Er,Cr:YSGG laser and radial firing tips in highly compromised endodontic scenarios

Authors_Miguel Rodrigues Martins, Manuel Fontes Carvalho, Irene Pina-Vaz, José Capelas, Miguel André Martins, Portugal & Norbert Gutknecht, Germany

_Introduction

As bacterial contamination is considered the primal etiologic factor for the development of pulpal and periapical lesions, to obtain the root canal system free of irritants has been showing to be the primordial endodontic therapy goal.[1-3]

The idea that an absence of cultivable microbes at the time of obturation will favor healing is consistent with the notion that microorganisms are the primary cause of persistent apical periodontitis.[4] Accordingly, other investigators have suggested that the presence of microbes at the time of root filling will adversely affect the outcomes.[5-7] The bactericidal effects of conventional irrigation strategies during and after root canal preparation with solutions such sodium hypochlorite (NaOCl) have been studied by numerous investigators, the ideal concentration and temperature of NaOCl in root canal therapy remains as controversy and topic of debate within endodontists.[8-11]

In fact, it is known that the bactericidal effectiveness of NaOCl is limited to a depth of 100 µm. However, heavy *E. faecalis* infection was found 800 µm deep into the canal lumen and other bacterial propagation into the dentinal tubules may reach up to 1.100 µm in depth.[12,13]

During canal enlargement proceedings, a smear layer is mechanically produced, covering the instrumented walls of the main root canal. Together with the possibility that the smear layer itself may be infected, it can also protect the bacteria harbored in the dentinal tubules by reducing root dentin permeability from 25 % to 49 %.[14] Hence, it is generally accepted that the complete removal of the smear layer would be consistent with the elimination of irritants from the root canal system.[15]

Whether adequate microbial control can be obtained in one appointment is an ongoing source of controversy. Although there are multiple scientific arguments to prefer multiple appointments in root canal therapy of infected teeth with apical periodontitis, clinical research to date has been equivocal.[16,17] Although calcium hydroxide paste is one of the most commonly used intracanal medications for multiple appointment root canal therapy, it's effectiveness against several microorganisms commonly associated with persistent apical periodontitis remains questionable.[18,19]

Though, newer treatment strategies designed to eliminate microorganisms from the root canal system should be considered in order to penetrate the dentinal tubules and destroy the microorganisms beyond the host defense mechanisms. Alternative possibilities such

Figs. 1 & 2_Initial clinical aspect and X-ray of the tooth 1.6 with an active fistula.
Figs. 3 & 4_Initial panoramic view.


Fig. 1


Fig. 2


Fig. 3


Fig. 4


Fig. 5

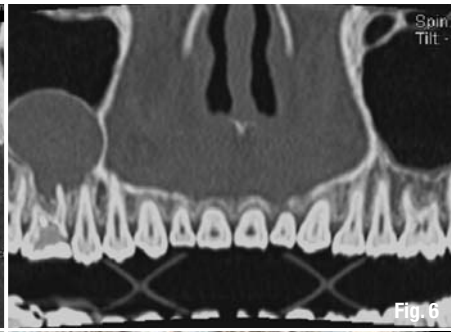
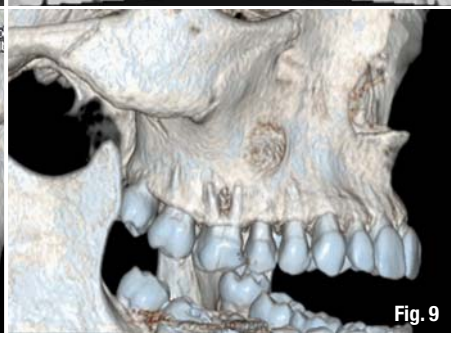

Fig. 6


Fig. 7


Fig. 8


Fig. 9

Figs. 5–7_Initial CT scan.
Figs. 8 & 9_Initial CT scan with three-dimensional reconstruction showing bone fenestration and sinus tract.

as ozone treatment, ultrasonic and laser-assisted treatments are being suggested as suitable methods to achieve endodontic disinfection, possibly overcoming the limitations of commonly used chemical solutions as well as any hazardous effects.[20-23]

The goals for the adjunctive application of erbium lasers in root canal therapy are: the ability of infrared light to interact with water and efficiently remove the smear layer and debris from the root canal walls, together with the ability of light to propagate into the dentinal tubules further than any chemical solution, providing deep disinfection.[24]

The goal of Er,Cr:YSGG laser-assisted endodontic treatment (LAET) is to provide successful long-term outcomes, namely in cases of persistent infections or per-operative obstacles (e.g. isthmus, recurrent canals, internal resorptions, root canal perforations, or wide apical constrictions) which are often associated to either lower or compromised clinical expectations.

