexidine to remove debris when used as a final irrigant during root-canal instrumentation.

_Material and methods

Tooth selection

Eighty freshly extracted human maxillary central incisors with a single straight root canal extracted from 35- to 60-year-old patients with periodontal disease were randomly selected and radiographed buccolingually and mesiodistally.

The teeth were devoid of caries and cracks, and had not undergone endodontic treatment or restoration. Only teeth with intact and mature root apices were selected. Teeth were placed in individual containers with 2 % formalin and stored in a refrigerator at 10 °C. The average root length was 12 mm. At the time of use, the teeth were removed from formalin and washed in tap water for 30 minutes (Table I).

Root-canal preparation

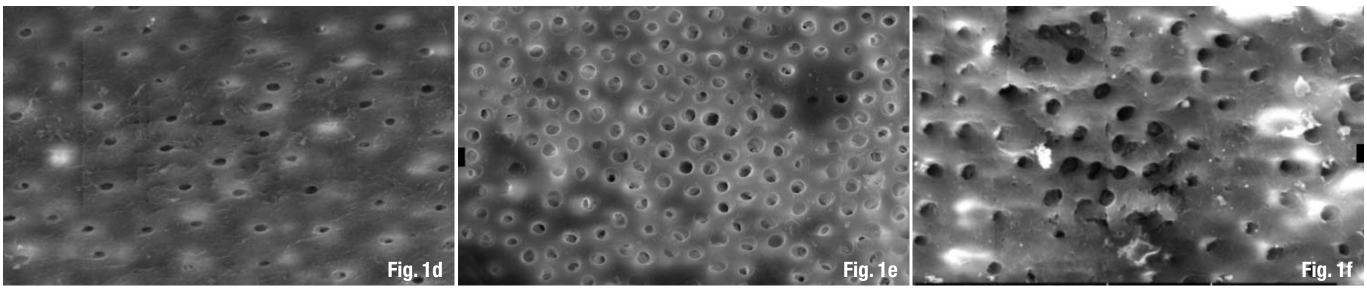
The teeth were de-coronated to a standard root length of 12 mm and randomly divided into four groups ($n = 20$). The working lengths were measured by deducting 1 mm from lengths recorded when the tips of #10 or #15 K-files (DENTSPLY Maillefer) were visible at the apical foramen and confirmed radiographically.

All root canals were then explored and prepared by rotary instrumentation with a size 25 LightSpeed LSX instrument (Discus Dental), in establishing the working length. All working lengths were confirmed radiographically.

Rotary instrumentation was performed with size 25 to 80 LightSpeed LSX instruments in the apical third. They were used at a constant speed of 2,000 rpm using an in-and-out movement. LightSpeed LSX instruments were changed every six canals and the instrumentation was performed according to the manufacturer's instructions. All canals were irrigated with 2 cc of distilled water. Gates Glidden drills (Mani) #1 to #3 were used on the body of the root-canal walls (cervical and middle thirds) before apical preparation.

Irrigation

After cleaning and shaping, all root canals were finally flushed with 30-gauge nickel-titanium needles (Stropko NiTi Flexi-Tip, SybronEndo), which penetrated to within 1 to 2 mm of the working length. The canal was irrigated with 2 ml of the respective irrigating solution: 17 % EDTA (Roth International), 2.5 % NaOCl, MTAD (BioPure MTAD, DENTSPLY Tulsa) or 2.0 % chlorhexidine. The same method was used for all of the 20 teeth in each group, only changing the



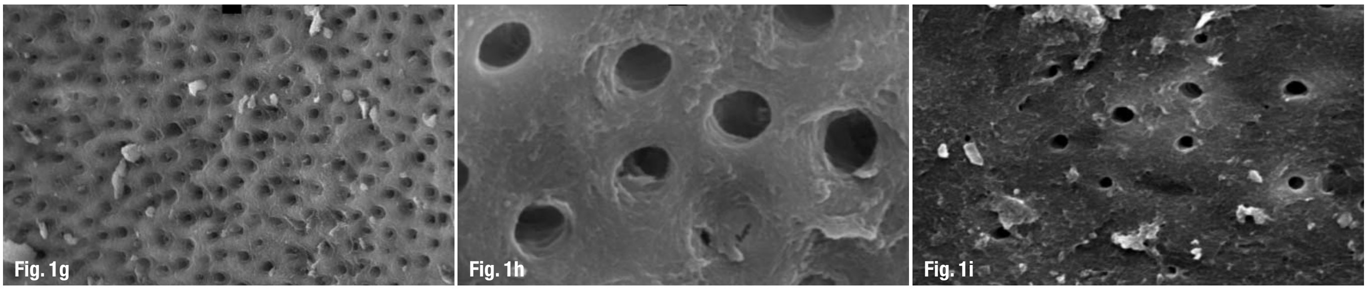


Fig. 1g Fig. 1h Fig. 1i

irrigating solutions tested. After cleaning and shaping, the canals were dried with absorbent paper points (DENTSPLY Maillefer).

