

# CASE REPORT: Use of Er:YAG and Nd:YAG Lasers During Orthodontic Treatment

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## ABSTRACT

In recent years laser technology has played an increasingly important role in modern dentistry and, recently, the utilization of laser devices has also been proposed in orthodontics. The aim of this work is to describe the use of combined laser devices (Fidelis and LightWalker AT, Fotona, Slovenia: 1064 nm and 2940 nm) in soft and hard oral tissues to improve orthodontic treatment. Several cases treated by Er:YAG and Nd:YAG in different stages of the treatment (before, during and after) are presented. All the cases showed, as reported in the literature, that the use of lasers with orthodontic treatment offers several advantages when compared to conventional methods. In soft-tissue surgery, it allows practitioners to reduce or eliminate the use of anesthetic injection, to avoid the use of sutures and to bond brackets in dry enamel. Combined with orthophosphoric acid, it provides a stronger adhesion of the brackets to the enamel and helps to prevent carious lesions around the brackets. It may even be used to repair broken appliances by welding them intra-orally.

**Key words:** Nd:YAG, Er:YAG, orthodontics.

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## I. INTRODUCTION

Laser technology has been used in dentistry since 1988 for soft-tissue surgery [1] and, since 1990 it has been employed in conservative dentistry as alternative to rotating instruments [2]. Several surveys, based on questionnaires from patients, have demonstrated that in terms of satisfaction, it represents an effective technique that may improve patient cooperation and diminish fears associated with the dental office [3], particularly in pediatric patients.

This is the main reason to recommend its application in orthodontics, where cooperation and good relationships between patient and operator are strictly necessary for full success of the treatment.

The possibility to use a device combining two wavelengths allows treating both soft and hard tissues with several advantages. Regarding the former, the possibility to eliminate the use of the anesthetic injection, the rapidity of the intervention, the avoidance of the sutures and the absence of post-op discomfort are highly appreciated by patients; in the latter, a stronger adhesion and a minimally invasive treatment are highly appreciated by clinicians.

The success of the treatment depends largely on the ability and know-how of the operator to utilize this kind of technology. This clinical work aim to demonstrate, through clinical cases, how it is possible to improve orthodontic treatment by using these two wavelengths, underlining the importance of respecting the correct parameters and observing safety rules in order to protect patients from side effects and to avoid the possibility of accidents.

## II. CASES

### a) Upper vestibular frenectomy

An 8-year-old female patient came to our clinics to have her dental occlusion checked. At oral examination, the only evident problem was the presence of a very large inter-incisive diastema associated with a pathological insertion of the upper vestibular frenum, with a positive traction test (Fig. 1).



Fig. 1: Pre-operating view.

It was decided for laser surgical intervention in order to correct the anomaly. A topical anesthetic was

applied on the mucosa and an Nd:YAG laser (LightWalker AT, Fotona, Slovenia, 1064 nm) was used with the following parameters: 3 W, 30 Hz, 320  $\mu$ m optical fiber, contact mode. The duration was for 105 sec and a suture was not required due to the perfect control of bleeding (Fig. 2).



Fig. 2: Immediately after intervention.

The patient reported that she had no pain. No drugs were prescribed. A one-week follow-up showed a good healing process and fibrin organization (Fig. 3).



Fig. 3: One week after.

Subsequently, a sectional fixed appliance was put on the upper arch (Fig. 4), and six months later the gap was completely closed with a complete outgrowth of permanent teeth (Fig. 5).



Fig. 4: Sectional appliance on upper arch.



Fig. 5: After orthodontic treatment.

#### b) Lingual frenectomy

A 5-year-old male patient was sent to our clinics by a speech therapist because, due to the lingual frenum shortness, he was not able to perform the exercises in order to solve his speech problems. At the clinical observation, it was noticed he had a 2<sup>nd</sup> class ankyloglossia of the Kotlow classification (Fig. 6).



Fig. 6: Pre-operating view.

It was decided for a surgical intervention using Nd:YAG laser (LightWalker AT, Fotona, Slovenia, 1064nm) with the following parameters: 3 W, 30 Hz, 320  $\mu$ m optical fiber, contact mode (Fig. 7).



