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Successful Endodontic Management Using Er,Cr:YSGG Laser Disinfection of Root Canal in a Case of Large Periapical Pathology

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Abstract Total elimination of bacteria from infected root canal systems remains the most important objective of endodontic 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 still an ongoing challenge. The task of cleaning and disinfecting a root canal system which contains microorganisms gathered in a biofilm is 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. The use of lasers in the field of endodontology represents an innovative approach to match these requirements. In general, dental lasers provide greater accessibility of formerly unreachable parts of the tubular network, due to their better penetration into dentinal tissues. The ability of lasers to remove smear layer and debris from the root canal wall and to open up the orifices of dentinal tubules can be exploited for disinfection of the root canal systems. This article describes the successful management of a case of lower anteriors with large periapical pathology. Er,Cr:YSGG laser was used as an adjunct to conventional root canal preparation that resulted in remarkable and faster healing of the periradicular lesion in lower anteriors.

Keywords: *endodontics, root canal, Er,Cr:YSGG laser, disinfection, healing, anterior*

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1. Introduction

One of the most critical and fundamental stages of endodontic therapy is the root canal disinfection in its three-dimensional network of dentinal tubules. It is generally accepted that microorganisms tend to remain in the root canal even after proper preparation and are responsible for flare-ups, after the completion of the endodontic therapy [1]. The complicated root canal system has accessory features, microbes can survive within the root canals, dentinal tubules, accessory canals, canal ramifications, apical deltas, and fins, once the tooth become infected [2]. These microbial factors can lead to an endodontic failure. To prevent this, effective means of disinfection of root canals are required.

Disinfection and preparation of the root canal system effectively to allow the host response to be turn toward the healing of the periapical tissues [3]. Antibacterial rinsing solutions, like NaOCl, for example, can, on the other hand, only penetrate into the dentin to a depth of 100 µm [4]. Irrigants such as sodium hypochlorite and chlorhexidine also have demonstrated useful antimicrobial effects; however, infection of the root canal and adjacent dentin may persist owing to the inability of these agents to reach all the infecting microorganisms [5].

During the last years, laser irradiation has been additionally introduced in root canal preparation, trying to gain acceptance for its disinfection ability in comparison with the common mechanical instrumentation and irrigation procedures. The use of lasers in disinfection of the root canal has been demonstrated by many studies [6]. Lasers have bactericidal effect and can be used effectively for disinfection of the root canal system following biomechanical instrumentation. Many studies examined the effectiveness of Nd: YAG, diode, Er,Cr:YSGG and Er:YAG laser, when used in different wavelengths, independently, or in addition with various solutions in the bacterial elimination inside the root canals.

Periapical lesions of endodontic origin may develop asymptomatically and become large. In cases of large periapical lesions, non-surgical approach should be attempted first as many newer endodontic disinfection and instrumentation modalities are available to eradicate the existing microflora of infected root canal systems. Many studies confirm that such lesions can respond favourably to non-surgical treatment [7].

Since the introduction of lasers in endodontics during the early 1970s, there have been several studies regarding the application of this technology as an aid to improve not only the cleansing and disinfection [8] but also the sealing of the root canal system [9]. Treatment of the radicular dentinal walls with the laser has been shown to promote cleaner surfaces when compared with a combination of sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA), which might result in better adaptation of the filling material to the root canal walls [10]. Thus, the application of the Cr, Er:YSGG laser has been shown to provide superior cleanliness of the canals when compared with instrumentation alone [11]. A study by Schoop et al [12] illustrated the bactericidal potential of the Er,Cr:YSGG laser applied to root dentine samples. In this case report, laser therapy was used as an adjunct to endodontic irrigants and biomechanical preparation for complete disinfection of root canal system. This could achieve adequate healing even in the presence of large periapical lesion. This case report highlights the importance of Er,Cr:YSGG laser disinfection as nonsurgical management for the resolution of the large periapical lesion present in mandibular anterior teeth.

