Paediatric laser-assisted dentistry

A clinical approach

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Fig. 1


Fig. 2a


Fig. 2b

Fig. 1_Female patient, 6.2 years old. Due to 3.6 eruption an hyperplastic tissue has formed.
Fig. 2 a & b_Immediately after Erbium excision:laser-assisted gingivoplasty procedure (a). Clinical outcome (b).

_Abstract

The approach to paediatric dental patient demands close cooperation between dentist-parents and the child himself. Laser-assisted therapy is a modern and effective strategy. Laser technology has a wide application in dental care and treatment, oral traumatology and minor surgical procedures, and it's suitable for the treatment both of primary and permanent teeth. The authors' aim is to stimulate more extensive scientific research in this area and to offer a clinical overview, showing also some clinical procedures.

_Introduction

One of the main roles of the paediatric dentist is to provide effective education on prevention in order to reduce the incidence of dental and oral disease throughout childhood and adolescence and into adulthood.

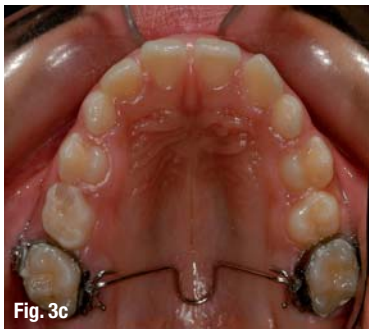
In this context, it is essential never to lose sight of a key aim: tissue preservation. Preferably, this is achieved by preventing disease from occurring in the first place, and by arresting its progress when it does occur. But tissue preservation also means removing diseased tissue and restoring defects with as little tissue loss as possible.

Today, we are assisted in this endeavour by techniques allowing early diagnosis (digital radiology with low radiation emission, diagnostic lasers and the dental operative microscope) and minimally invasive therapy (ozone therapy, air abrasion, rotary

Fig. 3 a–c_Female patient, 9.2 years old. An orthodontic band was placed on 1.6: hyperplastic tissue (a). A minor laser-assisted treatment of oral soft tissue was performed to insert the palatal barr and elastic ligation.


Fig. 3a


Fig. 3b


Fig. 3c

instruments for micropreparation and lasers). Laser-supported dental diagnosis and treatment, which allows us to meet the important aim of "filling without drilling", is an excellent approach from the tissue preservation point of view and, as reported by Martens[1] and reiterated by Gutknecht[2] "children are the first in line to receive dental laser treatment".

In this paper we look at the use of the Erbium family of lasers in soft- and hard-tissue ablation, and also at how other lasers (diode, Nd:YAG, CO_2) can help to make a trip to the dentist a minimally invasive and stress-free experience[3, 4], which, for children, is particularly important.

The laser is a new instrument in paediatric dentistry that sometimes complements and sometimes replaces traditional techniques. Lasers, which are available in a variety of types with different wavelengths (Table I), have a number of possible applications and can be used to treat both soft and hard oral tissue (Table II).

Without going into the physics of laser therapy in detail, it is necessary to appreciate that different wavelengths interact differently with different chromophores (haemoglobin, water, hydroxyapatite) contained in the target tissue (mucous membranes, gingiva, dental tissue) and therefore that the therapeutic effect is determined by the optical affinity and coefficient of absorption of the target tissue for the given wavelength.

_Soft-tissue applications of lasers in paediatric dentistry

Oral surgery

Lasers offer a series of important advantages in the treatment of oral soft tissues: they are simple and rapid to use, they reduce the need for local anaesthesia, they allow excellent control of bleeding during incision, and they can also eliminate the need for sutures. Furthermore, the post-operative recovery is often asymptomatic thanks to the decontaminating, antalgic and biostimulant effects of the laser radiation. In short the procedure, which produces excellent clinical results, is less invasive and less traumatic than the traditional approach. This is a particularly important consideration in children, who will more readily accept this treatment. Furthermore, laser treatments, compared with conventional procedures, are associated with a greatly reduced need for analgesics and anti-inflammatory medications.

