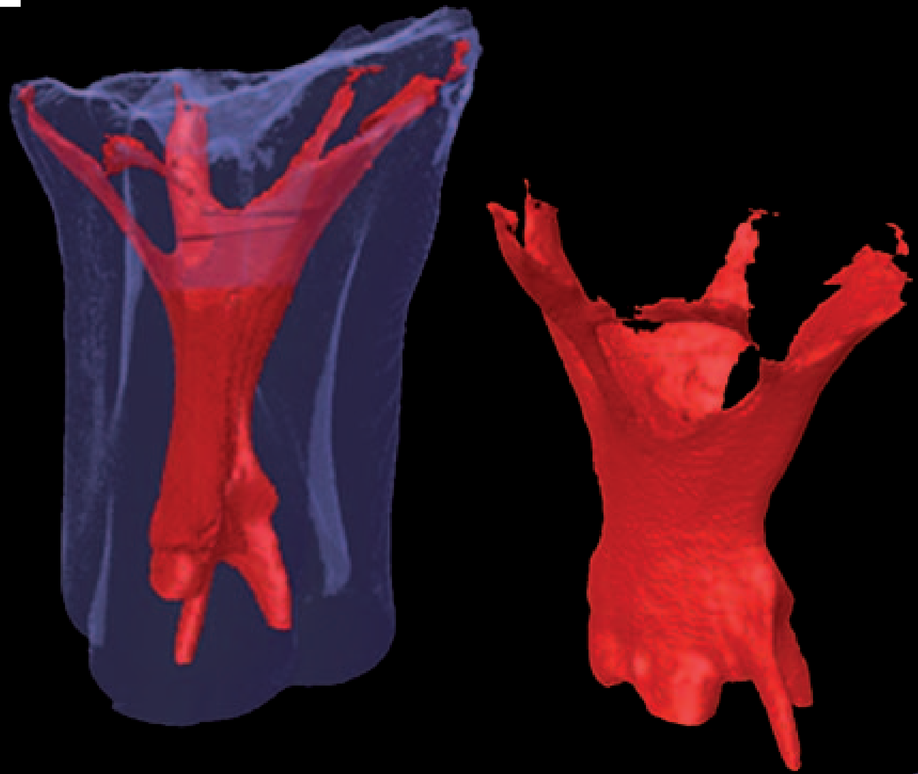
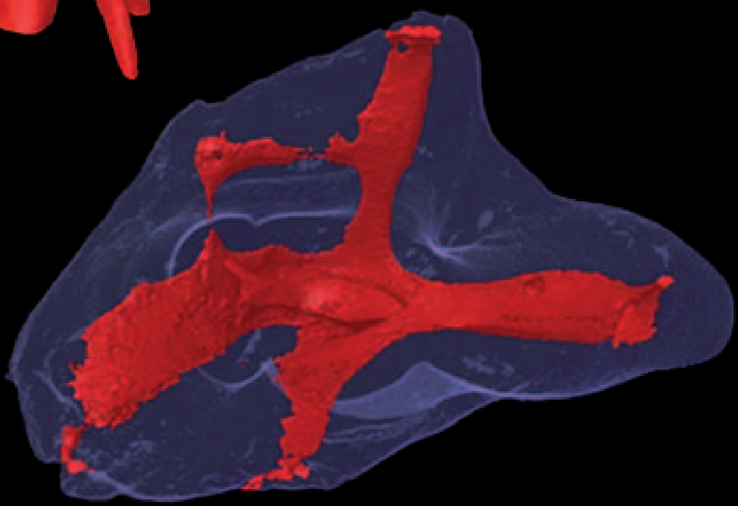
issn 1616-6345
Vol. 7 • Issue 2/2011