2. Case Report

A 30-year-old female patient visited the dental office with pain and swelling in the lower anterior region Figure 1. On examination there was a soft tissue swelling in relation to 31, 41. Patient had a history of traumatic injury to the same region 1 year back. She experienced intermittent pain and swelling in the lower anterior region since then. Clinical examination revealed an intraoral abscess in relation to mandibular central incisors. There was severe anterior deep bite with gross attrition of mandibular incisors. Electric (Parkell Inc, Edgewood, NY) pulp test was negative for both mandibular central incisors and right lateral incisor. An intraoral periapical radiograph Figure 1 revealed a large radiolucent lesion in relation to both central incisors and right lateral incisor. Based on clinical and radiographical findings, a diagnosis of acute exacerbation of chronic apical abscess in relation to both the mandibular central incisors and pulp necrosis in relation to both the mandibular lateral incisors were made. Treatment was planned as an emergency access opening in both the central incisors followed by root canal treatment in all four incisors. An emergency access cavity was prepared in both the central incisors with safety tip carbide bur. As soon as the canals were explored, copious, mucopurulent fluid was drained through the root canals. Below protocol was followed for the disinfection of root canal:

1. Access cavity was prepared in the lower anterior teeth under rubber dam isolation.

2. Working length was estimated using apex locator and was confirmed using radiography Figure 2. Biomechanical preparation was done with standardized technique using hand K files (Mani Inc., Tochigi Japan). Cleaning and shaping was done up to size 35 file, irrigation was done copiously and intermittently with 5% sodium hypochlorite and normal saline.

3. C100-Z3-25 mm endo tips in a sterilized laser handpiece were used to disinfect the root canals. Disinfection phase (0.75 W; 20 Hz; 10 % air; 0 % water) of Er,Cr:YSGG laser was employed for the same. We moved the laser tip by hand up and down in the canal in a cervical-apical and apical-cervical direction at a rate of 1 mm per second (that is, 10 seconds to traverse the full 5mm length of the canal in both directions). During this procedure, we kept the tip as close to the canal wall as possible.

Figure 1. preoperative radiograph

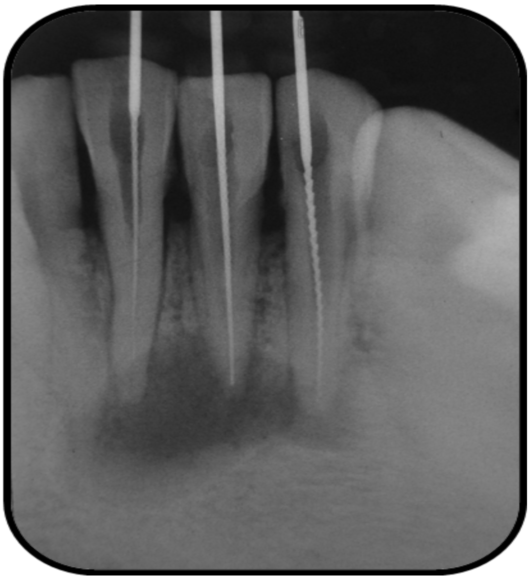

Figure 2. working length radiograph

After laser radiation, canals were dried and obturation was done using lateral compaction of gutta-purcha (Densply Maillefer) and AH Plus resin sealer (Maillefer Densply, Konstanz, Germany). During the first follow up after one week resolution of the acute symptoms were noticed. A final radiograph was taken to determine the quality of obturation Figure 3. Remarkable healing was observed at the 6 month recall visit radiograph Figure 4.

3. Discussion

The long-term success of root canal treatment attributes to an effective elimination of bacteria that cause an inflammation in the root canal and in the dentin tubules. The contamination of root canals with bacteria and its subsequent propagation in remnants of necrotic soft tissue are considered one of the main reasons for failure in endodontic treatment [13]. The success rate of teeth that give a negative culture for bacterial growth at the time of a root canal filling is higher than teeth that are culture positive [14]. In addition to mechanical instrumentation of the root canal system, irrigating the canal with disinfectant chemicals has been proposed to enhance the removal of vital and non-vital tissue remnants, tissue breakdown products, and bacteria and bacterial by products [15]. Sodium hypochlorite [16] and calcium hydroxide [17] have a limited ability to penetrate and disinfect the root canal system (approximately 130 µm penetration). Chlorhexidine and iodine-potassium-iodine are more effective in dentinal tubules than pure Ca(OH)2 in a water vehicle, but complete disinfection has not been demonstrated [18].

