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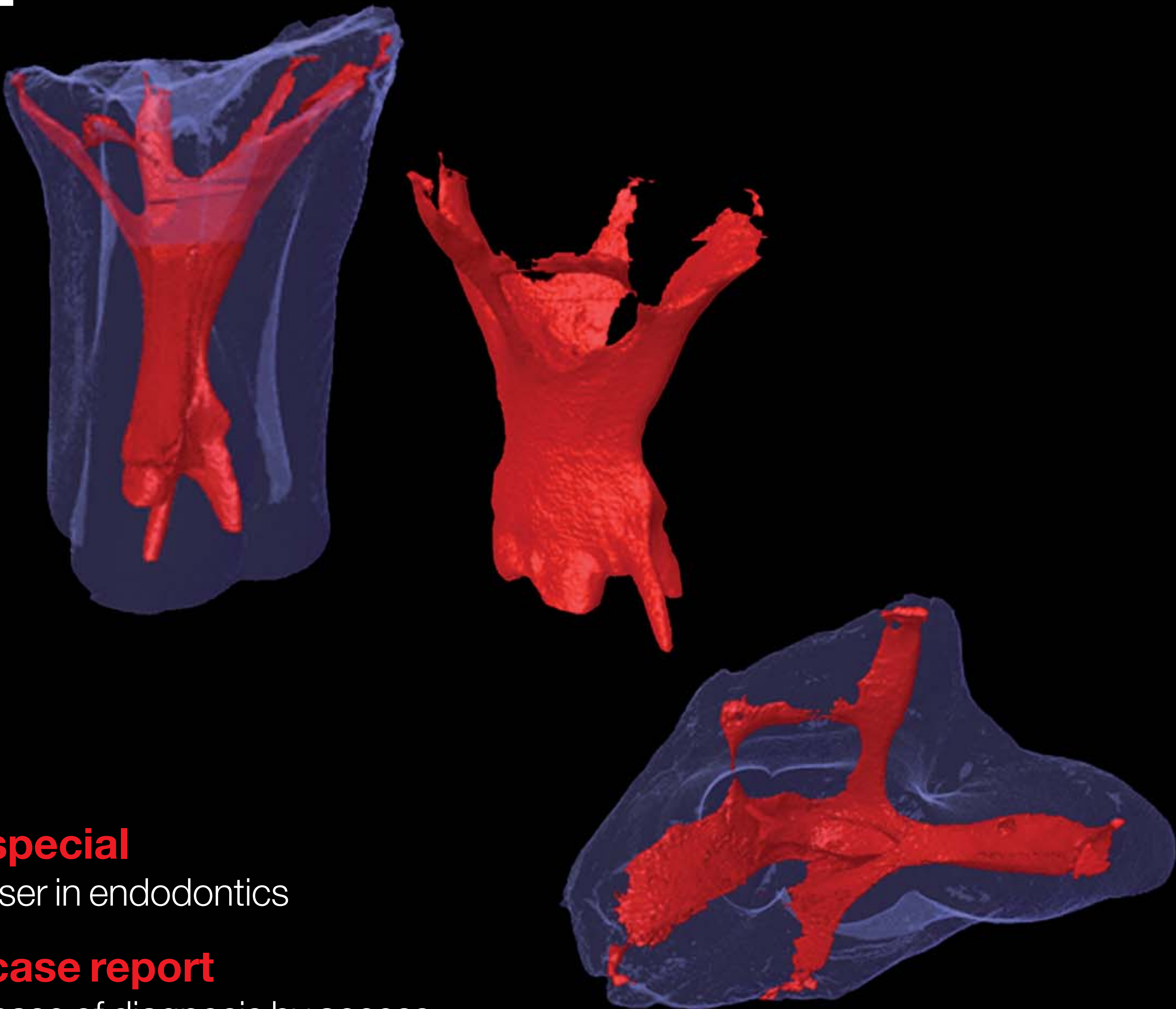

| special
Laser in endodontics

| case report
A case of diagnosis by access

| meetings
Record-breaking IDS 2011

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Dear Reader,

Dr Christian Gernhardt

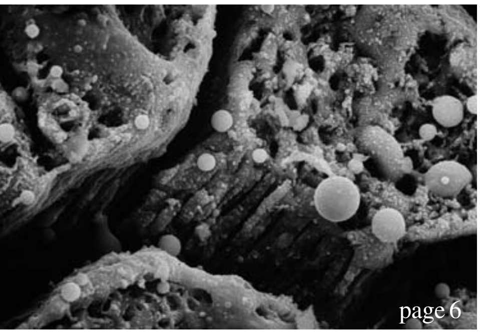
_**With the International Dental Show** in Cologne behind us, it seems the perfect time to look at recent developments and trends in endodontics. Even though the main principles of root-canal treatment—mechanochemical preparation of the root-canal system to remove pulp tissue and bacteria, 3-D obturation and adequate coronal restoration—have not changed, there have been a few remarkable developments in the form of systems that offer a completely new approach to root-canal preparation. Based on the established findings of the balanced force technique, new root-canal preparation techniques that use only one file with reciprocal motion have been introduced to the market. These new techniques may have the potential to make root-canal preparation easier for us and safer for our patients. However, at this point there are only a few published papers available to demonstrate the potential of these techniques. Therefore, further clinical studies are needed to corroborate the findings of these published studies in order to demonstrate the potential clinical benefit scientifically. In this regard, I am expecting there to be interesting information and publications over the next few months.

Furthermore, I would like to invite you to visit Germany this year. Following the intense efforts of the two leading endodontic societies in Germany, the German Endodontic Society and the German Society of Conservative Dentistry, the new German Society of Endodontology and Dental Traumatology (DGET), which is integrated into the German Society of Conservative Dentistry, was formed. The first annual meeting of the DGET will be held from 3 to 5 November 2011 in Bonn, Germany. The organising committee has invited a remarkable number of well-known international speakers and drawn up a clinically and scientifically interesting programme. It will be a great honour for us to welcome Profs Thomas Kvist, Markus Haapasalo, Syngcuk Kim, Marco Versani, Manoel Sousa-Neto, Junji Tagami and Roland Weiger, as well as Drs Arnaldo Castellucci and Roy Nesari to Bonn this year. For further information, please visit www.oemus.com.

It would be a great pleasure for us to welcome you to Bonn for the first annual DGET meeting!

Best wishes,

Dr Christian Gernhardt
Martin Luther University of Halle-Wittenberg
Department of Operative Dentistry and Periodontology
Halle (Saale), Germany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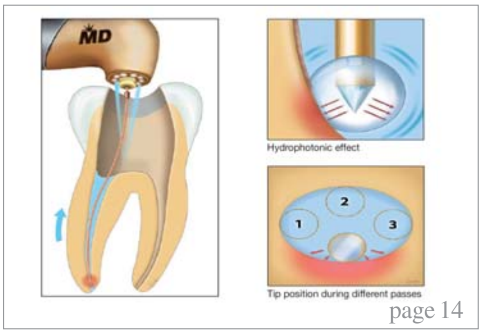

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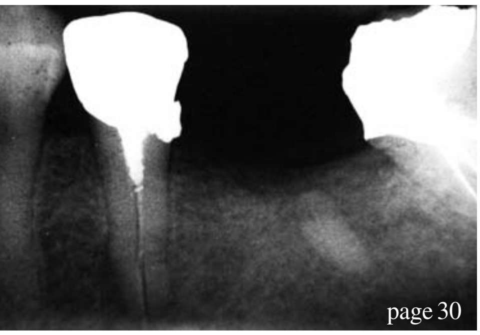
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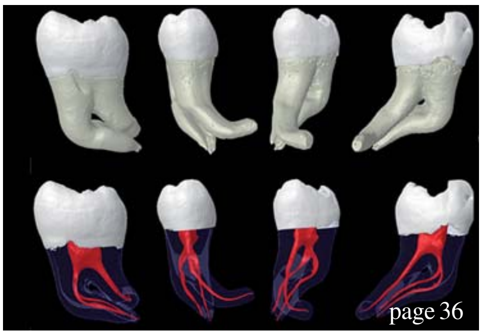
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Laser in endodontics (Part II)

Authors_ Prof Giovanni Olivi, Prof Rolando Crippa, Prof Giuseppe Iaria, Prof Vasilios Kaitsas, Dr Enrico DiVito & Prof Stefano Benedicenti, Italy & USA

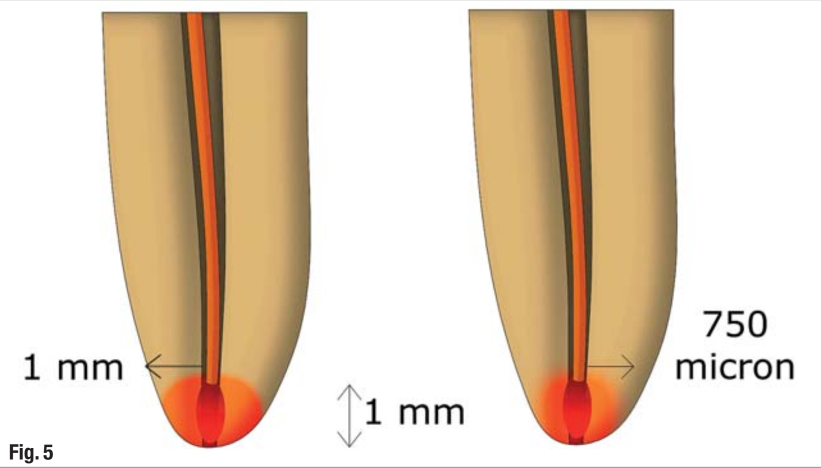


Fig. 5

Fig. 5_Localisation to 1 mm from the apex of the near infrared laser fibre and different penetration of the dentinal wall with Nd:YAG laser and diode 810 nm (on the right).

_After explaining the basic physics of the laser and its effects on both bacteria and dentinal surfaces, the second part of this article series will analyse some of the most important research in the international literature today and the new guidelines for the use of laser as a source of activation of chemical irrigants.

_Laser-assisted endodontics

Preparation of the access cavity

The preparation of the access cavity can be performed directly with Erbium lasers, which can ablate enamel and dentine. In this case, the use of a short tip is recommended (from 4 to 6 mm), with diameters between 600 and 800 µm, made of quartz to allow the use of higher energy and power. The importance of this technique should not be underestimated. Owing to its affinity to tissues richest in water (pulp and carious tissue), the laser allows for a minimally invasive access (because it is selective) into the pulp chamber and, at the same time, allows for the decontamination and removal of bacterial debris and pulp tissue. Access to the canal orifices can be accomplished effectively after the number of bacteria has been minimised, thereby avoiding the transposition of bacteria, toxins and debris in the apical direction during the procedure. Chen *et al.* demonstrated that bacteria are killed during cavity preparation up to a depth of 300 to 400 µm below the radiated surface.[20] Moreover, Erbium lasers are useful in the removal of pulp stones and in the search for calcified canals.

Preparation and shaping of canals

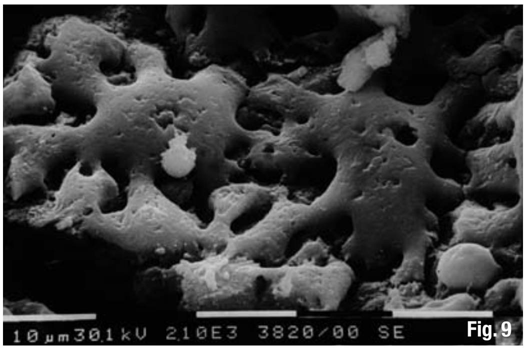
The preparation of the canals with NiTi instruments is still the gold standard in endodontics today. In fact, despite the recognised ablative effect of Erbium lasers (2,780 and 2,940 nm) on hard tissue, their effectiveness in the preparation of root canals appears to be limited at the moment and does not correspond to the endodontic standards reached with NiTi technology.[21–23] However, the Erbium,Chromium: YSGG (Er,Cr:YSGG) and the Erbium:YAG (Er:YAG)

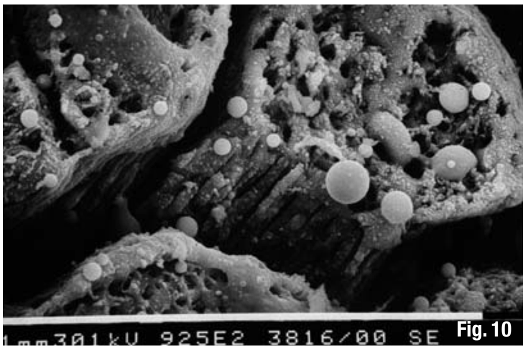

Fig. 6


Fig. 7


Fig. 8

Fig. 6_Radial firing tips for Er,Cr:YSGG laser.
Fig. 7_Undesirable thermal effects: during the retraction movement of the fibre of an Nd:YAG laser in a dry canal, contact with the dentinal wall can cause burns.
Fig. 8_Undesirable thermal effects: during the retracting movement of an Er,Cr:YSGG laser tip used according to a traditional method, the tip contacting the dry dentinal wall causes burns, ledging and transportation of canals.





Figs. 9 & 10_SEM images of radiated dentine with Nd:YAG laser (dry, 1.5 W, 15 Hz). Note the extensive areas of dentinal melting and bubbles. (Figures 9–16 courtesy of Prof Vasilios Kaitsas, Aristotle University of Thessaloniki, Greece.)

lasers have received FDA approval for cleaning, shaping and enlarging canals. A few studies have reported positive results for the efficacy of these systems in shaping and enlarging radicular canals. Shoji *et al.* used an Er:YAG laser system with a conical tip with 80 % lateral emission and 20 % emission at the tip to enlarge and clean the canals using 10 to 40 mJ energy at 10 Hz, obtaining cleaner dentinal surfaces compared with traditional rotary techniques.[24]

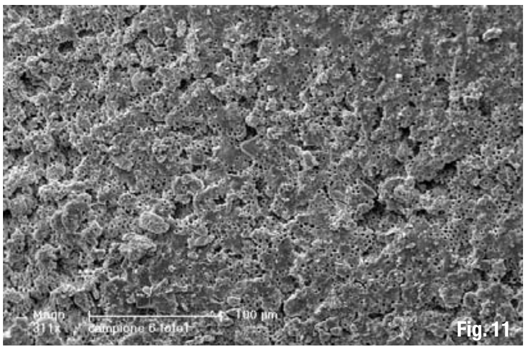
In a preliminary study on the effects of the Er:YAG laser equipped with a microprobe with radial emission of 200 to 400 µm, Kesler *et al.* found the laser to have good capability for enlarging and shaping in a faster and improved manner compared with the traditional method. The SEM observations demonstrated a uniformly cleaned dentinal surface at the apex of the coronal portion, with an absence of pulp residue and well-cleaned dentinal tubules.[25] Chen presented clinical studies prepared entirely with the Er,Cr:YSGG laser, the first laser to obtain the FDA patent for the entire endodontic procedure (enlarging, clearing and decontaminating), using tips of 400, 320 and 200 µm in succession and the crown-down technique at 1.5 W and 20 Hz (with air/water spray 35/25 %).[26, 27]

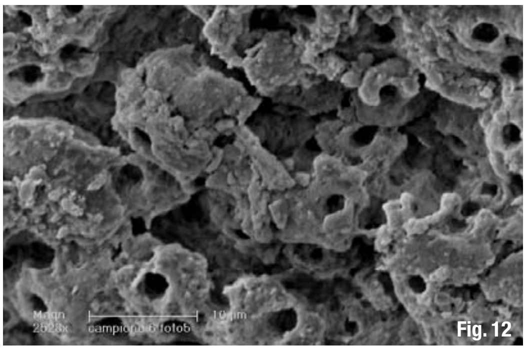
Stabholz *et al.* presented positive results of treatment performed entirely using a Er:YAG laser and endodontic lateral emission microprobes.[28, 29] Ali *et al.*, Matsuoka *et al.* and Jahan *et al.* used the Er,Cr:YSGG laser to prepare straight and curved canals, but in these cases, the results of the experimental group were worse than those of the control group. Using the Er,Cr:YSGG laser with 200 to 320 µm tips at 2 W and 20 Hz on straight and curved canals, they concluded that the laser radiation is able to prepare straight and curved (less than 10°) canals, while more severely curved canals demonstrated side-effects, such as perforations, burns and canal transportation.[21–23] Inamoto *et al.* investigated the cutting ability and the morphological effects of radiation of the Er:YAG laser *in vitro*, using 30 mJ at 10 and 25 Hz with a velocity of extraction of the fibre at 1 and 2 mm/seconds, again with positive results.[30] Minas *et al.* reported positive results using the Er,Cr:YSGG laser at 1.5, 1.75 and 2.0 W and 20 Hz, with water spray.[31]

The surfaces prepared with the Erbium laser are well cleaned and without smear layer, but often contain ledges, irregularities and charring with the risk of perforations or apical transportation. In effect, canal shaping performed by Erbium laser is still a complicated procedure today that can be performed only in large and straight canals, without any particular advantages.