SEM examination

To prepare the samples for imaging, all teeth were separated longitudinally and evaluated from the cervical, middle and apical third. Roots were split longitudinally along the buccolingual plane. To facilitate fracture into two halves, all roots were grooved longitudinally on the external surfaces with a diamond disk, avoiding penetration of root canals.

The roots were then split into two halves with a chisel. For each root, the half containing the most visible part of the apex was conserved and coded. The coded specimens were placed on metal stubs with composite, desiccated, sputter coated with gold, and viewed with a SEM (LEO 1430 VP, Carl Zeiss NTS).

The cleanliness of each canal wall was evaluated in each of the thirds and photographed at 1,500 magnification at the same height as the groove that defined each third. The scoring procedure, which did not identify the specimens' groups, was carried out by the authors using the following score system:[4]

Score 1: Clean canal wall; only very few debris particles;
Score 2: Few small conglomerations;
Score 3: Many conglomerations; < 50 % of canal wall covered;
Score 4: > 50 % of canal wall covered;
Score 5: Complete or nearly complete covering of canal wall by debris.

Table II_Results of the debris removal between irrigating solutions (x ± s; x: arithmetical mean, s: standard deviation).

Group/Irrigating solution	apical third	middle third	cervical third
EDTA (*n* = 20)	1.22 ± 0.35 0.545	1.15 ± 033 0.066	1.08 ± 0.10 0.031
NaOCl (*n* = 20)	1.94 ± 0.45 <0.001	1.76 ± 0.43 0.004	1.76 ± 0.43 <0.001
MTAD (*n* = 20)	1.54 ± 0.35 0.545	1.55 ± 0.39 0.076	1.69 ± 0.30 0.708
chlorhexidine (*n* = 20)	2.10 ± 0.80 0.064	2.15 ± 0.96 0.330	2.10 ± 0.94 0.082

_Results

The results showed that the increase in the percentage of debris always occurs in the same direction, that is, from the middle region to the apical, no matter which solution is utilised. Table II displays the debris findings and the comparisons among irrigating solutions. Group A (EDTA) demonstrated significant differences to the other groups. EDTA was more effective in debris removal than the rest of the irrigating solutions (Table II).

Statistical analysis

The experimental data used in this study consisted of the four groups and was tested with a Q-Cochran test.[28] The Q-Cochran test showed statistical significance between the four groups. The Kolmogorov–Smirnov test was used for checking the normality of the data distribution. As the data for each group did not follow a normal distribution, the variables were analysed using a non-parametric test. The level of statistical significance was set at $p<0.05$.

To determine which of the means of the irrigating solutions was significantly different from the others, the complementary Tukey test was used. The Tukey test showed a statistical difference between the means of 2 % chlorhexidine and EDTA. With the Tukey test, we found the means of EDTA and BioPure MTAD to be statistically equal.

Debris was removed mostly at the cervical and middle thirds, but remained visible in the apical third in all cases. The apical third of the root canals showed more debris than the middle third, and none of the irrigating solutions left the root-canal walls entirely free of debris (Fig. 1).

_Discussion

The main purpose of this investigation was to evaluate the ability of 17 % EDTA, 2.5 % NaOCl, MTAD and 2 % chlorhexidine to remove debris when used during root-canal instrumentation. Because debridement in the apical third has always been a challenge, the root canal was analysed and scored by thirds.

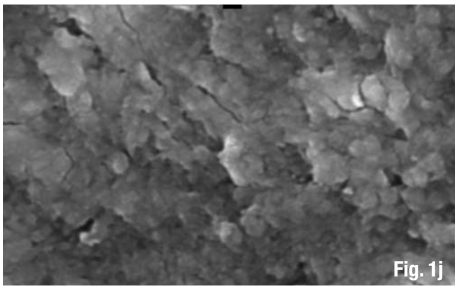


Fig. 1j

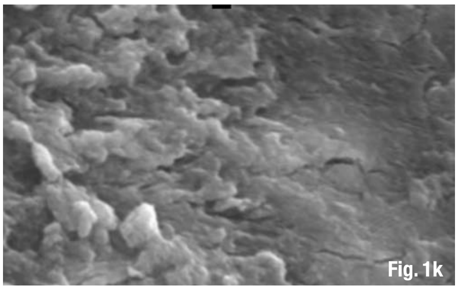


Fig. 1k

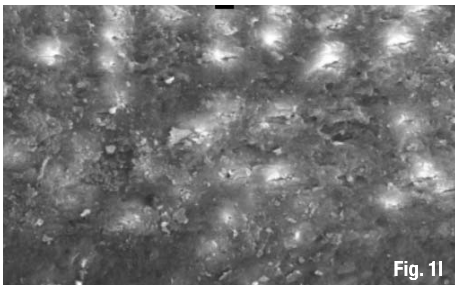


Fig. 1l

The combination of chemical and mechanical preparation forms the key requisite for the success of root-canal instrumentation. The objective of these two interdependent factors consists of the cleaning of the canal and its eventual ramifications removing the largest possible amount of debris in order to establish ideal conditions, which allow a functional recuperation of the dental organ and a regeneration of tissues.