roots

international magazine of endodontology

2 2011





| special
Laser in endodontics

| case report
A case of diagnosis by access

| meetings
Record-breaking IDS 2011

Dear Reader,

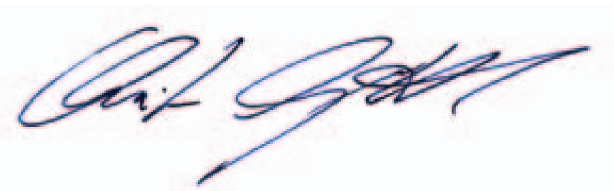

Dr Christian Gernhardt

_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,



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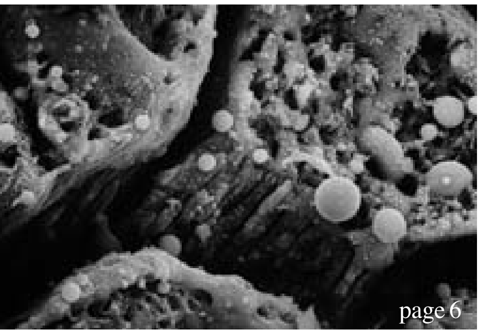
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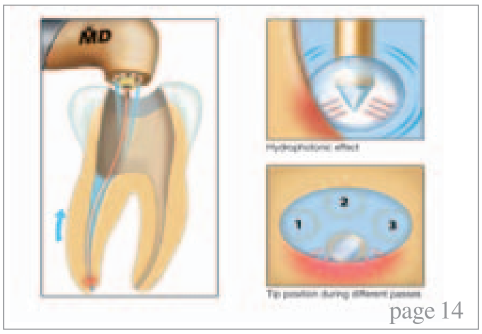
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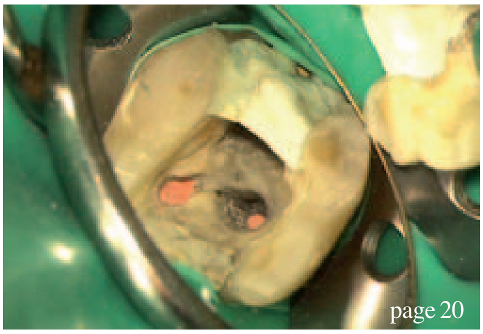
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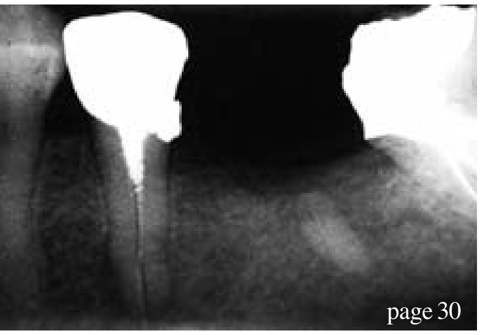
Cover image courtesy of Prof Marco Versiani and Prof Manoel D. Sousa Neto, Ribeirão Preto Dental School, University of São Paulo.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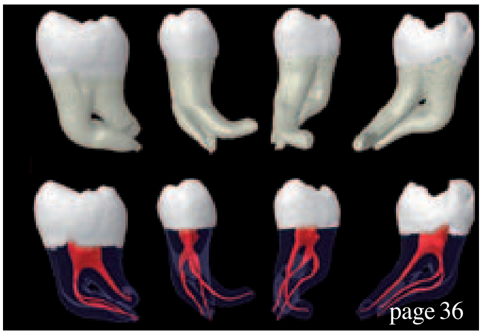
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Dr. Buchanan holds patents for some instruments used in these courses.