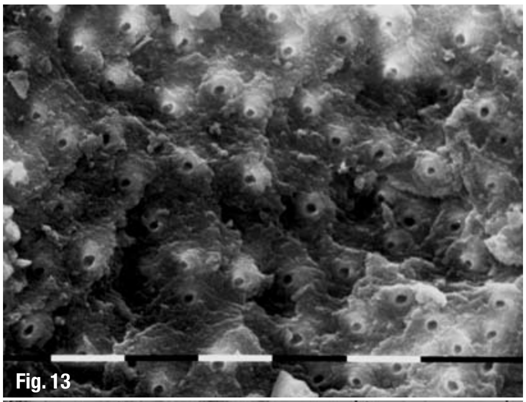
Decontamination of the endodontic system

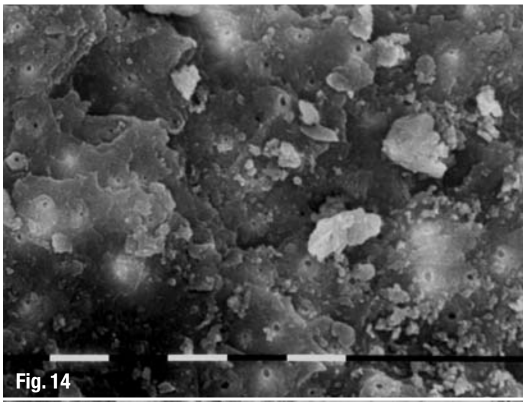
Studies on canal decontamination refer to the action of chemical irrigants (NaClO) commonly used in endodontics, in combination with chelating substances for better cleaning of the dentinal tubules (citric acid and EDTA). One such study is that of Berutti *et al.*, who reported the decontaminating power of NaClO up to a depth of 130 µm on the radicular wall.[32] Lasers were initially introduced in endodontics in an attempt to increase the decontamination of the endodontic system.[2–7]



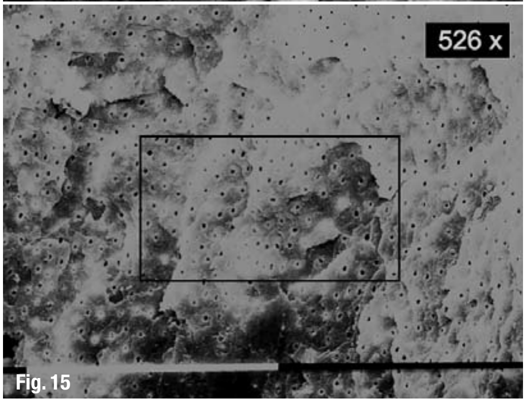


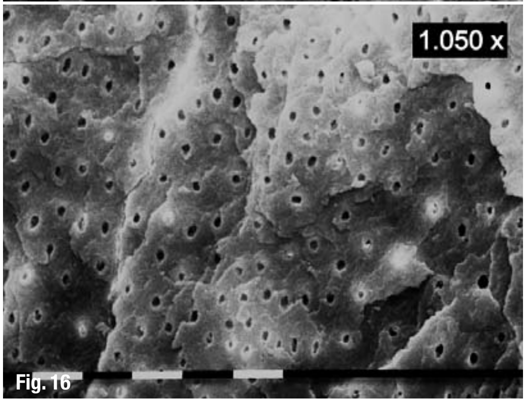
Figs. 11 & 12_SEM images of radiated dentine with diode 810 nm laser (dry, 1.5 W, 15 Hz) with 50 % ton-toff and 200 µm fibre, showing evidence of thermal effects, with detachment and smear layer.





Figs. 13 & 14_SEM images of irradiated dentine with Er,Cr:YSGG laser (1.0 W, 20 Hz, 1 mm to the apex), spray off and canal irrigated with physiological solution, showing evidence of smear layer and thermal damage.





Figs. 15 & 16_SEM images of irradiated dentine with Er,Cr:YSGG laser (1.5W, 20 Hz) with air/water spray of 45/35 %, showing open dentinal tubules without evidence of a smear layer. Note the typical pattern of laser ablation, both on the organic and inorganic dentine.

All the wavelengths have a high bactericidal power because of their thermal effect, which, at different powers and with differing ability to penetrate the dentinal walls, generates important structural modifications in bacteria cells. The initial damage takes place in the cell wall, causing an alteration of the osmotic gradient, leading to swelling and cellular death.[16, 34]

Decontamination with near infrared laser

Laser-assisted canal decontamination performed with the near infrared laser requires the canals to be prepared in the traditional way (apical preparation with ISO 25/30), as this wavelength has no affinity and therefore no ablative effect on hard tissue. The radiation is performed at the end of the traditional endodontic preparation as a final means of decontaminating the endodontic system before obturation. An optical fibre of 200 µm diameter is placed 1 mm from the apex and retracted with a helical movement, moving coronally (in five to ten seconds according to the different procedures). Today, it is advisable to perform this procedure in a canal filled with endodontic irrigant (preferably, EDTA or citric acid; alternatively, NaClO) to reduce the undesirable thermal morphological effects.[9, 35–38]

Using an experimental model, Schoop *et al.* demonstrated the manner in which lasers spread their energy and penetrate into the dentinal wall, showing them to be physically more efficient than traditional chemical irrigating systems in decontaminating the dentinal walls.[8] The Neodymium:YAG (Nd:YAG; 1,064 nm) laser demonstrated a bacterial reduction of 85 % at 1 mm, compared with the diode laser (810 nm) with 63 % at 750 µm or less. This marked difference in penetration is due to the low and varying affinity of these wavelengths for hard tissue. The diffusion capacity, which is not uniform, allows the light to reach and destroy bacteria by penetration via the thermal effects (Fig. 5).

Many other microbiological studies have confirmed the strong bactericidal action of the diode and Nd:YAG lasers, with up to 100 % decontamination of the bacterial load in the principal canal.[39–43] An *in vitro* study by Benedicenti *et al.* reported that the use of the diode 810 nm laser in combination with chemical chelating irrigants, such as citric acid and EDTA, brought about a more or less absolute reduction of the bacterial load (99.9 %) of *E. faecalis* in the endodontic system.[9]

Decontamination with medium infrared laser

Considering its low efficacy in canal preparation and shaping, using the Erbium laser for decontamination in endodontics requires the use of traditional techniques in canal preparation, with the canals prepared at the apex with ISO 25/30 instruments. The final passage with the laser is possible thanks to the use of long, thin tips (200 and 320 µm), available with various Erbium instruments, allowing for easier reach to the working length (1 mm from apex). In this methodology, the traditional technique is to use a helical movement when retracting the tip (over a five- to ten-second interval), repeating three to four times depending on the procedure and alternating radiation with irrigation using common chemical irrigants, keeping the canal wet, while performing the procedure (NaClO and/or EDTA) with the integrated spray closed.

The 3-D decontamination of the endodontic system with Erbium lasers is not yet comparable to that of near infrared lasers. The thermal energy created by these lasers is in fact absorbed primarily on the surface (high affinity to dentinal tissue rich in water), where they have the highest bactericidal effect on *E. coli* (Gram-negative bacteria), and *E. faecalis* (Gram-positive bacteria). At 1.5 W, Moritz *et al.* obtained an almost total eradication (99.64 %) of these bacteria.[44] However, these systems do not have a bactericidal effect at depth in the lateral canals, as they only reach 300 µm in depth when tested in the width of the radicular wall.[8]

Further studies have investigated the ability of the Er,Cr:YSGG laser in the decontamination of traditionally prepared canals. Using low power (0.5 W, 10 Hz, 50 mJ with 20 % air/water spray), complete eradication of bacteria was not obtained. However, better results for the Er,Cr:YSGG laser were obtained with a 77 % reduction at 1 W and of 96 % at 1.5 W.[42]

A new area of research has investigated the Erbium laser's ability to remove bacterial biofilm from the apical third,[46] and a recent *in vitro* study has further validated the ability of the Er:YAG laser to remove endodontic biofilm of numerous bacterial species (e.g. *A. naeslundii, E. faecalis, L. casei, P. acnes, F. nucleatum, P. gingivalis* or *P. nigrescens*), with considerable reduction of bacterial cells and disintegration of biofilm. The exception to this is the biofilm formed by *L. casei*.[47]

Ongoing studies are evaluating the efficacy of a new laser technique that uses a newly designed both radial and tapered stripped tip for removal of not only the smear layer, but also bacterial biofilm.[13] The results are very promising.

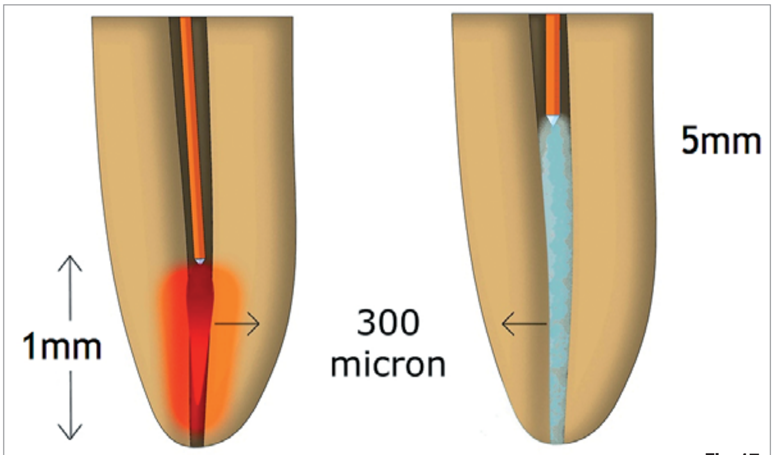


Fig. 17

The Erbium lasers with "end firing" tips—frontal emission at the end of the tip—have little lateral penetration of the dentinal wall. The radial tip was proposed in 2007 for the Er,Cr:YSGG, and Gordon *et al.* and Schoop *et al.* have studied the morphological and decontaminating effects of this laser system (Fig. 6).[48–50]

The first study used a tip of 200 µm with radial emission at 20 Hz with air/water spray (34 and 28 %) and dry at 10 and 20 mJ and 20 Hz (0.2 and 0.4 W, respectively). The radiation times varied from 15 seconds to two minutes. The maximum bactericidal power was reached at maximum power (0.4 W), with a longer exposure time, without water in dry mode and with a 99.71 % bacterial eradication. The minimum time of radiation (15 seconds) with minimum power (0.2 W) and water obtained 94.7 % bacterial reduction.[48]

The second study used a tip of 300 µm diameter with two different parameters of emission (1 and 1.5 W, 20 Hz), radiating five times for five seconds, with a cooling time of 20 seconds for each passage. The level of decontamination obtained was significantly high, with important differences between 1 and 1.5 W, with a thermal increase contained between 2.7 and 3.2 °C.[49] The same group from Vienna studied other parameters (0.6 and 0.9 W) that produced a very contained thermal rise of 1.3 and 1.6 °C, respectively, showing a high bactericidal effect on *E. coli* and *E. faecalis*.[50]

Fig. 17_Localisation 1 mm from the apex of the fibre and tips of the near and medium infrared lasers. According to the LAI technique, the tip must be localised in the middle third of the canal, approximately 5 mm from the apex (on the right).

Figs. 18–20_PIPS tip, radial firing, in quartz, 400 µ. The 3 mm terminals were deprived of their outer coating to increase the lateral dispersion of energy.


Fig. 18

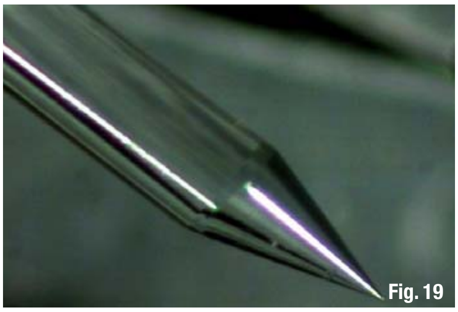


Fig. 19

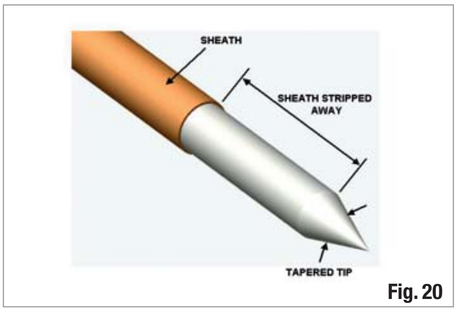
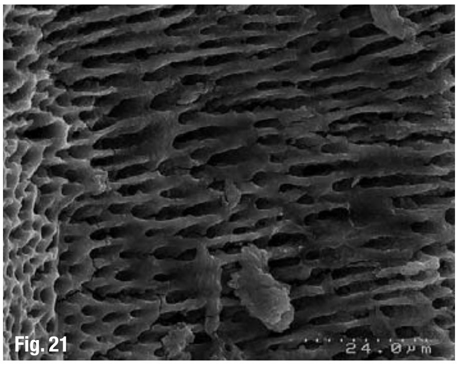
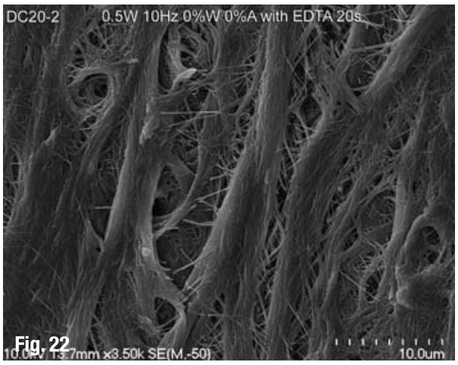
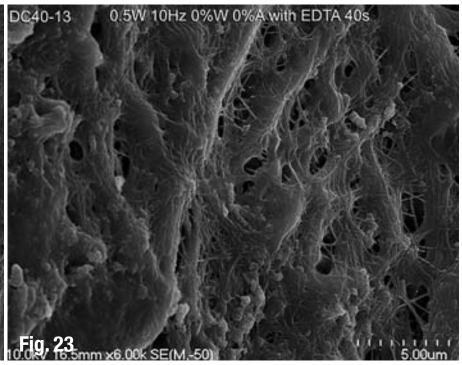


Fig. 20







Figs. 21–23_SEM images of radiated dentine with radial firing tip, at 20 and 50 mJ, 10 Hz for 20 and 40 seconds, respectively, in a canal irrigated with EDTA, showing noticeable cleaning of debris and smear layer from the dentine and exposure of the collagen structure. (Figures courtesy of Dr Enrico DiVito, USA.)

The need to take advantage of the thermal effect to destroy bacterial cells, however, results in changes at the dentinal and periodontal level. It is important to evaluate the best parameters and explore new techniques that reduce the undesirable thermal effects that lasers have on hard- and soft-tissue structures to a minimum.

Morphological effects on the dentinal surface

Numerous studies have investigated the morphological effects of laser radiation on the radicular walls as collateral effects of root-canal decontamination and cleaning performed with different lasers. When they are used dry, both the near and medium infrared lasers produce characteristic thermal effects (Figs. 7 & 8).[51] Near infrared lasers cause characteristic morphological changes to the dentinal wall: the smear layer is only partially removed and the dentinal tubules are primarily closed as a result of melting of the inorganic dentinal structures. Re-crystallisation bubbles and cracks are evident (Figs. 9–12).[52–55]

Water present in the irrigation solutions limits the thermal interaction of the laser beam on the dentinal wall and, at the same time, works thermally activated by a near infrared laser or directly vaporised by a medium infrared laser (target chromophore) with its specific action (disinfecting or chelating). The radiation with the near infrared laser—diode (2.5 W, 15 Hz) and Nd:YAG (1.5 W, 100 mJ, 15 Hz)—performed after using an irrigating solution, produces a better dentinal pattern, similar to that obtained with only an irrigant.

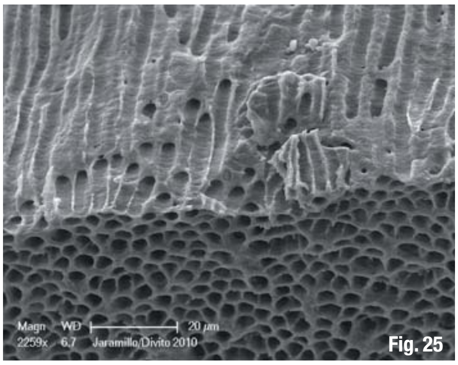
Radiation with NaClO or chlorhexidine produces a morphology with closed dentinal tubules and presence of a smear layer, but with a reduced area of melting, compared with the carbonisation seen with dry radiation. The best results were obtained when radiation followed irrigation with EDTA, with surfaces cleaned of the smear layer, with open dentinal tubules and less evidence of thermal damage.[35–38] In the conclusion of their studies on the Erbium laser, Yamazaki *et al.* and Kimura *et al.* affirmed that water is necessary to avoid the undesirable morphological aspects markedly present when radiation with the Erbium lasers is performed dry.[56, 57] The Erbium lasers used in this way result in signs of ablation and thermal damage as a result of the power used. There is evidence of ledge cracks, areas of superficial melting and vaporisation of the smear layer.

A typical pattern arises when dentine is irradiated with the Erbium laser in the presence of water. The thermal damage is reduced and the dentinal tubules are open at the top of the peri-tubular more calcified and less ablated areas. The inter-tubular dentine, which is richer in water however, is more ablated. The smear layer is vaporised by radiation with Erbium lasers and is mostly absent.[58–64] Shoop *et al.*, investigating the variations of temperature on the radicular surface *in vitro*, found that the standardised energies (100 mJ, 15 Hz, 1.5 W) produced a measured thermal increase of only 3.5 °C on the periodontal surface. Moritz proposed these parameters as the international standard of use for the Erbium laser in endodontics, claiming it as an efficient means of canal cleaning and decontamination (Figs. 13–16).[14,16]

Even with Erbium lasers, it is advisable to use irrigating solutions. Alternatively, NaClO and EDTA can be utilised during the terminal phase of laser-assisted endodontic therapy with a resulting dentinal pattern, with fewer thermal effects. This represents a new area of research in laser-assisted endodontics. Various techniques have been proposed, such as laser-activated irrigation (LAI) and photon-initiated photoacoustic streaming (PIPS).

Photo-thermal and photomechanical phenomena for the removal of smear layer

George *et al.* published the first study that examined the ability of lasers to activate the irrigating liquid inside the root canal to increase its action. In this study, the tips of two laser systems—Er:YAG and Er,Cr:YSGG (400 µm diameter, both flat and conical tips) with the external coating chemically removed—were used to increase the lateral diffusion of energy.



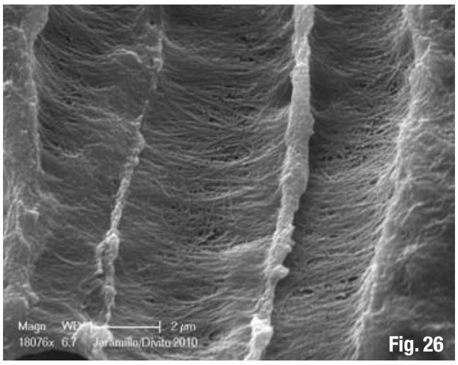


Fig. 24_SEM images of radicular dentine covered with bacterial biofilm of *E. faecalis* before laser radiation.