An NaOCl solution remains the most widely recommended irrigant in endodontics on the basis of its unique capacity to disinfect and dissolve necrotic tissue remnants and its excellent antimicrobial potency.[4] However, in this study, NaOCl did not remove the smear layer from the apical third of the canals, which is consistent with the results previously reported by other authors.[29] Numerous studies have compared the performance of irrigating solutions in RCT, including different concentrations of NaOCl, citric acid and EDTA.[30]

EDTA and the different salts from which they are formulated are effective chelating agents for smear layer removal. Numerous authors have reported that alternate applications of NaOCl and EDTA eliminated both organic and inorganic components.[16,19,20]

No significant differences were found by Hülsmann et al.[6,7] in either debris or smear layer removal when they used 3 % NaOCl as initial and final irrigation and 17 % EDTA in the form of a paste after each file and using two rotary instrumentation techniques.

The results obtained in the present study demonstrate that the EDTA and BioPure MTAD solutions were the solutions that left the smallest amount of residue in the interior of the canals, followed by NaOCl and finally chlorhexidine, which left the greatest amount of debris. With the rotary instrumentation technique, the results for EDTA and the rest of the irrigants were similar, as had been found in previous reports,[9] and both solutions (EDTA and MTAD) are recommended.

The finding that the EDTA solution was the best root-canal cleaner confirms the findings of Tanomaru et al.[13] This may be due to the potentiation of the solvent action when energised by temperature.[14] Irrigating solutions used in endodontic treatment not only have an antimicrobial action but also clean the pulp chamber.[11] None of the irrigating solutions studied in the present work was capable of eliminating all of the debris in the root-canal walls, since none of them left the root canals completely free of debris.

In the present study, no significant differences in the presence of debris were observed among root-canal thirds in the manually and rotary instrumented groups irrigated with NaOCl. Similar results were found by Tucker,[31] who compared rotary instrumentation with the hand technique using 1 % NaOCl as irrigating solution.

The removal of debris and the smear layer depends on the irrigation method, as well as on the endodontic instrument, the manner in which the instrument is used, and the preparation technique. The root-canal cleaning capacity of manual versus rotary instrumentation techniques with NaOCl is somewhat controversial.[4]

_Conclusion

1. The apical third showed a greater amount of debris than the middle third, regardless of the solution used.
2. None of the solutions used for irrigation of the root canals allowed complete removal of the debris from the interior of the canal.
3. The 17 % EDTA and BioPure MTAD irrigating solutions left the root canals with less debris than the 2.5 % NaOCl and 2 % chlorhexidine solutions.

_Acknowledgement

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

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The lazy man's guide to persistent apical periodontitis

Author_ Dr Patrick Caldwell, Australia

_Persistent apical periodontitis (AP) refers to AP that is associated with a tooth that has had root-canal therapy (RCT). As with primary AP, bacteria are the most common cause of the inflammatory response.[1] Previously, a large body of evidence indicated that persistent infections are commonly composed of a single species; however, recent evidence points to the presence of a mixed biofilm.[2,3] There are also non-microbial causes of AP, including foreign-body reactions, cystic formation, endogenous cholesterol crystals and scar formation. These will be discussed later.

The microbes that cause persistent AP are more commonly located intra-radicularly (inside the root).

Occasionally, these microbes will also be located extra-radicularly. We will discuss the far more common intra-radicular microbes first.

_Intra-radicular microbes

The key study referenced on the presence of microbes within the root in cases of persistent AP is Nair et al.[4] When considering the cause of the persistent infection, consider that the microbes were either present prior to RCT being initiated (primary infection) or they entered during or after treatment (secondary infection).[5] In considering those microbes that have survived from the primary infection, consider how they might have achieved this. They may have been resistant to the chemicals used in the disinfection process (*Enterococcus faecalis*, for example, has some mechanisms to survive calcium hydroxide), or they may have been located in a portion of the canal that was not instrumented nor cleaned via chemical means.

Regarding secondary infection, these microbes may have gained access to the canal during treatment or after treatment. Consider too that they may have been carried into the canal on a contaminated instrument or perhaps a leaking rubber dam may have allowed saliva to contaminate the root canal. Alternatively, a poorly placed temporary restoration may have allowed leakage into the root-canal system in-between visits. If caries has not been completely removed, or a previous restoration subject to micro-leakage is left in place, then this can also be a source of secondary infection. Alternatively, these microbes may have entered a previously clean root-canal system after the completion of RCT. This could be due to a leaking restoration, or through caries or a crack in the tooth. It is important to understand the microbial nature of AP, and to have this foremost in our minds when undertaking treatment.

_Which microbes are present in persistent AP caused by secondary infection?