Lasers are used in soft-tissue management to remove or treat lesions of the oral mucosa. All wavelengths of light with an affinity for haemoglobin and water (chromophores contained in the gingiva and mucosa) can be used for these applications: the Argon, KTP, diode, Nd:YAG and CO_2 lasers are useful for soft-tissue cutting, vaporisation and decontamination, achieving very good coagulation and haemostasis; they are also ideal for vascular lesions.[5, 6]

The Erbium lasers, Er,Cr:YSGG and Er:YAG, are also suitable for these applications, due to the good absorption of their light wavelengths by the water contained in the gingiva and oral mucosa, however, they are less effective at controlling bleeding. The performance of the Erbium lasers can be enhanced by the use of an air-water spray, delivered through the handpiece of the laser. This ensures a clean incision and helps to avoid excessive increases in the temperature of the soft tissue during vaporisation; furthermore, the absence of peripheral necrotic tissue allows accurate biopsies (Figs. 1 & 2).[7,8]

Periodontics and orthodontics

The decontaminating effect of different lasers in pockets of periodontal disease has been widely demonstrated in adults, but data on laser-assisted therapy of periodontitis in young patients are lacking. Conversely, in the context of orthodontic treatments, there emerge many clinical situations in which soft-tissue intervention is required before, during and after treatment. These are procedures (Table II) that can be accomplished simply, safely and effectively using different laser wavelengths, depending on the laser-tissue interaction required (Fig. 3).[9,10]

Fig. 4 a & b_Male Patient, 7.4 years old. Interproximal caries of 7.5 (a). Before isolation with rubber dam an Er:YAG laser preparation with minimum intervention is performed and analgesia is obtained by lasing (b).

Fig. 5 a & b_Enamel and dentin are etched, rinsed and dried (a). Final outcome (b).

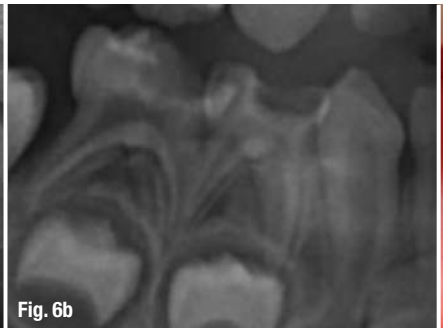

Fig. 4a


Fig. 4b


Fig. 5a


Fig. 5b


Fig. 6a


Fig. 6b

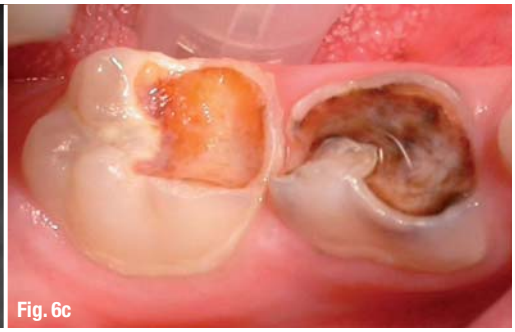

Fig. 6c

Fig. 6 a-c_Female patient, 5.2 years old. Deep caries on molar teeth. Panoramic view (a). X-ray control (b) and occlusal vision (c).

Frenectomies are among the most common and widely documented laser applications in orthodontics. Laser frenectomies, performed using diode, Nd:YAG, Er:YAG, Er,Cr:YSGG and CO_2 lasers, have been reported to be associated with less post-operative pain and discomfort and fewer functional complications (problems with speaking and chewing) compared to traditional techniques; these advantages improve the patient's perception of the therapy[9, 10], which, as mentioned, is an important consideration in children.