Figs. 25 & 26_SEM images of radicular dentine covered with bacterial biofilm of *E. faecalis* after radiation with Er:YAG laser (20 mJ, 15 Hz, PIPS tip) with irrigation (EDTA), showing destruction and detachment of bacterial biofilm and its complete vaporisation from the principal root canal and from lateral tubules. (Figures 25–29d courtesy of Drs Enrico DiVito and David Jaramillo, USA.)

The study was designed to irradiate the root canals that were prepared internally with a dense smear layer grown experimentally. Comparing the results of the groups that were laser radiated with the groups that were not, the study concluded that the laser activation of irrigants (EDTAC, in particular) brought about better cleaning and removal of the smear layer from the dentinal surfaces.[65] In a later study, the authors reported that this procedure, using power of 1 and 0.75 W, produces an increase in temperature of only 2.5 °C without causing damage to the periodontal structures.[66] Blanken and De Moor also studied the effects of laser activation of irrigants comparing it with conventional irrigation (CI) and passive ultrasound irrigation (PUI). In this study, 2.5 % NaClO and the Er,Cr:YSGG laser were used four times for five seconds at 75 mJ, 20 Hz, 1.5 W, with an endodontic tip (200 µm diameter, with flat tip) held steady 5 mm from the apex.

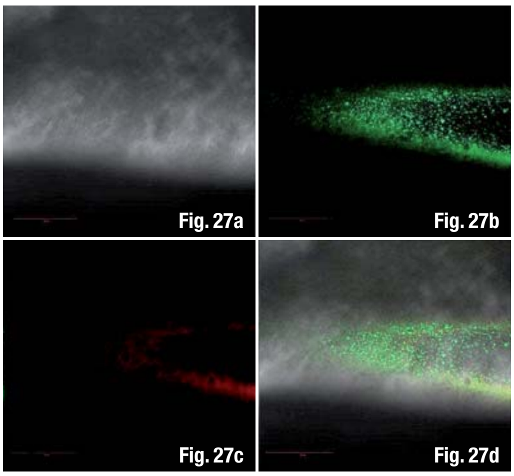
The removal of the smear layer with this procedure led to significantly better results with respect to the other two methods.[67] The photomicrographic study of the experiment suggests that the laser generates a movement of fluids at high speed through a cavitation effect. The expansion and successive implosion of irrigants (by thermal effect) generates a secondary cavitation effect on the intra-canal fluids. It was not necessary to move the fibre up and down in the canal, but sufficient to keep it steady in the middle third, 5 mm from the apex.[68] This concept greatly simplifies the laser technique, without the need to reach the apex and negotiate radicular curves (Fig. 17a).

De Moor *et al.* compared the LAI technique with PUI and they concluded that the laser technique, using lower irrigation times (four times for five seconds), gives results comparable to the ultrasound technique that uses longer irrigation times (three times for 20 seconds).[69] De Groot *et al.* also confirmed the efficacy of the LAI technique and the improved results obtained in comparison with the PUI. The authors underlined the concept of streaming due to the collapse of the molecules of water in the irrigating solutions used.[70]

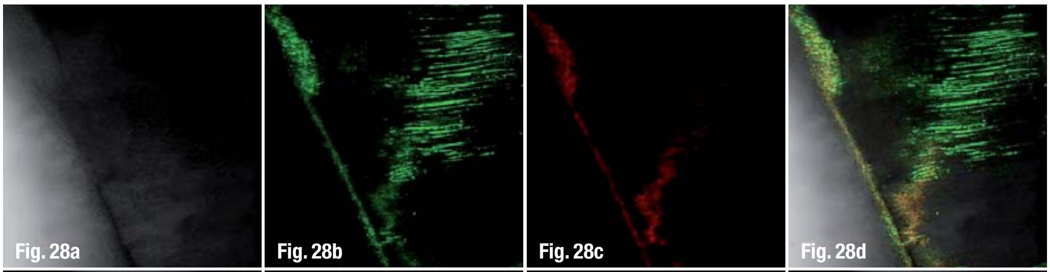
Hmud *et al.* investigated the possibility of using near infrared lasers (940 and 980 nm) with 200 µm fibre to activate the irrigants at powers of 4 W and 10 Hz, and 2.5 W and 25 Hz, respectively. Considering the lack of affinity between these wavelengths and water, higher powers were needed which, via thermal effect and cavitation, produced movement of fluids in the root canal, leading to an increased ability to remove debris and the smear layer.[71] In a later study, the authors also verified the safety of using these higher powers, which caused a rise in temperature of 30 °C in the intra-canal irrigant solution but of only 4 °C on the external radicular surface. The study concluded that irrigation activated by near infrared lasers is highly effective in minimising the thermal effects on the dentine and the radicular cement.[72] In a recent study, Macedo *et al.* referred to the main role of activation as a strong modulator of the reaction rate of NaOCl. During a rest interval of three minutes, the consumption of available chlorine increased significantly after LAI compared with PUI or CI.[73]

Photon-initiated photoacoustic streaming

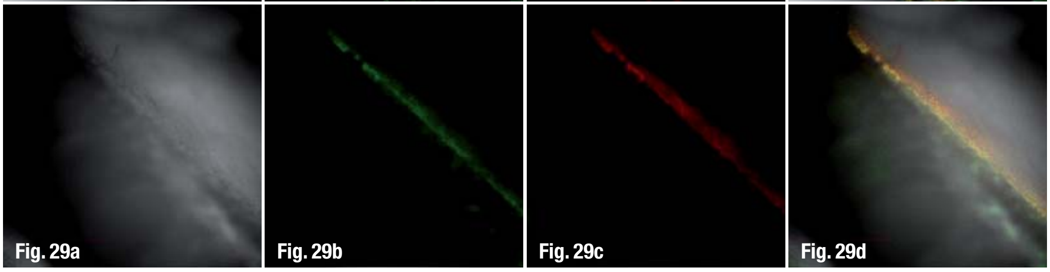
The PIPS technique presupposes the use of the Erbium laser (Powerlase AT/HT and LightWalker AT, both Fotona) and its interaction with irrigating solutions (EDTA or distilled water).[13] The technique uses a different mechanism from the preceding LAI. It



Figs. 27a–d_Confocal microscope images of the dentine of the root canal covered with biofilm (a). View in fluorescent light of bacterial biofilm (in green; b). Dentine auto-fluorescence (in red; c). 3-D view superimposed (d).



Figs. 28a–d_Confocal microscope images of the dentine of lateral tubules covered in biofilm (a). View in fluorescent light of bacterial biofilm (in green; b). Dentine autofluorescence (in red; c). 3-D view superimposed (d).



Figs. 29a–d_Confocal microscope image of dentine (a). Autofluorescence with no sign of bacteria (b & c). 3-D view superimposed (d).

exploits the photoacoustic and photomechanical phenomena exclusively, which result from the use of subablative energy of 20 mJ at 15 Hz, with impulses of only 50 µs. With an average power of only 0.3 W, each impulse interacts with the water molecules at a peak power of 400 W, creating expansion and successive "shock waves" and leading to the formation of a powerful stream of fluids inside the canal, without generating the undesirable thermal effects seen with other methodologies.

The study with thermocouples applied to the radicular apical third revealed only a 1.2 °C thermal rise after 20 seconds and 1.5 °C after 40 seconds of continuous radiation. Another considerable advantage is derived from the insertion of the tip into the pulp chamber at the entrance to the root canal only, without the problematic insertion of the tip into the canal or 1 mm from the apex required by the other techniques (LAI and CI). Newly designed tips (12 mm in length, 300 to 400 µm in diameter and with "radial and stripped" terminals) are used. The final 3 mm are without coating to allow a greater lateral emission of energy compared with the frontal tip. This mode of energy emission makes better use of the laser energy when, at subablative levels, delivery with very high peak power for each single pulse of 50 µs (400 W) produces powerful "shock waves" in the irrigants, leading to a demonstrable and significant mechanical effect on the dentinal wall (Figs. 18–20).

The studies show the removal of the smear layer to be superior to the control groups with only EDTA or distilled water. The samples treated with laser and EDTA for 20 and 40 seconds show a complete removal of the smear layer with open dentinal tubules (score of 1, according to Hulsmann) and the absence of undesirable thermal phenomena, which is characteristic in the dentinal walls treated with traditional laser techniques. With high magnification, the collagen structure remains intact, suggesting the hypothesis of a minimally invasive endodontic treatment (Figs. 21–23). The Medical Dental Advanced Technologies Group, in collaboration with the Arizona School of Dentistry and Oral Health (A. T. Still University), the Arthur A. Dugoni School of Dentistry (University of the Pacific), the University of Genoa and the University of Loma Linda's School of Dentistry, is currently investigating the effects of this root-canal decontamination technique and the removal of bacterial biofilm in the radicular canal. The results, which are forthcoming, are very promising (Figs. 24–29).

_Discussion and conclusion

Laser technology used in endodontics in the last 20 years has undergone an important development. The improved technology has introduced endodontic fibres and tips of a calibre and flexibility that permit insertion up to 1 mm from the apex. Research in recent years has been directed towards producing technologies (impulses of reduced length, "radial firing and stripped" tips) and techniques (LAI and PIPS) that are able to simplify the use of laser in endodontics and minimise the undesirable thermal effects on the dentinal walls, using lower power in the presence of chemical irrigants. EDTA has proved to be the best solution for the LAI technique that activates the liquid and increments its chelating capacity and cleaning of the smear layer. The use of NaClO increases its decontamination activity. Finally, the PIPS technique reduces the thermal effects and exerts a potent cleaning and bactericidal action thanks to its streaming of fluids initiated by the photonic energy of the laser. Further studies are necessary to validate these techniques (LAI and PIPS) as innovative technologies for modern endodontics._

Editorial note: Part I of this series was published in roots 1/11. A PDF of the article and a complete list of references are available from the publisher.

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The clinical use of the Er,Cr:YSGG laser in endodontic therapy

Author_ Dr Justin Kolnick, USA

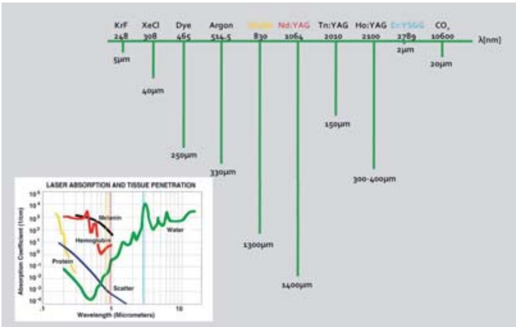

Fig. 1

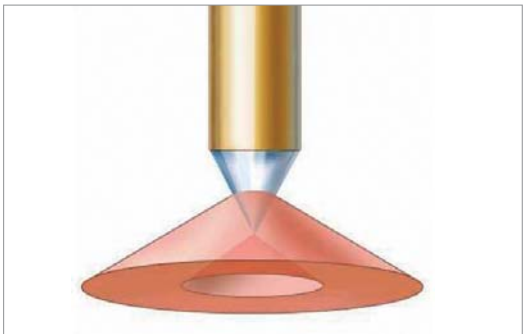

Fig. 2

Fig. 1_Comparison of different wavelengths used by lasers and their penetration depth in water/tissue. The higher the absorption, the greater the ability of the laser to cut or ablate tissue.

Fig. 2_Laser energy is emitted as a broad cone, providing better coverage of root-canal walls.

_Total elimination of bacteria from infected root-canal systems remains the most important objective of endodontic therapy. However, in spite of a plethora of new products and techniques, achieving this objective continues to elude our profession. Historically, endodontic treatment focused on root-canal disinfection with "entombment" of remaining bacteria within dentinal tubules and inaccessible areas of the root-canal system. Although many factors have been implicated in the aetiology of endodontic failures, it has become evident that these "entombed" bacteria play a pivotal role in the persistence of endodontic disease.[1]

Fig. 3_RFT2 (yellow) and RFT3 (blue) laser tips compared to hand files.

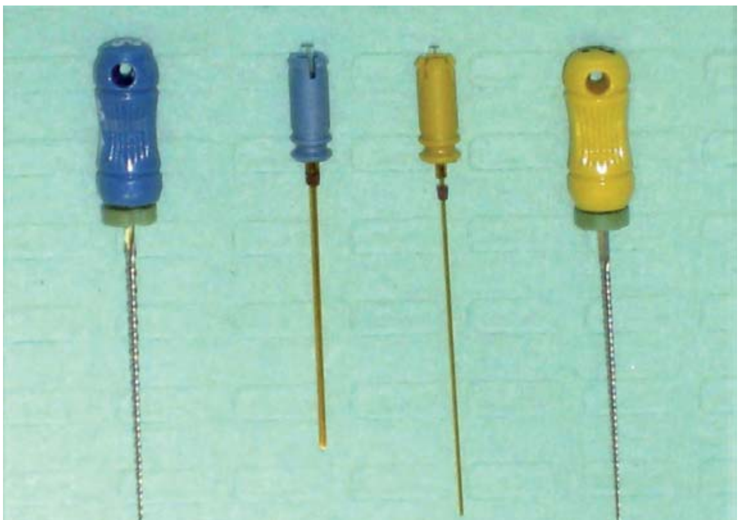

Fig. 3

Although impressive results have been obtained *in vitro*, laser energy alone has not been able to achieve total bacterial kill in extracted teeth. From a clinical perspective, it is apparent that a combination of different treatment modalities is required to sterilise root-canal systems. In addition, many clinical obstacles exist that further complicate the clinician's ability to achieve this goal. These include, but are not limited to: restricted endodontic access, complex root-canal anatomy, limitations of irrigation and instrumentation techniques, inability to entomb bacteria, and the inability to reach and eliminate bacteria deep within the tooth structure.

While the purpose of this article is to focus on the clinical use of the Er,Cr:YSGG laser with radial-firing tips, a definitive treatment protocol needs to be in place to reduce the intra-canal bacterial load prior to laser usage and to facilitate delivery of the

Fig. 4

Fig. 5

Fig. 4_Master delivery tip delivers irrigant to the pulp chamber and evacuates any overflow.

Fig. 5_True negative pressure apical irrigation and evacuation provided by macro- and micro-cannulas.

laser energy to the most critical part of the root canal, the apical third.

The erbium, chromium-doped yttrium, scandium, gallium and garnet (Er,Cr:YSGG) laser emits at a wavelength of 2,780 nm and is highly absorbed by water. The lower the penetration depth in water or tissue (or the higher the absorption), the greater the ability of the laser to cut or ablate tissue (Fig. 1). Since this wavelength is very similar to the absorption maximum of water in hydroxyapatite, photo-ablation occurs where water evaporates instantaneously, thereby ablating the surrounding tissue. Gordon *et al.* found that it was possible to achieve expansion and collapse of intratubular water as deep as 1,000 µm or more.[2] This micro-pulse-induced absorption was capable of producing acoustic waves sufficiently strong to disrupt and kill intratubular bacteria.

These findings are significant, as bacteria have been identified at depths of 1,000 µm, with *E. faecalis* at depths of 800 µm.[3,4] Irrigants such as sodium hypochlorite have a limited effect on these bacteria with penetration depths of only 100 µm.[5] Increasing concentration, exposure time and temperature was recently found to improve NaOCl penetration.[6]

Promising bacterial kill rates using the Er,Cr:YSGG laser with radial-firing tips have been reported in extracted teeth. A disinfection reduction of 99.7 % was obtained for *E. faecalis* at depths of 200 µm into dentine and 94.1 % (1 log) at depths of 1,000 µm.[2,7]

The development of the radial-firing laser tip (Biolase Technology, Inc.) with a tip shape that emits the laser energy as a broad cone allows better coverage of the root-canal walls than end-firing tips (Fig. 2). This facilitates entry of the emitted laser energy into the dentinal tubules reaching bacteria that have penetrated deep into the dentine.

_Treatment protocol

Current techniques incorporating hand and/or rotary instrumentation, positive pressure irrigation, with or without sonic and ultrasonic agitation, fall short of total canal disinfection. The treatment protocol presented in this article incorporates three main components: management of the working width of the root canal, negative pressure apical irrigation and intra-canal laser therapy.

Working width management

The working width (WW) of a root canal is the diameter of the canal immediately before its apical constriction. Allen found that 97 % of canals not cleaned to their WW had residual debris in the critical apical region, while 100 % of those cleaned to their WW were free of debris 1 mm from the apical constriction.[8] Studies have demonstrated that we need to clean to larger sizes to remove bacteria and debris.[9,10] Conventional tapered files cannot accomplish this without transporting the canal, creating strip perforations, weakening the tooth or separating instru-

Fig. 6_Laser removal of smear layer in apical third of canal (Biolase Technology; unpublished data).

Fig. 7_Single dentinal tubule after laser ablation (Biolase Technology; unpublished data).

Fig. 8_Accessory canal after laser ablation (Biolase Technology; unpublished data).