When we examine the composition of the infection in AP, we find a significantly different microflora than that found in primary infections.[6,7] Generally in persistent AP, there are only one to five species. These are predominantly Gram-positive and there is an equal amount of obligate and facultative anaerobes.[1,6,8] Owing to the fact that obligate anaerobes are easier to kill, it may be that facultative anaerobes are more likely to persist within the root-canal system after treatment.

_*E. faecalis* and *Candida albicans*

E. faecalis is an opportunist pathogen implicated in many general surgery post-operative infections. It has been identified as an opportunistic pathogen in persistent AP in a number of studies.[1,7,9] This particular microbe has been studied extensively. It possesses a proton pump on its cell membrane, which allows it to regulate its internal pH. This means that it is resistant to calcium hydroxide and this may be one of the ways that it survives and becomes implicated in persistent infections. It is also able to survive by itself and without nutrition for long periods. It is rarely found in untreated canals. *C. albicans* (a fungus) is also found more commonly in persistent infections than in primary infections.[1,4,10]

_Extra-radicular infections

Occasionally, we may find a situation where microbes establish themselves outside the root-canal system. The microbes may establish themselves on the external root surface in a biofilm, in association with infected dentine chips that have been displaced into the periapical region, or within a periapical cyst.[11,12] These microbes must be able to withstand the body's attempts to kill them and it is likely that biofilm formation allows this.[13] Similarly in the periapical cyst situation, it is the cyst itself that protects the microbe from the immune response.

In particular, two microbes have been implicated in extra-radicular infections. These are *Actinomyces* species and *Propionibacterium propionicus*.[14] These microbes are able to form cohesive colonies within an extra-cellular matrix. This helps them to avoid phagocytosis and so continue to survive and invoke the immune response.

_Non-microbial causes of AP: Cysts, foreign-body reactions and cholesterol crystals

In some cases, AP may not be maintained by micro-organisms. I say "maintained", because often the AP is initially caused by microbes, and after endodontic treatment, one of the following factors takes over, maintaining the immune response and thus AP.

Periapical cysts are an interesting topic. There are a range of studies that attempt to measure the incidence of periapical cysts in examined periapical lesions. In simple terms, the lesion is biopsied and then examined under a microscope. If an epithelium-lined sack is found, then the lesion is designated a cyst. But ... in 1980, Simon published a paper, which included serial sectioning of periapical lesions.[15] What he found was that some lesions that appeared as cysts on one section, appeared differently on other sections. Thus, it was deemed that the majority of studies (which did not use serial sectioning) relating to the prevalence of cysts were subject to error. If one just takes a random slice, the effect in two dimensions may be that of a cyst, when in reality the full 3-D structure of the cyst does not exist. Nair repeated this study 16 years later and confirmed Simon's findings.[16]

Nair studied far more lesions than Simon, and found that 15% could be classified as cysts (including both true and pocket varieties). This is probably the best figure to quote. Other studies report figures from 5 to 55%, but they failed to use serial sections. It is also important to realise that a large proportion of abscesses and granulomas will also contain epithelium. In Nair's study, 52% of the lesions were epithelialised, but only 15% were cysts. It is likely that the inflammatory process results in the proliferation of this epithelium and, over time, the epithelium develops into a cyst.

Through both of these studies, Simon and Nair found two distinct types of cysts. Simon called them true cysts—those with a complete epithelial lining, and bay cysts—those whose lining is attached to the root surface and the contents of the root canal are contiguous with the contents of the cyst. Nair referred to these as true cysts and pocket cysts (equivalent to Simon's bay cyst).

Nair contends that these two types of cysts are quite different.[12] He feels that the true cyst is self-sustaining and will remain independent of efforts to remove the micro-organisms from the root-canal system. The pocket cyst, on the other hand, is sustained by the microbes within the canal system. Removal of the microbes, which are maintaining the inflammatory response, may allow the pocket cyst to heal. In reality, it will be very difficult to prove or disprove this theory, but one could say that it makes sense.

Foreign-body reactions

When exogenous materials are located in the periapical region, they can induce and maintain an inflammatory response, which may be asymptomatic, but will be seen as a radiolucency. Materials may be gutta-percha, amalgam, sealants, calcium hydroxide or cellulose fibres, such as those contained in paper points.[17]

In practice, these lesions are rarely seen but have been reported in the literature, so it is important to understand that this mechanism for the maintenance of AP does exist. It also reminds us to be careful when using paper points and not to extend them into the periapical areas, as human cells cannot degrade cellulose and leaving fibres behind may result in a foreign-body reaction.

Gutta-percha may also induce a foreign-body reaction, especially in fine particles.[18] Overextended gutta-percha may, as a result, cause delayed healing of periapical tissue.

Cholesterol crystals

Cholesterol crystals are also seen in AP, and are probably released by disintegrating erythrocytes, lymphocytes, macrophages and plasma cells, as well as from circulating plasma lipids.[19] These collections of cholesterol are referred to as cholesterol clefts and induce a reaction similar to a foreign-body reaction as the macrophages and giant cells are unable to remove the cholesterol. Again, this may result in a non-healing lesion, despite well-completed endodontic treatment.

