Use of laser technology in orthodontics: hard and soft tissue laser treatments

ABSTRACT

Aim Modern technology has perfected a new instrument that has become almost indispensable in modern dentistry, in accordance with the philosophy of minimally invasive therapy: the laser. The aim of this work is to evaluate the effectiveness and efficacy of laser technology to solve mucogingival problems associated with orthodontic treatment. Some laser wavelengths work both on hard and soft tissues (2780 nm, 2940 nm), other lasers, such as the 810 nm diode, have a very good surgical and haemostatic action on soft tissues and an important analgesic and biostimulating effect that can help the healing of both TMJ painful symptoms as well as the pain following active orthodontic treatment. Several cases connected to orthodontic therapy are presented. Materials and methods Different laser systems (diode laser at 810 nm; Er,Cr:YSGG laser at 2780 nm; Erbium:YAG laser at 2940 nm) were used, both for soft tissue surgery and enamel etching, and for biostimulating effect. These wavelengths were used with different parameters for each case, according to international current studies in view of minimally invasive therapy. Results The cases reported showed very quick and good healing of the laser treated tissues. These treatments, necessary for the orthodontic therapy or for its completion, become extremely simple, safe and rapid and the orthodontic specialist can perform them himself. Conclusion The laser technique is very effective in many operative and surgical procedures during orthodontic therapy. Further studies are however necessary to set the treatment protocols in orthodontic biostimulation.

Key words Er:YAG, Er,Cr:YSGG, Diode laser, Orthodontics, Frenectomy.

Introduction

This study will present some of the possible uses of laser technology in the various branches of orthodontics, proposing techniques, comparisons of different wavelengths, and above all, results. Evidence based dentistry means not only experimental studies that confirm the clinical efficacy of the techniques used, or retrospective studies that confirm the results or studies that compare traditional methods with laser technology, but also immediate and long-term visible results, such as those presented in the case studies that show the real advantages that can be obtained in daily practice.

By reporting some cases, this study purposes to show the advantages derived from the use of laser technology in a field where it has yet to be fully applied: orthodontic therapy.

At times the orthodontist must call in a specialist in oral surgery to solve mucogingival problems that interfere with the ongoing therapy or that complicate the therapy itself. Using the laser, the orthodontist can intervene quickly and easily with a minimally invasive treatment for oral and mucogingival surgery, with noticeable advantages in terms of operating time, healing, intra- and post-operative comfort, quality of the results, which allow a faster completion of the orthodontic therapy.

Many clinical situations can benefit from laser therapy either for a surgical procedure or for its analgesic and biostimulating effect before, during and after orthodontic therapy.

- Closure of an upper median diastema between incisors sometimes depends on the presence of a hypertrophic frenum (abnormal frenum) or a frenum with palatal insertion (anomalous frenum) [Linde et al., 2003; Huang and Creath, 1995].
- Problems of ankyloglossia with a short lingual frenum cause problems related to the low position of the tongue: atypical swallowing, disproportionate growth of the lower jaw in relation to the upper jaw, possible opening of diastema between the lower incisors, and even the possibility of an open bite [Garcìa Pola et al., 2002; Queiroz Marchesan, 2004].
- Impacted teeth either at bone or mucogingival level, late in developing, are related to or can create orthodontic problems of crowding [Schindel and Duffy, 2007; Al-Nimri and Gharaibeh, 2005].
- The need to intervene on teeth not completely erupted, during orthodontic therapy, is caused by the presence of gingival tissue that prevents attachment of the brackets.
- Extreme dental crowding can cause gingival recession due to the lack of periodontal support (bone and gingiva) [Linde et al., 2003].
- The activation of arches and springs in fixed orthodontic therapy is often associated with pain in the first days.
- Orthodontic therapy in adults is sometimes necessary to solve problems of articulation and/or muscular problems that cause pain and limited functioning [Molina, 1994].

Aim of the study

Numerous wavelengths are proposed in the literature to obtain valid results in the clinical situations mentioned above [Sarver, 2005; Sarver, 2006; Kotlow, 2004; Fiorotti et al., 2004]. In our clinical practice we have looked in depth at the possibility of using three wavelengths: the 810 nm diode, the Erbium Chromium:YSGG 2780 nm and the Erbium:YAG 2940 nm.

- The 810 nm wavelength belongs to the near infrared
spectrum with a high affinity for oxyhaemoglobin and this characteristic determines its good incision capacity and its excellent coagulating capacity on soft tissues [Crippa, 2002]. The interaction with tissue is characterised by both the phenomena of surface absorption and lateral diffusion (scattering) that determine a deep interaction with the tissues (body interaction), while a small percentage is reflected.

