Intentional replantation: A viable treatment option for specific endodontic conditions

Intentional replantation is defined as the purposeful extraction of a tooth in order to preserve a defect or cause of treatment failure and thereafter the return of the tooth to its original socket. Any tooth that can beatraumatcally re moved in one piece is a potential candidate for intentional replantation. However, specific indica tions include:

• all endodontic non-surgical and surgical treatments have failed or are deemed impossible to perform;
• limited mouth opening that pre vents the performance of non-surgical or peri-radicular surgical procedures;
• root-canal obstructions; and
• restorative or perforation root de struction.

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 mesiodistal 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 mesial distal 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 facial surface was built up with composite. We decided not to proceed with the crown immediately after stabilization to prevent loading of the tooth. The patient was recalled periodically for follow-up.

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 realized that the fracture line extended 2 to 3 mm palatally. Once the mobile fragment had been extracted, we realized that the fracture line extended 2 to 3 mm palatally. A retrograde filling was done with mineral tri oxide aggregate (MTA). The extraction socket was then irrigated with 3 mm Class I root-end preparation. Thereafter, we performed a 5 mm class I root-end preparation with an ultrasonic tip, at the apical end of all three canals. A retrograde filling was then irrigated with normal saline and gently suctioned to remove blood clots. The socket was filled with tricalcium phosphate and sealed with a post in the mesial distal root.

The patient was back-filled with thermo-plasticized gutta-percha. The patient was re-evaluated after seven days.

Case III
A 25-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 palatal gingival groove (PGG) with respect to tooth #12 (Figs. 2a–e). The intraoral peri-apical radiograph revealed a peri-apical radiolucency. We decided to extract the tooth and seal the groove and then replant the tooth. After adequate anesthe sia had been obtained, the tooth was extracted with all the necessary precautions and immersed in Viaspan. With the help of the forceps, it was then held by its crown. The PGG was dehiscence 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 root of the root canal was back-filled with thermo-plasticized 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. In 1561, Pare recommended its use when a healthy instead of a diseased tooth was mistakenly extracted. In 1712, Pierre Fauchard replanted a tooth and reported it to be stable on follow-up. Several steps in the replantation were debated, for instance the need for amputation of root apices, immediate or delayed replantation, root-canal obturation before or after replantation, removal or preservation of periodontal ligament cells and the goal of ultimate healing—bony ankylosis or ligament repair.

It was in 1887 that Thompson presented the technique on the replantation of teeth and emphasised the importance of precise cementation for treatment success. Later, Evered in 1887 and Scheff in 1890 addressed the role of periodontal ligament cells with regard to external root resorption after replantation. As the replantation technique became increasingly refined, it was used as an easy alternative for failing root-canal treatment and hence evoked sharp criticism for the technique of replantation.

Reference:
“The ninth WEC will help to elevate the technical and scientific standards of endodontic research, practice and teaching”

An interview with IFEA congress president Prof. Hideaki Suda

The last World Endodontic Congress (WEC) in Athens, Greece, in 2010 was one of the most successful events the International Federation of Endodontic Associations (IFEA) has ever organised in its 27-year history. The next edition, to be held in Tokyo in Japan from 25 to 28 May 2013, has attracted even more interest from specialists around the world, according to the organisation.

Endo Tribune had the opportunity to speak with congress president and Tokyo Medical and Dental University professor Hideaki Suda.

Endo Tribune: IFEA’s ninth WEC is being held in Japan for the first time. What has the organisation been like, and what are your initial expectations for the event?

Prof. Hideaki Suda: The selection of the Japan Endodontic Association to host the congress in 2013 was a decision made by the IFEA general assembly in Vancouver, Canada, six years ago. Since then, the local organising committee and its five subcommittees have had over 50 meetings concerning the preparations for the congress. Each subcommittee has also held its own meetings. We expect that the ninth WEC will help to elevate the technical and scientific standards of endodontic research, practice and teaching, as well as disseminate them throughout the world in order to improve the dental care standards in many nations.

In what regard will this congress be different from that in Athens?

Looking back at the last congress, one has to admit that it was not only extremely well organised but also very successful both at an academic and social level. At this point, we can already say that the ninth WEC will be much larger in size and participation numbers, as we already have 1,100 preregistrations from 41 member and non-member countries. Almost 500 research papers have been accepted and will be presented in Tokyo. Furthermore, there will be nine symposia and 17 table clinic presentations, where the newest scientific methods and technologies will be on display.