_*The Endospot* easy study guide to persistent AP

A Persistent AP is most commonly caused by microbes remaining within the root-canal system.[1]

B It appears that a mixed biofilm may be responsible, contrary to the previous belief that usually only one microbe was responsible.[3]

C The microbes are either:[5]
  a) primary—remained within the canal from the initial infection; or
  b) secondary—entered during or after treatment.

D Persistent AP shows significantly different flora to primary AP:[7]
  a) one to five species per canal;
  b) predominantly G+;
  c) equal number of obligate and facultative anaerobes.

E *E. faecalis*—opportunist pathogen that has been identified more commonly in persistent AP:[1]
  a) possesses a proton pump, which allows it to survive in high pH (that is it can survive calcium hydroxide);
  b) can survive in mono-infection;
  c) can survive long periods of low/no nutrition.

F *C. albicans* also found more commonly in persistent infections than in primary.[10]

G Extra-radicular infections can occur in biofilm on the root tip,[13] or in the periapical area itself:[14]
  a) *P. propionicus* and *Actinomyces* species are able to form adhesive colonies in an extra-cellular matrix in the periapical tissue.

H Non-microbial causes of AP are:
  a) periapical cysts (15 % of lesions)[16]— serial sectioning indicates two types: true cysts and pocket cysts;
  b) foreign-body reactions; and
  c) cholesterol clefts._

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

_about the author roots

Dr Patrick Caldwell is a registered specialist in Endodontics. He graduated in dentistry with honours from the University of Queensland in 1998 and then went on to work for the Royal Australian Navy, both ashore and at sea. During this time, he undertook advanced training in restorative dentistry and in 2002 sat examinations and was elected a Fellow of the Royal Australasian College of Dental Surgeons. In 2003, Dr Caldwell began a three-year, full-time training programme in root-canal therapy, and graduated with a Master of Dental Science in Endodontics at the end of 2005. He returned to work with the Royal Australian Navy and was also engaged as a visiting specialist at the Sydney Dental Hospital. In 2009, he moved to Shanghai, China, where he was the only endodontist in a city of 21 million people. In late 2010, he returned home to Brisbane and started Brisbane Microsurgical Endodontics. He is involved in teaching at the University of Queensland and has conducted courses both nationally and internationally to help general dentists improve their root-canal skills. Dr Caldwell runs *The Endospot*, a blog at www.endospot.com, and can be contacted at reception@bmendodontics.com.au.

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New A-dec LED offers brilliant simplicity

_**Unveiled at the Chicago Dental Society's** 2012 Midwinter Meeting, the new A-dec LED dental operatory light is now available to doctors around the world. "Designed for optimal visual acuity and treatment-room ergonomics, the A-dec LED is an outstanding solution that outperforms all other industry options," says A-dec Product Manager Tom McCleskey. "By evolving LED technology, we've established a new benchmark for operatory lighting."

A-dec's advanced light-emitting diode (LED) technology has been optically engineered specifically for dentists and the dental operatory. The A-dec LED stands alone in the market because it reduces eyestrain significantly and provides optimal ergonomics, while ensuring ample illumination, clarity and depth during treatment. The new offering features multiple intensity levels, a cure-safe mode, low cost of ownership—in terms of cost, maintenance and downtime—and intuitive ergonomics.

Adjustable intensity levels of 15,000, 25,000 and 30,000 lux at 5,000 K are able to flood the oral cavity with a consistently neutral white light for true-to-life tones, which help practitioners diagnose clearly. The light's cure-safe mode emits a brilliant yellow light at 25,000 lux, enabling the dental team to work effectively without curing photoinitiated resins.

McCleskey also touts the solution's ability to reduce eye fatigue because the light's 'stadium effect' mitigates shadows and maintains a uniform light pattern. Plus, its unencumbered controls, unparalleled positionability and fluid movement combine to create outstanding ergonomics. The latest addition sets a premium standard for A-dec Dental Lights, a family of lighting solutions that also includes the A-dec 500 Halogen 3-Axis and A-dec 300 Halogen 2-Axis._

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G-Files—Rotary NiTi instruments for glide path enlargement

_**Regardless of the endodontic** instrumentation system used, initial exploration of the canal system has historically been accomplished by using stainless-steel, pre-curved hand instruments (files or reamers). Along with careful examination of radiographs and/or CBCT scans, this initial phase identifies possible difficulties and obstructions within the canal system that the clinician may encounter in preparation for use of rotary NiTi instruments, which will further shape the canal.

Initial penetration and glide path creation in the canal are usually accomplished by using a sequence of narrow-diameter instruments (sizes 06, 08, 10 and 15, with standard ISO .02 taper), such as MMC files (MICRO-MEGA). The clearing and enlargement of the passageway is critical for the safe introduction into the canal of rotary NiTi instruments that have larger diameters and cross-sections. Characteristic of almost all the instruments currently available, each instrument has a non-working (safety or rounded) tip that minimises canal distortion and reduces the possibility of the instrument ledging into the canal wall, which often precedes either a canal perforation or the separation of an instrument.