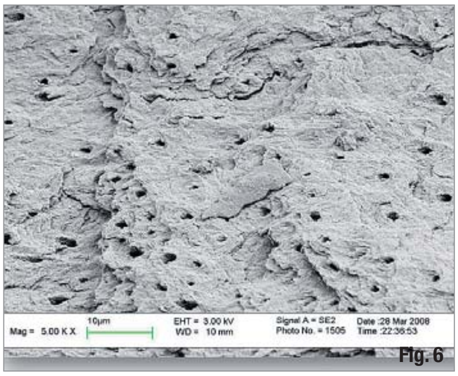

Fig. 6

Fig. 7

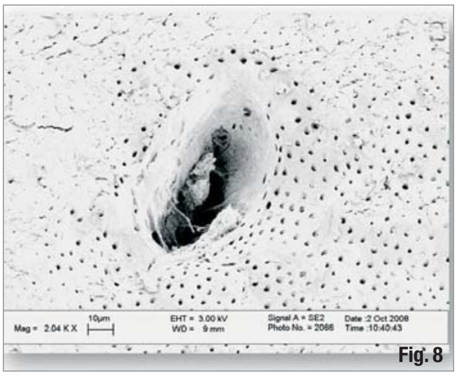

Fig. 8

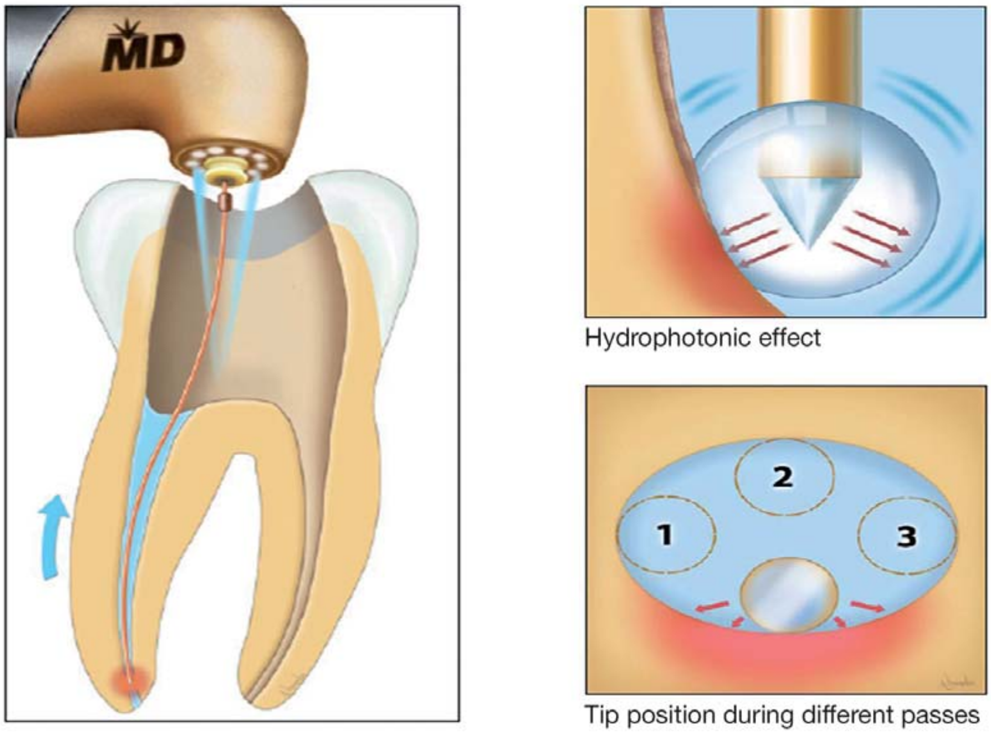

Fig. 9

Fig. 9_Technique for laser tip positioning in canal.

ments. The LightSpeed LSX (Discus Dental) file is a unique, extremely flexible, taperless, NiTi instrument capable of cleaning to the WW. The final apical size is the instrument size that completes WW preparation and is determined when the LSX file binds 4 mm (or more) from the working length (WL), and requires a firm push to reach WL. The customised apical preparations created are critical for predictably successful endodontics and provide significant advantages:

_effective removal of infected material, debris, inflamed and necrotic tissue from the apical region;
_allows placement of irrigating needle to WL for negative pressure apical irrigation;
_facilitates placement of intra-canal medication deeper within the canal; and
_facilitates placement of radial-firing laser tip within 1 mm of WL.

Negative pressure apical irrigation

There are two main reasons that irrigants fail to reach the critical last 3 mm of a root canal. Firstly, using positive pressure irrigation with a side-vented needle there is little flushing beyond the depth of the needle.[11] Most of the irrigant follows the path of least resistance and backs out of the canal, with apical flushing penetrating only 1 to 2 mm apical to the end of the needle. To achieve effective apical flushing, the needle tip needs to be placed 1 mm from WL, which dramatically increases the risk of a sodium-hypochlorite accident.

Secondly, the presence of apical vapour lock from air trapped in the canal, as well as ammonia and carbon dioxide released from the dissolving action of sodium hypochlorite on pulp tissue, prevents penetration of irrigants into the apical third. This vapour lock cannot be removed with hand or rotary files, sonic or ultrasonic activation. In a recent study, vapour lock resulted in "gross retention of debris and smear layer remnants" in the apical 0.5 to 1.0 mm of closed root-canal systems.[12]

The EndoVac (Discus Dental) is a true apical negative pressure irrigating system that provides continuous, high-volume irrigation of fresh fluids to the canal terminus with simultaneous evacuation. It is comprised of a master delivery tip (Fig. 3) that delivers fluid to the pulp chamber and a macro- and micro-cannula (Fig. 4) that draw the fluid from the chamber to the canal terminus by way of evacuation.

This system eliminates vapour lock and provides superior cleaning, disinfecting and smear layer removal, while virtually eliminating the threat of sodium hypochlorite accident.[13] When compared to positive pressure irrigation with a ProRinse needle, EndoVac produced canals that were 366 and 671 % cleaner 1 and 3 mm from WL, respectively.[14]

When EndoVac was used in combination with LightSpeed LSX instrumentation, canals were 99 and 99.5 % free of debris 1 and 3 mm from WL, respectively.[15]

Intra-canal laser therapy

The final stage of root-canal preparation and disinfection is completed with the Waterlase MD laser (Er,Cr:YSGG) using radial-firing tips (Biolase Technology).

The laser tips are available in two sizes: RFT2 and RFT3 with diameters of 275 and 415 µm, respectively (Fig. 5). The RFT2 tip is inserted 1 mm short of WL, requiring canal preparation sizes of ISO 30 or more while the RFT3 tip is inserted to the junction of middle and apical thirds, requiring canal sizes of ISO 45 or more. These sizes fall well within typical working width preparation sizes prepared with LSX files. Intra-canal laser therapy is performed in two phases, the Cleaning Phase for smear layer and debris removal, and the Disinfection Phase for tissue ablation and bacterial elimination.

Cleaning phase (1.25 W; 50 Hz; 24 % air; 30 % water)

This phase uses water and removes smear layer and debris without using chemical irrigants. It takes two to three minutes per canal and uses Hydro-Photonics to create a powerful micro-agitation effect throughout the canal system.

It is generally accepted that smear layer removal facilitates the cleaning and disinfecting of the dentinal tubules and improves the sealing of the root canal. When merging results of two studies, the Er,Cr:YSGG with radial-firing tips produced significantly better smear layer removal in the apical, middle and coronal thirds than two rotary techniques.[16,17] This extremely efficient action opens the dentinal tubules, lateral canals and isthmuses in preparation for disinfection (Figs. 6–8).

Technique for cleaning phase after completion of access, working width preparation and negative pressure irrigation:

_use the RFT2 to perform apical and partial coronal two-thirds cleaning;
_select the recommended laser settings in the wet mode;
_fill canal with sterile solution;
_insert RFT2 tip 1 mm short of WL;
_activate laser on withdrawal of tip coronally at approximately 1 mm/s and maintain tip in contact with the side surface of the canal wall during the entire apical to coronal pass;
_repeat steps 4 and 5 one or two more times to ensure that the entire inner canal has been cleaned (Fig. 9);
_place the RFT3 tip in handpiece to perform final cleaning of the coronal two-thirds;
_fill canal with sterile solution;
_insert the tip to the junction of apical and middle third of the root canal; and
_repeat steps 5 and 6.

Disinfection phase (0.75 W; 20 Hz; 10 % air; 0 % water)

As stated previously, the laser energy emitted from the Er,Cr:YSGG laser is highly absorbed by water in tissue and micro-organisms, resulting in instantaneous photo-ablation. In addition, the resulting micro-pulse expansion and collapse of intratubular water produce acoustic waves sufficiently strong to


Fig. 10


Fig. 11

Fig. 10_Upper premolar treated with laser protocol.
Fig. 11_Lower molar treated with laser protocol.


Fig. 12

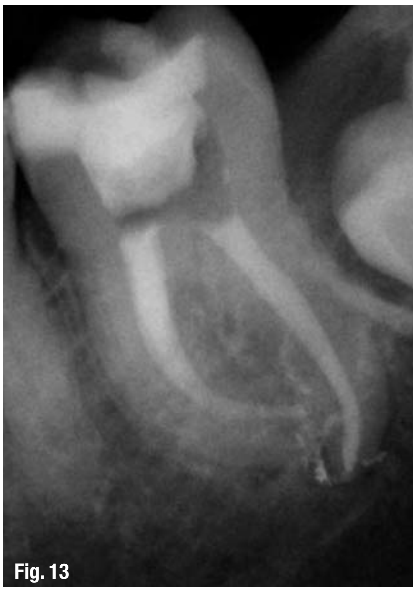
Fig. 13

Fig. 12_Lower premolar treated with laser protocol.
Fig. 13_Lower molar treated with laser protocol.

disrupt and kill intratubular bacteria. This effect is most effective in a dry mode, as the laser energy is not absorbed by the water spray and can exert its full effect on the bacteria. This was confirmed by Gordon *et al.*, who achieved a 99.7 % kill rate for *E. faecalis* in the dry mode.[2] Technique for the disinfection phase is the same as the cleaning phase but with different laser settings in the dry mode.

_Clinical applications

While this protocol is recommended for all endodontic treatments (Figs. 10–13), it is most valuable in the following clinical situations:

_infected cases with apical, lateral and/or furcal radiolucencies;
_retreatments with peri-apical periodontitis;
_acutely inflamed cases, especially those diagnosed with Cracked Tooth Syndrome;
_internal and external resorption;
_persistent infections not responding to conventional endodontic treatment; and
_unexplained, prolonged post-operative discomfort.

_Summary

A root-canal cleaning, shaping and disinfection protocol has been described that maximises the removal of tissue, debris, smear layer and bacteria from root-canal systems. Utilising a combination of working width management with LightSpeed LSX instruments, high-volume apical negative pressure irrigation and evacuation with the EndoVac system and intra-canal laser therapy with radial-firing tips using the Waterlase MD laser, the ability to eliminate bacteria from infected root-canal systems may soon be within our grasp._

_References

1. Siqueira JF, Rocas IN: Clinical Implications and Microbiology of Bacterial Persistence after Treatment Procedures. J Endod. 2008;34(11):1291–1301.
2. Gordon W, Atabakhsh VA, Meza F, Doms A, Nissan R, Rizoiu I, Stevens R: The antimicrobial efficacy of the erbium,chromium: yttrium-scandium-gallium-garnet laser with radial emitting tips on root canal dentin walls infected with Enterococcus faecalis. JADA. 2007;138(7):992–1002.
3. Kouchi Y, Ninomiya J, Yasuda H, Fukui K, Moriyama T, Okamoto H: Location of streptococcus mutans in the dentinal tubules of open infected root canals. J Dent Res. 1980;59:2038–46.
4. Haapasalo M, Orstavik D: In vitro infection and disinfection of dentinal tubules. J Dent Res. 1987;66(8):1375–9.
5. Berutti E, Marini R, Angeretti A: Penetration ability of different irrigants into dentinal tubules. J Endod. 1997;23:725–7.
6. Zou L, Shen Y, Li W, Haapasalo M: Penetration of Sodium Hypochlorite into Dentin. J Endod. 2010;36(5):793–6.
7. Schoop U, Barylyak A, Goharkhay K, Beer F, Wernisch J, Georgopoulos A, Sperr W, Moritz A: The impact of an erbium,chromium: yttrium-scandium-gallium-garnet laser with radial-firing tips on endodontic treatment. Lasers Med Sci. 2007;24(1):59–65.
8. Allen F: In vivo study of apical cleaning. General Dentistry. 2007;449–56.
9. Kerekes K, Tronstad L: Morphometric observations on root canals of human molars. J Endod. 1977;3:114–8.
10. Wu MK, R'oris A, Barkis D, Wesselink P: Prevalence and extent of long oval canals in the apical third. OOO. 2000;89(6):739–43.
11. Chow TW: Mechanical effectiveness of root canal irrigation. J Endod. 1983;9(11):475–8.
12. Tay FR, Gu L, Schoeffel GL, Wimmer C, Susin L, Zhang K, Arun SN, Kim J, Looney JW, Pashley DJ: Effect of Vapor Lock on Root Canal Debridement by using a Side-vented Needle for Positive-pressure Irrigant Delivery. J Endod. 2010;36(4):745–50.
13. Schoeffel J: The EndoVac Method of Endodontic Irrigation, Part 2–Efficacy. Dentistry Today. 2008;27(1).
14. Nielsen BA, Baumgartner JC: Comparison of the EndoVac System to Needle Irrigation of Root Canals. J Endod. 2007;33(5):611–5.
15. Prashanth VS: Evaluation of New System for Root Canal Irrigation to Conventional: An Ex Vivo Study. Discus Dental, Culver City, CA: The EndoFiles Newsletter. 2008.
16. Sung E, Rankin DD, Rizoiu I, Chueh P: Biolase Technology. unpublished study. 2008.
17. Peters O, Barbakow F: Effects of Irrigation on Debris and Smear Layer on Canal Walls: A Scanning Electron Microscopic Study. J Endod. 2000;26(1):6–10.

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Retreatment of a lower molar

Author_ Dr Konstantinos Kalogeropoulos, Greece


Fig. 1

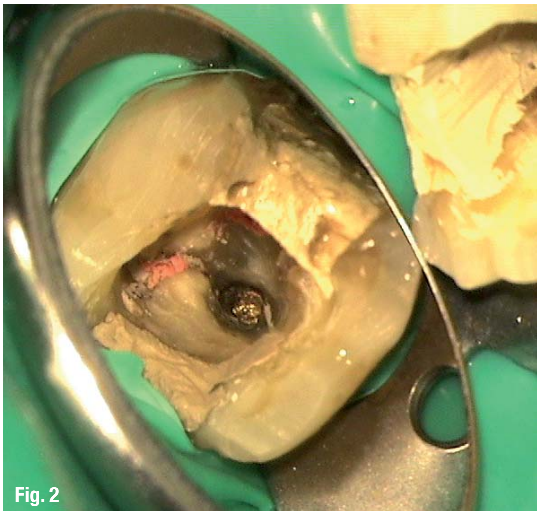
Fig. 2

_Endodontics is all about preserving the natural dentition. There is no better implant than the natural tooth, given the fact that it can be treated and restored effectively and predictably. Many factors, such as root perforation, affect the prognosis of endodontic treatment.[1] Today, perforations can be managed predictably with the use of MTA cement as sealing material.[2]

The purpose of this article is to illustrate the endodontic retreatment of a mandibular first molar with perforation in the coronal third of the mesiolingual root canal, aided by the use of magnification provided by the dental operating microscope (OM).

_Case report

A 61-year-old male patient, with a non-contributory medical history, was referred by a general dentist for retreatment of a mandibular first molar. The tooth was tender to percussion. Peri-apical radiolucency was evident in both roots and the furcation area. A previous root-canal treatment had been performed more than ten years ago. The canal filling was short in length and the remains of a screw post were present in the mesiolingual canal (Figs. 1 & 2). The treatment plan was to restore the tooth with a cast dowel and porcelain-fused-to-metal (PFM) crown.

After local anaesthesia had been administered, a rubber dam was placed and the temporary filling removed. The fragmented post was removed by means of ultrasonic tips under magnification (G6, Global Surgical). Owing to the vicinity of the post to the furcation, care was taken not to remove dentine distal to the post. The root-filling material apical of the post and from the orifices of the other root canals was also removed with ultrasonic tips. Observation under high magnification revealed a small perforation of the root-canal wall where the post was placed (Fig. 3). The patient and the referring dentist were informed that the tooth was to be retreated and the perforation defect sealed with MTA cement (DENTSPLY Maillefer).

A copious amount of irrigation (2.5 % NaClO) was used throughout the treatment. The root canals were

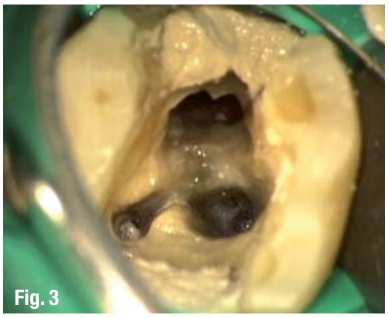
Fig. 3

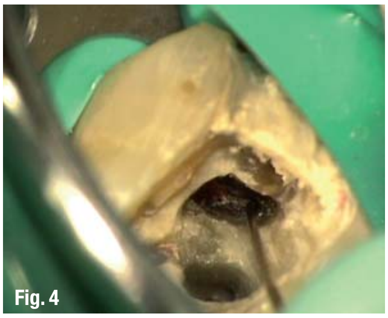
Fig. 4


Fig. 5

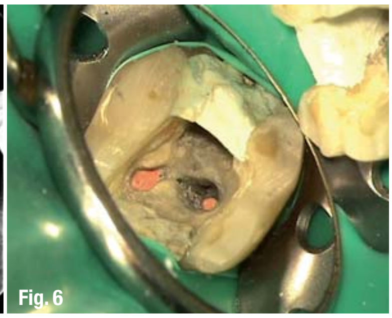
Fig. 6

flared with a combination of Gates-Glidden burs and rotary NiTi instruments. Under high magnification, an additional root-canal space was found in the distal root (Fig. 4). Remnants of the previous root-canal filling material were removed with a combination of hand files and rotary instruments, and patency was achieved with small stainless-steel hand files. Working length was calculated with an apex locator (Root ZX mini, J. Morita) and PathFile (DENTSPLY Maillefer) rotary instruments were used for pre-flaring.

The mesial root canals were instrumented to 40/.04 and the distal to 50/.04 with rotary instruments (BioRace, FKG). The smear layer was removed through one-minute irrigation with 17 % EDTA (Ultradent). Passive ultrasonic irrigation was performed with 2.5 % NaClO and ESI needles (EMS), three times for one minute each in every canal. The canals were dried and $Ca(OH)_2$ was placed with a Lentulo spiral (DENTSPLY Maillefer) as an intra-canal medicament. Cavit G (3M ESPE) was used as temporary filling material. The patient was given oral and written post-operative instructions and was told to return after 15 days.