Lasers can be used to perform labial upper and lower frenectomies: the technique is extremely simple and effective even for lingual or labial frenectomies in newborns, in cases of severe ankyloglossia or tight maxillary frenum that create breastfeeding difficulties. Gingivectomy, gingivoplasty and operculectomy can be performed easily and without anaesthesia using all laser wavelengths, and brackets can be glued immediately.[11,12] Low-level laser therapy (LLLT) has been successfully used to accelerate tooth movement in orthodontics, stimulating the modulation of the initial inflammatory response, with the advantage of anticipating the resolution of normal conditions at earlier periods; other other studies have reported a local effect of the CO_2 laser, which was found to reduce pain associated with orthodontic force application, without interfering with the tooth movement.[13,14]

_Hard-tissue applications of lasers in paediatric dentistry

Caries prevention

The first in vitro studies exploring the potential of laser radiation to prevent dental caries (by increasing the acid resistance and microhardness of the enamel tooth surface) were conducted at the end of the 1980s.

To date, several studies on this application have been performed, giving similar results, but clinical evidence is extremely limited. Studies in this area fall into two main categories: those using Argon lasers at 488–514 nm and those using CO_2 lasers at 9,300, 9,600 and 10,600 nm. However, the capacity of the Erbium 2,780 and 2,940 nm lasers to modify the physical-chemical characteristics of the enamel surface has also been investigated. The parameters assessed by these studies were cross-sectional microhardness and enamel solubility.

Argon laser irradiation combined with acidulated phosphate fluoride treatment (APF) was found to reduce lesion depth by more than 50 % compared with control lesions, and by 26 %–32 % compared with lased-only lesions. It was also reported that the use of a zinc fluoride and Argon laser combination significantly reduced white spotting and etching. This treatment appeared to stabilise the hydroxyapatite crystal and repair its structural defects.[15]

In 2003, Hicks *et al.* argued that Argon laser irradiation combined with APF may confer a protective barrier against cariogenic attacks in primary teeth, suggesting that the surface coatings associated with this treatment contain fluoride-rich calcium and phosphate mineral phases that could act as reservoirs for fluoride, calcium, and phosphate and thus provide teeth with a certain degree of protection. It was also confirmed that enamel surface microhardness was found to be greater in teeth exposed to low Argon laser irradiation only, or to Argon laser irradiation combined with APF, than in untreated teeth (controls).[16]

Another line of research dates back to 1998 when Featherstone *et al.*[17,18] reported inhibition of caries progression, obtained using 9,300nm and 9,600 nm lasers (fluences from 1 to 3 J/cm^2). The level of inhibition obtained, compared with that obtained through daily fluoride toothpaste treatments, was in the order of 70 %. Furthermore, the subsurface temperature elevation was minimal (< 1 °C at 2 mm depth), supporting the findings of another study that reported no thermal damage to the pulp (57). In 2008, it was confirmed that the CO_2 laser is efficient in reducing subsurface enamel demineralisation and that its association with a high frequent fluoride therapy may enhance this protective effect.[19]


Fig. 7a


Fig. 7b


Fig. 7c

Fig. 7 a–c_7.5 is isolated with rubber dam: cavity opening (a). Endodontic treatment is performed (b) by using an Er:YAG laser (300 µm tip at 70 to 75 mJ, 20 Hz and 1.4 to 1.5 W). Parameters are reduced in the middle third and the cavity is filled with ZOE and a thin layer of a glass ionomer cement is placed (c).

Recent research has indicated that the Erbium laser wavelengths, too, may have the potential to increase acid resistance: subablative Erbium energies can decrease enamel solubility, thereby increasing caries resistance, without greatly altering the structure of the enamel. However, these results failed to reach statistical significance (alpha = 0.05).[20]

Clinical Implications

Subablative CO_2 laser irradiation of young, healthy teeth could be an effective method of caries prevention; long-term clinical studies are needed to validate this hypothesis. There is also a need for further studies evaluating the capacity of Erbium laser treatment to increase the acid resistance of permanent teeth.