Owing to Japan’s unique hospitality, I am sure that participants will enjoy their stay throughout the event.

Japan is the country where the apex locator was developed, amongst other things. How would you describe the level of endodontic treatment and research in the country?

Another Japanese development was the application of adhesive dentistry principles to endodontic treatment. As you may also know, Prof. Shinya Yamanaka from the Kyoto University was awarded the Nobel prize last year for inducing pluripotent stem cells. Tissue engineering of the dental pulp has become one of the hottest topics for research in Japan and we may see the regeneration of the pulp become a reality in the near future owing to this development.

Unfortunately, there are still only a few general practitioners who are specialised in endodontic procedures, most of which are performed under the Japanese health insurance service. There- new techniques and treatment methods such as CBCT and the use of lasers and microscopes in endodontics are topics with which many of the papers are concerned.

Other topics include pain control, the newest apex locators, MTA, novel root-canal irrigation methods, the management of tooth fractures, as well as root-canal preparation and filling. Single-file preparation methods in particular will be demonstrated during the pre-congress courses by four world-famous endodontists.

Which presentations are you looking forward to most? Highlights will definitely be the plenary and keynote lectures, where the latest information on regenerative medicine of the dental pulp, re- and auto-transplantation of teeth, biofilms in endodontics, treatment outcomes, and retreatment will be presented. In addition, we are looking forward to the country representative speakers session, where the current trends in endodontic treatment in each member country will be discussed.

The general assembly will also meet again during the congress. What will be discussed at this gathering?

Endo Tribune: Will the programme be primarily focused on new techniques and treatment methods?

The theme of the congress is “Shaping the future of endodontics”. Will the programme be primarily focused on new techniques and treatment methods?

After the introduction of the latest instruments and materials to daily practice, it is encouraging to see however that endodontic seminars and hands-on courses for general dental practitioners here are always well attended, demonstrating that a large part of the profession is very keen on learning about the latest scientific and technological developments.

Thank you very much for this interview.
There are many reasons for an adverse outcome of a replantation: the tooth can fracture during extrac-
tion and may be completely lost, peri-
cemental tissues can be damaged, reducing the likelihood of reattatch-
ment, infection, external root resorp-
tion; and ankylosis. Therefore, it is extremely important to understand that intentional replantation should be the last choice, selected only when all other options of treatment—
non-surgical and surgical—have been exhausted. Replantation cannot be a treatment of choice in cases in which a surgical approach can be diffi-
cult, for example on the lingual root of a mandibular molar, or in cases in which a surgical approach would be very invasive, such as the removal of thick bone from the buccal aspect of a second mandibular molar.

Intentional replantation has a better prognosis when the extra-oral time is kept as short as possible and trauma to the periodontal ligament and cementum is minimised. It is advisable to perform routine en-
dodontic treatment intra-oral be-
fore the tooth is extracted to min-
imise its 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 eleva-
tors should be avoided, and the breaks of the extraction forces should not go beyond the CEJ. The corticall bone integrity should be maintained, and the tooth should be extracted as atraumatically as possible.

The medium in which the tooth is kept must play an important role. saline, HBSS, milk, Viapain, to name a few, are widely used. Viapain is issued for organ transplantation and pre-
servation. Owing to its antioxidant activity, the solution keeps the perio-
dontal ligament moist and reduces the likelihood of surface resorption.

We generally use ultrasonic tips to prepare the root-end and the de-
bridement of the PGG. It conserves the tooth structure and produces significantly less smear layer com-
pared with burs. Commonly used root-end filling materials are amal-
gam, Intermediate Restorative Ma-
terial (IRM), SuperEBA, GIC, Diakal,
composite and MTA. The sealing ability and marginal adaptation of MTA have been proven to be su-
perior and not adversely affected by blood contamination. In addition, MTA promotes deposition of new ce-
mentum and stimulates osteoblastic adherence to the retrofilled 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 root supragingivally so that the integrity, aesthetics and prognosis of the case were improved. Tricalcium phos-
phate is an osteo-conductive mate-
rial that acts as scaffold for bone growth and is gradually degraded and replaced by bone.