At the second appointment, the anti-microbial irrigation regimen was repeated and the canals were dried with sterile paper points. Gutta-percha points were placed in the canals and a master-cone radiograph was taken (Fig. 5). The sealer used was AH Plus (DENTSPLY DeTrey). The continuous wave of condensation technique was applied during obturation with System B (SybronEndo) at 4 mm from the apical terminus of the canal, and back-filling was done with thermo-plasticised gutta-percha using the Obtura III Max (Obtura Spartan).

Care was taken not to accidentally push sealer into the perforation site. The mesiolingual root canal was back-filled to a level apical of the perforation (Fig. 6). After obturation, white MTA, delivered with the MTA gun (both DENTSPLY Maillefer), was used to seal the perforation site. As requested by the referring dentist, no post space was left in the distal root canal, as he wished to create his own space to place an intra-radicular post (Fig. 7). Cavit-G was used as temporary filling material. The patient was referred back to the dentist for the final restoration and was told to return after a six-month period for a recall examination.

At the recall appointment seven months later, the radiograph showed no evident radiolucency in the peri-radicular tissues of the tooth (Fig. 8). However, it also revealed that the new post had not been placed at the adequate length. The general dentist was contacted and reassured me that a new dowel and PFM crown would be placed.


Fig. 7


Fig. 8

_Conclusion

Advances in technology and biomaterials have not yet been proven to enhance overall success rates in endodontics.[3] Root perforations can affect prognosis in a negative way.[1] Nevertheless, the OM allows clinicians to work with great precision even under the most demanding circumstances,[4] and MTA greatly enhances success when treating perforations in the furcal area.[2] In addition, the use of ultrasonics under magnification facilitated the removal of the post despite its small size. Passive ultrasonic irrigation removed debris and necrotic tissue effectively from the mesial isthmus area, allowing obturation material to fill it, as can be observed in the final X-ray (Fig. 8)._

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

_about the author roots

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A case of diagnosis by access

Author_ Dr L. Stephen Buchanan, USA

Fig. 1_Pre-op radiograph showing a well-performed root-canal therapy on tooth #19 (conservative access preparation and coronal shapes, dense fills to each canal terminus). Tooth #20 was treatment planned for root-canal therapy after the patient's pain had not been alleviated by treatment of #19.

Fig. 2_Pre-op radiograph of the maxillary arch, showing relatively large pulp horns in the chambers of teeth #13, 14 and 15, with restorations near each of them.

_**She was related to my practice** neighbour, a good friend and a very talented oral surgeon (OS), and was visiting him in Santa Barbara for the holidays. She was experiencing intractable pain in her left facial region. Could I see her today?

Two weeks before, her general dentist had referred her to an endodontist, who treated the root canal in tooth #19. However, the pain continued to escalate thereafter and endodontic treatment of tooth #20 was his secondary treatment plan. Fortunately, she left before that tooth was invaded.

When I met her at my front desk, I questioned her about her chief complaint—the chronology, eliciting factors and the pain referral pattern of her symptoms. She stated that the pain had been intensifying for the last two weeks, was spontaneous in onset and, for the most part, she was not aware of thermal sensitivity.

The patient felt pain in her upper and lower left teeth and down her neck. I immediately thought that this might be a classic case of myofascial pain masquerading as an endodontic problem. While dying pulp will refer pain indiscriminately to both upper and lower jaws, it never refers pain below the lower border of the mandible or above the patient's cheekbone. I call it the endodontic zone (EZ). When asked whether she had any history of myofascial or joint pain, the patient informed me that her temporomandibular joint clicked and that she had an occlusal night guard, which she had not been wearing lately.

So, not reactive to thermal stimulus, pain referred outside the EZ and a history of temporomandibular dysfunction—interesting. I thought that I had diagnosed this case in my reception area and that I had the wonderful opportunity to tell the patient that she did not need another root-canal treatment.

My assistant took the patient back to an operatory, took conventional X-ray (Figs. 1 & 2) and CBCT images, and gathered clinical findings and pulp testing data. No peri-radicular pathosis was seen in any of the X-rays, cold tests of all teeth on the left side of the patient's face were within normal limits (WNL), and I was itching to find the myofascial trigger-point that had been making her miserable. I had her open half-way—as per Dr Janet Travel—then palpated her left masseter and temporalis muscles but they were stellar—surprising!

I then felt like I was in the "Twilight Zone" instead of the EZ. The patient had not reported thermal sensitivity and had pain referred beyond where dying pulp refers. But I was unable to reproduce the pain by palpating her muscles of mastication.

At this point, I had no option but to turn to my standard process of pulp testing to rule pulpitis out as the aetiology of her symptoms (although the previous endodontist had ruled out tooth #19). I did cold testing (with an H_2O ice pencil formed in an autoclaved empty anaesthetic carpule) on all of her teeth on the upper and lower left side of her face, and while they all responded WNL, teeth #18, 14 and 15 responded sharply, but transiently—not definitive by any means.

The possibility of more than one tooth being irreversibly inflamed was virtually zero. I still did not know what was going on, although tooth #14 was very slightly sensitive to biting pressure and percussion. It had been restored recently with composite and was nearly in crossbite and therefore more likely to be affected by bruxism.

Therefore, I was left to my best next move in these kinds of situations. I heat tested all of the upper and lower teeth (except #19 of course) with my System B Heat Source (SybronEndo). SybronEndo sells a special heat-testing tip for Touch 'n Heat and System B Heat Source that allows users to apply a sustainable heat stimulus to both quadrants of teeth in under a minute, with gutta-percha on the tip and the sources set to 200 °C.

In my experience, using sustainable sources of thermal stimuli to test pulp is the *sine qua non* of endodontic diagnosis. With transient sources of thermal stimuli—spray refrigerants and flame-heated gutta-percha—the temperature is never the same, which adds another variable to an already subjective data point. Additionally, it sometimes takes a bit of time to elicit a response when insulating acrylic, porcelain or calcification of the pulp chamber delays the response of a tooth with a relatively healthy pulp.

I tested teeth #18, 20, 21, 12 and 13 and achieved WNL responses (little or no response to heat is normal). However, when I heated #14, I reproduced the patient's chief complaint *exactly* and it had a prolonged effect. This was a huge relief and far better than having to say "I just don't know what is making your sister-in-law miserable." We scheduled the patient for an emergency appointment the next day, as her pain was at a manageable level when she had taken an adequate dose of ibuprofen and as my schedule was already full, with three other emergency appointments.

Fig. 3_CT axial view, showing the MB root of tooth #14 with two canals.

Fig. 4_CT sagittal view, of the MB root from the mesial direction. Note the common orifice of the MB1 and MB2 canals that immediately bifurcate and are apically confluent where the canal terminates in a severe curve in the hidden palatal plane.

My OS buddy called me the next morning to inform me that his sister-in-law was nervous about another possible misdiagnosis and erroneous treatment plan. In my mind, this concern qualified her as passing the IQ test. I repeated the thermal testing just to be certain that I was not going to be the second endodontist that would perform a needless root-canal treatment on a dentist's relative, while failing to resolve her chief complaint. Cold testing gave the same vanilla responses, but heat testing on the mesiobuccal (MB) line angle of #14 reproduced her pain, and it was also a bit more sensitive to percussion and bite.

I felt even more confident in my diagnosis when the patient's pain was totally alleviated by infiltration with 1.5 carpules of 2% lidocaine 1/100k epinephrine on the buccal side of tooth #14 and 0.5 carpule on the palatal side—given comfortably with extremely slow administration of the anaesthetic using the STA Anesthesia Delivery System (Milestone Dental)—in this very tight tissue.

As an aside: I really do not trust local anaesthesia as a diagnostic procedure. It is not specific enough to rule out a single tooth, it may mask adjacent myofascial aetiology and, after giving any local anaesthesia, further diagnostic work is not possible.

Fig. 5_CT sagittal view of the DB root from the mesial direction. Note the multiplanar curvatures ending in an apical bend to the hidden buccal direction.

Fig. 6_CT sagittal view of the palatal root, showing nearly perfect tapered canal shape.

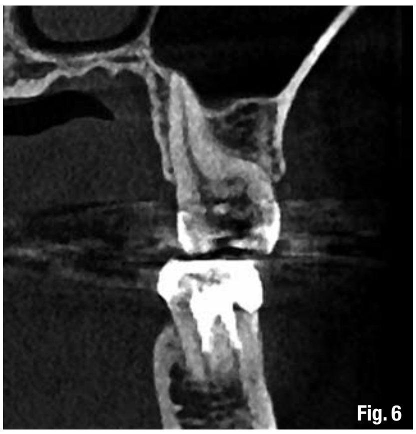



Fig. 7


Fig. 8

Fig. 7_Dental pulp extirpated from the palatal canal. A bent #25 broach was rotated as it was carefully inserted into the canal, after which it was gently and slowly removed with the intact pulp wrapped around it. Bending a #25 broach causes its mid-portion to sweep around the periphery of the canal wall of medium and large canals regardless of their size and taper, obviating the need for other sizes.

Fig. 8_Access cavity in tooth #14, showing the preparation limited to the mesial half of the occlusal surface. Note the Khademi Groove cut into the mesial wall for easier treatment of the MB2 canal—the only canal in the upper molars without an access line angle to guide instruments and materials. The small amount of time needed to cut this groove pays dividends throughout the procedure, especially during negotiation when lubricant is filling the access cavity.

As a confirmation of our definitive pulp testing results, however, the elimination of her symptoms after anaesthesia was good to see.

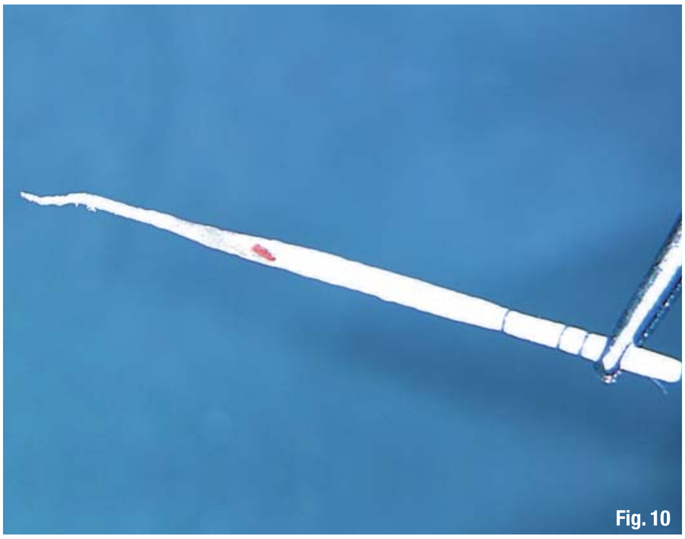
After anaesthesia had been confirmed by heat testing and percussion, tooth #14 was isolated with a rubber dam and an access cavity into the pulp chamber was cut. As was expected from the tooth's sensitivity to heat stimulus, the pulp was partially necrotic—the MB and distobuccal (DB) canals having fully degenerated tissue and the palatal canal pulp virtually intact (Fig. 7).

The volumetric images gathered with my Accuitomo (J. Morita) revealed that the MB root held two canals that diverged from a single orifice and then joined again in the apical third, where it appeared to have a severe palatal curve (Figs. 3–6). As I had learned from my friend and colleague Dr John Khademi, I cut a shallow MB2 groove in the mesial access wall to facilitate treatment of the only canal in the upper molars that does not have an access line angle dropping into it (Fig. 8).

All canals were negotiated with rotary NiTi instruments—first with a Vortex (DENTSPLY Tulsa) 15/.06 file to mid-root, followed by a Vortex 15/.04 to length in each canal except the MB1 and MB2, which required the more flexible PathFiles (DENTSPLY Tulsa) to reach the terminus owing to their abrupt apical curves. Rotary negotiation (in most cases without using hand files beforehand) has been a gratifying procedural upgrade in my practice. While I have not found the PathFiles to be dependable as first instruments in tight canals, Vortex files accomplish this in a way that is counter-intuitive to my previous paradigm (using # 8, 10 and then 15 K-files to length in the presence of a lubricant). By a fluke I found that in all but the most severely curved canals (of course those with impediments as well) these small Vortex instruments usually cut to length in less than a half-minute.

I am not exactly certain why Vortex files work so well for handpiece-driven negotiation, but my best guess is that their triangular cross-sectional geometry has enough space between the three cutting flutes to auger, rather than compact, vital pulp tissue from the apical thirds of small canals. I have yet to block a canal with these instruments, although I am very careful to stop using them at the slightest hint of apical resistance. If the 15/.06 meets resistance, I use the 15/.04. If the 15/.04 becomes stuck, I bring in hand files in sizes 08 and 10 C-files to length, and then I use the # 1, 2 and 3 rotary PathFiles to length (all 0.02 tapered with tip diameters of 0.13, 0.16 and 0.19 mm).

I used the Root ZX II (J. Morita) with all initial files taken to length, thereby knowing at all times when I had reached the termini, and obviating the need for a length determination X-ray. As usual, I used the straight apex locator probe instead of the test clip version. Even with hand files, I dislike the spring clip file probe, as it interferes with my tactile sense and it gets in the way of the rubber dam field. With rotary negotiation, the straight probe with its v-cut tip makes it very easy to pick up as estimated length is approached with the rotary negotiating file, and its tip notch rides smoothly on the rotating file. The final reason I prefer this probe set is because it is thinner and fits more easily between the stop and handle and it is very effective at positioning the stop exactly at the reference point once length has been indicated. An additional advantage of doing the initial negotiation procedure with Vortex 15/.06 and 15/.04 files is that with these tapers being greater than the typical 0.02 tapered hand files, there is less change in curved canal lengths during the shaping procedures to follow.



I *never* do initial negotiation procedures with NaOCl irrigant in the access cavity. While all the current apex locators work in the presence of conductive fluids, none of them work as well as when relatively non-conductive lubricants are used instead. NaOCl short-circuits the apex locator to metallic restorations and even without metal nearby, the readings in the presence of this irrigant are much less stable.

A note of caution: while non-landed shaping instruments are safe in the smallest sizes, I would not recommend using them for shaping canals. To prevent apical damage, I use only radial-landed rotary files (Fig. 9) to cut final shapes after initial negotiation. Final shapes were cut in the palatal canal with a single 30/.08 GTX File, with a 20/.06 and a 30/.06 GTX File in the DB canal, and three instruments in the apically curved MB canals. I cut a crown-down shape in these canals with first a 20/.06 and then a 20/.04 GTX File.

After confirming that there was apical continuity of taper in each canal, by using NiTi K-files as radial feeler gauges—this is done in the presence of 17% EDTA (to remove the smear layer)—my efforts turned to cleaning the root-canal system with preheated 6% NaOCl. I began by ultrasonically vibrating the irrigant with a #10 K-file taken 1 mm beyond the terminus—this prevents the micro-ledging that occurs when the vibrated file tip is held inside the apical third—for a couple of minutes in each canal, and then switched to active irrigation with the negative pressure EndoVac System (Discus Dental).

Despite heating the solution, using ultrasonication and a state-of-the-art delivery method, in an inflamed vital case like this I still feel that the NaOCl needs additional time to digest any tissue that may remain in lateral and accessory canals. Failure to clean the lateral aspects of root-canal systems containing severely inflamed pulp remnants adequately is what causes some of these patients to complain of persistent pain to biting and percussion despite apparently ideal root-canal treatment results evidencing no peri-radicular pathosis.

Obturation was accomplished after cleaning with the System B/Elements Obturation Unit (SybronEndo) using the Continuous Wave of Obturation Technique. Interestingly, when I was drying the palatal canal in preparation for cementing the pre-fit master cone of gutta-percha, the paper points were coming out soaked in blood. While this may be disconcerting to clinicians, it does not mean anything has necessarily gone awry, it just means that the bleeding must be stopped.

I soaked a paper point in 30% ferric sulphate (known by the brand name Cutrol or the pharmaceutical name Monsel's Solution), placed it to the end of the canal and a bit beyond, and after 10 or 15 seconds removed it, irrigated with NaOCl, gained patency with a K-file that could be passively placed beyond the terminus, and resumed drying the canal. Sometimes this must be done two or three times to staunch bleeding, but I have never seen it fail. In this case, while the paper point stopped absorbing blood at its tip, it continued to show a spot of blood in the middle of the cone (Fig. 10). The post-operative X-ray images revealed a lateral canal filled in the middle of the palatal canal (Figs. 11 & 12).

A piece of sponge and Cavit (3M ESPE) were placed in the access cavity and the patient was dismissed after post-operative images had been taken and instructions given. As usual, the patient also received enough Aleve to last four days at two tablets BID and instructions about managing her pain of myofascial origin (finally located as ema-

Fig. 9_Rotary GTX File with variable-width lands—thinner at the tip and shank, thicker in its middle region. This geometry optimises the radial lands to cut much more efficiently than rotary files with consistent-width lands, while maintaining identical fidelity to canal curvatures.

Fig. 10_Paper point used to dry the palatal canal, showing blood mark only on its middle region.

Fig. 11

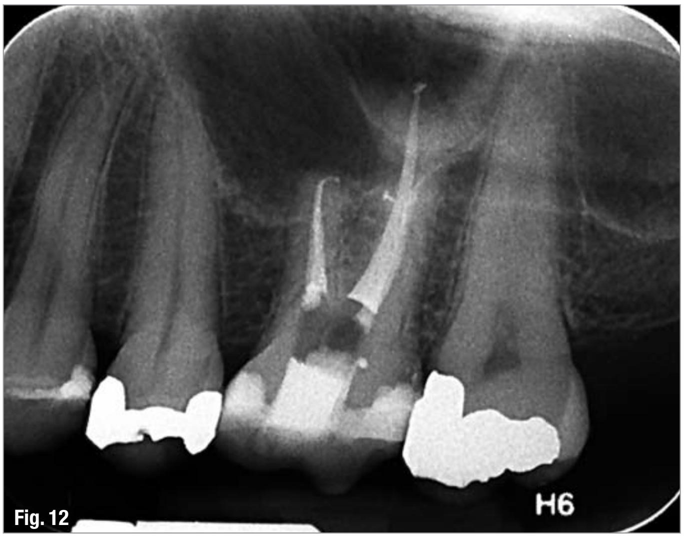


Fig. 12

Fig. 11_Post-op radiograph, revealing—to a limited degree—the multiplanar curvature of the DB canal and the apparently straight MB canal form. Note the conservative, mesially angulated access cavity preparation and the filling material in the distal pulp horn, which was intentionally left unroofed to preserve coronal tooth structure.