Caries detection

Of the various laser applications in paediatric dentistry, the one most investigated is their use as a means of detecting caries: the non-ablative laser emits fluorescence visible in the red spectrum at 655 nm; this has made it a useful complement to conventional methods for detecting occlusal caries. Lussi *et al.*, in 2003, affirmed that laser fluorescence (LF) could a useful additional tool in the detection of occlusal caries in deciduous teeth, also suggesting that, thanks to its good reproducibility, the laser could be used to monitor the carious process over time.[21, 22]

Several studies have compared different caries detection methods – visual inspection alone, visual inspection with magnification, bite-wing X-ray and LF. The reliability and the diagnostic validity (sum of sensitivity and specificity) of LF have been found to be very high, the technique even outperforming bite-wing radiography as a means of proximal caries detection in primary teeth. Other studies, too, have found that LF methods for detecting occlusal caries are more efficient in deciduous than in permanent teeth, even though LF proved unable, in primary teeth, either to detect in vitro remineralisation of natural incipient caries lesions, or to quantify ongoing mineral loss due to carious processes. According to the results of a 2008 study by Braga *et al.*, the LF device performs better at the dentin threshold than at the enamel threshold; the authors therefore concluded that this method is unsuitable for detecting initial enamel caries lesions, instead confirming its efficiency, which they had already demonstrated in previous studies, as a means of predicting the extent of caries lesions.[23, 24]

Finally, studies conducted to establish the possible impact of the operator on LF treatment have concluded that the operator factor does not determine the reliability, predictability and reproducibility of outcomes obtained using this approach.

Clinical implications

In daily dental practice, the LF system emerges as a reliable complementary tool for the visual exploration of occlusal surfaces, both in primary molars and permanent first molars. In addition, thanks to the availability of new tips, the system can now be used to detect proximal lesions.

Sealing of pits and fissures

Several *in vitro* studies have evaluated the possible role of lasers in the preparation, prior to sealant application, of pits and fissures on the occlusal surfaces of young teeth.

Most of these studies compared invasive techniques and laser irradiation, with or without acid etching, finding no significant difference between the two types of enamel preparation when etching was performed.

In one study, preparing and treating the enamel surface exclusively with the Er:YAG laser resulted in the highest degree of leakage[25], while in another, there emerged no difference in microleakage between lasing and acid etching, suggesting that the lasing technique may be efficacious.[26] However, pre-treatment with the Er,Cr:YSGG laser was not found to influence the resistance to microleakage of bonded fissure sealant in primary teeth. Other studies have investigated the energy level appropriate for this application: they found that mechanical preparation prior to fissure sealing did not enhance


Fig. 8a

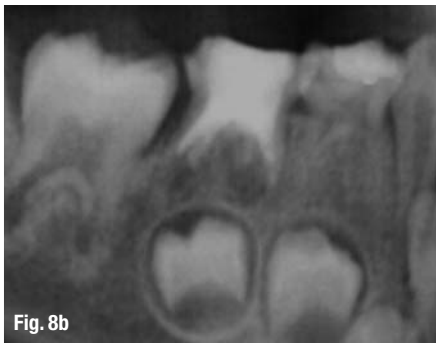

Fig. 8b

Fig. 8 a & b_Final outcome: colour and morphology are restored by the anatomical layering technique. Post-treatment X-ray control (b).

the final performance of the sealant, and that laser irradiation at 600 mJ and bur drilling eliminated the greatest amount of hard tissue.

Clinical implications

Laser irradiation does not appear to eliminate the need for acid etching of enamel prior to the application of a pit and fissure sealant. It may be considered a useful adjunct in the sealant application procedure, thanks to its cleansing and disinfecting effects. Attention must be paid to the level of energy applied in order to avoid overpreparing the pit and fissure surfaces.

Cavity preparation and caries removal

The idea that a dental drill can be replaced by a laser instrument, which is less traumatic for the patient, led to the introduction of this device into the field of pediatric dentistry. Indeed, the laser, unlike the traditional dental drill, works on hard tissue without coming into contact with the tooth; furthermore, it does not generate vibration and noise and it is less painful.

Various studies and clinical reports have demonstrated the additional safety conferred by the laser, used as an alternative to rotary instruments in paediatric restorative dentistry, even in the treatment of very young children. Thus opens up the way for minimal interventions targeting only carious tissue and overall better acceptance compared to traditional techniques.[9,10,32,33,34]

Fig. 9 a & b _Male patient, 8.9 years old. Uncomplicated crown-fracture of 2.1, which was previously protected with a $Ca(OH)_2$ paste by a colleague (a). X-ray control (b).