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

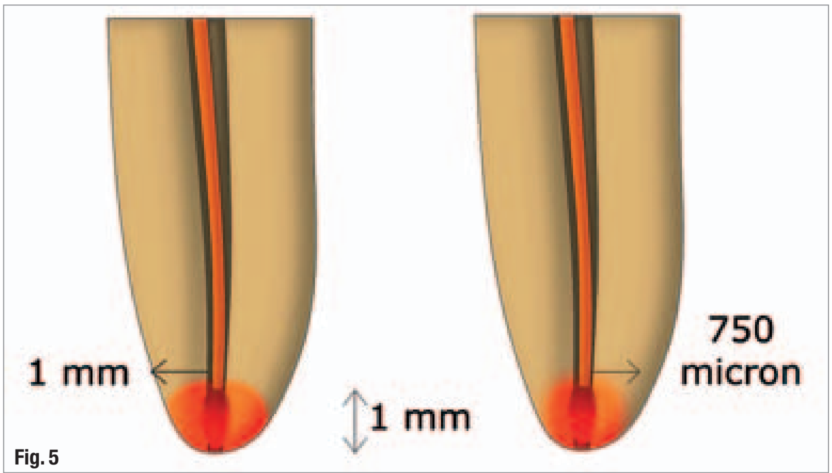


Fig. 5

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

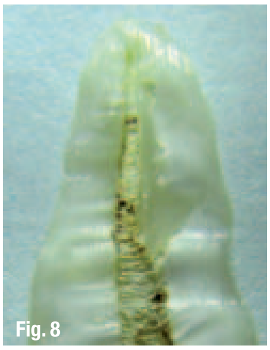
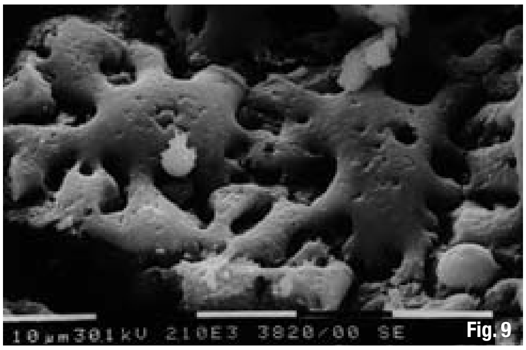
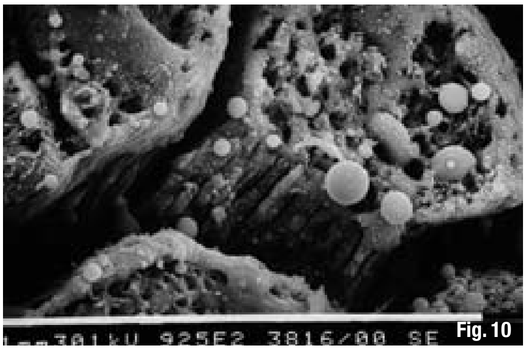


Fig. 8

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]

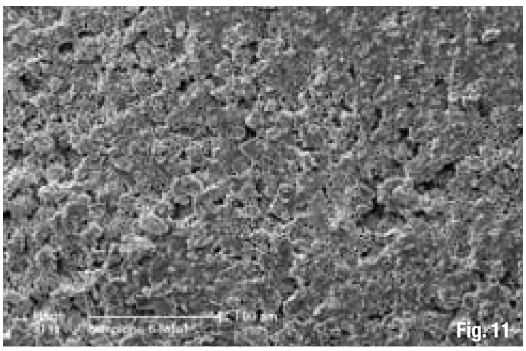
In a preliminary study on the effects of the Er:YAG laser equipped with a microprobe with radial emission of 200 to 400 µm, Kesler *et al.* found the laser to have good capability for enlarging and shaping in a faster and improved manner compared with the traditional method. The SEM observations demonstrated 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]

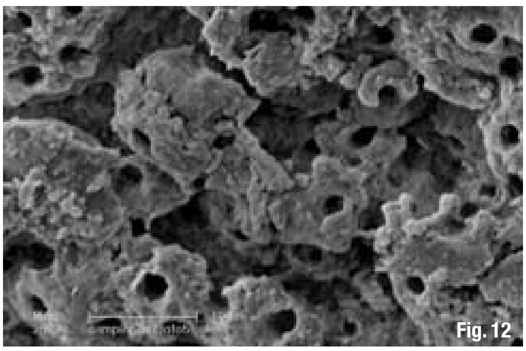
Stabholz *et al.* presented positive results of treatment performed entirely using a Er:YAG laser and endodontic lateral emission microprobes.[28, 29] Ali *et al.*, Matsuoka *et al.* and Jahan *et al.* used the Er,Cr:YSGG laser to prepare straight and curved canals, but in these cases, the results of 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.

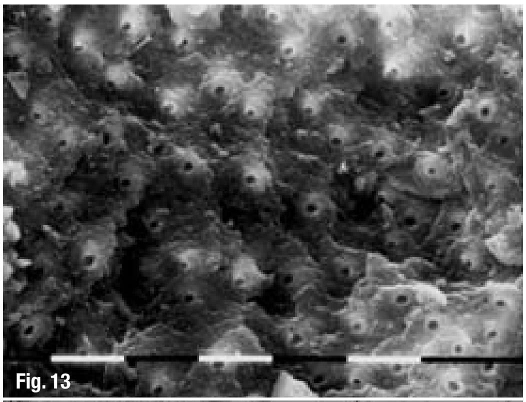
Decontamination of the endodontic system

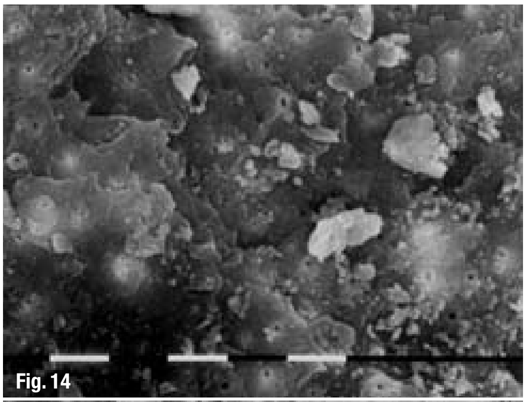
Studies on canal decontamination refer to the action of chemical irrigants (NaClO) commonly used in endodontics, in combination with chelating substances for better cleaning of the dentinal tubules (citric acid and EDTA). One such study is that of Berutti *et al.*, who reported the decontaminating power 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]