A palato-gingival groove is a de-
velopmental anomaly that repre-
sents an infolding of enamel and Herwigs epithelial root sheath. PGG can vary in depth, length and complexity, causing varying de-
gress of periodontal defects. Mild grooves terminate at the CEJ, whereas moderate grooves con-
tinue apically along the root surface. A treatment option for a PGG termi-
nating close to CEJ is to expose the groove surgically and to seal it there-
after. As presented, the groove ex-
tended 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 chemi-
cally adheres to the tooth structure and has a good sealing ability and anti-haemorrhage effect.

After replantation, the tooth was splinted for ten days. The splint en-
abled physiological movement of the tooth to prevent ankylosis. En-
dodontic treatment was completed one week after replantation in order to prevent inflammatory resorption and ankylosis and to allow splintering of periodontal fibres, which limits the seapage of potentially harmful root-filling materials into the traus-
seminated periodontal ligament. Fi-
nal restoration of the tooth was de-
layed to avoid loading and to ensure that proper healing of periodontal ligament took place.

In recent years, several bio-mod-
sulators, such as enamel matrix pro-
tin, hydroxyapatite and platelet-
rich plasma, have been used in intentional replantation cases to improve the success rates. Guided tissue-regeneration techniques can also be employed along with these supplements to further improve the likelihood of success. We conclude that intentional replantation is a viable treatment option in carefully selected cases in which all other treat-
ment options have been exhausted.

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

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Endodontic retreatment
Achieving success the second time around

Dr Brett E. Gilbert
USA

Root-canal treatment has been shown to have a success rate of 92.8%. However, as research methodologies move towards higher levels of substantiation, clinicians must rely on the best current evidence available to gain insight into the expected outcomes of their treatment. The highest level and best current evidence we have on the clinical success of endodontic treatment comes from a meta-analysis of the literature.

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

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

The success rate of retreatment has been shown to be in the range of 80%; healing. Phases III and IV of the Toronto Study showed such a healing rate four to six years after non-surgical retreatment.2 In a systematic review by Torabinejad et al., comparing non-surgical retreatment to endodontic surgery, it was demonstrated that non-surgical retreatment had a success rate of 85% versus 71.8% for endodontic surgery, it was demonstrated that non-surgical retreatment had a success rate of 85% versus 71.8% for endodontic surgery after four to six years.4

The presence of pretreatment apical periodontitis is one factor that has been shown to decrease the success rate. Without apical periodontitis, a ten-year success rate of 92 to 96% has been shown for both initial and retreatment root-canal therapy.5 With the preoperative presence of apical periodontitis, there is a decrease in the success rate to 74 to 98% over the ten years.6 This is evident that endodontic healing is attainable through retreatment procedures, allowing us to maintain our patients’ natural teeth (Figs. 2a-c). Although the alternative clinical treatment option of implant placement can provide an effective method for replacing a missing tooth, healthy maintenance of the natural tooth should remain the overall goal.

Post-treatment disease is, inevitably, a result of bacteria and the host response of the patient to the bacteria. These microorganisms are the most critical etiology of post-treatment disease, as they are present within the root-canal system of a previously endodontically treated tooth owing to a combination of substandard endodontic techniques, iatrogenic treatment issues and restorative failure. The intra-radicular bacteria are the primary etiology of post-treatment disease7 and eradication of these bacteria is the primary goal of retreatment procedures.

The intra-radicular bacteria present in the previously treated tooth are persistent and resist removal methods. Bacteria are able to hide and survive in canal ramifications, deltas, irregularities (fins) and dentin tubules.

Figure 2 shows the complex root-canal anatomy properly (green areas) and the minimal amount of canal-wall cleansing that was accomplished during canal instrumentation (red areas). The remaining green areas illustrate the space that might be left untreated, thereby providing a source of bacteria and supporting substrate for intra-canal infection. The potential substrates that are found inside the canal and the bacteria survive can include untreated pulpal tissue, the presence of a biofilm and tissue fluid. This may be present in the canal owing to a poor conal or radicular seal and microbial proliferation. The presence of a poor seal, bacteria and substrate for their growth results in ideal conditions for persistent inflammation and disease.8

The bacteria present in the initial infection of a root canal differ markedly from the bacteria infecting a previously treated tooth. Pre-treatment flora is polymicrobial with equal numbers of Gram-negative and -positive bacteria. Post-treatment bacteria are predominately Gram-positive9 and they have been shown to be able to survive in harsh environments and to be resistant to many treatment methods.