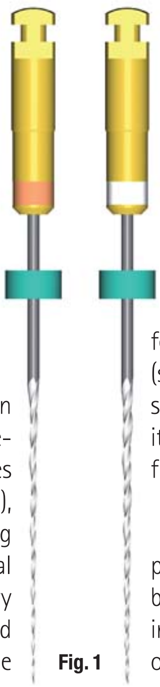
Fig. 1

In addition, hand instruments used at this stage initially enlarge the canal, facilitating the circulation of irrigating solutions, reducing the risk of impacting dentinal debris, which can lead to the loss of apical patency.

In the majority of endodontic procedures, initial glide path enlargement can be a delicate and time-consuming task. The innovative design of the G-File instruments simplifies this delicate step and increases safety in using canal preparation instruments.

_G-File instrument description

To increase endodontic efficiency in the initial glide path formation by simplifying the procedure, while increasing safety, MICRO-MEGA has introduced two new rotary NiTi instruments, the G-Files (Fig. 1).

The G-File NiTi instruments are machined with a narrow diameter (n°12 and n°17) and a slight .03 taper. The superior cross-section of the G-File combines efficiency and safety. Along the length of the instrument, the G-File has cutting edges on three different radiuses, creating a large and efficient area for upward debris removal.

The angular offset of the cutting edges also creates a different pitch along the length of the blade, avoiding any screwing or engaging effect into the walls of the canal. The non-working (safety) tip is asymmetrical, which helps the instrument move forward safely; this is also facilitated by the high degree of flexibility resulting from the small diameter (Fig. 2).

The G-Files are electropolished, which improves their mechanical properties, particularly by releasing internal stresses that develop during machining, thereby increasing the flexibility of the G-File. The electropolished surface increases the efficiency in apical progression of the G-File, while aiding in debris removal. The G-Files are available in 21, 25 and 29 mm.

_Operating protocol

Once access has been attained (direct access to the canal opening and removal of overhangs), initial instrumentation is performed with pre-curved, small diameter, stainless-steel instruments (MMC 08 and 10 files). The working length is determined with the MMC 10 file.

The canal is now ready for the G1 file. The recommended motor setting for the G-File is 400 rpm with a torque of 1.2 N.cm (ENDOAce). The G1 file is placed into the canal and will advance slowly, without apical pressure, until the working length has been reached. After irrigation, the G2 file is then placed into the canal and used in the same way as the G1 file. The MMC 10 file is then used again to check apical patency. (It may be advantageous to use the ENDOFLARE to allow easy direct access of the G-File to the entrance of the canal).

Root-canal treatment can now be completed with the clinician's endodontic instrumentation system of choice (Revo-S, HERO)._

Fig. 1_G-Files.
Fig. 2_SEM view of a G2 file.

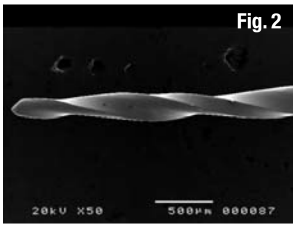
Fig. 2

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MICRO-MEGA
5–12, rue du Tunnel
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France

www.micro-mega.com


Fig. 1


Fig. 2


Fig. 3

The 20th annual SSE conference left nothing to be desired

Author_ Dr Philipp Kujumdshiev, Switzerland

Fig. 1_Prof. Pierre Machtou.
Fig. 2_Dr Gilberto Debelian.
Fig. 3_Prof Andrea Mombelli.

_**Dr Ramachandran Nair** had the honour of opening the conference. As one of the founding members, he touched on the history of the Swiss Society for Endodontology (SSE). A group of seven enthusiastic scientists and practitioners evolved into a well-organised society with over 300 members dedicated to the further development of the SSE. After his speech, Dr Nair was awarded with the society's Guldener Prize. This award honours the late Dr Peter H.A. Guldener, who had been the spokesperson of endodontics in Switzerland for the last 30 years. He was also an eminent endodontic practitioner, educator, motivating force, founding member and the first SSE President. The award is endowed with 5,000 Swiss francs and is presented annually at the SSE meetings, provided a worthy recipient is nominated. The award is for achievement of outstanding quality in the field of endodontic research or of significant contributions in endodontic education, clinical practice and/or to a professional organisation.

_Recommendations concerning endodontic controversies

In his speech, Dr Beat Suter focused on the current controversies in endodontics. According to Suter, the use of the dental dam, the features of an ideal root-canal preparation and the ideal root filling are undisputed. He referred to the literature for the most controversial points, but provided his own recommendations too:
_if possible, existing reconstructions should be retained for the time being;
_electronic determination of working length and use of patency technique;
_the diameter of the apical canal should be enlarged such that the irrigating solution can move freely;
_root canals should be prepared to the greatest possible apical taper;
_use of 2.5 % NaOCl as irrigating solution;
_overfilling should be avoided; however, it is better to overfill than to underfill;

_use of $Ca(OH)_2$ as filler;
_single-visit root-canal treatment (RCT) is permitted;
_orthograde treatment is preferred; resection if orthograde treatment is not successful.

