Clinical evaluation of a new laser enhanced ablation procedure (LEAP) in regenerative endodontics: a case report

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Abstract

A new laser enhanced ablation procedure (LEAP) has been recently proposed in order to maximize the efficiency of intracanal disinfection and minimize the risk related to the extrusion of the irrigating solutions during endodontic therapy. The LEAP technique is based on the use of a diode laser which activates a laser absorption solution containing indocyanine green (ICG). In the present study, the use of LEAP was suggested as a final irrigation procedure which utilizes a safer and more biocompatible approach, avoiding the use of sodium hypochlorite and the risk related to its use in teeth with resorption. A 13-year-old boy was referred for endodontic treatment of a symptomatic lower left incisor. Dental history revealed a previous trauma. At the radiological examination, internal external resorption and large apical lesion were observed. Following the traditional chemomechanical approach, the LEAP protocol was used as an adjunct to improve disinfection before a regenerative procedure. After one-year radiographic healing had occurred and revealed normal periapical structures. The resorption process was stopped, and the patient reported being free of pain and able to use the tooth normally.

Key words: Laser; LEAP; Root canal; Disinfection; Antimicrobial; Regenerative endodontics; Root Resorption.

Introduction

The basic principle of endodontic therapy is based on the disinfection of the root canal system using a chemo-mechanical instrumentation approach (combining root canal instruments and syringe irrigation) and a final enhanced irrigation technique using antimicrobial solution activated by different types of energy, i.e. sonics, ultrasonics, lasers, etc. (1,2). Even if root canal instrumentation plays a significant role in canal disinfection and debridement (3,11,21), irrigation is often regarded as the most important part of the root canal therapy, in particular for the elimination (ideally) or significant reduction of root canal microbes. During and following instrumentation, irrigating solutions are currently used to improve the killing of and removal of microorganisms, removal pulp and debris, and new solutions and new devices have been proposed in the last decades to improve the efficacy and safety of this fundamental step (12). Several studies have shown the importance of abundant and frequent irrigation, the importance of activating the irrigating solutions inside the root canal system to allow them to ideally reach all the instrumented and non-instrumented endodontic spaces, the dentinal tubules and ideally eliminate all bacteria (16,20). This effort is necessary because the root canal systems are very complex (19) and it is not easy for an irrigating solution, even when using activation, to reach all these areas. Moreover, some enhanced irrigation techniques which are mostly used in combination with sodium hypochlorite increase the risk of extrusion of the solution beyond the apex. This procedural accident may lead to increased post-operative pain (8,9) but also to more serious complications, known as “a hypochlorite accident,” These “accidents” are not very common in conventional endodontic therapies, but have been widely reported in several published scientific articles. Moreover in immature teeth, in teeth with wide open and resorpted apex, this risk is much more relevant (17).

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As a consequence safety of an irrigating procedure is considered as important as its efficacy.
The 980 nm diode laser in previous studies was found to be a valid adjunct to the treatment of necrotic cases with periapical lesions in terms of postoperative pain and root canal disinfection, but laser tips also have some limitations when dealing with complex anatomy (5,7). Recently a new laser enhanced ablation procedure (LEAP) has been proposed in order to maximize the efficiency of intracanal disinfection and minimize the risk related to the extrusion of the irrigating solutions (6). The LEAP technique is based on the use of a diode laser which activates a laser absorption solution containing indocyanine green (ICG). This LEAP solution has a high absorption efficiency of 810 nm diode laser energy. At optimal conditions, the laser induces a local thermal explosion to ablate residual and infected tissues in the canal without heating the surrounding dentin, providing a significant and safe disinfection and debridement of the root canal systems. The LEAP solution is injected with a 30-gauge needle with the laser energy delivered through a specialized 200µm tip, and consequently, canals only need a minimally invasive approach. More precisely the need to be enlarged to about 250 µm size in the apical third area. According to the manufacturer, LEAP can optimize irrigation procedure both in terms of efficacy and safety, also by simplifying the operative procedure and reducing time, with a reliable and predictable clinical approach.
In the present clinical work, this new technology was used in regenerative endodontics (13-15), which proposes the use of a combination of antimicrobials and irrigants, less invasive canal walls instrumentation, induced apical bleeding to form a blood clot and a tight seal into the root canal to promote healing. Regenerative endodontics in necrotic mature teeth is a complicated procedure to perform, due to the presence of wide, open resorpted apex and the need to guarantee a really significant reduction of bacteria inside the canal to promote healing and regeneration, while not affecting the regenerative potential of stem cells. In the last decade, alternative antimicrobial strategies in lieu of traditional triple antibiotic paste have been proposed for regenerative endodontic procedures. In the present study, the use of LEAP was suggested because the final irrigation procedure utilizes a more biocompatible approach (solution containing indocyanine green), avoiding the use of sodium hypochlorite and the risk related to its use in immature teeth. The article has been written according to the PRICE guidelines for case reports provided by the International Endodontic Journal and it is the first published clinical case where LEAP is used in regenerative endodontics.