Fig. 7: Just after intervention.

The intervention, which didn't require injection and sutures but only topic anesthetics, had a duration of 77 sec. Just after the intervention (Fig. 8) it was noticed that the tongue was able to protrude over the lower lip and the speech therapist instructed the patient to repeat this exercise also in the postoperative days in order to avoid the risk of relapse.



Fig. 8: A week after.

### c) Enamel conditioning

A 14-year-old female patient came to our clinics in order to have an orthodontic treatment in the upper arch. In consideration of the age and of the kind of malocclusion, we decided to choose a fixed appliance.

To condition the enamel by Er:YAG laser, a new particular type of handpiece (X-Runner with LightWalker AT, Fotona, Slovenia) was used, which is based on scanner technology and thus able to precisely ablate an area programmed in advance (Fig. 9).



Fig. 9: X-Runner handpiece.

After polishing all the teeth with a non-fluoride paste and marking the center of the crown with a pencil, the enamel surface of each tooth was irradiated by Er:YAG laser (LightWalker AT, Fotona, Slovenia) (Fig. 10) with the parameters determined by SEM observation in order to give the best enamel conditioning coupled with minimal ablation: 55 mJ energy, 8 Hz frequency, MSP mode (100  $\mu$ s), 4/6 air/water spray.



Fig. 10: Enamel conditioning with minimal ablation.

The dimension of the ablation area was 2.5 X 3.0 mm and the number of passes was 10, once for each tooth. Subsequently brackets were bonded with composite resin and the wire inserted (Fig. 11).



Fig. 11: Arch inserted into upper arch.

### d) Intra-oral welding

A 13-year-old female patient, in orthodontic treatment with a fixed appliance in order to insert premolars into the upper arch, came to our clinics for a check and we noticed that an arm of the appliance was broken (Fig. 12).



Fig. 12: Appliance with broken arm.

We evaluated that the removal of the appliance was full of risks, in particular the impossibility, due to space closure, to replace it after repairing. So, it was decided

to laser weld the arm intra-orally. In order to protect the soft tissues from the ejection of metal pieces during irradiation, we used a silicon sheet. The appliance used was an Nd:YAG laser (Fidelis Plus III, Fotona, Slovenia) with the following parameters: 1064 nm, 9.84 mJ, 1 Hz, 15 msec, 0.6 mm spot (Fig. 13).

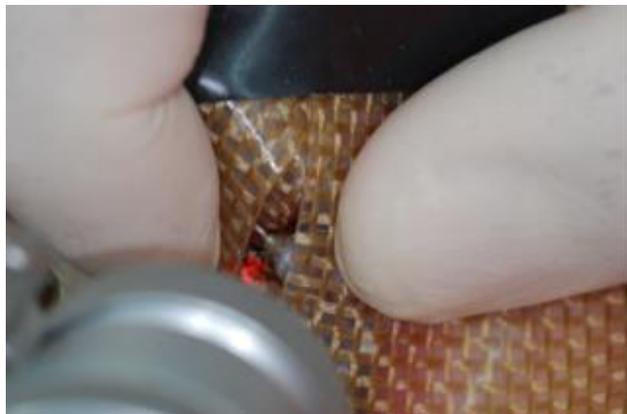


Fig. 13: Intraoral Welding by Nd:YAG laser.

After the repair of the arm (Fig. 14) the appliance was re-activated by turning the screw, until the space required to insert the premolar was reached (Fig. 15).



Fig. 14: Appliance repaired.



Fig. 15: Space for premolar insertion reached.

During the laser welding process the patient didn't feel pain or discomfort and, the vitality of the teeth and the periodontal and gingival health were maintained, also after months and years.

#### e) Bone and mucosal retained canine exposure

An 18-year-old male patient came to our clinics for orthodontic treatment. At the clinical examination, the absence of an upper lateral incisors and left canine was noticed. The Rx analysis confirmed the absence of the permanent incisors but showed the presence of the canine retained into the maxillary bone. So, an upper fixed orthodontic appliance was applied with two coil springs (Fig. 16).