_Chronic apical periodontitis and apical cysts

Following the formation of a periapical inflammatory lesion secondary to pulpal necrosis, chronic apical periodontitis (granuloma) is considered the next step in the progression of these inflammatory events showing the replacement of adjacent tissue by inflammatory cells, typically containing fibrous tissue and cholesterol crystals.[25]

Over time, due to inflammatory stimulation and proliferation of the epithelial rests of Malassez, an inflammatory cyst can develop around the root apex and through the bone. If the lumen of the cyst is continuous with the infection source at the pulpal entry, it may not be a self-sustained ("pocket" cyst); this will heal following infection source elimination. On the other hand, if the cyst is completely encased by epithelium and removed from the source of infection, it may be a self-sustained ("true" cyst) and become refractory to treatment except by surgical excision.[26]

Cysts mostly appear as round or pear-shaped, unilocular, radiolucent lesions in the periapical region. They are usually classified when they become bigger than 1 cm in diameter, being bordered by a thin rim of cortical bone. Cysts may displace adjacent teeth or cause mild root resorption.[27]

The differentiation between radicular cysts and granulomas is difficult or impossible by traditional radiographic techniques, even if several radiographic features have been proposed to make this distinction. These may include the lesion size and the presence of a radiopaque rim lining the cystic lesion. While the probability of a lesion being a cyst may increase with its size, a reliable diagnosis still remains based on histology.[28, 29]

Although being very prevalent, the location of periapical lesions in the oral cavity was found quite similar in different populations. The majority is found in the anterior maxilla (46,5–47,3 %) followed by the posterior maxilla (20,7–28,7 %), posterior mandible (15,3–18,3 %), and anterior mandible (8,7–14,3 %).[30,31]

The stages in development and healing of chronic apical periodontitis, granulomas and cysts are, depending on several circumstances, reflected by changes in the radiographic appearance of periapical areas. Gener-



Fig. 10_Intermediate panoramic view, after gutta-percha removal.
Fig. 11_Final X-ray.
Fig. 12_Ten months follow-up.
Figs. 13 & 14_Two years follow-up.

ally, the prognosis for complete healing of endodontically treated teeth with diagnosis of apical periodontitis is approximately 10%–15% lower than teeth without apical periodontitis.[32,33] Thus, if with ideal conditions for root canal therapy the success rate can reach over 90%, for teeth with periapical radiolucencies, the success rate can decrease to 80%.[34] So, it may be considered that the real challenge for endodontists is to achieve the disinfection of the complete root canal system in teeth associated with chronic apical periodontitis.

_The role of Er,Cr:YSGG laser in endodontics

The rapid development of laser technology as well as a better understanding of laser interaction with biological tissues has broadened the spectrum of possible laser applications in endodontics. The development of new delivery systems, including thin and flexible fibers as well as newly designed endodontic tips, has enabled the use of this technology in almost all range of endodontic procedures.

According to the wavelength and tip configuration, they are applied to disinfect strongly curved root canals and those susceptible to small enlargement. Due to either absorption or transmission properties in dentin, laser energy was found to be still effective in deep dentine layers adjacent to the canal lumen as well as in periapical regions.[35,36]

Figs. 15 & 16_Two years follow-up CT scan.

Generally, lasers may be especially recommended in the following situations: teeth with purulent pulpitis or pulp necrosis, periapical lesions, abscesses, lateral canals, reabsorption of the apex caused by inflammation or trauma and for teeth retreatments with low prognosis of success.