Clinical Case

A 13-year-old boy was referred for endodontic treatment of a lower left incisor. Dental history revealed a previous trauma to the mandibular anterior teeth approximately 3 years ago. No dental treatment was administered at that time. During the following years the tooth become slightly symptomatic. According to the patient, the pain was now constant and diffuse with moderate severity, spontaneous in onset, and aggravated by mastication. Extraoral examination revealed no abnormalities. Intraoral examination revealed a small carious lesion on the proximal side of the tooth, with no coronal restoration present. The tooth was tender to vertical percussion and palpation. There was no horizontal mobility or depressibility.
The tooth (#31) had a negative response to both the cold test and the electrical pulp test. Cold and electrical pulp tests were performed on all mandibular incisor teeth, and normal responses were observed. Periodontal probing revealed probing depths of less than 2 mm. At the radiological examination, internal external resorption and large apical lesion were observed (Fig. 1a).
Based on clinical and radiographic findings, a pulpal diagnosis of necrotic pulp with resorption was made for tooth 31, and due to the age of the patient a revitalization treatment was proposed and was chosen as the treatment modality after discussion with parents, providing all information about the risks and limitations of the treatment
After rubber dam isolation, an access cavity was prepared and all necrotic infected tissue remnants were removed. The root canal was instrumented with nickel-titanium rotary instruments, aiming for a final shape with a .06 taper and an apical size of 25. Syringe irrigation with %1 NaOCl was used during instrumentation. then %17 EDTA was used to rinse and deactivate NaOCl. Then the LEAP procedure was started following the manufacturer's IFU. After drying the canal with paper points, ICG dye was placed and left the canal for 1 minute. The laser fiber (size 30) was placed 1 mm shorter than the working length, and the laser was then activated with a LEAP setting, slowly removing the fiber from the canal in a circular motion over 30 seconds. This step was repeated 2 times. Then the dye was rinsed from the canal using saline; the canal was dried with sterilized paper points and calcium hydroxide medication was placed to the canal. After 14 days, the tooth was asymptomatic, with no pain or sensitivity reported by the patient. After removing the calcium hydroxide with EDTA, the LEAP protocol was again applied as described before, before starting the regenerative procedure. Apical bleeding was initiated and CGF fibrins obtained from the patient's blood, were placed to the root canal which is full of blood. A bioceramic putty was placed in the coronal 2 mm to ensure a three-dimensional seal in the coronal part of the canal, and an immediate post-operative radiograph was taken (Fig. 1b). Patient was recalled every 3 months for clinical examination, and never referred significant discomfort or pain while chewing. Radiological examination was done at 6 months (Fig. 1c) and 12 months (Fig. 1d) intervals. The 12-month follow-up radiograph (Fig. 1d) showed that healing had occurred and revealed normal periapical structures. The resorption process was stopped. The patient reported that he was free of pain and could use the tooth normally.

Discussion

Photodynamic therapy is a treatment modality that has been suggested for medicine and dentistry since many decades and more recently it has been commercially proposed in fields like periodontics and endodontics where bacterial reduction or elimination is a key factor in determining successful therapies (4,10). In the last decade, a few devices based on the concept of

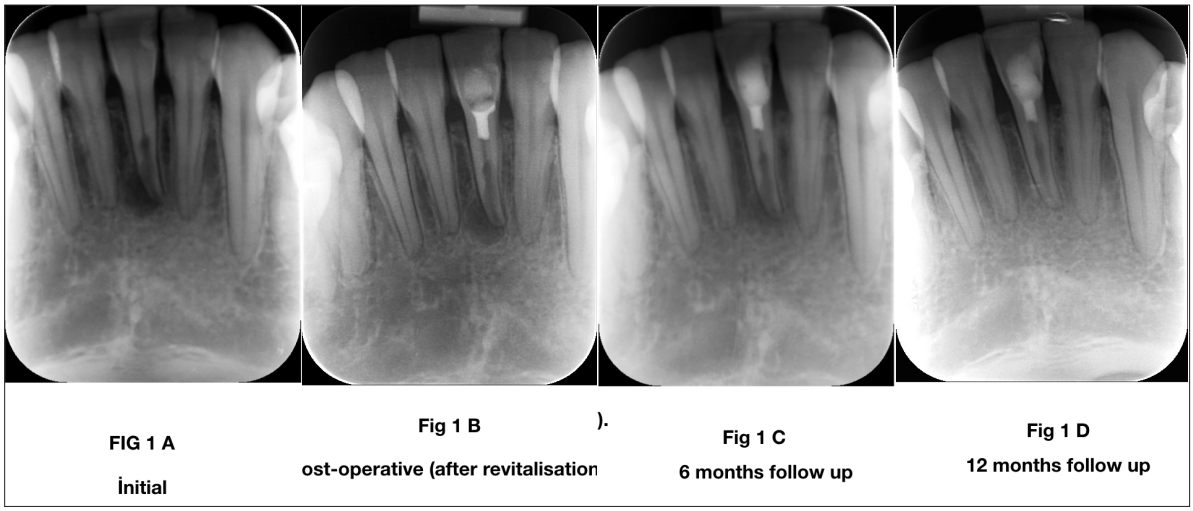

Figure 1 A-D. Radiographic images.

