EFFICACY OF LASER IN ROOT CANAL TREATMENT

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Abstract: Although the interest in clinical use of laser systems for endodontic procedures is increasing there are still some concerns associated with their use, mainly, lack of sufficient well-designed clinical studies, which clearly demonstrate the advantage of lasers over currently used conventional methods and techniques. Bacterial contamination of the root canal system is considered the principle etiologic factor for the development of pulpal and periapical lesions. Obtaining a root canal system free of irritants is a major goal of root canal therapy. Biomechanical instrumentation of the root canal system has been suggested to achieve this task. However, because of the complexity of the root canal system, it has been shown that the complete elimination of debris and achievement of a sterile root canal system is very difficult and a smear layer, which covers the instrumented walls of the root canal, is formed. The task of cleaning and disinfecting a root canal system which contains microorganisms gathered in a biofilm became very difficult; certain bacterial species become more virulent when harbored in biofilm, demonstrating stronger pathogenic potential and increased resistance to antimicrobial agents since Biofilm has the ability to prevent the entry and action of such agents. Bergmans et al, tried to define the role of laser as a disinfection tool by using Nd:YAG laser irradiation on some endodontic pathogens ex vivo. The apparent consensus is that laser irradiation emitted from laser systems utilized in dentistry has the potential to kill microorganisms. In most cases the effect is directly related to the amount of irradiation and to its energy level.

Key words: endodontics, root canal, laser, disinfection

INTRODUCTION

The rapid development of laser technology as well as better understanding of lasers interaction with biological tissues widened the spectrum of possible applications of lasers in endodontics.

The development of new delivery systems, including thin and flexible fibers as well as new endodontic tips, made it possible to apply this technology in various endodontic procedures such as:

- Pulpal diagnosis
- Pulp capping and pulpotomy,
- Cleaning and disinfecting the root canal system
- Obturation of the root canal system
- Endodontic retreatment
- Apical surgery.

Although the interest in clinical use of laser systems for endodontic procedures is increasing there are still some concerns associated with their use, mainly, lack of sufficient well-designed clinical studies, which clearly demonstrate the advantage of lasers over currently used conventional methods and techniques.

Selection of the suitable wavelength from the various laser systems offered to the dental practitioners requires advanced training and good understanding of the different characteristics of each laser system. One of the most significant applications of lasers in endodontics relates to the cleaning and the disinfection of the root canal system and this article will focus on it.

MATERIAL AND METHOD

Cleaning and disinfecting the root canal system

Bacterial contamination of the root canal system is considered the principle etiologic factor for the development of pulpal and periapical lesions (1-3). Obtaining a root canal system free of irritants is a major goal of root canal therapy. Biomechanical instrumentation of the root canal system has been suggested to achieve this task. However, because of the complexity of the root canal system, it has been shown that the complete elimination of debris and achievement of a sterile root canal system is very difficult (4, 5) and a smear layer, which covers the instrumented walls of the root canal, is formed (6-8).

The smear layer consists of a superficial layer on the surface of the root canal wall approximately 1-2μ thick and a deeper layer packed into the dentinal tubules to a depth of up to 40μ (8). It contains inorganic and organic substances that include also microorganisms and necrotic debris (9). In addition to the possibility that the smear layer itself may be infected, it can also protect the bacteria already present in the dentinal tubules by preventing the application of successful intra-canal disinfection agents (10). Pashley (11) 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 (12). Also, Peters et al. clearly (13) demonstrated that more than 35% of the canals' surface area remained unchanged following instrumentation of the root canal using four Ni-Ti 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 was 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 an area beyond the host defense mechanisms, where they cannot be reached by systematically administered antibacterial agents (14).

It has also been documented in numerous studies that CO2 (15), Nd:YAG (15-17), argon (15,18), Er,Cr:YAG (19) and Er:YAG (20, 21) 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; certain bacterial species become more virulent when harbored in biofilm, demonstrating stronger pathogenic potential and increased resistance to antimicrobial agents since Biofilm has the ability to prevent the entry and action of such agents (22). Bergmans et al, tried to define the role of laser as a disinfection tool 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 supplement 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 (23).

RESULTS

However, there are several limitations that may be associated with the intra- canal use of lasers that cannot be overlooked (24).