There are high numbers of Enterococcus species.10 Enterococcus faecalis, for example, has been shown to be a common isolate in 27 to 77% of teeth with post-treatment disease.11 A contaminated canal space may result from incomplete cleaning initially or subsequent leakage into root-canal spaces following root-canal treatment. Once present inside the canals, E. faecalis has a variety of characteristics that allow it to evade our best efforts to eradicate it from the root-canal system, including the ability to invade dentinal tubules and adhere to collagen.12 It is also resistant to calcium hydroxide application inside the canal system, which is an interappointment treatment technique used to help remove micro-organisms and their by-products, such as lipopolysaccharides, from the canal space.13,14 E. faecalis’s resistance of calcium hydroxide action arises from its ability to pump hydrogen ions from a proton pump. The hydrogen ions combine with the hydroxyl ions of calcium hydroxide and neutralises the high pH value.15 E. faecalis is also able to resist calcium hydroxide by being part of a biofilm. The protection of bacteria within a biofilm matrix prevents the contact of the bacteria with treatment methods.

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We ♥ to create
Fig. 7a: FireSafe tip from Saetté. (Courtesy of Acteon Group, Praxmos.) — Fig. 8a: Tooth #30 with silver-point fillings in the mesial root and a post in the distal root. The mesial root-canal preparations are transported towards the mesial. There is a radiolucent periapical lesion. — Fig. 8b: Post-op radiograph. — Fig. 8c: Fifteen-month follow-up. (Courtesy of Dr. Brett E. Gilbert)

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

Decay in a previously treated tooth is another source of bacterial contamination. Structural damage to a tooth by trauma, cracking or fracture may provide an entry point for bacterial contamination of the canals. Our patients are responsible for their own oral health and must commit to effective oral hygiene techniques. Failure of the patient to perform effective oral hygiene can result in the failure of even the most well-executed root-canal and restorative treatments.

With the bacterial challenges clinicians have to face, retreatment techniques must be capable of effective elimination of bacteria and their substrates. The use of a dental operating microscope and ultrasonic instruments allows clinicians to uncover all existing canal anatomy properly to ensure that they are able to cleanse the root-canal system completely. The following clinical case demonstrates the extent of the canal space left untreated in the initial root-canal therapy by not opening the mesiobuccal canal adequately and not locating and cleansing the hidden second mesiobuccal canal.

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

Once the canals have been located and instrumented, the ability to irrigate becomes essential to successful treatment. The irrigant solutions target the bacteria we are trying to eliminate. While sodium hypochlorite is a potent and proven antimicrobial and tissue dissolver,23 EDTA 17 % is often used as an effective means to remove core or instrumental obturation. The use of a dental operating microscope and ultrasonic instruments allows clinicians to uncover all existing canal anatomy properly to ensure that they are able to cleanse the root-canal system completely. The following clinical case demonstrates the extent of the canal space left untreated in the initial root-canal therapy by not opening the mesiobuccal canal adequately and not locating and cleansing the hidden second mesiobuccal canal.
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New tips for non-surgical endodontic retreatment

MÉRIGNAC CEDEX, France: The new EndoSuccess kit from Satelec was designed to address problems that commonly occur during non-surgical endodontic retreatment procedures. According to the French instrument manufacturer, which is part of the Acteon Group, the mini-tips of this product line are made of an alloy especially selected for this specific clinical application.

A major innovation, the use of Niobium-titanium an alpha-beta microcrystalline structure alloy, is claimed to allow optimal handling with ultrasound in even the most challenging circumstances and with the best mechanical and clinical performance. Even under intensive usage, it provides good stability/time ratios, the company said. With only a diameter of 3 µ, three to four times smaller than that of standard steel, the grain of the alloy has excellent ultrasound transmission, allowing practitioners to work efficiently and with the required resistance at high power.

The Newton technology in Satelec piezoelectric generators further gives the tips unbeatable efficiency, as the instruments are driven with great precision and respond specifically to the power settings chosen by the practitioner.

According to Satelec, EndoSuccess tips are compatible with all Suprasson generators.