The Er,Cr:YSGG laser shows high absorption coefficients in hydroxyapatite and water so that germ reduction would theoretically take place predominantly in the main canal(s). However, apart from being useful to remove organic tissue and smear layer through cavitational effects, researchers reported that dentinal tubules may act as light optical conductors and therefore erbium lasers could still be considered effective for root canal disinfection up to a depth of 500 µm.[35]

Although *in vitro* investigations may support the use of Er,Cr:YSGG laser in endodontics, few clinical trials have been reported regarding the potential benefits and long-term outcomes after such treatments.[24]

_Radial firing tips

Up to now, endodontic fibers have bare tips so the energy is transmitted forward with a relatively small divergence. This limitation required the clinician to move the fiber in a withdrawing and rotating action in order to attempt a uniform coverage of the root canal walls. Thus, with bare fibers, it was found almost impossible to obtain uniform coverage of the canal surface along with reproducible results.[37]

The direct emission of the laser from the tip of the optical fiber near the root end may also result in the transmission of the irradiation beyond the apical foramen leading to undesirable effects on either teeth in close proximity to the mental foramen or the mandibular nerve.[38] Most lasers have then commonly reported disadvantages: (1) most of the laser energy is directed only in the axial direction, and little energy can be obtained perpendicular to the fiber; and (2) many wavelengths cannot eliminate the smear layer and the bacteria in the root canal wall, making the use of lasers less applicable.

To overcome concerns related to the energy emission in axial direction and not towards the canal wall, the unique emission profile obtained for the Er,Cr:YSGG

laser radial firing tips (RFT) played a significant role in increasing the efficiency of laser delivery for endodontic application. Not only does the beam expansion by the tip geometry reduce emissions in the forward direction, but it favours homogeneous energy distribution along the root canal wall.[39, 30]

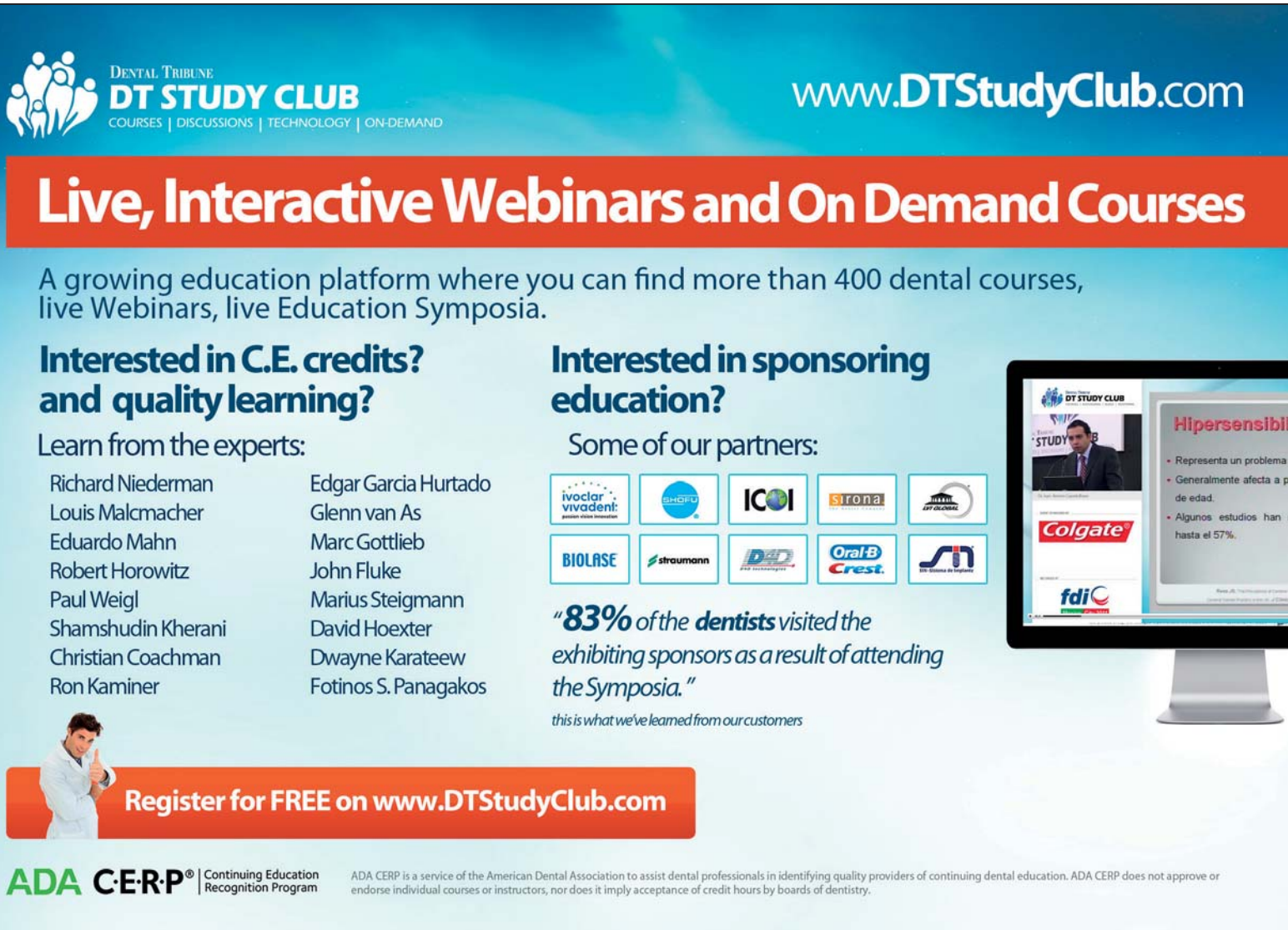
The debriding action of a laser in endodontics has shown to be better when delivered through conical fibers than with bare fibers as the divergent laser energy will interact with the canal walls, causing direct and indirect ablation through photomechanical effects. In fact, erbium lasers have been demonstrating to induce shock waves in aqueous solutions inside root canals and radial firing tips positively influence their configuration. Hence, through the activation of aqueous solutions (e.g. water, EDTA) the Er,Cr:YSGG laser induces primary and secondary cavitation effects, useful for debris and smear layer removal.[41-44]