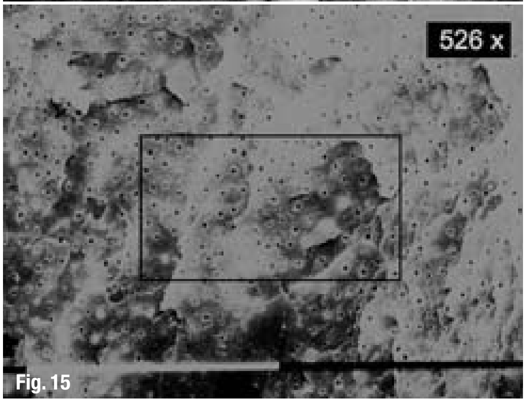


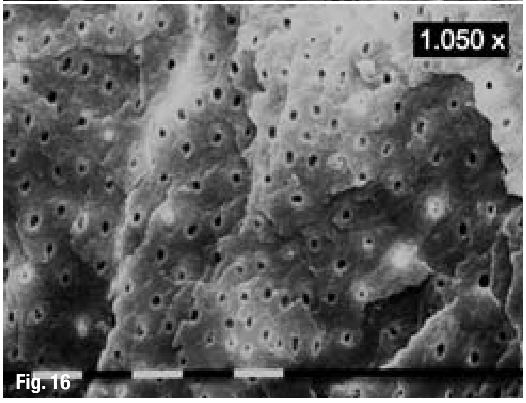
Figs. 11 & 12_SEM images of radiated dentine with diode 810 nm laser (dry, 1.5 W, 15 Hz) with 50 % ton-toff and 200 µm fibre, showing evidence of thermal effects, with detachment and smear layer.





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.

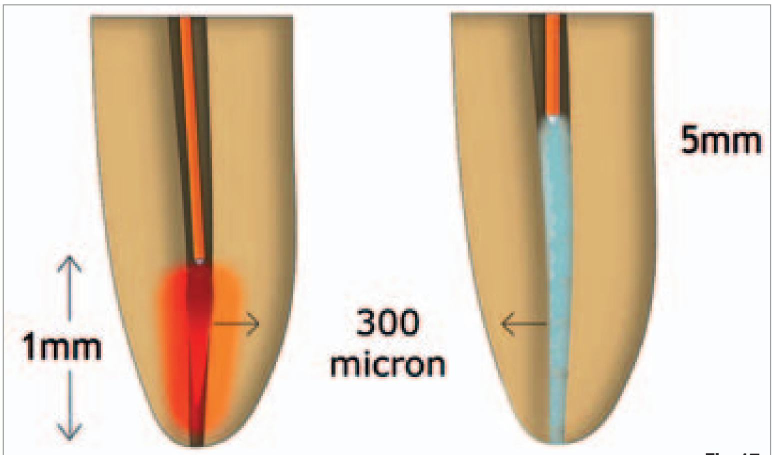


Fig. 17

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).

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]

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.

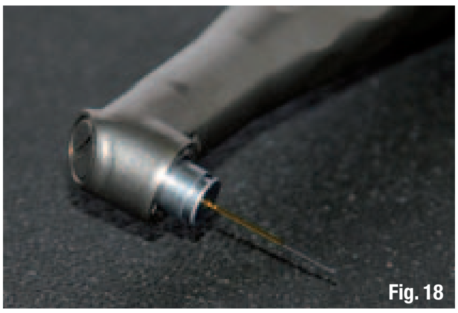


Fig. 18

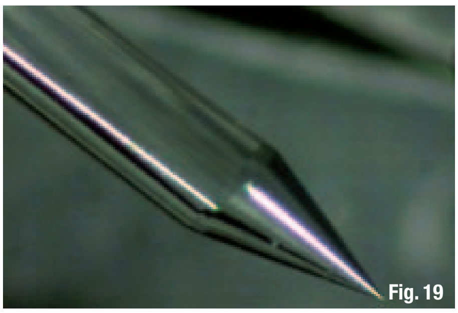


Fig. 19

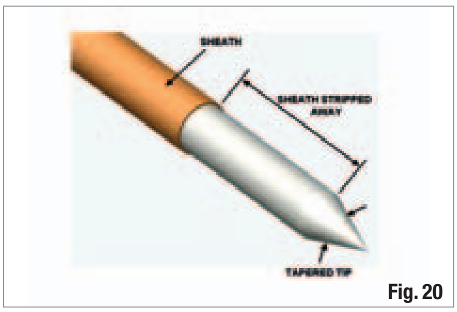


Fig. 20