Fig. 12_Shallow, distally angulated post-op radiograph, revealing the severe apical curvature of the MB canal system and the mid-root lateral canal in the palatal canal that spotted the middle of the paper point in Figure 10 with blood.

nating from her left sternocleidomastoid muscle). A phone call four days later confirmed that she had no spontaneous pain referral, just the expected soreness to biting pressure.

So, looking back at this case, why the misdirection and wrong turns?

Firstly, my initial hypothesis about the aetiology of her chief complaint was misdirected by the lack of thermal sensitivity and by the pain she described in her neck region. Ironically, the patient did not relate thermal sensitivity because she does not care for really hot or cold foods or beverages and therefore had not thermally challenged tooth #14. As to the muscle tenderness outside the EZ, when I heard her describe this referral of pain below her mandible, I assumed she also had trigger-point myopathy in her masseter and temporalis muscles, the muscles that commonly refer pain *into* the EZ.

Regarding the first endodontist needlessly treating tooth #19 and failing to resolve the original aetiology of the patient's pain syndrome, it is a profound truth that endodontic disease becomes less obscure and easier to diagnose with time. Therefore, being the second one in on the case undoubtedly was an advantage at some level. With that said, a pulpal status like this one (partial necrosis) will return a WNL cold test response, albeit a delayed and vague one, virtually every time.

Interpreting sharp but transient responses to cold testing as indicative of irreversible pulpitis is a very common mistake. Until sharp, prolonged responses are seen—ideally with identical reproduction of the patient's pain—clinicians must obtain further pulp testing results outside of normal limits before they start diving into pulp chambers. In this case, every tooth—except #19 (no response) and 14 (delayed, vague)—responded in a very sharp but transient manner. I had no doubt that #19 responded the same way before it was treated, as evidenced by the endodontist's secondary treatment plan of accessing #20, a perfectly healthy tooth.

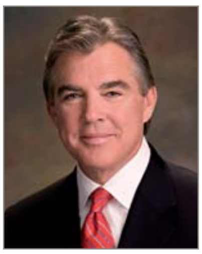
Partially necrotic pulp is nearly impossible to diagnose without using a sustainable source of heat. Classically, partially necrotic pulp responds to cold tests WNL, although sometimes cooling the tooth will alleviate the pain. Unless a heat stimulus is applied, thereby increasing the pressure inside the dead space, patients will be left in pain until the remaining pulp dies and clinicians will feel inclined to cut access cavities until the patient's pain is relieved.

We can and must do better than diagnosis by access._

Please visit www.endobuchanan.com for video clips of this case.

_about the author

roots



After 30 years, **Dr L. Stephen Buchanan** continues to enjoy his Santa Barbara, California, practice limited to conventional and microsurgical endodontics, as well as implant placement. He also teaches part-time at University of Southern California; University of California, Los Angeles; and every month in his state-of-the-art Santa Barbara teaching facility—Dental Education Laboratories.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"WaveOne is a simple system"

An interview with Dr Julian Webber, UK

Photos: Johannes Eschmann

_**The new WaveOne NiTi file system** from DENTSPLY Maillefer is a single-use, single-file system to shape the root canal completely from start to finish. Drs Julian Webber, Pierre Machtou, Wilhelm Pertot, Sergio Kuttler, Clifford Ruddle and John West were involved in the development, field testing and research associated with WaveOne. roots had the opportunity to speak to Dr Webber, The Harley Street Centre for Endodontics (London, UK), about the benefits of the system and the responses it received from visitors during IDS 2011.

_roots: Would you briefly describe the benefits of WaveOne to our readers?

Dr Julian Webber: WaveOne should initially benefit the many general dental practitioners who while desiring to move away from hand preparation of root canals to a simplified mechanical preparation technique have been reluctant to do so in the past. Dentists who have been reluctant to embrace rotary NiTi for fear of instrument breakage, as well as the excessive number of instruments and costs, will find WaveOne to be the perfect solution.

Using WaveOne is simple and involves only one file in many cases to shape the canal to length fully. As a single-file technique, it is reasonably priced compared with a sequence of files to prepare the root canal, which should be very appealing. We are talking about one file to produce a perfectly shaped root canal; and when the root canal is perfectly shaped, we can irrigate and clean it properly and then fill it properly.

_How exactly does the system work?

In most cases, the technique only requires one hand file followed by one single WaveOne file to shape the canal to length. The specially designed NiTi files work in a similar but reverse "balanced force" action, using a pre-programmed motor to move the files back and forth ("reciprocating motion"). The files are manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times compared with other brands of rotary NiTi files.

There are many dentists who are reluctant to use NiTi rotary instruments to prepare canals, despite the recognised advantages of flexibility, less debris extrusion and improved maintenance of canal shape, amongst other advantages. For them, the use of a single reciprocating file will be very attractive both in terms of time and cost saving.

_A general practitioner might get the impression that the WaveOne system makes root canals easy. Do you think encouraging this view might be cause for concern amongst endodontists?

Well, I have read this argument about making root-canal treatment simple. Many colleagues struggle with the complexities of root-canal treatments and I do not see why we can't make it simpler. Any competent dentist has good manual skills. If we can simplify the treatment procedure for general dentists and thereby improve their skills in completing more root-canal treatments to a higher standard, our patients will surely benefit. If you look at the majority of root-canal instruments and the many preparation systems available in today's market, as many as three to five files may be needed to produce a perfectly shaped canal. However, with WaveOne, one file is needed to get to that shape. It's so simple! It's simple to understand, it's simple to use and it's simple to teach.

_What sort of response to the system have you had this far?

People have been very excited by the concept of a single-file system. Yes, root-canal treatment is difficult for many and causes much anxiety, but the majority of people who tried out the technique at the stand during IDS were able to appreciate the simplicity and the benefits of WaveOne for themselves. There was a big buzz around the stand.

_Is the WaveOne system already available in Europe and North America?

Yes, it was launched on 10 February in Europe and in North America at the April meeting of the American Association of Endodontists in San Antonio.

_Will there be courses offered so dentists can learn how to use the WaveOne system?

DENTSPLY Maillefer has a great continuing education programme, and they work with all their dealers in the countries in which their products are for sale by holding events. In Europe, I will be travelling extensively, with some courses coming up in Bulgaria, the Czech Republic, Poland, Slovakia and Spain, which are organised by the local DENTSPLY dealers.

DENTSPLY is also very involved with dental schools, so there will be some great teaching going on in different venues. We have a team of six involved in WaveOne. There are Pierre Machtou and Wilhelm Pertot from Paris and me in London. In the USA, there are Sergio Kuttler from Fort Lauderdale, John West from Seattle and Clifford Ruddle from Santa Barbara. So hopefully, amongst the six of us, we should be able to get this exciting message out to our dental colleagues._

Key principles that enhance success when restoring endodontically treated teeth

Authors_ Dr Nadim Z. Baba & Dr Charles J. Goodacre, USA

_**Restoring endodontically treated teeth** and retaining them throughout life remains a challenge. Several factors play a key role in the long-term survival of endodontically treated teeth and associated restorations. The purpose of this article is to identify the key principles that affect tooth and restoration survival.

_Principle #I

Most endodontically treated posterior teeth should be restored with crowns to enhance their longevity.

Clinicians have observed a difference between endodontically treated teeth and vital teeth. Endodontically treated teeth fracture more often than vital teeth: they tend to break during extraction and pulpless molars without crowns can fracture.[1,2]

Multiple studies have shown that endodontically treated teeth benefit from the placement of crowns. One study determined that endodontically treated teeth without crowns were lost at six times the rate of those with crowns.[3] Another study demonstrated that endodontically treated teeth without crowns were lost after an average time of 50 months, whereas endodontically treated teeth with crowns were lost after an average time of 87 months.[4] Fixed partial dentures have increased clinical failure when supported by endodontically treated abutment teeth compared with vital abutment teeth.[1, 5–8] However, while crowns significantly improved the success of endodontically treated posterior teeth it has not been shown that they improve the success of anterior teeth.[9] Therefore, intact or minimally restored endodontically treated anterior teeth do not need complete coverage by a crown. They only need a crown when they are weakened by large and/or multiple coronal restorations or when they require significant colour/form changes that cannot be managed by a more conservative treatment.[10]

In contrast with the above studies, a group of researchers[11] found similar success rates when they evaluated endodontically treated premolars restored with a post and direct composite resin restorations both with and without complete coverage. Similarly, a retrospective cohort study[12] indicated that endodontically treated molars that are intact, except for the access opening, could be restored successfully using composite resin restorations.

After considering the available data, we recognise the potential benefits of using composite resin to restore posterior teeth that are intact except for a conservative access opening. However, more clinical data is needed that identifies the long-term success of these teeth when occlusal wear and heavy forces or para-functional habits are present. For this reason, we recommend that endodontically treated teeth that have been previously restored receive crowns that encompass the cusps because of the occlusal forces that will be applied to cusps that have been weakened by previous tooth structure removal. Conversely, it may be possible to avoid crowns on some previously restored posterior teeth with only conservative access openings and little to no wear visible that would indicate the presence of detrimental occlusal forces. Another example of a tooth that may not need a crown is a mandibular first premolar, which typically has a small, poorly developed lingual cusp and a lack of occlusal interdigitation that might spread the cusps apart and induce fracture.[13]

_Principle #II

Posts do not reinforce endodontically treated teeth. Their only purpose is to retain the core.

Historically, the use of posts was based on the concept that they reinforce teeth. Virtually every laboratory study has shown that either posts do not reinforce teeth or they decrease the fracture strength resistance of the tooth when a force is applied via a mechanical testing machine.[14–24] Additionally, studies have compared the fracture resistance of endodontically treated extracted teeth without posts or crowns with the fracture resistance of teeth restored with posts, cores and crowns. Maxillary incisors, without posts, resisted higher failure loads than the other groups with posts and crowns,[16] and mandibular incisors with intact natural crowns exhibited greater resistance to transverse loads than teeth with posts and cores.[17] These studies show no evidence that posts have a strengthening reinforcement effect (Fig. 1).

Clinical studies have also failed to provide definitive support for the concept that posts strengthen endodontically treated teeth.[2, 10, 25, 26] When the radiographs of 200 consecutively treated patients were examined several years after endodontic treatment, it was determined that teeth with posts had significantly more apical periodontitis.[2] An analysis of data from multiple clinical studies noted that 3 % of teeth with posts fractured and found no evidence that posts enhanced the survival of teeth.[26] Posts have had little enhancing effect on the clinical success of fixed partial denture abutments, but they have improved the clinical success of removable partial denture abutments compared with endodontically treated abutments where no posts were used.[10]

Since clinical and laboratory data indicate that teeth are not strengthened by posts, their purpose is the retention of a core that will provide adequate retention and support for the definitive crown or prosthesis. Unfortunately, this primary purpose has not been completely recognised. A survey demonstrated that 24 % of general dental practitioners felt that posts strengthen the teeth.[27] Another survey found that 62 % of dentists over the age of 50 believed that posts reinforce the teeth (39 % of part-time faculty, 41 % of full-time faculty and 56 % of non-faculty practitioners), whereas only 41 % of dentists under the age of 41 did not believe this.[28] An additional survey found that 29 % of general dental practitioners felt that posts reinforced the teeth, and 17 % of board-certified prosthodontists in Sweden believed this too.[2]

Fig. 1

Fig. 1_A radiograph of a fractured maxillary second premolar with a metallic prefabricated post.

Since posts do not reinforce a tooth, they should only be used when the core cannot be retained by some other means.

_Principle #III

The radiographic minimal length of gutta-percha should be 5 mm to ensure an adequate apical seal.

After the preparation of an endodontically treated tooth to receive a post, the remaining gutta-percha at the apex is a barrier against the passage of bacteria to the peri-apical area. Several studies[29–31] have found that there is greater leakage when only 2 to 3 mm of gutta-percha is present, but that the preservation of 4 to 5 mm of gutta-percha ensures an adequate seal.[21, 31, 33–35] Although multiple studies have indicated that 4 mm produces an adequate seal, stopping precisely at 4 mm is difficult and radiographic variations in angulation could lead to retention of less

Fig. 2

Fig. 3

Fig. 2_A radiograph of an excessively long parallel-walled post in a maxillary first premolar with a less than ideal amount of gutta-percha remaining at the apex.

Fig. 3_A very short post in the root of a maxillary second premolar.

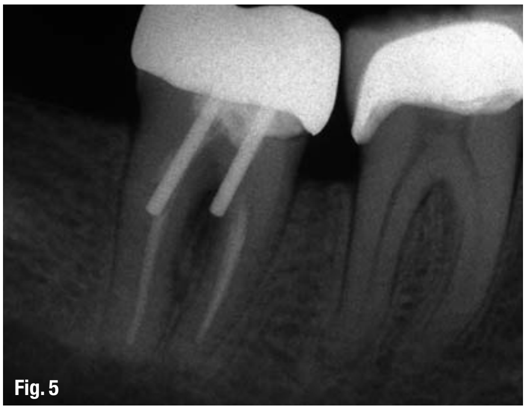

Fig. 4_A threaded post in a mandibular second premolar that caused a root fracture.
Fig. 5_Perforation of the roots of a mandibular second molar, the result of post space preparation with instruments not held parallel to the root canals.

than 4 mm. Therefore, 5 mm appears to be a safer minimal radiographic length than 4 mm (Fig. 2).

The best method of preserving the apical seal during preparation of a post space is use of the working length determined during endodontic treatment. The same reference point on the tooth used during endodontic therapy should be used during the post preparation. Additionally, a canal preparation instrument with an appropriate diameter should be used in conjunction with a rubber stopper placed around the instrument at the proper location to help ensure that an adequate amount of gutta-percha is retained apically.

Three methods have been advocated for removal of gutta-percha during preparation of a post space without disturbing the apical seal: chemical, thermal and mechanical.[29, 32, 36–39] It has been determined that both hot hand instruments and rotary instruments can be safely used to remove condensed gutta-percha adequately when 5 mm is retained apically.[29, 32, 3–39]

The immediate removal of gutta-percha after endodontic treatment has also been studied for its effect on the apical seal. Several studies have determined that the removal of gutta-percha immediately after root-canal treatment has no detrimental effect on the apical seal.[30, 31, 33, 36, 40]

_Principle #IV

The optimal post length for all teeth, except molars, is determined by retaining 5 mm of apical gutta-percha and extending the post to the gutta-percha. For molars, only the primary root should be used and it should not extend more than 7 mm into that root. Short posts should be avoided.

The appropriate length for a post should be based on minimising the potential for damage to the tooth, optimising post retention and maintaining an appropriate apical seal for the root-canal filling. Several length guidelines have been proposed.[41–45] A review of scientific data provides the basis for differentiating between these varied guidelines.

While short posts have never been advocated, studies have shown that they are frequently observed on radiographs (Fig. 3). It was found that only 34 % of 327 posts were as long as the inciso-cervical length of the crown.[46] An evaluation of 200 endodontically treated teeth, determined that only 14 % of posts were two-thirds or more of the root length.[47] Another radiographic study of 217 posts determined that only 5 % of the posts were two-thirds to three-fourths of the root length.[48] Root fractures caused by high stresses occur more frequently when short posts are used,[23, 49–52] whereas increasing the length of a post increases the root fracture resistance.[21]

It was determined that posts that are three-fourths of the root length offered the greatest rigidity and produced the least root deflection.[21] However, use of this apparently optimal post length is difficult with many teeth. When a tooth has an average or below average root length and the post occupies two-thirds or more of the root length, it is not possible to retain 5 mm of gutta-percha at the apex.[54] Therefore, optimal post length is determined by retaining 5 mm of apical gutta-percha and extending the post to that depth.

The use of this post length guideline is appropriate for all teeth, except molars. A study of 150 extracted maxillary and mandibular molars determined that molar post spaces should not be prepared more than 7 mm apical to the orifice of the root canal in the primary roots (the distal root of mandibular molars and the palatal root of maxillary molars) because of the increased likelihood of root perforation.[55] Secondary roots (facial roots of maxillary molars and mesial roots of mandibular molars) cannot even accommodate posts that are 7 mm long without excess root thinning and the potential for perforation or root fracture after restoration. Therefore, molar posts should not extend more than 7 mm into the primary roots and secondary roots should be avoided whenever possible.

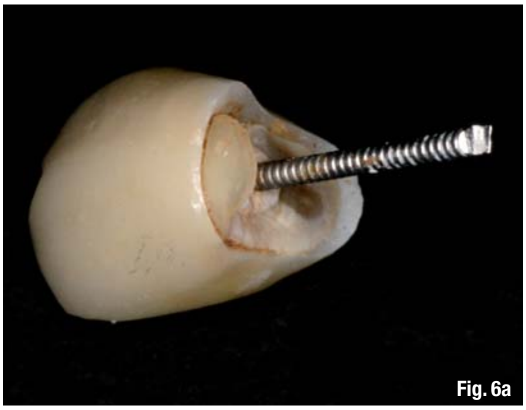
Fig. 6a

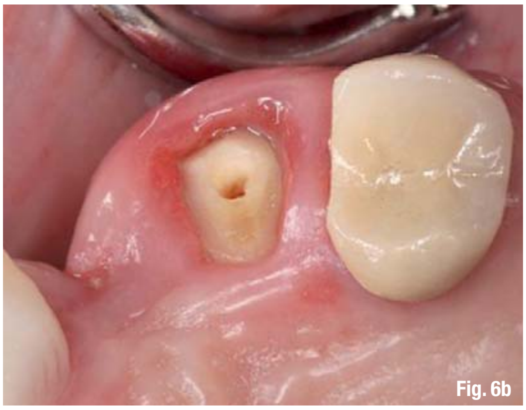
Fig. 6b

Figs. 6a & b_Post and crown loosened from maxillary canine a few months after placement. Both the core/prefabricated post and the crown came off (a). Clinical photograph shows the absence of cervical tooth structure (ferrule) for retention of the crown (b).

