Use of laser technology in the endodontic treatment

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Laser technology is being developed very quickly, as well as the understanding of laser interaction with biological tissues. The development of new delivery systems, including thin and flexible fibers and new endodontic tips, has made it possible to apply this technology in various endodontic procedures. The purpose of this article is to describe the clinical applications of lasers in endodontics where conventional treatments cannot provide comparable results or are less effective.

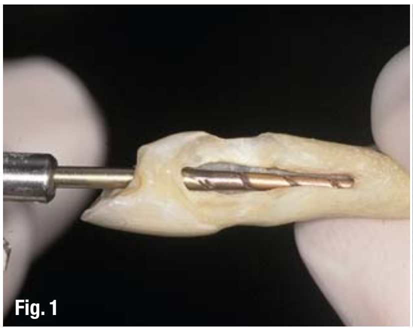
Fig. 1


Fig. 2

Fig. 1_The prototype of the RCLase™ Side Firing Spiral Tip is shown in the root canal of an extracted maxillary canine in which the side wall of the root was removed to enable visualization of the tip.

Fig. 2_The RCLase™ Side Firing Spiral Tip.

_**Successful endodontic therapy** mainly depends on the elimination of microorganisms from the root canal system. This is accomplished by means of biomechanical instrumentation of the root canal. However, studies showed that the complete removal of microorganisms and smear layer from the root canal system is virtually impossible Bystrom (1981), Sjogren et al.(1990).

The smear layer consists of a superficial layer on the surface of the root canal wall approximately 1–2 µ thick and a deeper layer packed into the dentinal tubules to a depth of up to 40 µ. Mader et al. (1984). It contains inorganic and organic substances including microorganisms and necrotic debris, Torabinejad et al.(2002).

In addition to the possibility that the smear layer may be infected, it can also protect the bacteria already present in the dentinal tubules by obstructing intra-canal disinfection agents Haapasalo & Orstavik (1986). Pashley (1984) considered that a smear layer containing bacteria or bacterial products might provide a reservoir of irritants. Thus, complete removal of the smear layer would be consistent with the elimination of irritants from the root canal system, Drake et al (1994).

Also, Peters et al. (2001) demonstrated that more than 35 % of the canals' surface area remained un-

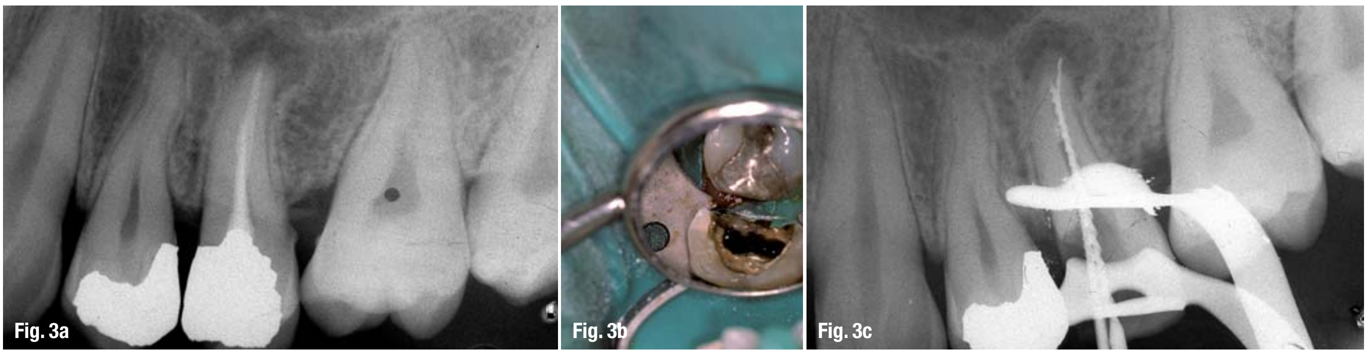
Fig. 3a Fig. 3b Fig. 3c

changed following instrumentation of the root canal using four NiTi preparation techniques.

Since most currently used intra-canal medicaments have a limited anti-bacterial spectrum and a limited ability to diffuse into the dentinal tubules, it has been suggested that newer treatment strategies designed to eliminate microorganisms from the root canal system should be considered. These must include agents that can penetrate the dentinal tubules and destroy the microorganisms, located in areas beyond the host defense mechanisms, where they cannot be reached by locally administered antibacterial agents, Oguntebi (1994).

Numerous studies by Anic et al.(1996), Harashima et al. (1997), Moshonov et al. (1995), Yamazaki et al. (2001), Takeda et al. (1998), Kimura et al. (2002) have documented that CO_2, Nd:YAG, argon, Er,Cr:YAG and Er:YAG laser irradiation has the ability to remove debris and smear layer from the root canal walls following biomechanical instrumentation.

The task of cleaning and disinfecting a root canal system which contains microorganisms gathered in a biofilm became very difficult.

Bacteria in a biofilm are resistant to both antibiotic therapy and host defense mechanisms, Costerton et al. (1999).

Biofilm is the manner of bacterial growth to survive unfavorable environmental and nutritional conditions; the root canal environment in both primary and post-treatment infections will favor biofilm formation. Additionally, biofilm mode of bacterial growth offers other abilities such as resistance to antimicrobial agents, increase in the local concentration of nutrients, opportunity for genetic material exchange, ability to communicate between bacterial populations of same and or different species and produce growth factors across species boundaries.

Bergmans et al. (2006), tried to define the role of laser as a disinfection toll by using Nd:YAG laser irradiation on some endodontic pathogens ex vivo.