Fig. 16: Spring for space opening inserted into upper arch.

Once the space required was obtained, an intervention was performed in order to discover the canine. Due to the bony inclusion, two wavelengths were used: Er:YAG for hard tissues and Nd:YAG for soft tissues. The device used was a Fidelis Plus III (Fotona, Slovenia), which offers a combination of the two wavelengths, with the following parameters: Nd:YAG, 1064 nm, 4 W, 40 Hz, SP, 320  $\mu$ m fiber, contact mode; Er:YAG, 2940 nm, 300 mJ, 10 Hz, MSP, non-contact mode. After the application of topical anesthetics, a gingival tissue portion of 3 mm diameter was removed with Nd:YAG (Fig. 17); then, a window of the same dimension was produced in the bone with Er:YAG (Fig. 18). In order to eliminate bleeding, the operative field was coagulated by Nd:YAG: in this way, it was possible to bond the bracket into dry enamel (Fig. 19).



Fig. 17: Nd:YAG irradiation on soft tissues.



Fig. 18: Er:YAG irradiation on bone.



Fig. 21: Good periodontal health at the end of the treatment.



Fig. 19: Bracket bonded to the retained canine.



Fig. 22: Temporary prosthetics applied.

Three months later the tooth was placed into the arch (Fig. 20), and after six months the appliance was removed (Fig. 21) showing a good aspect of the periodontium.

Two temporary elements were bonded to the retainer in order to improve the aesthetics and, at the same time, to maintain the opening of the spaces (Fig. 22).

#### f) Gingival hypertrophy

A 13-year-old female patient, at the end of fixed orthodontic treatment, developed a gingival hypertrophy in the upper arch (Fig. 23) probably related to the fast closure of the spaces and poor oral hygiene due to bleeding during teeth brushing.



Fig. 20: Canine inserted into the upper arch.



Fig. 23: Pre-operating view.

Prior to removal of the appliance, a topical anesthetic was applied to the gum and a gingivectomy was performed for the elimination of the interdental papilla (Fig. 24).



Fig. 24: Just after intervention.

The appliance used was an Nd:YAG laser (LightWalker AT, Fotona, Slovenia), with these parameters: 4 W, 40 Hz, SP, 320  $\mu$ m fiber, contact mode. The intervention had a duration of 275 sec. and the patient didn't report any kind of pain, and five days later the healing process was complete (Fig. 25). Even for several years afterward the gingival health remained very good (Fig. 26).



Fig. 25: Five days after.



Fig. 26: Four years after.

### III. DISCUSSION

Lasers may be used before the beginning of the orthodontic treatment, during each of its steps and after the removal of the appliances [4].

Before the therapy, its use is related to oral soft-tissues surgery, in particular to normalize anomalies of upper vestibular and lingual frenulum [5].

The advantages of its utilization consists of the possibility of reducing or avoiding the use of anesthetics, especially important in pediatric patients, as well as a bloodless surgical field and reduced postoperative pain [6].

Moreover, suturing is generally not required and the biostimulatory effect enhances the healing process together with the antimicrobial properties of laser energy [7].

Upper vestibular frenectomy is indicated, if related to inter-incisive diastema, when it is attached to the papillar gingiva (positive traction test) [8, 9] and when the distance between central incisors is larger than 6-8 mm. Interventions beyond the elimination of frenulum insertion must also cut the inter-incisive fibers until reaching the periostium, in order to allow the space closure.

In some cases, we noticed that if the intervention is done according to these principles, and by choosing the correct timing during denture development, it may be sufficient to reach a good result without a classical orthodontic treatment and without appliance wearing.

Another condition, without presence of diastema, is often associated with a short upper lip and gummy smile, and also in this case the surgery, combined with functional re-education by a speech therapist, may correct the defect [6].