Figure 3. postoperative radiograph

Figure 4. healing evident after 6 months

It has been shown that bacteria colonize the periluminal dentine up to a depth of 1,100µm [19]. Berutti et al [20] stated that chemical disinfectants penetrate only 100µm into the dentine. In addition, curved root canals or lateral canals can be a hinderance in the endodontic treatment. The use of lasers helps to combat this problem. The high penetration efficacy of the laser light in the dentinal tissue seems to be the most appropriate solution for the appropriate bactericidal effect of different laser wavelengths. The high penetration depth of the laser beam in the dentinal tissue seems to be the best explanation of the satisfying bactericidal effect of different laser wavelengths. 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 [21]. It has been proved in numerous studies that an emission of laser light directly in the root canal does have such a bactericidal effect. The laser radiation may be transmitted through quartz optical fibers, a property that could facilitate introducing laser light around canal curvatures and irregularities [22]. Vaarkamp and colleagues [23] and Odor and colleagues [21] provide a possible explanation for this kind of light propagation; they describe the ability of enamel prisms and dentin tubules to act as optical fibers. The monochromatic, coherent, and directional characteristics of laser light, and the fact that direct contact between target and fiber tip is not required, raise the possibility that emission of laser energy could provide a means to disinfect areas deep within the dentin [24].

Perin et al [25] evaluated the antimicrobial effect of Er:YAG laser irradiation versus 1% NaOCl irrigation for root canal disinfection. The study found that both methods were effective to working length against all microorganisms. Wang et al [26] evaluated the bactericidal effect of the Er,Cr:YSGG laser and the Nd: YAG laser in straight root canals that were inoculated with E faecalis for 3 weeks. After laser irradiation, the number of bacteria in each root canal was determined. The study found that the Er,Cr:YSGG laser irradiation resulted in a reduction in bacteria of 77% after irradiation at 1 W, and a reduction of 96% after irradiation at 1.5 W, but there was no significant difference. Schoop et al [27] found that the disinfecting effect of the chromium: yttrium-scandium-gallium-garnet Er,Cr:YSGG (2,780 nm) laser in root dentin samples was dependent on the output power but was not specific for the bacterial species investigated. Gordon et al [28] investigated the ability of an Er,Cr:YSGG laser with radial emitting tips to disinfect dentin infected with Enterococcus faecalis. The study found that bacterial recovery decreased when laser irradiation duration or power increased. Schoop et al [29] evaluated the use of the Er,Cr:YSGG laser with radial-firing tips in terms of bacteriology, morphology, and temperature measurements in root canals. The canals were inoculated with 2 test strains of bacteria and were irradiated with power settings of 0.6 W and 0.9 W and a repetition rate of 20 Hz. The bacteriological evaluation revealed a decisive disinfectant effect. It was also observed that the smear layer was homogeneously removed from the root canal walls, and temperature elevation at the root surface during irradiation was moderate. The study concluded that in conjunction with radial-firing tips, the Er,Cr:YSGG laser is a suitable device for eliminating bacteria in root canals and for the removal of smear layer.

Technique for the disinfection phase is the same as the cleaning phase but with different laser settings in the dry mode. The penetration of the laser into the root dentin is governed by several factors. At the wavelength of the Er,Cr:YSGG laser (2.78 μm), there is absorption by dentin owing to the presence of hydroxide and interstitial water (dentin matrix and intratubular). On the basis of the fact that each laser pulse is composed of approximately 150 micropulses and each micropulse is responsible for the penetration of this energy of about 3 μm into water, depending on fluence, it is possible to achieve expansion of intratubular water and the collapse of water vapor as deep as 1,000 μm or more. This effect, known as "micropulse-induced sequential absorption," with expansion and collapse of water vapor, is capable of producing acoustic waves strong enough to disrupt intratubular bacteria.

In this case, significant bactericidal effect and disinfection of the root canals were achieved using Er,Cr:YSGG laser, that resulted in substantial healing in a short period of time. The large periapical lesion present was hence dealt with nonsurgical management, which was otherwise deemed for surgical intervention. 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 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 [28], who achieved a 99.7% kill rate for E. faecalis in the dry mode.

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