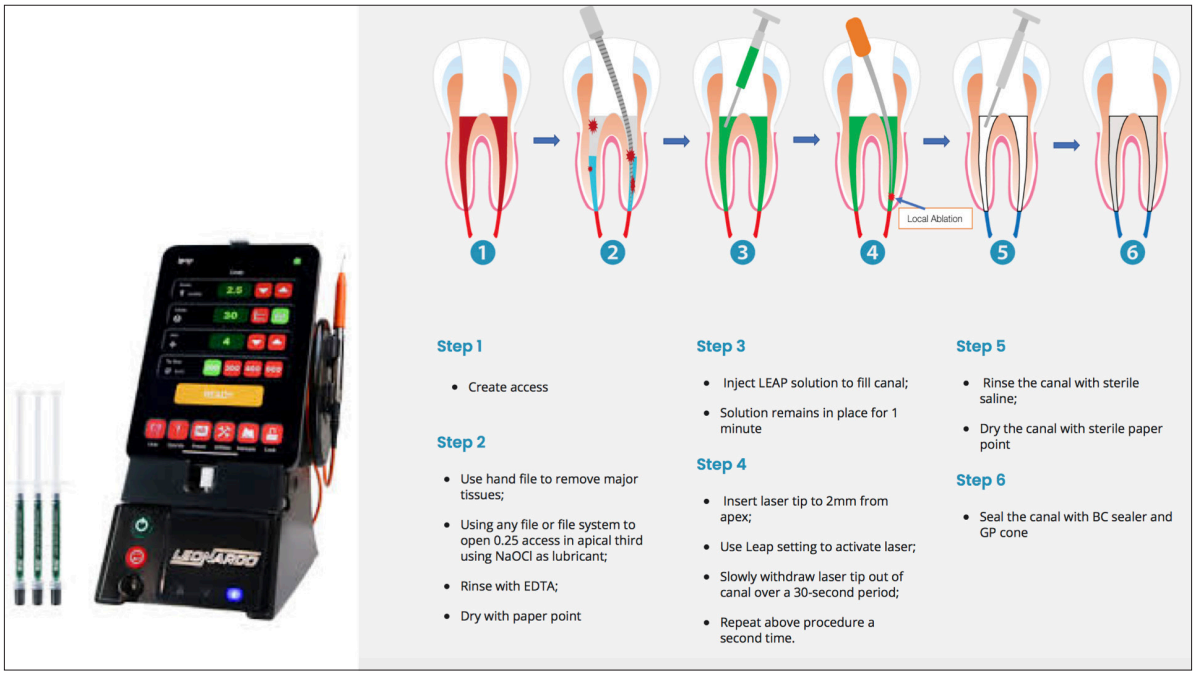

Figure 2. Leap device and protocol.

photodynamic inactivation were commercialized as a promising effective adjunct to standard antimicrobial intracanal cleaning and several articles published showing bacterial load reduction in vivo, in vitro and ex vivo, with promising results (16,20). Such procedures require microbial exposure to either exogenous or endogenous photosensitizer molecules, which are introduced in the canal systems as fluids or gels. Then visible light energy is provided, usually by wavelengths in the red/near-infrared region. This energy results in the excitation of the photosensitizers and in the production of reactive oxygen species that react with intracellular components. As a final consequence cell inactivation and death is achieved.

Despite these favorable premises photodynamic therapy in endodontics has not gained popularity amongst clinicians due to the complexity of the root canal systems which requires ideal properties of the solution, in terms of diffusion inside the endodontic space and in terms of excitation of the photosensitizers. It also requires proper light energy and a procedure which is simple to use and reliable. According to manufacturer LEAP aims at reaching these goals by using a new proprietary solution with ideal intracanal diffusion and a proper lase activation which optimize excitation of the photosensitizers, allowing a significant reduction of bacteria and infected debris inside root canal. In a recent clinical study LEAP therapy with ICG significantly reduced bacterial contamination inside canals and the protocol was suggested as a valuable adjunct to endodontic treatment in mature teeth with periapical lesions (6).

In the present case report LEAP was used as a final irrigation technique, aiming at properly disinfecting a necrotic immature tooth with periapical lesions with an irrigating procedure more delicate and probably safer than those using activated sodium hypochlorite. The

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one year control showing healing of the lesions and advancement in the root maturation process confirmed the clinically relevant antimicrobial results provided by LEAP and the minimal negative effect on the stems cells, which allowed a quick regenerative effect. The successful removal of intracanal bacteria and infected tissue is essential in regenerative endodontics, as the presence of bacterial contamination adversely affects the regenerative process. Such a delicate approach was also assessed by the absence of post-operative pain which is also due to a non-significant extrusion of the solutions and/or its biocompatibility, and also related to the use of more biocompatible sealers (18).

Hence we may conclude that the LEAP technique seems to be a very promising effective adjunct to standard antimicrobial intracanal disinfection and debridement for the treatment of periapical lesions both in mature and immature teeth due to its proprietary mechanism of action, photosensitizers, and light sources.

The authors deny any conflict of interest

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