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DIODE LASER IN ORTHODONTICS - CASE PRESENTATIONS

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INTRODUCTION

The term "LASER" is an acronym for "Light Amplification by Stimulated Emission of Radiation". A laser is a device that can produce light by converting electrical energy into optical energy. To generate laser light, the atoms must be excited at a higher energy level and release the energy in phase. The result is an almost parallel, monochromatic and coherent beam of light, different from conventional lights. The unique properties of the laser that distinguish it from the conventional light are: monochromaticity (the wavelength of light emitted by the laser is very narrow compared to common sources that emit light with a broad wavelength; this is why, instead of containing multiple colors, laser light has a single specific color), collimation (the laser beam has a constant direction, size and shape, while conventional light diverges in all directions) and coherence (all light waves are identical in the laser). (1)

Regarding the working mechanism of the laser, when the laser beam strikes the target tissue, four types of interactions occur: reflection, transmission, scattering and absorption. Reflection occurs when the beam is redirected away from the tissue surface, which has no effect on the target. When the laser energy passes through the tissue and has no effect on the target tissue, transmission occurs. Scattering tends to transfer heat produced by the laser beam to the adjacent site, which weakens the laser's energy. The absorption of laser energy by the target tissue is the main and desirable effect of the laser. The amount of energy absorbed by the target tissue depends on the laser wavelength, the emission mode and the characteristics of the tissue. (1–3)

Lasers have been used in dentistry since 1988, for soft-tissue surgeries and later its applications have expanded, being used in conservative dentistry (as an alternative to rotating instruments), prosthetics, periodontics, endodontics, oral surgery and last but not least in orthodontics. (4) There are currently six basic types of lasers used in dentistry, named after the chemical elements, molecules or compounds that make up the active medium that is stimulated; carbon dioxide (CO_2) laser, neodymium-doped yttrium aluminum garnet (Nd:YAG) laser, diode laser, argon laser, erbium,chromium:yttrium-scandium-gallium-garnet (Er, Cr:YSGG) or erbium-doped yttrium aluminum garnet (Er:YAG) lasers and yttrium-aluminum-garnet doped with holmium (Ho:YAG) laser. (1)

In orthodontics, lasers have a multitude of applications, including acceleration of tooth movement, bone remodeling, enamel etching before adhesive bonding of fixed appliances and ceramic bracket debonding. Some types of lasers (low-level laser therapy – "LLLT") have proven effects on pain control associated with orthodontic treatment. Among the most common applications of laser in current orthodontic practice is soft tissue management, such as gingivectomy/ gingivoplasty for gingival reshaping and crown lengthening, removal of hypertrophic and inflamed tissues, impacted tooth exposure or frenectomy/frenuloplasty. (5)

Laser therapy widely applied in orthodontic treatment has proven to have many benefits. Dental lasers offer superior comfort and precision during soft tissue incision. They cause minimal tissue damage, control bleeding and promotes less wound contraction. Swelling and postoperative pain are also reduced. (1)

AIM

This paper aims to highlight the efficiency of laser therapy in the orthodontic treatment by presenting three clinical cases in which diode laser with a wavelength of 940 nm was used for soft-tissue management.

MATERIAL AND METHOD

In all the presented clinical cases, the interventions were performed with the BIOLASE Epic X 940nm diode laser (Fig. 1) with initiated peaks, E4-400nm, power 2w, in continuous mode (CW = continous wave). The BIOLASE Epic X 940nm laser has pre-programmed settings for various dental procedures, including the excision of gingival hypertrophy and the exposure of impacted teeth. For these soft tissue surgical procedures it is necessary to initiate the fiber tip. You can use CP0 mode with peak power 5.0 w, average power 1.0w, with a pulse interval of 0.04ms and a length / duration of 0.01ms using E4 initiated peaks (fiber peak diameter is 400nm) with a duty cycle of 20%, in which case the tissue temperature remains low. To expose impacted teeth, the CP2 mode with an output power of 1.8w and an average of 0.9w is recommended, using initiated E4 peaks.

Figure 1. The Biolase Epic X diode laser used for the presented soft tissue interventions

All interventions were performed in a private dental clinic, where the risks of the therapeutic intervention were discussed and explained and the written consent of the patient (and/or parent) was obtained. After the patients were clinically evaluated and all data was fully recorded in the individual file they were prepared for the surgical procedure. Soft tissue interventions were performed under topic and local anesthesia. At the end of the intervention, the patients received verbal instructions regarding the diet and rigorous oral hygiene regimen anf analgesics were prescribed when required.