- The 2780-2940 nm wavelengths of the Erbium family of lasers (respectively Er,Cr:YSGG and Er:YAG) belong to the medium infrared spectrum. These lasers have an elective affinity for hydroxyapatite and for water, which characterises the versatile interaction of these wavelengths on both hard and soft tissues. The interaction of these wavelengths with tissue occurs mainly by surface absorption (surface interaction) and also in this case a small part is reflected [Iaria, 2005].

Laser therapy can help us to solve many situations:

- it can be used as a surgical procedure in the case of labial and/or lingual frenectomies, operculectomies, gingivectomies, disimpacting teeth from mucosa and bone; all these procedures are now commonly practiced and documented [Olivi et al., 2006; Olivi et al., 2007; Olivi, 2007];
- it can be used to induce an analgesic effect that can be helpful during the first days following the application of orthodontic brackets and situations of acute locking often associated with pain;
- the biostimulating effect in orthodontic therapy is still being studied clinically, but could be considered in terms of faster movement and regeneration of bone following orthodontic activation (from fixed appliances to rapid palatal expander to removable appliances);
- the analgesic and biostimulating effects of the 635-655 nm e 810, 830, 903, and 980 nm lasers have been documented in the literature for years [Benedicenti, 2005].

Materials and methods

Different wavelengths were used:

- 810 nm diode (cw/gated, 3 watt max);
- 2780 nm Er,Cr:YSGG (10-50 pps adjustable – 8 watt max – 400 mJ max);
- 2940 nm Er:YAG (3-50 pps adjustable - 9 watt max - 400 mJ max).

Case reports

First case report

A 13-year-old female patient needed an upper labial frenectomy due to the persistence of a diastema between the central incisors associated with an anomalous frenum inserted in the palate (Fig. 1a). The treatment, which lasted about 8 minutes, was performed with minimal infiltration anaesthesia (0.4 ml of 3% articaine), with the Er,Cr:YSGG laser, using a 400 microns conic shape tip in contact mode, at 1.5 W power and 20 pps frequency, with water spray. After the incision of the frenum held in traction (with the hand or with the fingers), the mucogingival line was incised to delineate the new point of insertion of the frenum, and the deep connective fibers were vaporised from the palatal side to the mucogingival line, exposing a collagen-free periosteum, to avoid the possibility of recurrence: the surgical wound was not sutured (Fig. 1b).

![Fig. 1 A - A 13-year-old patient with persistent interincisal diastema due to the anomalous Class IV frenum with palatal insertion.](image)

![Fig. 1 B - After incision of the frenum along its axis as far as the palatal insertion, an incision along the mucogingival line and complete vapourisation of connective fibers as far as their periosteal insertion were performed (laser Er,Cr:YSGG 2780 nm).](image)

![Fig. 1 C - 7-day check-up with classic healing by second intention with abundant presence of organised fibrin.](image)

![Fig. 1 D - 3-month check-up: the closure of the diastema helped by a functional appliance.](image)

![Fig. 1 E - 9-month check-up: stability of results obtained after the laser frenulectomy and functional orthodontic monoblock.](image)
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postoperative period (no medications were used except the topic application of 0.5% chlorhexidine gel for 1 week) went without symptoms and was very well accepted by the young patient, who returned fora checkup after 7 days with the wound in an advanced phase of healing by second intention (Fig. 1c). The 3 month checkup showed a closed diastema, by means of a monoblock functional appliance (Occlus-O-Guide technique). The 9-month checkup showed the stability of the new frenum attachment and of the closure the midline diastema (Fig. 1e).

Second case report
A 16-year-old male patient being treated by a colleague for postural alterations correlated with ankyloglossia due to a short lingual frenum (Fig. 2a, b, c).

The anatomical problem to be treated had already been studied from the photographic images taken with the operating microscope: the procedure was performed with a diode laser 810 nm, with 1.2 W power in continuous mode (cw) for about 20 seconds, with only topical gel anaesthesia (20% benzocaine). By the third day, the patient had already begun speech therapy to rehabilitate the lingual function. The extensive vascularization led us to choose a near infrared wavelength, which allowed for an incision with excellent bleeding control (Fig. 2e).

The 7-day checkup showed a second intention healing and the initial rehabilitation of the lingual function; the 6 month follow-up showed an advanced mouth opening and a correct lingual function, positioned on the palatal spot of the upper central incisors (Fig. 2d, e, f, g).