_Apical lesions

In his lecture, Dr Paul Dummer pointed out that correct canal preparation is a prerequisite for the healing of apical lesions and that the antibacterial effect of $Ca(OH)_2$ in the canal is rather limited. However, the patient's individual immune response apparently also has an influence on the long-term result of RCT. Studies have demonstrated that dentists—that is, their lack of expertise, lack of practice, impatience, poor risk management and poor professional conduct—are the primary reason for persistent lesions.

_SSE Student Prize and mini-workshops well received

Prior to the lunch break, three students from the universities of Basel, Bern and Zurich each presented a case and the panel awarded Noemi Kaderli the SSE Student Prize. For the first time, visitors were also able to try out different instruments in mini-workshops offered by various companies during the lunch break.

_New NiTi file systems in focus

Prof Zvi Metzger introduced the self-adjusting file (SAF) system. The SAF file is hollow and designed as a thin cylindrical NiTi lattice that adapts to the cross-section of the root canal. The file is moved up and down in the canal with high frequency and continuous rinsing. In the process, an equal amount of dentine is removed at virtually all canal walls so that a truly 3-D canal preparation takes place. Owing to the completely different geometry of the system, Metzger spoke of a paradigm shift and showed impressive µCT images that confirmed the system's efficiency. However, the price for one such file (single use!) is over €40, in addition to the costs for the system.

Following this lecture, Prof Pierre Machtou introduced the WaveOne system from DENTSPLY Maillefer. With WaveOne, the canal system is mechanically prepared with a single NiTi file, which is available in various sizes. The system's highlight is the file's reciprocating motion—it constantly changes its rotational direction in the canal.

Dr Eric Bonnet talked about MICRO-MEGA's Revo-S system. With this system, the canal is prepared with three mechanically rotating files. The asymmet-

Fig. 4

Fig. 5

Fig. 4_Dr Ramachandran Nair was awarded with the SSE's Guldener Prize 2012.

Fig. 5_The SSE Executive Board (from left to right): Dr Denis Honegger, Dr Bernard Thilo, Dr Monika Marending Soltermann, Dr Birgit Lehnert, Dr Klaus Neuhaus, Prof Serge Bouillaguet, Dr Patrick Sequeira, Dr Reto Lauper and Dr Andreas Aebi.

ric cutting-edge geometry of the instrument is the system's secret. It ensures good cutting performance with less stress on the instrument and guarantees good removal of dentinal debris from the canal.

Finally, Dr Gilberto Debelian discussed the BioRaCe concept from Swiss manufacturer FKG. He demonstrated that bacterial penetration into the dentine is greater in the apical region than commonly assumed. That is the reason that a root canal should be prepared to at least ISO 35 or 40. He also explained the fracture characteristics (cyclic and torsional fatigue) of NiTi instruments comprehensibly. Microcracks always form during rotary root-canal preparation, but considerably less with BioRaCe. He also briefly touched on a system still under development for the preparation of non-rotationally symmetrical canals.

_The search for the best obturation techniques

Prof Roland Weiger had the task of evaluating the best root-canal filling method. In principle, obturation is an important cornerstone of RCT, but not the decisive factor. In fact, the success of RCT depends on the quantity of bacteria remaining in the canal. He compared the various methods—lateral condensation, cold gutta-percha with central pin, Thermafil (DENTSPLY), vertical condensation, apical partial pin and GuttaFlow (Coltène/Whaledent)—with each other and came to the conclusion that each system is useful for different cases. Adhesive obturation materials did not prove to be of value. However, a (adhesive) tight coronal seal is an essential component of RCT.

_Possibilities and limitations

The second day of the conference began with a review of the last 40 years of endodontics. Prof Gunnar Bergenholtz reviewed what worked and what did not. For instance, short (but not too short) root fillings do not necessarily result in failure. Iatrogenic infections of the canal are to be avoided at all times. It has been shown that apical lesions are better detected using digital volume tomography (DVT) than apical dental film; however, the known disadvantages—radiation dose, expensive equipment, over-interpretation, etc.—need to be taken into consideration. With regard to potential risks—obliterated canals, difficult canal geometry—Bergenholtz advised preparing an individual treatment plan while considering advantages and disadvantages, preparing canals as far as possible, avoiding producing artefacts (zipping, steps), and regularly observing the course of healing.

_Instrument history

In his second lecture, Prof Pierre Machtou gave an overview of the development of endodontic instruments over the past two decades. Milestones certainly were the crown-down, step-down and balanced force concepts, as well as the introduction of NiTi instruments in sequences of rotary systems. Owing to their high elasticity, NiTi hand instruments were not instantly successful. The added rotation made them effective.

