Intentional replantation: A viable treatment option for specific endodontic conditions

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

- all other endodontic non-surgical and surgical treatments have failed or are deemed impossible to perform;
- limited mouth opening that precludes 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.

The contraindications may include:

- long, curved roots;
- advanced periodontal diseases that have resulted in poor periodontal support and tooth mobility;
- multi-rooted teeth with diverging root apices; 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 Dextran 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 root in the mesial and distal root canals of tooth #48. 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-gingival 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.

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Once the cementum and the periodontal ligament were re-established, the tooth was successfully replanted. The patient was recalled periodically for follow-up.

Case II

A 22-year-old male patient presented with a history of trauma to his anterior maxillary region. Clinical examination revealed an Ellis Class III fracture of tooth #12, with the fragment extending to the root palatally. If the mobile fragment had been extracted, we realised that the fracture line extended 2 to 3 mm sub-cementally. In order to bring the apical end of the fracture line to a supra-cemental position, we considered two options: orthodontic extrusion and intentional replantation.

Following extraction, we kept the tooth moist by immersing it in ViaSpan. With the breaks of the fracture, we held the tooth by its crown and cut the overextended Lentulo spiral. Thereafter we performed a 5 mm root-end preparation with an ultrasonic tip, at the apical end of all three canals. A root canal 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 in its socket with a suture. The patient was re-evaluated after seven days, and the sutures were removed.

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 palatal gingival groove (PGG) with respect to tooth #12. 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 anaesthesia had been obtained, the tooth was extracted with all the necessary precautions and immersed in ViaSpan. With the help of 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 cured and the tooth reinserted. Sutures were placed in the inter-alveolar 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. In 1561, Pare recommended its use when a healthy instead of a diseased tooth was mistakenly extracted. In 1712, Pierre Fauchet 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 obliteration before or after replantation, or preservation of periodontal ligament cells and the goal of ultimate healing—bony ankylosis or ligament repair.

It was in 1881 that Thompson presented the technique on replantation of teeth and emphasised the importance of peri-crestal-infiltration for treatment success. Later, Everse in 1887 and Schell in 1990 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 evolved sharp criticism for the technique of replantation per se.
“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, Japan from 23 to 26 May 2013, has attracted much larger in size and participation numbers, as we already have 1,100 pre­registrations from 41 member and non­member 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, among 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. Therefore, the country has tended to be behind other markets regarding 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.

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

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 regeneration 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?

Thank you very much for this interview.

Who are the professionals in Japan very keen on learning about the latest scientific and technological developments?

Besides reports from officers and representatives from different regions, the general assembly meeting on Sunday, 26 May, will select the location of the 12th WEC in 2019. Last time, it was decided that the next congress (in 2018) will be held in Cape Town in South Africa. Future concepts concerning science and business will also be discussed. Through these activities, we hope to foster international professional relationships and the exchange of information in endodontics.

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/or it can be completely lost. Peri-implant tissues can be damaged, reducing the likelihood of reattachment, 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 of the other options of treatment—non-surgical and surgical—have been exhausted. Replantation can be a treatment of choice in cases in which a surgical approach can be difficult, for example on the lingual root of a mandibular molar, or in cases in which a surgical approach would be very invasive, such as the removal of thick bone from the buccal aspect of a second mandibular molar.

Intentional replantation has a better prognosis when the extra-oral time is kept as short as possible and trauma to the periodontal ligament and cementum is minimised. It is advisable to perform routine endodontic treatment intra- orally before the tooth is extracted to minimise the extra-oral time. It is also suggested that a team of two dentists work in tandem to prevent prolonged treatment time, thus improving the chances of success. The use of elevators should be avoided, and the breaks 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 must play an important role. Saline, HESS, 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.

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

In two of our cases, tricalcium phosphate was placed in the apical five 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 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 Herity's epithelial root sheath. PG can vary in depth, length and complexity, causing varying de-grees 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 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 chemi-cally adheres to the tooth structure and has a good sealing ability and anti-bacterial effect.

After replantation, the tooth was splinted for ten days. The splint en-abled physiological movement of the tooth to prevent ankylosis. En-odontic 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 trauma-tised periodontal ligament. Fi-nal restoration of the tooth was de-layed to avoid loading and to re-ensure that proper healing of periodontal ligament took place.