Obturators entirely made of gutta-percha

MUNICH, Germany: VDW’s latest innovation makes use of the advantages commonly associated with gutta-percha, as the new GUTTAFUSION carriers for the thermoplastic obturation of root canals are now made entirely of this material. These obturators now feature a core made of cross-linked gutta-percha that remains stable even when heated and therefore simplifies post space preparation procedures, according to the German specialist company.

In addition, they are coated with gutta-percha, which flows evenly when heated in the GUTTAFUSION oven, for example, filling the whole root-canal system, including ramifications, isthmuses and the apex.

Root canal fillings done with GUTTAFUSION can be removed easily for retreatment, the company said. Specially designed for use with tweezers and fingers, the obturator handle allows for easy application of the obturators in molars. According to VDW, no other instruments are required for separation.

GUTTAFUSION has a high radiopacity and is compatible with most rotary NiTi systems. The three obturator sizes correspond to the R25, R40 and R50 instruments. The correct obturator size can also be determined with a NiTi size verifier, which is available in sizes 20 to 55. GUTTAFUSION obturators for RECIPROC are particularly convenient.
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Endodontic irrigants and irrigant delivery systems

Dr Gary Glassman
Canada

Endodontic treatment is a predictable procedure with high success rates. Success depends on a number of factors, including appropriate instrumentation, successful irrigation and decontamination of the root-canal space to the apices and in areas such as isthmuses. These steps must be followed by complete obturation of the root canals, and placement of a coronal seal, prior to restorative treatment.

Several irrigants and irrigation delivery systems are available, all of which behave differently and have relative advantages and disadvantages. Common root-canal irrigants include sodium hypochlorite (NaOCl), chlorhexidine gluconate, alcohol, hydrogen peroxide and ethylenediaminetetraacetic acid (EDTA). In selecting an irrigant and technique, consideration must be given to their efficacy and safety.

With the introduction of modern techniques, success rates of up to 98% are being achieved. The ultimate goal of endodontic treatment per se is the prevention or treatment of apical periodontitis such that there is complete healing and an absence of infection. While the overall long-term goal is the placement of a definitive, clinically successful restoration and preservation of the tooth. For these to be achieved, appropriate instrumentation, irrigation, decontamination and root-canal obturation must occur, as well as attainment of a coronal seal. There is evidence that apical periodontitis is a biofilm-induced disease. A biofilm is an aggregate of microorganisms that adheres to each other and/or to a surface. These adherent cells are frequently embedded within a self-produced matrix of extracellular polymeric substance. The presence of micro-organisms embedded in a biofilm and growing in the root-canal system is a key factor for the development of peri-apical lesions. Additionally, the root-canal system has a complex anatomy that consists of arborisations, isthmuses and cul-de-sacs that harbour organic tissue and bacterial contaminants (Fig. 1).1

The presence of micro-organisms extracellular polymeric substance. The challenge for successful endodontic treatment always has been the removal of vital and necrotic remnants of pulpal tissue, debris generated during instrumentation, the dentine smear layer, micro-organisms, and micro-tors from the root-canal system.4

Even with the use of rotary instrumentation, the nickel-titanium instruments currently available only act on the central body of the root canal, resulting in a reliance on irrigation to clean beyond what may be achieved by these instruments. In addition, Enterococcus faecalis and Lactobacillus species are frequent inhabitants of the root-canal system.5 At present, intracanal irrigation is commonly used and a good seal obtained to ensure a good rubber dam seal. It is also important to protect the patient’s eyes with safety glasses and remove the scratch layer, ease of use, and moderate cost.

As mentioned above, root-canal irrigants currently in use include the temperature,36–38 or adding surfactants to increase the wetting efficiency of the irrigant.39 However, although NaOCl appears to be the most desirable single endodontic irrigant, it cannot dissolve necrotic dentine particles and thus cannot prevent the formation of a smear layer during instrumentation.40

Calculations hindering mechanical preparation are frequently encountered in the root-canal system, further complicating treatment. Demineralising agents such as EDTA have therefore been recommended as adjuvants in root-canal therapy.41–44 Thus, in contemporary endodontic practice, dual irrigants such as NaOCl with EDTA are often used as initial and final rinses to circumvent the shortcomings of a single irrigant.45 These irrigants must be brought into direct contact with the entire canal-wall surfaces for effective action.39,46 Particularly in the apical portions of small root canals.47