_Regenerative medicine

Prof Antony Smith managed to bring practical relevance to his lecture on this rather dry and heavily scientific subject. In comparison with oral surgery, endodontists have already been very successful in regenerative medicine for over 100 years (tertiary dentine formation in pulp capping with $Ca(OH)_2$). EDTA apparently stimulates tertiary dentine formation similar to $Ca(OH)_2$. Dentine contains many bioactive substances necessary for regeneration and science now has to find and activate these substances. Perhaps we will actually implant cells for regeneration in the future.

_Biofilm management

Prof Fouad Ashraf discussed a similar topic. He demonstrated the regenerative potency of the pulp with impressive images and reported about at-

tempts to eliminate the biofilm developing in open canal lumen with new combinations of antibiotics (ciprofloxacin + metronidazole + minocycline). The well-known Augmentin (amoxicillin + clavulanic acid) or the newer tigecycline are other, very potent antibiotics. Irrigating solutions such as NaOCl and chlorhexidine have an antibacterial effect, but are potentially lethal for the stem cells important for regeneration. He resumed by mentioning the well-known and proven use of 17 % EDTA as an alternative.

_Endodontic-periodontal lesions

In his lecture, Prof Andrea Mombelli discussed the issue of endo-perio lesions and their characteristics. In principle, the same (Gram-positive, usually anaerobic) bacteria (organised in a biofilm) always dominate the environment. Differences between extra- and intra-canal environments exist in the availability of oxygen and other crucial substances. The endodontic problem is to be approached therapeutically in the instance of a combined lesion.

_Vertical root fractures

Prof Claus Löst lectured about vertical root fractures. Although only slight incidence rates are described in the literature—between 1 and 5 %—his personal research has revealed a much higher occurrence—up to 37 %. The cause of this discrepancy, in his opinion, is for the most part very small fractures (mini-fissures) in the root, which are evidently not detected very often after extraction. He sought to explain the uncertain aetiology as possibly due to high loss of substance (owing to root-canal preparation), the actual root-filling method or its material (lateral condensation?), the materials utilised (sealer containing glass ionomer cement), irrigating solutions and fillers (NaOCl, $Ca(OH)_2$) or the type of post-endodontic care (pin or no pin; crown). It is clear that such fractures can appear anywhere on the root, not only apically or cervically. Prior to a planned extraction, a vertical root fracture should always be ruled out by means of explorative opening. Such fissures are also not (yet) identifiable by means of DVT.

_Ongoing conflict

In his lecture, Dr Jan Berghmans switched over to implantology. He questioned the statement of a well-known, American implantologist, who had said that, in general, an implant is a better choice for a prosthetic treatment than an endodontically treated tooth. Although Berghmans showed several—partially bizarre—X-ray images of teeth that had obviously not been treated *lege artis*, he was able to convince the audience that correctly treated root canals are less of a compromise than implants. Whereas implant-related problems are often merely considered complications, endodontic problems are immediately stigmatised as failures or mistakes. Berghmans recommends mounting of the cusp (primarily with premolars) after endodontic treatment. Whether the biological width will be sufficient for restoration after the treatment must repeatedly be examined. It must also be considered whether the existing hard tooth tissue permits a ferrule (1–2 mm high and 1 mm thick) and what the crown-to-root ratio will be after the restoration. He explained the higher fracture rate with the high loss of substance and associated debilitation. Investigations still have to demonstrate the extent to which poor proprioception has any relevance. In his opinion, the success rates of endodontic tooth restorations and single-tooth implants are easily comparable.

Following the final presentation, prizes—equipment and materials worth over 7,000 Swiss francs, courtesy of the exhibitors—were awarded by the SSE Executive Committee to members of the audience who had stayed until the very end.

Overall, it was once again a successful conference. The only downside was that the national conference of the Osteology Foundation was held in Zurich at the same time and many colleagues had to choose between the two events._

Figs. 6–8_Various companies (from left to right: FKG, VDW and DENTSPLY Maillefer) offered mini-workshops during the lunch break.

(Photos courtesy of Johannes Eschmann, DT Switzerland, and Dr Philipp Kujumdshiev.)

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2012

BAET International Dental Traumatology Symposium
23 March 2012
Brussels, Belgium
www.baet.org

Russian Endodontic Congress
30 March–1 April 2012
Moscow, Russia
www.congress2012.endoforum.ru/e/index.html

AAE Annual Session
18–21 April 2012
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www.aae.org

SCANDEFA
26–28 April 2012
Copenhagen, Denmark
www.scandefa.dk

IADR General Session & Exhibition
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www.iadr.org

Trans-Tasman Endodontic Conference
21–23 June 2012
Queensland, Australia
www.tteconference.com

Skand Endo
23–25 August 2012
Oslo, Norway
nina.gerner@c2i.net

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29 August–1 September 2012
Hong Kong, China
www.fdiworldental.org

ROOTS Summit
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