They concluded that Nd:YAG laser irradiation is not an alternative but a possible supplemental to existing protocols for canal disinfections as the properties of laser light may allow a bactericidal effect beyond 1 mm of dentine. Endodontic pathogens that grow as biofilms, however, are difficult to eradicate even upon direct laser exposure.

In their review, "Lasers in Endodontics", Matsumoto and his team (2000) suggested that "removal of smear layer and debris by laser is possible, however it is difficult to clean all root canal walls, because the laser beam is emitted straight ahead, making it almost impossible to irradiate the lateral canal walls." They strongly recommended improving the endodontic tip to enable irradiation of all areas of the root canal walls. The Er:YAG laser has gained increasing popularity among clinicians following its approval by the Food and Drug Administration (FDA) for use on dental hard tissues Cozean et al. (1997).

Stabholz et al. (2003) and his colleagues reported the development of a new endodontic tip to be used with an Er:YAG laser system. The beam of the Er:YAG laser is delivered through a hollow tube, with an endodontic tip that allows lateral emission of the irradiation (side-firing), rather than direct emission through a single opening at its far end. This new endodontic side-firing spiral tip was designed to fit the

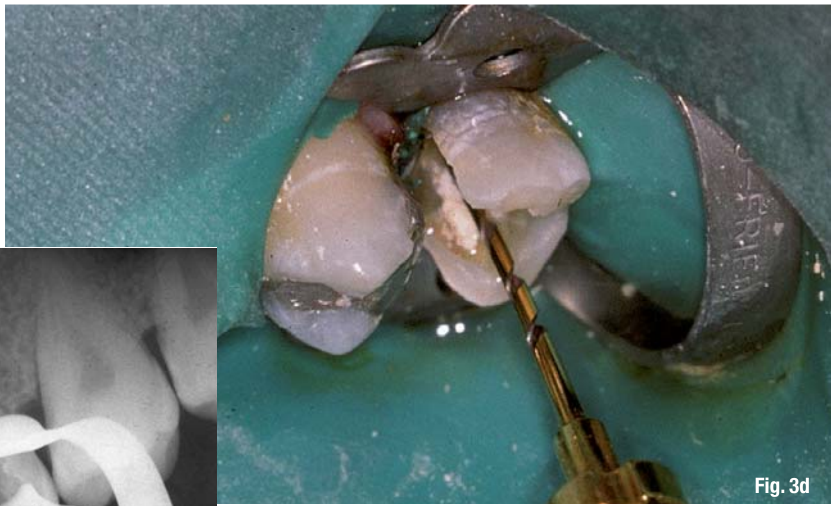
Fig. 3d

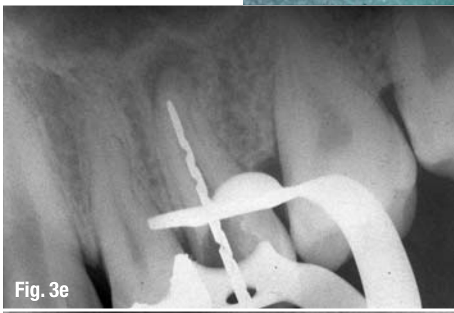
Fig. 3e


Fig. 3f


Fig. 3g


Fig. 3h

Fig. 3a–h

3a_Preoperative radiograph of a second left maxillary premolar with chronic apical periodontitis. A periapical radiolucent area can be clearly seen; a root canal retreatment is indicated. Following access opening, the old root canal filling material was removed; the occlusal view shows very unclean root canals.

3b_A length measurement radiograph.

3c_Demonstrates the presence of two separate root canals. Using Er:YAG laser irradiation for cleaning of the root canal system, the RCLase™ Side-firing Spiral Tip is introduced to the root canal (**3d** and **3e**) after biomechanical preparation of the root canal with NiTi (ProTaper™) files was completed.

3f and **3g**_Radiographs showing both root canals filled with gutta-percha. A Six-month postoperative radiograph shows good repair (**3h**).

shape and the volume of root canals prepared by NiTi rotary instrumentation. It emits the Er:YAG laser irradiation laterally to the walls of the root canal through a spiral slit located all along the tip. The tip is sealed at its far end, preventing the transmission of irradiation to and through the apical foramen of the tooth (Fig. 1 and 2).

The efficacy of the endodontic side-firing spiral tip, in removing debris and smear layer from distal and palatal root canals of freshly extracted human molars, was examined. SEM of the lased root canal walls revealed clean surfaces, free of smear layer and debris Stabholz et al. (2003). The dentinal tubules in the root run a relatively straight course between the pulp and the periphery, in contrast to the typical S-shaped contours of the tubules in the tooth crown Pashley (1984).

In various laser systems used in dentistry, the emitted energy can be delivered into the root canal system by a either thin optical fiber (Nd:YAG, KTP/Nd:YAG, Er:YSGG, argon, and diode) or by a hollow tube (CO_2 and Er:YAG). Thus, the potential bactericidal effect of laser irradiation can be effectively utilized for additional cleansing and disinfecting of the root canal system following biomechanical instrumentation. It was demonstrated in this vitro study that in addition to its ability to remove smear layer from the walls of root canals, Er:YAG laser irradiation when used inside the root canal system with the RCLase™ side-firing spiral tip has also an antibacterial effect on Enterococcus faecalis, by reduction the bacteria in more the 50 %, Sahar-Helft et al.(2008)

Based on these results it appears that an efficient cleansing of the root canal system can be achieved by using the Er:YAG laser irradiation with the RCLase™ side-firing spiral tip following bio-mechanical preparation of the root canal with NiTi (ProTaper™) files (Fig. 3 a–h)._

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