The combination of NaOCl and EDTA has been used worldwide for antisepsis of root-canal systems. The concentration of NaOCl used for root-canal irrigation ranges from 2.5 to 6%, depending on the country and local regulations. It has been shown, however, that tissue hydrolysis is greater at the higher end of this range, as demonstrated in a study by Hand et al. comparing 2.5 and 5.25% NaOCl. The higher concentration may also favour superior microbial outcome, particularly in the apical micro-environment,39 but is not limited to E. faecalis. NaOCl is superior among irrigating agents that dissolve organic matter. EDTA is a chelating agent that aids in the removal of necrotic tissue and protect clothing from irrigant spill, and may be used prior to performing the procedure to ensure a good rubber dam seal. It is also important to protect the patient’s eyes with safety glasses and protect clothing from irrigant spill or spray.

Regardless of which irrigant and irrigation system is used, and particularly if an irrigant with tissue toxicity is used, there are several general precautions that must be followed. A rubber dam must be used and a good seal obtained to ensure that no irrigant can spill from the pulp chamber into the oral cavity. If deep caries or a fracture is present adjacent to the rubber dam on the tooth being isolated, a temporary sealing material must be used prior to performing the procedure to ensure a good rubber dam seal. It is also important to protect the patient’s eyes with safety glasses and protect clothing from irrigant spill or spray.
Irrigant delivery systems
Root canal irrigation systems can be divided into two categories: manual agitation techniques and machine-assisted agitation techniques. Manual irrigation includes positive-pressure irrigation, which is commonly performed with a syringe and a side-vented needle. Machine-assisted irrigation techniques involve ultrasonic and ultrasonic systems, as well as newer systems such as the EndoVac (SybronEndo), which delivers apical negative-pressure irrigation, the plastic rotary file (Endo), and the Vibe (Vibe), the Runendo (Air Techniques), and the EndoActivator (DENTSPLY Tulsa Dental Specialties). Two important factors that should be considered during the process of irrigation are whether the irrigation system can deliver the irrigant to the whole extent of the root canal system, particularly to the apical third, and whether the irrigant is capable of debriding areas that could not be reached with mechanical instrumentation, such as lateral canals and isthmuses. When evaluating irrigation of the apical third, the phenomenon of apical air lock should be considered. Apical air lock
Since roots are surrounded by the periodontium, and unless the root canal is open, the root canal behaves like a closed-ended channel. This produces an apical air lock that resists displacement during instrumentation and final irrigation, thus preventing the flow of irrigant into the apical region and adequate debridement of the root canal system. Apical air lock also results in gas entrapment at the apical third. During irrigation, NaOCl reacts with organic tissue in the canal system, and the resulting hydrolysis liberates abundant quantities of ammonia and carbon dioxide. This gaseous mixture is trapped in the apical region and quickly forms a column of gas into which further fluid penetration is impossible. Extension of instruments into this vapour lock does not reduce or remove the gas bubble, just as it does not enable adequate flow of irrigant.

The phenomenon of apical air lock has been confirmed in studies in which roots were embedded in a polyvinylalcohol impression material to restrict fluid flow through the root apertures, simulating a closed-ended channel. The result in these studies was incomplete debridement of the apical part of the canal walls with the use of a positive-pressure syringe delivery technique. Micro-CT scanning and histological tests conducted by Tay et al. have also confirmed the presence of apical air lock. In fact, studies conducted without ensuring a four-ended channel cannot be regarded as conclusive on the efficacy of irrigants and the irrigant system. The apical air lock may also explain why in a number of studies investigators were unable to demonstrate a clean apical third in sealed root canals.

In a paper published in 1983, researchers Chou determined that traditional positive-pressure irrigation had virtually no effect apical to the orifice of the irrigation needle in a closed root canal system. Fluid exchange and debris displacement were minimal. Equally important to his primary findings, Chou set forth an infallible paradigm for endodontic irrigation: “For the solution to be mechanically effective in removing all the particles, it has to: (a) reach the apex; (b) create a current (force); and (c) carry the particles away.” The apical vapor lock and consideration for the patient's safety have always prevented the thorough cleaning of the apical 5 mm. It is critically important to determine which irrigation system will effectively irrigate the apical third, as well as isthmuses and lateral canals, and in a safe manner that prevents the extrusion of irrigant.