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

We would like to acknowledge the assistance of Dr Akanksha Gupta and Dr Nikhil Sinha.
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 95%. 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 controlled outcome studies. They found a 90% pooled success rate of 68 to 85%, with at least one year of follow-up. This review considered the strictest of criteria for determining that a tooth has healed, and included 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 be addressed to be able to attain complete healing of the diseased tooth. The armamentarium and techniques available today allow us the ability to disrupt 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. 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 81.4% versus 76.6% for endodontic surgery after four to six years.

The presence of pretreatment apical periodontitis is one factor that has been shown to decrease the success rate. Without apical periodontitis, a ten-year success rate of 92% to 98% has been shown for both initial and retreatment root-canal therapy. With the pre-operative presence of apical periodontitis, there is a decrease in the success rate to 74 to 98% over the ten years. From this, it 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 micro-organisms 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.

Intra-radicular bacteria are the primary etiology of post-treatment disease and eradication of these bacteria is the primary goal of retreatment procedures.

The intra-radicular bacteria present in the previously treated tooth are persistent and resist removal methods. Bacteria are able to hide and survive in canals ramifications, defects, irregularities (fiss) and dentinal tubules.

Figure 2 shows the complex root-canal anatomy preferentially (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 help 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 coronal 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.

The bacteria present in the initial infection of a root canal differ markedly from the bacteria infecting a previously treated tooth. Post-treatment flora is polymicrobial with equal numbers of Gram-negative and -positive bacteria. Post-treatment bacteria are predominantly Gram-positive and 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. Enterococcus faecalis, for example, has been shown to be a common isolate in 20 to 76% of teeth with post-treatment disease. Enterococcus faecalis has a variety of characteristics that allow it to evade our best efforts to eradicate it from the root-canal system, including the ability to invade dentinal tubules and adhere to collagen. It is also resistant to calcium hydroxide application inside the canal system, which is an inter-appointment treatment technique used to help remove micro-organisms and their by-products, such as lipopolysaccharides, from the canal space. Enterococcus 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 neutralise the high pH value. Enterococcus 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 the antibiotic agent.
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We ❤️ to create
with irrigants and medicaments, and allows communication between bacteria to aid in survival capabilities.\textsuperscript{15-18} The presence of \textit{E. faecalis} is well documented; however, Iatrogenic issues encountered during the initial root-canal treatment may be the cause of intra-} 

filed canals, ledging, canal trans- } 

portation, over-instrumentation, as well as obstruction of the canal by debris or separation of instruments. Failure to use or using too small a volume of an appropriate irrigant solution, such as sodium hypochlo- } 

rite, is an iatrogenic error. Full-strength 6 % sodium hypochlorite has been shown to be highly antiseptic and able to dis- } 

solve tissue and disrupt bacterial biofilms.\textsuperscript{19-22} These qualities in an irrigant are ideal for the debride- } 

ment of residual bacteria and tissue debris. The use of a rubber dam to isolate the treatment field is the standard of care for endodontic treatment. Failure to use a rubber dam may be a fundamental contri- } 

butor to post-treatment disease. The following case illustrates the ability to overcome prior incom- } 

plete treatment to achieve suc- } 

cessful healing (Figs. 3a-c).

Clinical example

Restorative failure is a common cause of post-treatment disease. Failure to place an effective per- } 

manent access restoration in a timely manner can allow for bacte- } 

rial 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 dam- } 

age 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, retreat- } 

ment 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 (Fig. 8a-c) illustrates 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 haiden second mesiobuccal canal.

Endodontic ultrasonic tips are highly efficient at removing core build-up material, paste fills, posts and silver point fillings, as demon- } 

strated in Figure 5. These instru- } 

ments 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 (Axxis, SybronEndo) is efficient for the removal of gutta-percha and resin materials from the coronal third. Hand and rotary files can remove root fillings and shape canals to appropriate work- } 

lengths. Current NITI rotary files are highly flexible and re- } 

sistant to separation and allow us to mechanically enlarge the apical third of root canals safely and effi- } 

ciently 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 lo- } 

cated 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 antiseptic and tissue dissolver,\textsuperscript{15,22} 2 % chlorhexidine has been shown to prevent the adhesion of \textit{E. faecalis} to dentine.\textsuperscript{23} EDTA 17 % is often used as an effective smear layer removal agent.\textsuperscript{23} Therefore, me- } 

chanical debridement and canal instrumentation provide a pathway for copious chemical irrigation deep into the canal.