Third case report
A 9-year-old male patient, with the permanent lower right canine impacted in oblique lingual position, at the mucosa level of the floor of the mouth (Fig. 3a-f).

The procedure was performed with an Er:YAG laser with microscope control, with topical anaesthesia at 0.8 W (10 pps – 80 mJ) (Fig. 3b). In this case the extensive vascularisation of the mucosa of the floor of the mouth would have required the use of a near infrared laser to achieve a good bleeding control. The choice to use the Er:YAG laser is compatible with the lower energy used and the possibility of using photothermal energy without water.

Fig. 2 A, B, C - Short lingual frenum and ankyloglossia.
Fig. 2 D - Preoperatory view.
Fig. 2 E - Incision and vaporisation of the frenum performed with 810 nm diode laser with 300 µm fiber in CW at 1,5W: excellent coagulation of the incision.
Fig. 2 F - 7 days check-up showing a second intention healing and initial improving of lingual function.
Fig. 2 G - 6 months follow up shows evident, improved mouth opening and lingual function.
spray to control bleeding and with the need for macro etching of the enamel to attach the bracket. The surgery was performed only with topical gel anaesthesia (20% benzocaine) and required 15 minutes (Fig. 3c-d). After five months the canine, orthodontically moved, reached its normal position, as confirmed by the panorex (Fig. 3 e, f, g). The therapy resulted in the good aspect of periodontal tissues after 2 years, despite a poor oral hygiene (Fig. 3h).

Discussion

Different wavelengths interact in different ways on the target tissue. Let us clarify a basic concept: each tissue has an optical affinity for light that defines a precise coefficient of absorption relative to each wavelength: the targeted tissues for the therapies described here are gingiva, mucosa, connective fibers, bone and periosteum, and enamel.

The wavelengths of the near infrared spectrum have an excellent coagulating capacity (given the high affinity for the oxyhaemoglobin) and a deeper interaction with tissues (body interaction).

Soft tissues are easily incised and vaporised with lasers of the visible light spectrum (532 nm KTP) or the near infrared (810, 830, 940, 980 nm diode laser and at 1064 nm Nd:YAG), which are well absorbed by the target tissue of soft tissues: hemoglobin and, partially for the Nd:YAG, water.

These wavelengths do not interact with the hard tissue and therefore do not etch the enamel of unimpacted teeth; their action is less safe for the periosteum when
working on collagen fibers and on the periosteum in cases of frenectomies, and they cannot work on bone in case of need of extraction of bone impacted teeth.

The 810 nm diode laser used in our daily clinical practice was used with success in the lingual frenectomy case reported. The analgesic effect and the almost bloodless incision of this laser, performed in continuous energy mode (cw) with 300 µm fiber, allowed us to complete the procedure without anesthesia and without sutures.

The 810 nm diode laser has recently been introduced into fixed orthodontic practice for its biostimulating and analgesic effect: the few cases treated with low friction-low force technique and with laser induced biostimulation have had excellent results so far, both in terms of length of therapy and tissue response, and will be used for a broader study and discussion when the clinical cases reach a significant number.

The Erbium family of lasers used in our daily clinical practice has not disappointed our expectations even in paediatric dentistry and orthodontic applications presented in this article. The versatility of use allowed us to use these instruments on both soft and hard tissues for etching of the enamel of exposed teeth.

The bleeding control resulting from the use of these lasers is due above all to the surface interaction of laser-tissue and the skilled use of air/water spray.

Pain control, closely correlated to the low power, is even better managed with a pulsating emission of low pulse repetition rate, in cases of sensitivity (10 pps), increasing in this way the relaxing time of the nerve fibers, always cooling the incision with water spray to avoid heating and consequent thermal stimulation of the nerve endings of the tissue.

The tissues treated in this way, with incisions with a low thermal impact, showed quick and comfortable healing.

**Conclusion**

The near infrared lasers are the elective choice for vascular lesions, and remain the instruments of choice for both frenectomies, mucosa-covered teeth, and gingivectomies. The risks of lateral and deep damage (body interaction) need to be controlled.

The Erbium lasers, which have a lower haemostatic capacity, have been shown to be versatile and excellent instruments for low intra-operative sensitivity and for the rapid and good healing of tissues (surface interaction); the Erbium lasers are the elective choice for impacted osteomucosal surgery and for intra-operative etching of the teeth that are thus exposed.

**References**


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