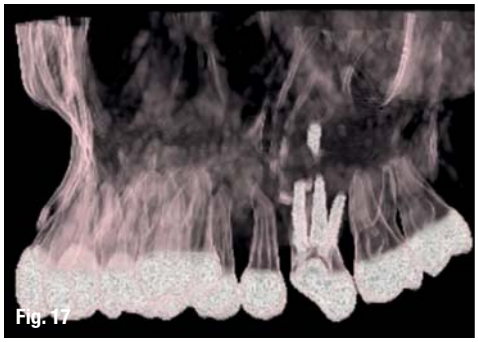
However, the best results in terms of thorough root canal disinfection with the Er,Cr:YSGG laser are achieved while operating in dry conditions, relying on the fact that—without water inside the main root canal—the ability of such wavelength to penetrate into the dentinal tubules is increased.[35, 40] Today, limited literature addresses the clinical outcome of endodontic therapy using RFTs without the aid of any chemical substances.[24] This clinical case study aims to represent an interesting proof of concept for the benefits of using radial firing tips in highly compromised teeth with apical pathology.

_Clinical case

A female patient (S.F.), 33 years old, presented a history of recurrent sinusitis and multiple antibiotic administrations. A previous endodontic treatment was performed within the past two years. At this time, she was referred by her dentist to an oral surgeon for cyst ablation and tooth extraction under general anaesthesia. An active fistula on the apical-buccal area of the tooth 1.6 was detected; vertical percussion was also found positive (Fig. 1). A non-surgical laser-assisted endodontic retreatment was proposed prior to surgery for cyst ablation. A written informed consent was previously signed. The endodontic retreatment was performed in two appointments according to the protocol described in Martins et al.[24] During the first appointment, initial carious excavation was performed and the resin filling was removed. Rubber dam isolation was obtained and the access cavity prepared. The working length (WL) was electronically established as 1 mm short of the biological apex of the root.

AD




Fig. 17

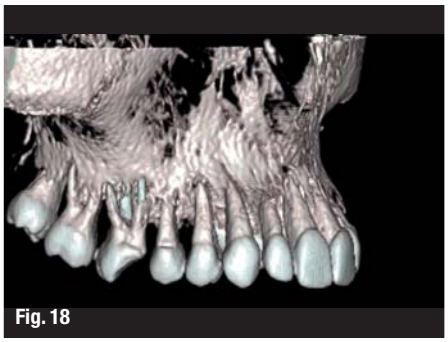

Fig. 18


Fig. 19

Figs. 17 & 18_Two years follow-up CT scan with three-dimensional reconstruction.
Fig. 19_Two years follow-up clinical aspect.