Passive ultrasonic irrigation allows clinicians to place an irrigant solution into the pulp chamber and activate it as it is carried down to the apical end of the root canal. The Irriso Safe tip from Satelec (Acteon, Paris, France) is designed to hide and resist debridement. The tip extends apically in front of where the tip extends apically up to 3 mm into the canal. The ultrasonic instruments are designed to be used as an effective smear layer dissolver (Figs. 6a-b). A heat source such as a System B tip (Axxis, SybronEndo) is efficient for the removal of gutta-percha and resin materials from the coronal third. The instruments and irrigants, rotary NITI files and appropriate irrigation mate- } 

rials increases our ability to attain complete treatment to achieve successful healing of post-treatment disease. Endodontic complications occur when proper disinfection have been completed. This case illustrates the reason that retreat- } 

ment is the primary treatment op- } 

tion for post-treatment disease.

The following silver-point case (Figs. 8a-c) with a large post and apical transportation in the mesial root, demonstrates the suc- } 

cessful healing of post-treatment disease when proper disinfection has been accomplished. This case illustrates the reason that retreat- } 

ment is the primary treatment op- } 

tion for post-treatment disease.

Once debridement and dis- } 

infection have been completed, appro- } 

priate obturation methods are used to seal the canal spaces. The warm vertical technique using gutta-percha or resin with an ap- } 

propriate sealing agent provides a thorough seal of the well-cleaned and shaped canal spaces. The final restoration must provide a proper seal of the pulpal chamber to prevent coronal micro-leakage.

Current evidence has demon- } 

strated that we can retreat previ- } 

ously endodontically treated teeth properly and successfully. The literature has also shown that specific bacteria, such as \textit{E. faecalis}, are able to survive inside a previously filled canal. The use of a dental op- } 

erating microscope, ultrasonic instru- } 

ments, irrigants, rotary NITI files and appropriate obturation mate- } 

rials increases our ability to attain healing after retreatment. As we continue to strive to maintain heal- } 

thy natural teeth for our patients, endodontic retreatment should be the primary treatment op- } 

tion for post-treatment disease.\textsuperscript{24} A complete list of references is avail- } 

able from the publisher.

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ationally on clinical endo- } 

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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 furthermore 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.

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 pre-
dictable procedure with high
success rates. Success depends
on a number of factors, including
appropriate instrumentation,
successful irrigation and decon-
amination 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 restaura-
tive treatment.

Several irrigants and irrigant delivery systems are available, of
which behave differently and have
relative advantages and disadvan-
tages. Common root-canal irrig-
ants 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 efficiency and safety.

With the introduction of mod-
ern techniques, success rates of
up to 98% are being achieved.3
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.4 While
the overall long-term goal is the
placement of a definitive, clinically
successful restoration and preser-
vation of the tooth. For these to be
achieved, appropriate instrumen-
tation, 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.5 A biofilm is an
aggregate of micro-organisms in
which cells adhere to each other
and are occasionally embedded
which cells adhere to each other
corona seal. There is evidence that
apical periodontitis is a biofilm-
induced disease.5 A biofilm is an
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and are occasionally embedded

The challenge for successful
endodontic treatment has always
been the removal of vital and
necrotic remnants of pulp tissue,
debris generated during instru-
mantation, the dentine smear layer,
micro-organisms, and micro-tox-
ins from the root-canal system.6

Even with the use of rotary in-
strumentation, the nickel-titanium
instrument currently available only
act on the central body of the root
canal, resulting in a reliance on in-
strumentation to clean beyond what
may be achieved by these instruments.7
In addition, Enterococcus faecalis
and Actinomyces prevention or treat-
ment of apical periodontitis such as
Actinomyces israelii—which are
both implicated in endodontic infec-
tions and in endodontic failure—
penetrate deep into the dentinal tubules,
making their removal through me-
chanical instrumentation impossi-
ble.8 Finally, E. faecalis commonly
expresses multidrug resistance,9,10
complicating treatment.

Therefore, a suitable irrigant
and irrigant delivery system is es-
sential for efficient irrigation and
patibility and lack of toxicity, the
ability to dissolve necrotic material,
and remove the smear layer, ease of
use, and moderate cost.