Manual agitation techniques
By far the most common and conventional set of irrigation techniques, manual irrigation involves dispensing of an irrigant into a canal through needles/ cannulas of variable gauges, either passively or with agitation by moving the needle up and down in short 2 to 3 mm strokes within an instrumented canal and the volume of irrigant that is flushed through the canal. However, the closer the needle tip is positioned to the apical tissue, the greater the chance of apical extrusion of the irrigant. This must be avoided; were NaOCl to extrude past the apex, a catastrophic accident could occur.

Manual dynamic irrigation
Manual dynamic irrigation involves gently moving a well-fitting gutta-percha master cone up and down in short 2 to 3 mm strokes within an instrumented canal, thereby producing a hydrodynamic effect and significant irrigant extrusion. Recent studies have shown that this irrigation technique is significantly more effective than sonically driven irrigation and static irrigation. Machine-assisted agitation systems

Sonic irrigation
Sonic activation has been shown to be an effective method for rotational irrigation. Over 40 years of clinical success! Accept no imitations!
disinfecting root canals, operating at frequencies of 1–6 kHz. There are several sonic irrigation devices on the market. The UltiLiner allows delivery and sonic activation of the irrigation solution in one step. It employs a two-piece syringe with a rechargeable battery. The Irrigation tip is sonically activated at the needle that attaches to the syringe. The EndoActivator is a more recently introduced sonically driven canal irrigation system. It consists of a portable handpiece and three types of disposable polymer tips of different sizes. The EndoActivator has been reported to effectively deliver debris from lateral canals, remove the smear layer, and dissolve clumps of biofilm within the curved canals of molar teeth.

Ultrasonics

Ultrasonic energy produces higher frequencies than sonic energy but low amplitudes, oscillating at frequencies of 25–50 kHz. Two types of ultrasonic irrigation are available. The first type is simultaneous ultrasonic instrument and irrigation, and the second type is referred to as passive ultrasonic irrigation operating without simultaneous irrigation (PUI). The literature indicates that it is more advantageous to apply ultrasonics after completion of canal preparation rather than as an alternative to conventional instrumentation. PUI allows energy to be transmitted from an oscillating file or smooth wire to the canal when it is positioned at work and sonic activation of the irrigant in the root canal by means of ultrasonic waves. There is consensus that PUI is more effective than syringe irrigation in removing pulp tissue remnants and dentine debris. This may be due to the much higher velocity and volume of irrigant flow that are created in the canal during ultrasonic irrigation. PUI has been shown to remove the smear layer; there is a large body of evidence with different concentrations of NaOCl. In addition, numerous investigations have demonstrated that the use of PUI after hand or rotary instrumentation results in a significant reduction in the number of bacteria, or achieves significantly better results than syringe needle irrigation.

Studies have demonstrated that effective delivery of irrigants to the apical third can be enhanced by using ultrasonic and sonic devices that demonstrate acoustic micro-streaming and cavitation. Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the ultrasound energy creating mechanical pressure changes within the tissue. Cavitation is defined as the formation and collapse of gas bubbles in the fluid. It employs a two-piece syringe with a non-toxic polymer. The F File will deliver approximately 2 ml of NaOCl actively while the G File will deliver approximately 2 ml of NaOCl passively.

The Apical Vacuum Lock theory, proven in vitro by Tay, has been clinically demonstrated to also include the middle third by Vera: “The mixture of gases is originally trapped in the apical third, but then it might grow quickly by the nucleation of the smaller bubbles, forming a gas column that might not only impede penetration of the irrigant into the apical third but also push it coronally after it has been delivered into the canal.” However, more recently Munoz demonstrated that both: passive ultrasonic irrigation (PUI) and EndoVac are more effective than the conventional endodontic needle in delivering irrigant into the WL of root canals.

This brings the efficacy question. Two recently published studies examined this issue with both systems by testing their ability to eliminate microorganisms during clinical treatment from infected root canal systems. Paiva fund that after a supplementary irrigation procedure using PUI with NaOCl 25 % of the samples produced positive cultures. Cohenca’s study examining the clinical efficacy of the EndoVac fund no microbial RNM, or achieved significantly better results than syringe needle irrigation.

When questioning these different irrigation systems, there is a large body of evidence with different concentrations of NaOCl. In addition, numerous investigations have demonstrated that the use of PUI after hand or rotary instrumentation results in a significant reduction in the number of bacteria, or achieves significantly better results than syringe needle irrigation.