CASE REPORTS

First case report

A 14-year-old female patient (P.P.) with a class III Angle malocclusion presented an upper right canine (1.3) impaction, with persistence without mobility of the temporary canine (5.3). Within the personal medical history, it should be noted that during the mixed dentition the patient had an anterior edge to edge frontal occlusion with bimaxillary spacing. Between 8-11 years old, the patient underwent an orthodontic treatment with removable and functional appliances to normalize the anterior occlusion and guide growth. The treatment continued at the age of 12 with supervising the eruption of permanent teeth, extracting temporary canines to guide the eruption of permanent teeth and after one year, due to the lack of upper right canine (1.3) eruption (Fig. 2a), a fixed upper orthodontic appliance was bonded, obtaining the space necessary for permanent canine eruption and alignment.

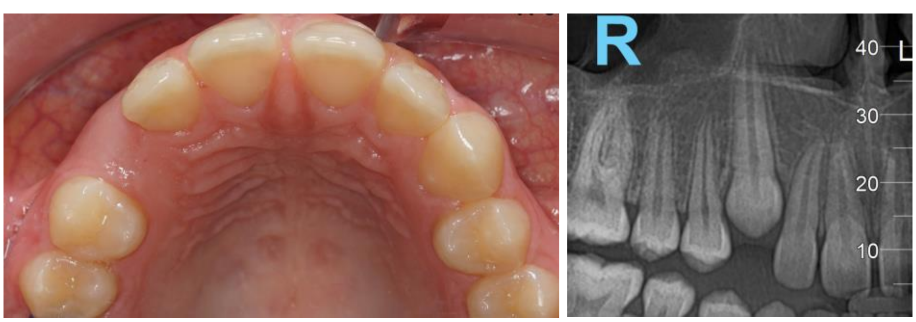

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Figure 2. Patient P.P. a. clinical (left) and radiological (right) image of impacted canine before applying the fixed orthodontic appliance; b. surgical exposure of 1.3 with diode laser; c. favorable post-therapeutic evolution 7 days after the intervention; d. applying the bracket in order to engage the canine in the fixed orthodontic appliance; e. therapeutic progress

After reaching the objectives of this treatment phase, surgical exposure of 1.3 was performed using the diode laser (Fig. 2b). The intervention went without complications, with a good evolution after a week (Fig 2c), at 6 weeks after the intervention a bracket is bonded on 1.3 (Fig 2d), with a good evolution in terms of leveling and alignment (Fig 2e), the orthodontic treatment continuing according to the therapeutic plan.

Second case report

The second case report regards a 14-year-old female patient (M.M.) with a class I Angle malocclusion and bilateral upper canine impaction. At the first consultation the patient it was assessed that on the upper arch both temporary canines with periradicular complications, thus blocking the eruption of the permanent successors. At this stage, a fixed upper orthodontic appliance was applied for leveling, alignment and creating the space necessary for the permanent canine eruption. 4 months after the extraction of the temporary teeth, the upper right canine (1.3) resumed its eruption but the upper left canine (2.3) remained in submucosal impaction (Fig. 3a).