As mentioned above, root-canal
irrigants currently in use include
the temperature,11,12 or adding sur-
factants to increase the wetting
efficacy of the irrigant.13 However,
although NaOCl appears to be the
most desirable single endodontic
irrigant, it cannot dissolve inor-
genic dentine particles and thus
cannot prevent the formation of a
smear layer during instrumen-
tation.14,15,16,17

Calculations hindering me-
chanical preparation are frequently
encountered in the root-canal sys-
tem, further complicating treat-
ment. Demineralising agents such
as EDTA have therefore been rec-
ommended as adjuncts in root-
canal therapy.18-21 Thus, in contem-
porary endodontic practice, dual
irrigants such as NaOCl with EDTA
are often used as initial and final
rinses to circumvent the drawbacks
of a single irrigant.22-24,25 These
dual irrigants must be brought into
direct contact with the entire canal-
wall surfaces for effective ac-
tion.22,23,24,25,26 Particularly in the apical
portions of small root canals,10,17,27,28

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 5.25%, depending on
the country and legal regulations. It
has been shown, however, that tissue
hydrolysis is greater at the higher end
of this range, as dem-

sponded in a study by Hand et al.32
comparing 2.5% and 5.25% NaOCl.
The higher concentration may also
 favour superior microbial out-
come.33,34 Which irrigant may be
markedly dependent on the speci-
cum—such as EDTA will be rec-
mended as an adjunct.29-31,32
Decontamination agents such as
EDTA have therefore been rec-
ommended as adjuncts...,33,34

Among the many irrigants
agents that have been tried in order
to achieve tissue dissolution and
bacterial decontamination, the des-
ted attributes of a root-canal irrigant
in-
clude the ability to dissolve necrotic
and pulpal tissue, bacterial deconta-
nination and a broad antimicrobial
spectrum, the ability to enter deep
into the dentinal tubules, biocon-

EndoVac® SET-UP

EndoVac® SET-UP

Micro cannula and Micro cannula tubing

Micro cannula and Micro cannula tubing

Master delivery tip

Micro cannula tubing

High volume suction

Micro cannula tubing

Master delivery tip

Fig. 2: EndoVac setup — Fig. 2: Irrigation accident with widespread trauma.

Fig. 2: EndoVac setup — Fig. 3: Irrigation accident with widespread trauma.

Micro cannula tubing

Micro cannula tubing

Master delivery tip

Micro cannula tubing

High volume suction

Fig. 3: EndoVac set-up. — Fig. 3: Irrigation accident with widespread trauma.
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 include sonic and ultrasonic instruments, as well as newer systems such as the EndoVac (SybronEndo), which delivers apical negative-pressure irrigation, the plastic rotary F File (Plastic Endo),19,20 the Vibringe (Vibringe),21 the Rinsendo (Air Techniques),22 and the EndoActivator (DENTSPLY Tulsa Dental Specialties).23 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 debridging 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 vapour lock should be considered.24-26

Apical vapour lock

Since roots are surrounded by the periodontium, and unless the root-canal oramen is open, the root canal behaves like a close-ended channel. This produces an apical vapour 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.26,27 Apical vapour lock also results in gas entrapment at the apical third. During irrigation, NaOCl reacts with organic tissue in the root-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 vapour lock has been confirmed in studies in which roots were immersed in a polyvinylacetal impression material to restrict fluid flow through the apical foramen, simulating a close-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.28,29 Micro-CT scanning and histological tests conducted by Tay et al. have also confirmed the presence of apical vapour lock.30 In fact, studies conducted without ensuring a four-ended channel can not be regarded as conclusive on the efficacy of irrigants and the irrigant system.31,32 The apical vapour lock may also explain why in a number of studies investigators were unable to demonstrate a clean apical third in sealed root canals.33,34

In a paper published in 1983, based on research Chow determined that traditional positive-pressure irrigation had virtually no effect apical to the orifice of the irrigation needle in a closed root-canal system.35 Fluid exchange and debris displacement were minimal. Equally important to his primary findings, Chow 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.”36 The apical vapour 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,37-39 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 the canal space without binding it on the canal walls. This allows good control of needle depth and the volume of irrigant that is flushed through the canal.40 How ever, the closer the needle tip is positioned to the apical tissue, the greater the chance of apical extrusion of the irrigant.41-43 This must be avoided; were NaOCl to extrude past the apex, a catastrophic accident could occur.44

Manual-dynamic irrigation

Manual-dynamic irrigation involves gently moving a well-fitting gutta-percha master cone up and down in short 2 to 5 mm strokes within an instrumented canal, thereby producing a hydrodynamic effect and significant irrigant extrusion.45 Recent studies have shown that this irrigation technique is significantly more effective than either static-dynamic irrigation and static irrigation.46,47

Machine-assisted agitation systems

Sonic irrigation

Sonic activation has been shown to be an effective method for48-52

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RC-Prep’s unique formulation of glycol, urea peroxide and EDTA in a special water-soluble base helps remove calcifications and lubricates the canal. This produces an apical vapour 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.