Desobturation and root canal preparation were performed with both ProTaper® retreatment and treatment files respectively (DENTSPLY Maillefer, Switzerland). Both Mesio-Buccal and Disto-Buccal canals were prepared up to a #F3 file, while the palatal canal was prepared up to an #F4 file. Irrigation was performed with 2.0 ml of saline solution between files. After root canal enlargement, the main canals were filled with distilled water and laser irradiation was performed with the 2,780 nm Er,Cr:YSGG laser (Waterlase MD; Biolase Technology, Inc, San Clement, CA) and a 270 µm in diameter radial firing tip (RFT2 Endolase, Biolase Technology, Inc; calibration factor of 0.55) with panel settings of 0.75 W, 20 Hz (37,5 mJ), 140 µs pulse, 0 % water and air. The tip was placed at the working length and irradiation was performed approximately at the speed of 2 mms^{-1} until the most coronal part of each canal was reached.

The irradiation procedure was repeated four times (two with the canal filled with distilled water and two in dry conditions), resting approximately 15 seconds between each irradiation. This protocol was described by Martins et al.[2] Finishing the first appointment, a sterile cotton pellet was placed in the pulp chamber, and the access cavity was sealed with a reinforced zinc-oxide eugenol intermediate restorative material (IRM—intermediate restorative material, DENTSPLY). On the second appointment, which took place 15 days after the first visit, the patient was inquired for symptoms history such as pain, sensitivity to percussion, or swelling. As none of these clinical conditions were registered, apical patency was confirmed, the main canals were filled with distilled water and laser irradiation was now performed with a 320 µm radial firing tip (RFT3 Endolase, Biolase Technology, Inc; calibration factor of 0.85) with panel settings of 1.25 W, 20 Hz (62.5 mJ), 140 µs pulse, 0 % water and air. The irradiation protocol was identical to the first appointment.

After irradiation, canals were irrigated with 5.0 ml of saline solution during approximately 1 minute of final rinsing and dried with sterile paper points, checking for the absence of any suppuration or exudate. Root canals were filled with a single gutta-percha tapered cone technique, a resin-based sealer (TopSeal, DENTSPLY) and vertical compaction.

_Discussion and conclusion

To adopt a single wavelength treatment protocol that more reliably renders root canals free of smear layer and bacteria before filling seems interesting. This could be an additional clinical evidence to suggest that the Er,Cr:YSGG laser with radial firing tips could be a valuable strategy to (1) remove smear layer in wet conditions and (2) achieve deep disinfection in dry conditions, within the same protocol.

While clinical as well as radiographic data can be used to access treatment outcomes, the relative absence of clinical symptoms in CAP makes the assessment primarily a radiographic one. As a consequence, in endodontic controlled clinical studies, data generated by radiographic means are often used.[45] Furthermore, this clinical report has shown that, presumably, even apical cysts could be successfully treated by endodontic means, by using a 2,780 nm wavelength and radial firing tips. The Er,Cr:YSGG laser should be considered a predictable tool to assist endodontic treatments overcoming possible limitations commonly associated to conventional strategies. However, few clinical trials and single-reports have been reported. This clinical case should stimulate either researchers to conduct additional blind randomised trials or clinicians to report their clinical findings in order to provide an evidence-based concept for the use of radial firing tips in endodontics._

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

_contact laser

Miguel Rodrigues Martins
DDS, MSc
Endodontic Department, Faculty of Dental Medicine, Universidade do Porto – Portugal
Rua Dr. Manuel Pereira da Silva, 4200-393 Porto
PORTUGAL

Tel.: +351 914610046
miguel.ar.martins@gmail.com



ISTANBUL WELCOMES DENTAL PROFESSIONALS

22 International Speakers
Lectures on implantology, oral surgery, aesthetics, endodontics, laser dentistry
Workshop / Live demonstations
Hands-on courses
Visit free exhibition area on 2.500 sqm
Enjoy open buffet lunch from the chef masters
Online congress booking is available at
dentalistanbul.com

To book your booth please contact derya.arslan@vyg.com.tr

di DENTAL ISTANBUL'13
ARALIK / DECEMBER 07-08, 2013
GRAND CEVAHİR KONGRE MERKEZİ

dti Dental Tribune International

VYG vestiver publishingroup