The presence of an abnormal short lingual frenulum, also called "ankyloglossia" or "tongue-tie" is a condition in which the tip of the tongue cannot protrude over the incisors [10] and it may be related to several kinds of malocclusion such as total open bite, caused by interdental lingual interposition, or a third class relation with a push on the mandibular arch [11]. A classification of this condition, based on the measure of the distance between frenulum insertion and tongue tip while the patient is touching the palate with an opened mouth, allows for distinguishing four classes of importance [12]. These anomalies have a great importance in the functional re-education of deglutition and phonation and, sometimes, speech

therapists send these patients to our clinics because they cannot do their exercises due to the tongue movement limitation [13]. In cases where surgical intervention is indicated, the use of a laser makes the therapy safe, effective and perfect [14]. Recently, several authors have described a relation between anchyloglossia and postural diseases, and lingual frenulectomy has been proposed to improve physiotherapeutic treatment [15].

In this case, another advantage of the use of laser is given by the possibility to mobilize the tongue just after the intervention, due to the absence of sutures: this is important to decrease the probability of relapse [16].

The employment of the Er:YAG laser combined with orthophosphoric acid etching to enhance the strength adhesion of composite resins has been proposed by several authors in conservative dentistry, as well as for bracket bonding in orthodontics [17].

The advantage in using a plastic template or the new "scanner handpiece" (X-Runner, Fotona, Slovenia) is the ability to prepare a very small surface of enamel of exactly the same dimension as the bracket.

Several studies, based both on traction and microleakage tests, have showed the best values were obtained with the samples irradiated by an Er:YAG beam before the acid etching [18].

Recently, another interesting in vitro study [19] based on strength analysis by traction test and morphological observation by SEM and Atomic Force Microscope, showed the same effects with Er:YAG irradiation alone as with acid etching. This was obtained by using the so-called "QSP" mode (Fotona, Ljubljana, Slovenia) in which each pulse is split into several shorter pulses that follow each other at an optimally fast rate. In this way, a specific surface roughness is achieved, representing a real alternative to acid etching.

Moreover, other authors have underscored these results by using lasers to prepare the enamel surface to make it more resistant to decay [20]; the process consists of the modification of the hydroxyapatite crystals, which is very important in the prevention of the decalcification zones around brackets, particularly in patients with a scanty oral hygiene [21].

Recently, the possibility to employ the Nd:YAG fiber-optic laser was described, which is normally

used in the dental office for soft-tissue surgery, to weld the metallic parts of broken appliances [22]. The advantages of this technique consist in time reduction, the avoidance of the impression and the maintenance of the integrity of acrylic portions, even close to the welded area. With this device it was also showed that it is possible to weld appliances intra-orally without the necessity to remove them from the mouth [23].

When one tooth is retained, a combined orthodontic-surgery treatment allows, in most of the cases, to replace it into the arch without damage and, particularly from the periodontal point of view, the success seems to be related to the possibility to perform a minimally invasive surgery [24].

The advantages of laser utilization, beyond this, consist of good pain control and the increase of the bracket adhesion strength even in the case of bonding just after intervention, due to the dry enamel surface from the absence of bleeding.

In the case of bony retention, both 2940 and 1064 nm wavelengths are required, the first for bone cutting and the second, well absorbed by hemoglobin, to produce coagulation.

One of the problems related to the wearing of orthodontic fixed appliances is represented by gingival overgrowth, in particular when spaces are closed quickly in patients who don't attend to good oral hygiene. Some studies have described the presence of hyperplastic gingivitis two months from the treatment beginning and for the whole duration of it [25]. Others evidenced the worse of the OH index [30], while others proposed the removal of the gingival papilla in the closure areas to favorite the new formation of normal connective tissue [26]. The intervention of papillectomy may be done just after the removal of the appliance as it doesn't require anesthetic injection; if an Erbium laser is used, it is necessary to protect the teeth surfaces, which may be damaged by the beam. Two-to-three days after the intervention, the condition of the gum is almost back to normal and after seven days, the healing process is totally complete [27].

#### IV. CONCLUSIONS

Laser technology represents an important advantage which may be used before, after and during all the steps of orthodontic treatment. It may improve the success of the therapy, diminish the discomfort of patients, increase their cooperation, and reduce the duration as well as the pain produced by the treatment.

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