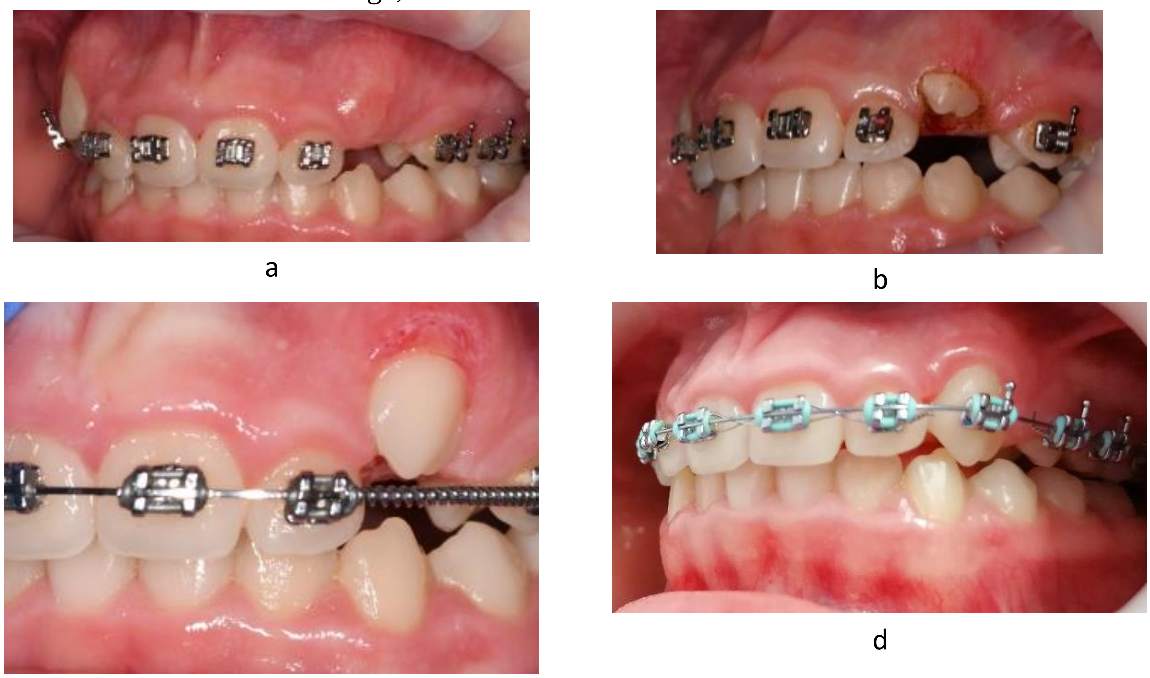
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Figure 3. Patient M.M. a. orthodontic treatment stage, noting the inclusion of 2.3; b. intraoperative aspect during the diode laser exposure of 2.3; c. favorable evolution after diode laser intervention at 7 days; d. therapeutic progress

With the help of the laser, the surgical exposure of canine 2.3 was made (Fig. 3b). The evolution after this intervention was a favorable one (Fig. 3c), followed by bracket bonding on both upper canines and proceeding of treatment for their alignment (Fig. 3d).

Third case report

A 24-year-old male patient (P.A.) was diagnosed with a class II/2 Angle malocclusion, second left premolar crossbite, diastema, bimaxillary spacing, bilateral lower second premolar agenesis and right mandibular first molar edentation (Fig. 4a). The patient underwent orthodontic treatment with fixed metal appliance, aimed in particular at preparing the case for implants in the lower edentulous areas. During the space closing stage, the patient developed gingival hyperplasia in the upper and lower frontal group (Fig. 4b).

Figure 4. Patient P.A. a. intraoral aspect before treatment; b. gingival hyperplasia located in the upper and lower frontal areas; c. intraoperative aspect during the laser intervention aiming excision of gingival hyperplasia and gingival remodeling; d. intraoral aspect after laser intervention;

By means of diode laser, the hyperplastic gingival fibromucosa was excised and the gingival contour was restored bimaxillary (Fig. 4c), with a subsequent good evolution after one week (Fig. 4d), thus facilitating treatment progress.

DISCUSSIONS

The cases presented in this paper display small-scale soft tissue interventions, applied to patients undergoing orthodontic treatment.

In the first two cases, the interventions are surgical exposures of impacted maxillary canines (uni- and bilateral). This type of pathology is often encountered in orthodontic practice, requiring a timely treatment of consisting of exposure of the impacted tooth in order to bond an attachment thus allowing orthodontic traction.

The third case presents another pathology often associated with orthodontic treatment, namely gingival hypertrophy. Gingival overgrowth may affect orthodontic therapy from the beginning of treatment to the final stage. The etiology of excessive gingival growth is multifactorial but most often it is related to a mechanical irritation caused by poor oral hygiene. Enlarged or irregularly contoured gingival margins tend to change the size and shape of the clinical crown, which in turn changes the proportion of teeth, causing confusion and difficulty in the correct placement of orthodontic brackets/ tubes, even the inability to continue the bonding procedure. (6) During orthodontic treatment, the disproportion of the teeth caused by gingival enlargement causes difficulties for clinicians to correctly assess the inclination of the dental axes and the clinical crown center. If the procedure continues the finishing phase of the treatment will certainly be unsatisfactory and the final result will be aesthetically compromised. Also, these periodontal changes can create difficulties in closing post-extraction spaces. Gingivectomy and gingivoplasty are required to correct the problems brought by gingival enlargement.