Energy but low amplitudes, oscillating at frequencies of 1–6 kHz. There are several sonic irrigation devices on the market. The UltiLiner allows delivery and sonic activation of the irrigation solution in one step. It employs a two-piece syringe with a rechargeable battery. The Irrigation tip is sonically activated at the needle that attaches to the syringe. The EndoActivator is a more recently introduced sonically driven canal irrigation system. It consists of a portable handpiece and three types of disposable polymer tips of different sizes. The EndoActivator has been reported to effectively deliver debris from lateral canals, remove the smear layer, and dissolve clumps of biofilm within the curved canals of molar teeth.
Length, 46,104,116 When comparing at 1.5 and 3.5 mm from working length using apical negative-pressure irrigation, both resulted in clean root canals, but that apical negative pressure that these methods resulted in less debris remaining at 1 mm from the apical area. Shin et al. found in an in vitro study of 69 teeth comparing traditional needle irrigation, while Shim et al. found in an in vitro study of 22 teeth by Siu and Baumgartner, traditional needle irrigation, while when apical negative-pressure irrigation was performed (EndoVac) than with apical positive-pressure irrigation.111

Efficacy
In vitro and in vitro studies have demonstrated greater removal of debris from the apical walls and a statistically cleaner result using apical negative-pressure irrigation in closed root-canal systems with sealed apices. In an in vitro study of 42 teeth by Shin and Baumgartner, less debris remained at 1 mm from working length using apical negative-pressure compared to use of traditional needle irrigation, while Shim et al. found in an in vitro study of 69 teeth comparing traditional needle irrigation with apical negative pressure that these methods both resulted in clean root canals, that but that apical negative pressure resulted in less debris remaining at 1.5 and 3.5 mm from working length.112,113 When comparing root-canal debridement using manual-dynamic agitation or the EndoVac for final irrigation in a closed system and an open system, it was found that the presence of a sealed apical foramen adversely affected debridement efficacy when manual-dynamic agitation was used, but did not adversely affect results when the EndoVac was used. Apical negative-pressure irrigation is an effective method to overcome the fluid-dynamic challenges inherent in closed root-canal systems.114

Microbial control
Hockett et al. tested the ability of apical negative pressure to remove a thick biofilm of E. faecalis, finding that these specimens rendered negative cultures obtained within 48 hours, while those irrigated using traditional positive-pressure irrigation were positive at 48 hours.88

One study found that apical negative-pressure irrigation resulted in similar bacterial reduction to use of apical positive-pressure irrigation and a triple antibiotic in immature teeth.115 In a study comparing the use of apical positive-pressure irrigation and a triple antibiotic that has been utilized for pulpal regeneration/revascularisation in teeth with incompletely formed apices (Trimix = Cipro, Minocin, Flagyl) versus use of apical negative-pressure irrigation with NaOCl, it was found that the results were statistically equivalent for mineralised tissue formation and the repair process.116 Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discoloration, and allergic reactions.118,119

Conclusion
Since the dawn of contemporary endodontics, dentists have been striving NaOCl into the root-canal space and then proceeding to place endodontic instruments down the canal in the belief that they were carrying the irrigant to the apical terminus. Biological, scanning electron microscopy, light microscopy, and other studies have proven this belief to be in error. NaOCl reacts with organic material in the root canal and quickly forms microbubbles at the apical termination that coalesce into a single large apical vapour bubble with subsequent instrumentation. Since the apical vapour lock cannot be displaced via mechanical means, it prevents further NaOCl flow into the apical area. The safest method yet discovered to provide fresh NaOCl safely to the apical terminus to eliminate the apical vapour lock is to evacuate it via apical negative pressure. This method has also been proven to be safe because it always draws irrigant to the source via suction—down the canal and simultaneously away from the apical tissue in abundant quantities.119 Using the proper irrigating agents are delivered safely to the full extent of the root-canal terminus, thereby removing 100 % of organic tissue and 100 % of the microbial contaminants, success in endodontic treatment may be taken to levels never seen before.120

Editorial note: A complete list of references is available from the publisher. This article has been reprinted in part from G. Glassman, Safety and Efficacy Considerations in Endodontic Irrigation (PenWell, January 2011).