The emission of laser energy from the tip of the optical fiber or the laser-guide is directed along the root canal and not necessary laterally to the root canal walls (25). Thus, it is almost impossible to obtain uniform coverage of the canal surface using a laser (24, 25). Also, since thermal damage to the periapical tissues is potentially possible, the safety of such a procedure always has to be considered (25). Direct emission of laser irradiation from the tip of the optical fiber in the vicinity of the apical foramen of a tooth may result in transmission of the irradiation beyond the foramen. This, in turn, may undesirably affect the supporting tissues of the tooth and can be hazardous in teeth with close proximity to the mental foramen or to the mandibular nerve (25, 26) .In their review, “Lasers in endodontics”, Matsumoto and his team (26) also emphasized the possible limitations of the use of laser in the root canal system. They 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 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 hard dental tissues (27).

Stabholz and his colleagues (25, 26) recently reported the development of a new endodontic tip which can be used with an Er:YAG laser system. The beam of the Er:YAG laser is delivered through a hollow tube, making it possible to develop 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 shape and the volume of root canals prepared by Ni-Ti 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, 2).

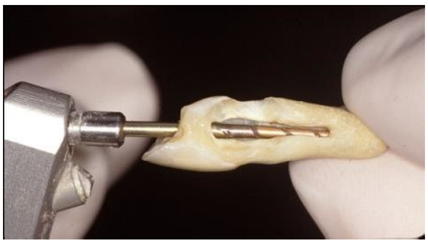

Fig. 1. The prototype of the RCLase™ Side Firing Spiral Tip is shown in the root canal of an extracted maxillary canine in which the side wall of the root was removed to enable visualization of the tip.

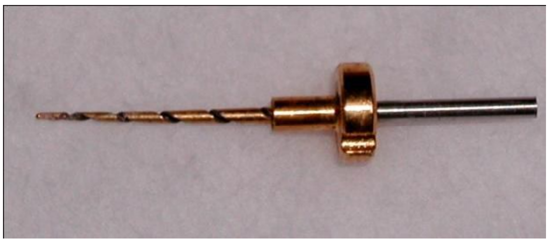

Fig. 2. The RCLase™ Side Firing Spiral Tip.

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 (26) - Figs. 3, 4, 5, 6A, 6B.

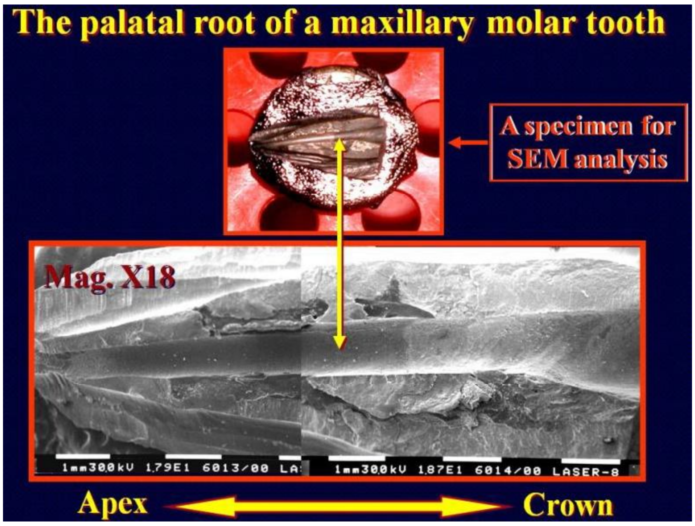

Fig. 3. Longitudinally split palatal root of a maxillary molar, sputter coated by gold and ready for a scanning electron microscope evaluation. The vertical arrow indicated the root canal as shown on the SEM photograph.

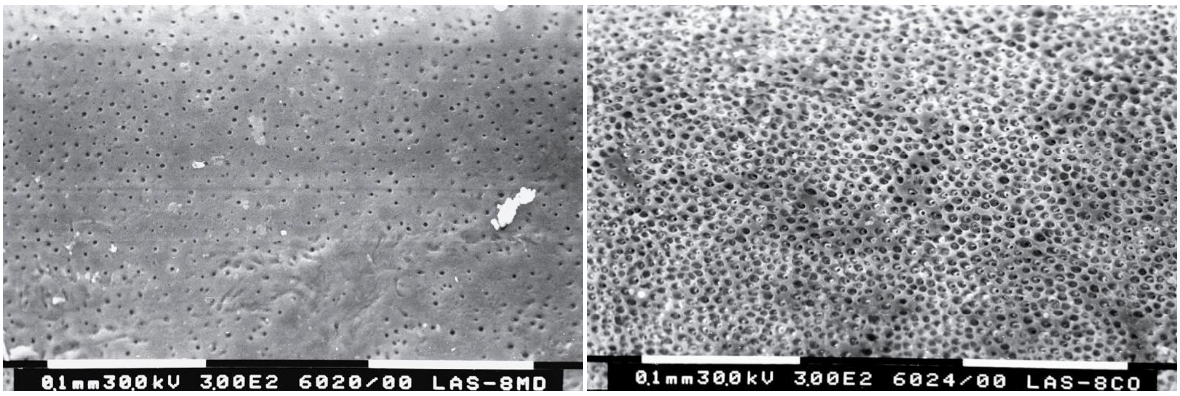

Fig. 4, 5. Scanning electron microscope photographs of a lased wall of a root canal demonstrate very clean surfaces of the root canal walls, free of smear layer and debris and clean open dentinal tubules (magnification X 300).