_Principle #V

Large diameter posts increase the possibility of root thinning, root perforation and root fracture. It is recommended that posts not exceed one-third of the root diameter.

Increasing the diameter of a post weakens the remaining root. It has been determined that stresses increase in a root as the post diameter increases;[56] larger post diameters decrease the resistance to tooth fracture.[53] With large diameter posts (1.5 mm or more), it was determined[57] that there was a six-fold increase in the potential for root fracture for every mm of increased post diameter.

Studies have shown that root fracture is the second most common cause of post and core failure.[58–62] Multiple factors have been associated with the potential for root fracture, including large diameter posts,[23, 50, 56] short posts,[23, 49–52] and threaded posts (Fig. 4).[44, 49, 50, 57, 63–65] It is recommended that the post diameter not exceed one-third of the root diameter[55] and that the post diameter be proportionally related to average root dimensions.

To ensure that posts do not exceed one-third of the root diameter, the post diameter should be between 0.6 and 1.2 mm, depending on the tooth.[66–68] Only post preparation instruments that match the desired diameter of the post space should be used. When using a particular brand of post, make sure that the matching drill belongs to the same type of post (Tables I & II).

A good understanding of dental anatomy, the configuration of the roots and their variations, and use of an appropriate instrument angulation help in avoiding root thinning and perforation. Instruments should be angled so that they follow the canal (Fig. 5).

When posts are needed in premolars, they are best placed in the palatal root of the maxillary premolar and the straightest root of any mandibular premolar with multiple roots. Root taper, curvature and depressions should be reviewed prior to post preparation.

Table I_Suggested maximum diameter based on root dimensions and pulp morphology for maxillary teeth.

Maxillary teeth	Central incisor	Lateral incisor	Canine	First premolar	Second premolar	First molar	Second molar
Number of canals*	100 %: 1 canal			83 %: 2 canals 12 %: 1 canal 2 %: 3 canals	48 %: 1 canal 43 %: 2 canals 0.6 %: 3 canals	mesiobuccal root 59.2 %: 2 or more canals 40.8 %: 1 canal distobuccal root 98.3 %: 1 canal 1.7 %: 2 or more canals palatal root 99 %: 1 canal 1 %: 2 or more canals	mesiobuccal root 51.5 %: 1 canal 47 %: 2 or more canals distobuccal root 99.7 %: 1 canal 0.3 %: 2 or more canals palatal root 99.9 %: 1 canal 0.1 %: 2 or more canals
Number of roots*	1 root			75 %: 2 roots 23 %: 1 root 2 %: 3 roots	90.7 %: 1 root 9 %: 2 roots 0.3 %: 3 roots	95.9 %: 3 roots 3.9 %: 2 roots	88.6 %: 3 roots 7.8 %: 2 roots 2.8 %: 1 root 0.4 %: 4 roots
Suggested post diameter in mm**	1–1.7	0.8	1–1.5	0.8–1 in the palatal root		1 in the palatal root	

Table I

Manibular teeth	Central incisor	Lateral incisor	Canine	First premolar	Second premolar	First molar	Second molar
Number of canals*	75 %: 1 canal 25 %: 2 canals 6 %: >2 canals	72 %: 1 canal 28 %: 2 canals 2 %: >2 canals	89.4 %: 1 canal 10.6 %: canal	74 %: 1 canal 25 %: 2 canals 1 %: 3 canals	93 %: 1 canal 7 %: 2 canals <0.05 %: 3 canals	*2 rooted teeth* **mesial root** 95.7 %: 2 or more canals 4.3 %: 1 canal **distal root** 68.4 %: 1 canal 31.6 %: 2 or more canals *3 rooted teeth* **mesial root** 100 %: 2 or more canals **distobuccal root** 97.6 %: 1 canal 2.4 %: 2 or more canals **distolingual root** 100 %: 1 canal	**mesial root** 86 %: 2 or more canals 14 %: 1 canal **distal root** 85.1 %: 1 canal 14.9 %: 2 or more canals
Number of roots*	100 %: 1 root		94.8 %: 1 root 5.2 %: 2 roots	95 %: 1 root 5 %: 2 roots	98.5 %: 1 root 1 %: 2 roots 0.5 %: 3 roots	80.9 %: 2 roots 12.8 %: 3 roots 0.04 %: 4 roots	84.1 %: 2 roots 1.5 %: 3 roots 2.5 %: 1 root
Suggested post diameter in mm**	0.5–0.8	0.5–1	1–1.5	0.8–1		1 in the distal root	

Table II

Table II_Suggested maximum diameter based on root dimensions and pulp morphology for mandibular teeth.
**Adapted from data present in* Dental Anatomy & Interactive 3-D Atlas *and provided by Dr Blaine Cleghorn, Dalhousie University, Canada, November 2007.*
***Adapted from data published by Shillingburg, 1982 and Tilk, 1979.*

When posts are needed in molars, they should be placed in roots that have the greatest dentine thickness. These roots are known as the primary roots and they are the palatal roots of maxillary molars and the distal roots of mandibular molars. However, it is important to remember that extension of a post more than 7 mm apical to the root-canal orifice in primary canals increases the risk of perforation.[55] The mesial roots of mandibular molars and the facial roots of maxillary molars should be avoided if at all possible. Attention should also be given to avoiding instrument pressure on the root surface towards the furcation, as this surface is thinned more easily than the outer surface owing to root curvature.

With all teeth, the apical 5 mm of the roots should be avoided because most root curvatures occur within 5 mm of the root apex[69] and entrance into this area increases the risk of excessive root thinning or perforation.

_Principle #VI

A cervical ferrule should engage 2 mm of tooth structure to prevent root fracture.

Ferrules can be established by the core engaging tooth structure (core ferrule)[70–73] or by the crown overlying/encompassing sound tooth structure apical to the core (crown ferrule).[74–79] The data indicates that crown ferrules are more effective than core ferrules[71–73, 80] and crown ferrules increase the tooth's resistance to fracture.[74,75,80] In spite of the data supporting the benefit of crown ferrules, not all practitioners recognise their value. A survey published by Morgano *et al.*[80] evaluated the percentage of respondents who felt a ferrule increased a tooth's resistance to fracture: 56 % of general dentists, 67 % of prosthodontists and 73 % of board-certified prosthodontists felt that core ferrules increased a tooth's fracture resistance.

Different lengths and forms of the ferrule have been studied.[74, 76, 77, 81] The length and form are essential to the success of the "ferrule effect". When possible, encompassing 2 mm of intact tooth structure around the entire circumference of a core creates an optimally effective crown ferrule. Ferrule effectiveness is enhanced by grasping larger amounts of tooth structure. The amount of tooth structure engaged by the overlying crown appears to be more important than the length of the post in increasing a tooth's resistance to fracture (Fig. 6).

If insufficient cervical tooth structure remains to develop a ferrule, surgical crown lengthening or orthodontic extrusion should be considered to expose more tooth structure. In some situations, it may be prudent to extract a tooth and replace it with an implant and crown when one or more of the following conditions is present: a ferrule cannot be developed; crown lengthening would create an unacceptable aesthetic environment or produce a furcation defect; or a short root is present that would not permit appropriate post length to be developed.

_Principle #VII

Until more long-term data is available, fibre-reinforced resin posts should be used with caution.

For many years, the standard method of restoring endodontically treated teeth has been either a custom cast post and core or a prefabricated metal post with a restorative material core.[41, 82, 83] A nationwide survey of dentists in 1994 reported that 40 % of general practitioners used prefabricated posts, and the most popular post was the parallel-sided serrated metal post.[28] The usage of prefabricated posts has undoubtedly increased even more substantially since the 1994 survey. The high demand for aesthetic restorations and all-ceramic crowns led to the development of a variety of non-metallic prefabricated post systems as alternatives to metal posts.[84–87] In addition to the aesthetic advantages of non-metallic posts, laboratory studies have shown that the resin-based alternative posts have favourable physical and mechanical properties and there is less root fracture with fibre-reinforced resin posts than with metal posts.[88–92] However, clinical studies of fibre-reinforced posts have produced a wide range of reported failure percentages, ranging from 0 % after a mean of 2.3 years to 11.4 % after 2 years.[9, 58–61, 63, 93–96] Post loosening and root fracture have been the most commonly reported complications (Fig. 7).[58–62, 93, 97, 98] Because the core depends on the retentive capacity of the post, the prognosis of the final restoration is highly dependent on the retention of the post.[99] Given the wide range of reported failure percentages, it appears that additional long-term clinical data is needed to determine the efficacy of fibre-reinforced posts.

_Conclusion

Based on this review of available research, the following clinical recommendations are made:

1. Crowns are not needed for intact or minimally restored anterior teeth except when substantial colour or form changes cannot be accomplished by more conservative means.
2. Crowns should be placed on most endodontically treated posterior teeth to enhance their long-term survival. There is some data that indicates posterior teeth that are intact, except for the access opening, can be satisfactorily restored with composite resin rather than a crown. However, the long-term success of this more conservative treatment in the presence of heavy occlusal forces is not known.
3. Posts weaken teeth and they should only be used when the core cannot be adequately retained by some other means.
4. An adequate apical seal is retained by preserving 5 mm of gutta-percha.

Fig. 7

Fig. 7_A radiograph of a fractured maxillary lateral incisor with a glass fibre post.

5. Short posts should be avoided, as they increase the potential for root fracture. For all teeth except molars, optimal post length is determined by retaining 5 mm of apical gutta-percha and extending the post to that depth. For molars, posts should only be placed in the primary roots (palatal roots or maxillary molars and distal roots of mandibular molars) and they should not be extended more than 7 mm apical to the orifice of the root canal owing to the possibility of root thinning or perforation.
6. The diameter of posts should not exceed one-third of the root diameter to minimise root thinning and the potential for root fracture. Post preparation instrument diameter should be matched to root diameters.
7. When crowns are placed on endodontically treated teeth, they should encompass 2 mm of tooth structure apical to the core whenever possible, since crown ferrules increase the resistance of teeth to fracture.
8. Until more long-term clinical data becomes available, fibre-reinforced resin posts should be used with caution owing to the wide range of reported failure rates in clinical studies._

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

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Endodontic parousia—*Nullius in verba* redux

Author_ Dr Ken Serota, Canada

_The intent of this article is to see whether I can finally shake up those of you who read my blog (on www.oralhealthjournal.com), spend time on it and yet do not post. The point of this "mashup" is to engender "discovery" of information, trends, likes, dislikes etc. and to DIALOGUE in the truest manner and context of social networking within this profession. Read away McDentist and offer your commentary, good, bad or indifferent, but never overlook the opportunity to make your voice heard.

Every era lives with contradictions that it manages to ignore: the Greeks talked of justice and kept slaves, the Crusaders preached the gospel of the Prince of Peace and rode off to annihilate the infidels, and the 17th century believed in a universe that ran like clockwork, entirely in accord with natural law, and also in a God who reached down into the world to perform miracles and punish sinners.[1]

Historically, the decision to perform endodontic therapy and restore a tooth or to extract and replace it in some manner was a relatively "straight-line" decision; however, in the implant-driven treatment planning era of the new millennium, dentists face a multitude of complicating factors, most notably the irrefutable success of dental implant therapy and the relative ease and facility of "nuts and bolts" restoration, provided the foundational aspects of surgical placement are met.[2]

As a discipline specifically and as a profession in general, we must ensure that our process does not engender "rearranging the deck chairs on the Titanic".[3] The identification and quantification of specific factors that affect rehabilitative prognosis in individual patients are essential to formulating standardised treatment protocols and individual treatment plans. Such factors include bone quantity and quality, caries and periodontal disease risk, as well as the critically important factor of the amount of remaining tooth structure. Minor or even moderate differences in overall treatment outcomes or costs must not affect clinical decisions and must not sway critical thinking.[4]

Endodontics mandates, as does any discipline, the aggregation and verification of scientific knowledge and proof in order to create the proficiency inherent in the desired positive treatment outcomes; it does not manifest as a paint-by-numbers technical approach whereby the illusion of science is discernible only in the design and perceived innovation of the equipment or product brought to market without retrospective studies or meta-analyses of multivariate, multicentre treatment outcomes. In a Madoffian world, it is lunacy to be driven by guru-centric claims and pronouncements.

It would be disingenuous and gratuitous to suggest that condemnation of salvageable and healthy teeth has not reached epidemic proportions. Yet, the treatment outcomes studies on implant survival for the most part report survival as a binary outcome rather than using the Kaplan–Meier survival analysis, which is a far more accurate reflection of the percentage of success.[5] It is because binary outcome has been the benchmark to justify removal of salvageable teeth that the pendulum swung too far too fast. Dentistry needs a "Sputnik" moment to reinvigorate our basic tenets and grounding fundamentals. Sadly, endodontists are infrequent visitors to the critical-thinking, treatment-planning loop, as the technological simplification of the discipline is negating its biological contribution to the interdisciplinary team approach.

This article serves to determine whether endodontics as a specialty has made a case for true partnership in the landscape of foundational, interdisciplinary dentistry. Its intent is to assess the innovations and iterations in the toolbox of the endodontic discipline and ensure that retention of natural teeth is keeping pace with biological reality and not marketing budget-driven science.

There are two historic milestones that bracket our understanding of the myriad complexities of the root-canal system; the first, the work of Hess, was woven into the fabric of the era of Focal Infection

Theory and stimulated the annihilation of millions of salvageable teeth and put dentistry firmly back in the Dark Ages of science (Fig. 1). The second, the use of micro-CT technology to map the inner space of teeth, replicated the Hess studies using digital tools (Fig. 2). Unfortunately, the outcome of this renewed awareness has not resulted in a more sophisticated approach to preservation of natural teeth using a century of evolutionary advances in material and technique, but has fostered a "simpler is better" mentality, which will inevitably be as devastating to retention of the natural dentition as Dr Hunter's egregious dental witch hunt of the early 1900s.[6]

plethora of product launches that has now reached its crescendo with the arrival of a "single file that does all".

From a metamorphosis of instruments borne of angioplasty materials to the enhanced elasticity of NiTi and its reformulation in newly ground shapes and its use in reciprocating rather than rotary feed rates, the market is once again driving science and our patients and ultimately our profession will pay the price for the oversimplification and obtuse denial of the reality we know for the expediency we are being trained to crave.

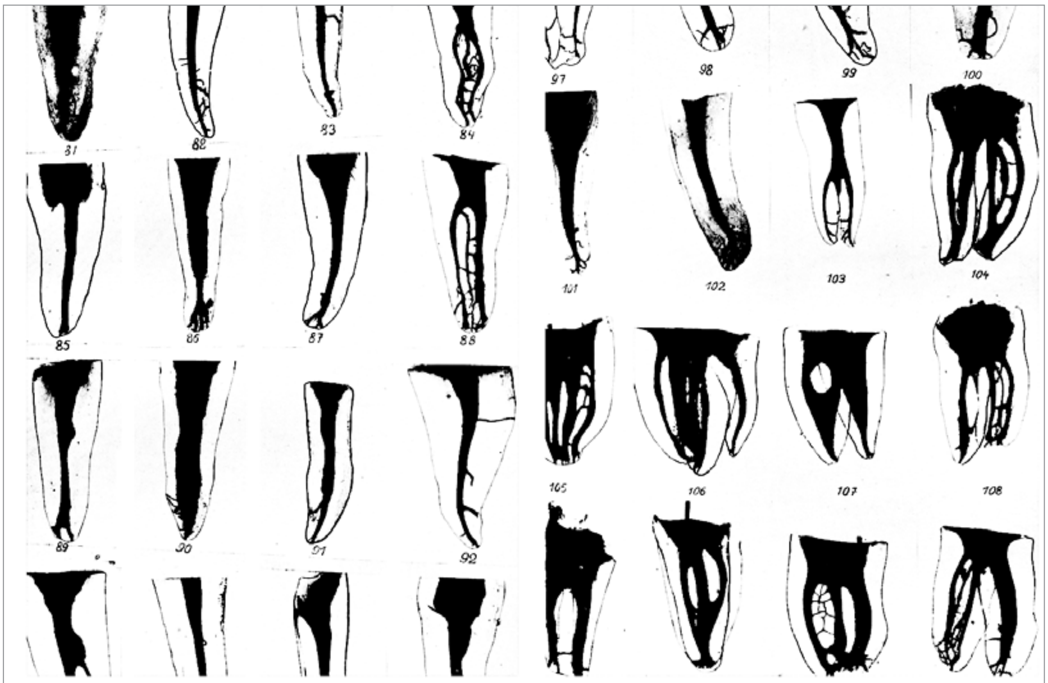


Fig. 1

Fig. 1_Images of perfusion studies to illustrate the complexities of the root-canal system of all tooth types.[10]

The hard-tissue repository of the human dental pulp takes on numerous configurations and shapes. A thorough knowledge of tooth morphology, careful interpretation of angled radiographs, use of small FOV CBT, proper access preparation and detailed exploration of the interior of the tooth are essential prerequisites for a successful treatment outcome. A thorough understanding of the complexity of the root-canal system is essential for understanding the principles and problems of debridement, disinfection and root filling for determining the apical limits and dimensions of canal preparations, and for performing successful microsurgical procedures when necessary.