For all three cases, we opted for diode laser interventions with a wavelength of 940 nm. The post-therapeutic evolution was favorable for all cases, without edema and pain, observing the compliance of patients (of different ages) to this therapeutic alternative.

The favorable evolution of diode laser interventions can be explained by the characteristics of wavelength used. The wavelength of 940 nm has affinity and attraction to melanin and is strongly absorbed by hemoglobin so this type of laser works optimally when energy is applied in the presence of pigments, which is why hemostasis occurs at this wavelength. By heating the elements, the laser has the ability to perform a hemostatic surgery by sealing small blood vessels, by desiccating and contracting the vascular wall resulting in a clean, dry and sealed wound. (7–9)

The mechanisms of tissue-laser interaction are mainly determined by two parameters, namely the time of laser exposure on the tissue and the actual power density taking into account the tissue-specific absorption. By making an appropriate selection of wavelength, exposure time and laser intensity, the biological effect on the target tissue can be optimized and the unwanted side effects on adjacent tissues can be minimized and a selective effect on the target tissue can be obtained. The basic concept and understandable effect of the diode laser with tissue was the photothermal interaction.

In this process, the laser light was absorbed by the target tissue, converted and transformed into thermal energy by changing the structure of the tissue. The photothermal effect of the laser, one of its photobiological effects, is the transformation of light into heat, so the surgical incision, excision and ablation with precision and hemostasis can be considered the results of the photothermal effect. (1)

The laser treatments performed in the presented cases were associated with less wound contraction, scar formation and a rapid healing period. Some studies explain that the wound produced by laser surgery has a reduced contraction because less collagen and fewer myofibroblasts are formed (10), and other studies have shown a shorter healing time and less scarring.(11,12) Controversy arose after some researchers reported that wound healing was similar between laser, classic scalpel, or electrocautery.(13,14) There are also studies that have shown that the laser created more tissue damage than the scalpel, delaying wound healing. (15) However, these studies included inconsistency of chosen working parameters, such as wavelength, frequency, exposure time and power, which affect tissue response and healing duration. Furthermore, the existing studies are mostly case reports, uncontrolled studies and histological studies on animals, making it difficult to form a clear unitary conclusion. (1)

It was also found that for all cases presented postoperative infections were absent. This finding is also highlighted in specialized research, which states that the laser can lower the rate of infection after surgery and reduce edema by sealing the lymphatic vessels at the time of surgery. (16)

Another aspect worth mentioning is the high compliance of patients with laser treatments. This is largely due to the reduced discomfort during and after laser surgery, based on the ability of the laser to cauterize and seal the neural pathways.(16) Several animal studies and randomized controlled clinical trials (17–21) compared the level of pain produced by laser and scalpel surgery. Most results indicate a dramatic reduction in postoperative pain in laser surgery.

Several studies (22,23) have shown that laser has a biostimulation effect (photobiological effect) causing rapid wound healing and pain relief, an improvement in collagen growth and generates an anti-inflammatory effect. Surgical exposure of impacted teeth and interventions on the periodontium are usually performed by conventional surgical methods that most patients associate with "fear of scalpel", pain and difficult postoperative recovery. In this sense, the approach of these pathologies using the diode laser is an alternative appreciated by patients, thus increasing the patient's acceptance of various associated interventions during orthodontic treatment.

CONCLUSION

The cases presented support the effectiveness of the diode laser in auxiliary interventions on soft tissues during orthodontic treatment, especially in terms of its photobiostimulation effect, which refers to the laser's ability to increase healing speed, increase circulation and reduce pain. Histological changes that occur with biostimulation include increased collagen synthesis, proliferation of fibroblasts and increased osteogenesis. Most of these reactions are due to the interactions of the laser with the cell matrix and mitochondria. Biostimulation (also known as low-level laser therapy- "LLLT") has been shown to be helpful in reducing postoperative discomfort.

The diode laser is easy to use, provides excellent hemostasis, a dry intraoperative field, leaves a clean wound and eliminates the need to apply sutures. Through its working mechanism, the diode laser provides soft tissue interventions associated with a reduction in postoperative edema and a decrease in postoperative infections. Also, diode laser treatment reduces the patient's discomfort, decreasing both duration of the clinical procedure, time of postoperative healing and pain , the need of analgesics being often eliminated.

The use of the diode laser in orthodontic practice has a remarkable versatility, it is a safe and effective alternative for soft tissue interventions and/or surgical exposures associated with orthodontic treatment.

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