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Ultrasonics canals of molar teeth.9,20,77 This may be due to contamination and irrigation, and the simultaneous ultrasonic instrumentation with different concentrations of NaOCl.9,40 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.77,80 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 and vapour-filled bubbles or cavities in a fluid.78–80

The Apical Vapor Lock theory, proven in vitro by Tay, has been clinically demonstrated9 to also include the middle third by Vera: “The mixture of gases is originally trapped in the apical third, but these cannot 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 Munoz9 demonstrates that both: passive ultrasonic irrigation (PUI) and EndoVac are more effective than the conventional endodontic needle in delivering irrigant to WL of root canals. This helps the efficacy question. Two recently published studies examined this issue with both systems testing their ability to eliminate microorganisms during clinical treatment from infected root canal systems.94 Paiva fund that after a supplementary irrigation procedure using PUI with NaOCl that 25 % of the samples produced positive cultures. Cohenca’s study examining the clinical efficacy of the EndoVac fund no microbial Rinn, which may be due to its ability to achieve significantly better results than syringe needle irrigation.9,102

Studies have demonstrated that effective delivery of irrigants to the apical third can be enhanced by using ultrasonic and sonic devices that demonstrate acoustic microstreaming and cavitation.9,40,91 This may be due to the endodontic polymer-based rotary finishing file was developed. This new, single-use, plastic rotary file has a unique file design with a diamond abrasive embedded into a non-toxic plastic core (Fig. 2). The file will remove dental wall debris and agitate the NaOCl without enlarging the canal further.95

Pressure-alternation devices Rinusendo irrigates the canal by using pressure and suction technology. Its components are a handpiece, a cannula with a 7 mm exit aperture, a plastic MacroCannula, a plastic MicroCannula and a syringe carrying irrigant. The handpiece is powered by a dental air compressor and has an output of 60 psi/min. Research has shown that it has promising results in cleaning the root-canal system, but more recent research did not provide scientific evidence of its efficacy. Periapical extrusion of irrigant has been reported with this device.103,104

The EndoVac apical negative-pressure irrigation system has three components: the Master Delivery Tip, MicroCannula, and MasterCannula. The Master Delivery Tip simultaneously delivers and evacuates the irrigant (Fig. 2). The MacroCannula is used to suction irrigant from the canal into the canal and middle segments of the root canal. The MacroCannula contains 12 microscopic holes and is capable of evacuating debris to full working length.95,96 The ISO size 0.02 mm diame ster stainless-steel MicroCannula has four sets of three laser-cut, laterally positioned offset holes adjacent to each other and .04 mm diameter and spaced 100 μm apart. This is attached to a finger piece for irrigation of the apex of the canal when it is positioned at working length. The MicroCannula can be used in canals that are enlarged with endodontic files to ISO size 55.04 or larger.95

During irrigation, the Master Delivery Tip delivers irrigant to the pulpal chamber and sinusoids of the excised root to prevent over-flow. Both the MacroCannula and MicroCannula evacuate apical pressure that pulls fresh irrigant from the chamber, delivering it into the tip of the cannula, into the cannula, and out through the suction hose. Thus, a constant of fresh irrigant is delivered by negative pressure to working length. A recent study showed that the volume of irrigant delivered was significantly higher than the volume delivered by conventional syringe needle irrigation throughout the same period,95 and resulted in significantly more debris removed from the root working length than did needle irrigation.95,96

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When comparing at 1.5 and 3.5 mm from working length using apical negative-pressure irrigation, it resulted in less debris remaining at 1 mm from the apical area. Biological, scanning electron microscope, light microscope, 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 drains irrigants to the source via suction—down the canal and simultaneously away from the apical tissue in abundant quantities. When 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. 

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 termination. 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.

One study found that apical negative-pressure irrigation resulted in less extrusion using the EndoVac for final irrigation in a closed root-canal system. When manual-dynamic agitation or the EndoActivator 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.10,11 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 with NaOCl were positive at 48 hours.99

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.10,10 In a study comparing the use of apical positive-pressure irrigation and a triple antibiotic that has been utilized for pulp regenerative/restoration 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 mineralized tissue formation and the repair process.10 Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discoloration, and allergic reactions.10,10

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