And yet, the past few decades have been entombed in the most egregious nihilistic "Mad Men" description of the technological wizardry and biological understanding necessary to ensure long-term predictable prognosis of the endodontically treated tooth: "clean, shape, pack". This has produced a

Sealers based on restorative fundamentals were to be the *sine qua non* of monobloc creation in the root-canal space. Unfortunately, one of the most exhaustive studies done to evaluate evidence-based support on the merits of their clinical use concluded that "on the basis of the *in vitro* and *in vivo* data available to date, there appears to be no clear benefit with the use of methacrylate resin-based sealers in conjunction with adhesive root filling materials at this point in their development".[7]

Science has shown that the direction for eradication of refractory and chronic disease related to biofilm elimination lies in photodynamic therapy, which has provided clear evidence of clinical efficacy and applicability continues to be demonstrated.[8] And yet, an array of sonic and ultrasonic products have infused the market with specious claims to optimise microbial control through innovations in irrigation protocols designed to disinfect and remove the smear layer of the prepared root-canal space in spite of the

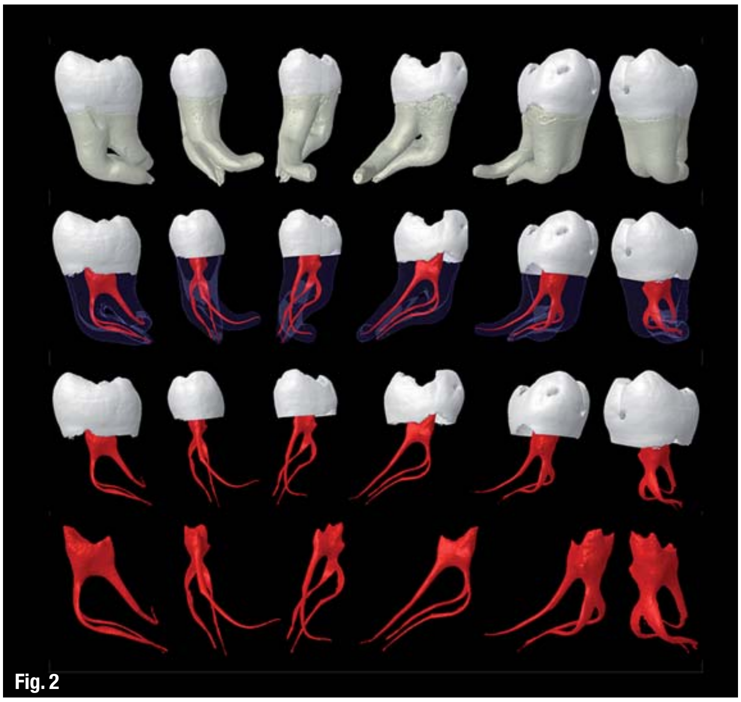


Fig. 2

Fig. 2_Micro-CT images of a molar tooth. (Images courtesy of the Root Canal Anatomy Project; http://rootcanalanatomy.blogspot.com/).

fact that their ability to remove mixed-species biofilm remains unproven.

The great virtue of mathematics is that its truths alone are certain and inevitable; in any universe, the shortest distance between two points is a straight line. And yet, the pundits of the new wave in endodontics would have us believe that single files regardless of their envelope of motion, be it reciprocating, rotary or piston-like, can effectively debride the negative space of the root-canal system in defiance of the morphometrics and myriad complexities of the inner world of teeth. Similarly, insubordinate to the science of rheology, carrier-based obturation is deemed equivalent to the force generation and resultant gravitometrics of injection-moulded, warm thermolabile techniques as described initially by Blaney and made mainstream by Schilder.

And yet, we have a new wave of carrier-based obturation devices that, in concert with simplified instrumentation protocols, are being marketed by their developers in the context that, "I have read this argument about making root-canal treatment simple. Many colleagues struggle with the complexities of root-canal treatments and I do not see why we can't make it simpler. Any competent dentist has good manual skills. If we can simplify the treatment procedure for the general dentists and thereby improve their skills in completing more root-canal treatments to a higher standard, our patients will surely benefit."[9]

For those who would suggest that this article is self-serving, I would suggest that you simply replace the discipline cited with any other. Perhaps we have reached the point that we no longer wish to advance and support the art and science of ________ (fill in the blanks) with definitive research that will refute the nattering nabobs of nihilism on the other side of that proverbial line in the sand. It is time for dentists to acknowledge the gravity of the problem where industry is the driver and the profession the passenger. We need leadership to regenerate the science of dentistry before the artistry truly becomes pre-planned and pre-programmed by those outside the profession whose vested interests lie in profit and loss statements, and not in the eradication of oral disease._

Editorial note: A complete list of references is available from the publisher. To comment on this article, please contact the Managing Editor at c.salwiczek@oemus-media.de

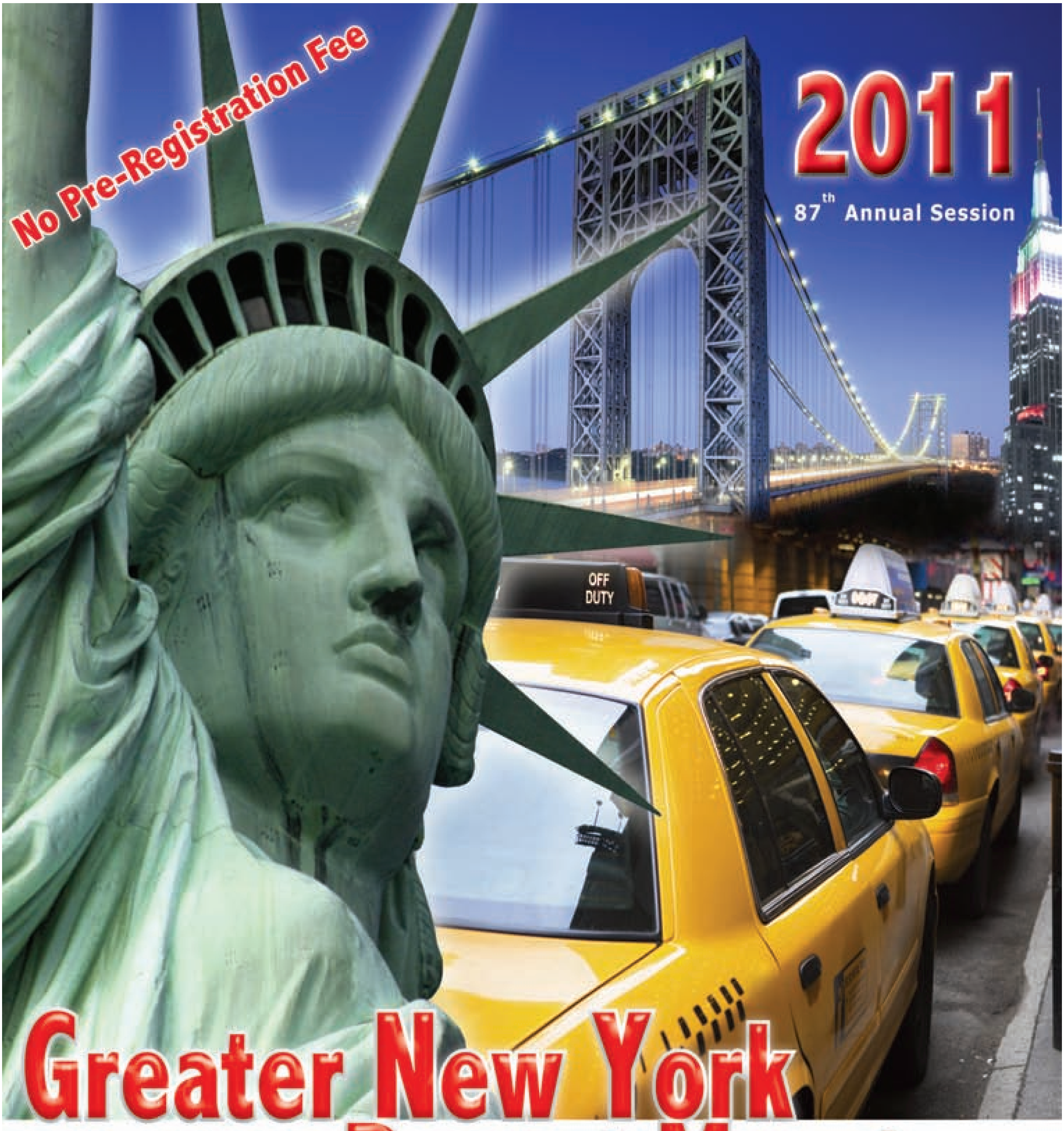
_about the author

roots

Dr Kenneth S. Serota graduated from the University of Toronto in 1973 and was awarded the George W. Switzer Memorial Key for Excellence in Prosthodontics. He received his Certificate in Endodontics and Master of Medical Sciences degree from the Harvard-Forsyth Dental Center in Boston.

A recipient of the American Association of Endodontics Memorial Research Award for his work in nuclear medicine screening procedures related to dental pathology, his passion is education, and most recently e-learning, and rich media. Dr Serota provided an interactive endodontic programme for the Ontario Dental Association from 1983 to 1997 and was awarded the ODA Award of Merit for his efforts in the provision of continuing education.

The author of more than 60 publications, Dr Serota is on the editorial board of *Endodontic Practice, Endo Tribune* and *Implant Tribune*. He founded ROOTS, an online educational forum for dentists from around the world who wish to learn cutting-edge endodontic therapy, and recently launched IMPLANTS (www.rximplants.com) and www.tdsonline.org in order to provide dentists with a clear understanding of the endodontic–implant algorithm in foundational dentistry.



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AAE aims to 'bridge the gap'

Author_ Sierra Rendon, USA

_The American Association of Endodontists (AAE) held its annual session from 13 to 16 April 2011 at the Henry B. Gonzalez Convention Center in San Antonio. The theme of the meeting, which offered attendees the chance to earn up to 31 continuing education credits, was *Bridging the Gap: Partners in Interdisciplinary Care*. The focus of the meeting was on collaboration among dental professionals for optimal patient care.

"The AAE emphasizes the importance of working with general dentists and other specialists to improve patient outcomes," said AAE President Dr Clara M. Spatafore.

The meeting commenced with a keynote presentation by Christopher Gardner, an acclaimed motivational speaker and author of the bestselling autobiography *The Pursuit of Happyness*.

Gardner shared the important steps to creating a successful and fulfilling life while telling his personal story of seemingly never-ending obstacles and the ways he overcame them. Other special guests included comedians John Pinette and Kathleen Madigan, who entertained attendees the last evening of the annual session during the President's Dinner.

To further enhance communication and strengthen relationships among dental practitioners, the AAE 2011 annual session included two new events promoting networking and the sharing of ideas and experiences. A lunch-n-learn event and roundtable discussions allowed attendees the opportunity to share professional opinions and questions in a less structured environment.

For exposure to endodontic techniques, the AAE's popular Master Clinician Series showcased live surgeries by leading experts in the field. Master clinicians included Drs Dan B. Ang, Todd M. Geisler, James L. Gutmann, James C. Kulild, Stephanie L. Mullins, Richard A. Rubinstein and Fabricio B. Teixeira. Attendees were able to witness implant placement, molar surgeries and a demonstration of regenerative endodontic procedures.

The AAE also hosted its *Access to Care Project* during the annual session. Through a partnership with the San Antonio Christian Dental Clinic and Henry Schein Dental/Henry Schein Cares, pre-screened patients received care from licensed Texas endodontists and endodontic residents from dental schools throughout the state.

"We wanted to give our members and all attendees an intimate look at the best technique for performing endodontic procedures," Spatafore said. "Participants were able to return to their own practices with a new appreciation for the spectrum and efficacy of the endodontist's armamentarium."

Headquartered in Chicago, the AAE represents more than 7,200 members worldwide. The AAE was founded in 1943 and is dedicated to excellence in the art and science of endodontics and to the highest standard of patient care. The association inspires its members to pursue professional advancement and personal fulfilment through education, research, advocacy, leadership, communication and service.

Next year's AAE meeting will be held from 18 to 21 April 2012 in Boston._


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Photos: Koelnmesse GmbH

Record-breaking IDS 2011

Author_Yvonne Bachmann, Germany

_**With 115,000 visitors** and nearly 2,000 exhibitors, this year's International Dental Show (IDS) was the biggest dental trade show ever. The show boasted a 9 % increase compared with 2009. People from 148 countries travelled to Cologne to see new products, learn about innovative treatment methods and network with other dental professionals. Exhibitors from 85 countries seized the opportunity to establish and further contacts, win new customers and open up new markets.

"The world's leading dental trade fair IDS closed, having achieved outstanding results," the organisers summed up after five busy days. Organisers and exhibitors were especially pleased with the large number of visitors from abroad. "The most customers we've had so far are from abroad," Marian Tempel, responsible for marketing at Korean company Neobiotech, told roots on the third day of the exhibition. IDS visitors came mainly from Latin America and South America, Australia, the US and Canada, but also from Italy, France, the Netherlands, Spain, the UK, Switzerland, Russia, Ukraine, Turkey, Israel, China and India. The exhibition halls were constantly busy and booths extremely well visited. According to the exhibitors, 66 % of which came from outside Germany, representatives of everything related to dentistry—dental practices and laboratories, trade, the higher education sector—visited their booths. The trade show meant a huge financial success for many exhibitors. Many companies took numerous orders, both domestically and internationally.

"We have succeeded in making IDS even more attractive, both domestically and internationally. The strong increase in international participants especially shows that IDS is the world's leading dental trade show," Dr Martin Rickert, Chairperson of the Association of German Dental Manufacturers, said. "Participants were able to forge high-quality business contacts between industry and trade professionals as well as between the industry, dentists and dental technicians. Thus, the trade fair once again signalled better times ahead and generated momentum that will help the dental sector stay on course for a successful business year."

Koelnmesse Executive Vice-President Oliver P. Kuhrt added: "IDS more than satisfied everyone's expectations. Once again, IDS offered a whole range of new products and excellent opportunities to exchange information, communicate with partners and place orders. That's why exhibitors, visitors and media representatives were all delighted with the trade fair."

A visitor survey carried out during IDS found that not only exhibitors, but also trade visitors considered the exhibition a success. According to the organisers, 95 % of the respondents indicated that they were satisfied/very satisfied with the event. They were pleased with the range of products and had achieved their goals at the trade fair. Furthermore, 93 % would recommend a visit to IDS to a close business associate. "It's my first time at the IDS and this is the biggest dental trade fair I have ever been to. I have scheduled three days to see everything," Dr Dusan Dimitrijevic told roots. This dentist from Serbia brought his son and second-year dental student Lazar with him to Cologne.

_Focus on digital innovation

This year, the focus of interest was on the innovative new products and technologies on display. According to Dr Rickert, the trade fair demonstrated that digital processes and technologies are becoming increasingly popular, since they facilitate even more efficient and higher quality treatments. In particular, products and systems that offer users and patients improvements in preventative care, diagnostics and dental treatment were in high demand. Those include ultrasound systems with expanded capabilities that enable painless and professional preventative care, digital intra-oral scanners, improved root-canal treatment methods, new dental filling materials, aesthetic dental crowns and bridges that look most natural, as well as improved digital X-ray diagnostics that are especially useful in the field of implantology.

"As far as we are concerned, the trade fair was very successful," said Jost C. Fischer, Chairperson and CEO of Sirona Dental Systems, leader in CAD/CAM technology. "The number of visitors was amazing. In fact, all of our employees were in dialogue around the clock. You could clearly see that the economy has picked up again.

As a result, the atmosphere at the fair was extremely positive. In my opinion, it was the best IDS ever."

Jürgen Schwichtenberg, President of the Association of German Dental Technicians' Guilds (VDZI), an IDS partner, was also very pleased with the trade fair. "From the point of view of the dental technician trade, the IDS 2011 once again proved the dental sector's innovative power. Considering the variety of products on display in Cologne and the rapid development of new, particularly digital technologies, it will be even more important in the future for dental technicians to actively supplement these new technologies and solutions with their expert knowledge and to put these into practice in their laboratories in order to ensure an all-round high-quality treatment. Our partners in the dental industry in general and dentists in particular will be able to continue to rely on these important services."

One partnership that was started at IDS is becoming an important political aspect of the profession: collaboration between the VDZI and the European Association for Dental Technology. The aim of the collaboration is to combine dental technology expertise and provide further training of the highest standard in both theory and practice so that practitioners can learn about the latest state-of-the-art dental technology.

_Speakers' Corner well visited

Many IDS visitors took advantage of the Speakers' Corner feature to gather information on the latest developments in science and research. Around 80 exhibitors presented their new products and technologies. The presentation topics included implant systems, digitisation, dental aesthetics, laser technology, dental anaesthesia and the benefits of modern stress management for dentists.

Dr Peter Engel, President of the German Dental Association (GFDI), one of the IDS organisers, is happy with the positive outcome of the trade fair: "Even more visitors and exhibitors than in previous years can mean only one thing: The profession is progressive and medium-sized German businesses are fostering innovation—and they're attracting enormous interest internationally."

At the exhibition, the GFDI held a coordinating conference for aid organisations, at which over 40 participants presented aid projects seeking to improve the dental health of the world's poor. The projects were developed by dentists and dental students who work in impoverished regions all over the world. Some of them also work in Germany. They provide dental services to a range of disadvantaged patients, including orphans, homeless people, disabled patients, drug addicts and inhabitants of remote areas, who would not receive treatment otherwise. To do this work, dentists and students often have to overcome enormous challenges. The coordinating conference offered participants a special opportunity to share their experiences in organising aid efforts.

In collaboration with the VDZI, the GFDI will also organise the 35^{th} IDS, which will take place from 12 to 16 March 2013._


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14–17 September 2011
Mexico City, Mexico
www.fdiworldental.org

SRRDG & ACSRD Annual Conference
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www.britishendodonticsociety.org.uk

Czech Endodontic Society Annual Congress
1 October 2011
Prague, Czech Republic
www.e-s-e.eu

DGET Annual Meeting
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Bonn, Germany
www.dgendo.de

AAE Fall Conference
3–5 November 2011
New Orleans, LA, USA
www.aae.org

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Liverpool, UK
www.pandental.co.uk

Greater New York Dental Meeting
25–30 November 2011
New York, NY, USA
www.gnydm.org

BAET International Dental Traumatology Symposium
16 December 2011
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2012

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Questions?

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