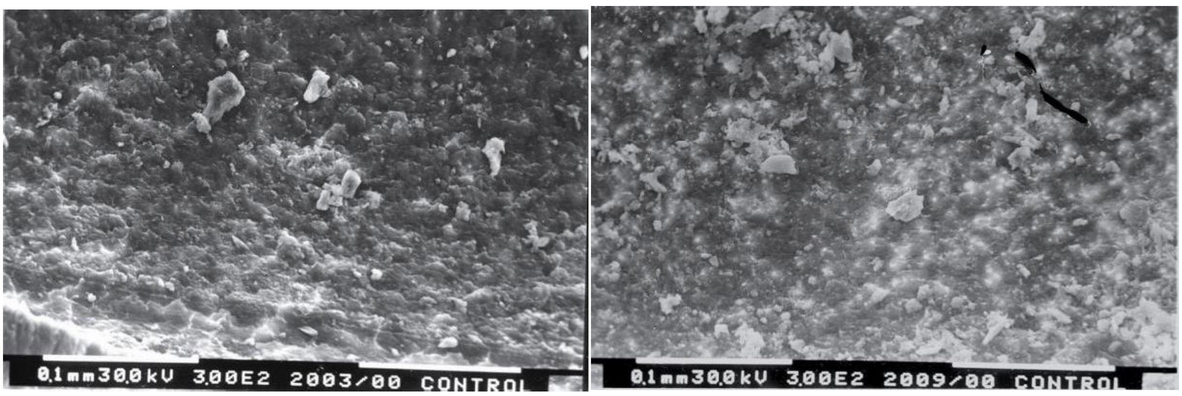

Fig.6 A, B. Scanning electron microscope photographs of a non lased wall of a root canal demonstrate unclean surfaces of the root canal walls with smear layer and debris. The dentinal tubules can not be seen (magnification X 300).

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 (11). Studies have shown that bacteria and their byproducts, present in infected root canals, may invade the dentinal tubules. The presence of bacteria in the dentinal tubules of infected teeth at approximately half the distance between the root canal walls and the cementodentinal junction was also reported (28, 29). These findings justify the rationale and need for developing effective means of removing the smear layer from root canal walls following biomechanical instrumentation. This would allow disinfectants and laser irradiation to reach and destroy microorganisms harboring in the dentinal tubules.

In various laser systems used in dentistry, the emitted energy can be delivered into the root canal system by a thin optical fiber (Nd:YAG, KTP-Nd:YAG, Er;YSGG, argon, and diode) or by a hollow tube (CO2 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.

This effect was extensively studied using lasers such as CO2 (30, 31), Nd:YAG (32-35), KTP-Nd:YAG (36), excimer (37, 38) diode (39) and Er:YAG (40-42).

The apparent consensus is that laser irradiation emitted from laser systems utilized in dentistry has the potential to kill microorganisms. In most cases the effect is directly related to the amount of irradiation and to its energy level (Figs. 7A -7H).

Fig. 7A

Fig. 7B

Fig. 7C

Fig. 7D

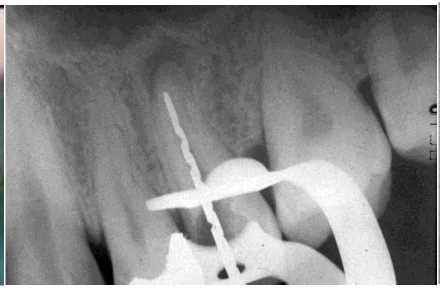

Fig. 7E

Fig. 7F


Fig. 7G


Fig. 7H

Fig. 7 (A to G). A, 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 B. A length measurement radiograph, C demonstrates the presence of two separate root canals. Using Er:YAG laser irradiation for cleaning of the root canal system - the RCLaseTM Side-firing Spiral Tip is introduced to the root canal after biomechanical preparation of the root canal with Ni-Ti (ProTaperTM) files was completed, D and E (as seen on a radiograph). F and G, Radiographs showing both root canals filled with gutta-percha. A Six-month postoperative radiograph shows good repair, H.

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