Fig. 9a


Fig. 9b

In this context, different laser wavelengths were studied for cavity preparation: the CO_2 laser was investigated first and found to induce thermal damage of the irradiated dental tissues; other clinical and experimental investigations indicated the possibility of treating early childhood caries of the enamel with the Nd:YAG laser, but micromorphological analysis of the irradiated primary teeth revealed the presence of collateral damage to the dental tissues.

Today, just two wavelengths, the Er,Cr:YSGG at 2,780 nm and Er:YAG at 2,940 nm, are used successfully for treating dental hard tissues. The earliest studies on the use of the Erbium laser for cavity preparation and caries removal date back to 1989, when Hibst and Keller were the first to evaluate the capacity of the Er:YAG laser to cut human hard dental tissue.[3,4] The first decade of research saw various authors studying different parameters and variables of Erbium laser application in caries removal and cavity preparation, evaluating its morphological effects on hard and pulp tissue, as well as the effects of energy density, of pulse repetition rate, and of air-water spray use.[27,28]

Moritz *et al.*, in 1998, found that the results of laser etching of the enamel were the same as those obtained with orthophosphoric acid etching.[29] Finally, Olivi *et al.* confirmed the efficacy of the Erbium laser in cavity preparation and removal of carious tissue.[30,31]

_Laser and resin composite adhesion

Different studies investigating composite adhesion to lased surfaces have given contrasting results, and this is still a controversial issue.

Many authors have reported that adhesion to laser-ablated or laser-etched dentin and enamel of permanent teeth is inferior to adhesion to dentin and enamel submitted to conventional rotary preparation and acid etching. These studies stressed how important it is to pay close attention to the energy output, in order to avoid substructural damage. They also called for standard laser energy outputs for different tooth substrates and stressed that acid etching should be mandatory even after laser conditioning of dentin and enamel.[35,36]

Studies on primary teeth reported that Er:YAG laser irradiation of dentin, at 60 mJ/2 Hz, 80 mJ/2 Hz and 100 mJ/2 Hz, prior to the adhesive protocol, adversely affected bond strength.[37]

Conversely, other authors reported that primary dentin treated with the Er,Cr:YSGG laser at lower en-


Fig. 10a

Fig. 10b

Fig. 10c

Fig. 10 a–c_A minimally invasive treatment is performed with an Erbium laser (a). Application of enamel-dentin system and building up the incisal edge (b). Final outcome after finishing and polishing (c).

ergy output 0.5 Watt (50 mJ) did not require etching; however, as the energy level increases, it is beneficial to add etching as part of the conditioning protocol in order to guarantee adequate bonding.[17]

Studies on shear bond strength to the enamel of primary teeth reported superior results in Er:YAG laser-treated patients (using 60 and 80 mJ) compared with a control group, while Er:YAG laser-treated patients receiving using 100 mJ recorded similar results to those of a control group undergoing mechanical preparation and acid etching.[38, 39] Other studies investigated microleakage at laser-prepared cavities, again producing differing results: some authors, using the dye penetration method, found less microleakage of GIC and composite materials at laser-prepared than at mechanical bur-prepared cavities.

Comparative studies of different methods of cavity preparation (drill, air abrasion and laser) found that cavities prepared using the Er:YAG laser at 300 mJ/4 Hz and 400 mJ/4 Hz showed the highest degree of infiltration, while better composite resin marginal adaptation was obtained when Er:YAG laser preparation was followed by a total acid etching procedure (Figs. 4 & 5).[40]

Clinical implications

Laser cavity preparation is closely related to a series of variables. Fluence, power density and pulse length, but also laser beam angle, focus mode, and amount of air-water spray are all factors that can cause substructural damage. A final conditioning step at low power, both on dentin and enamel, is advisable. Acid etching on lased dentin and enamel produces uniform results, eliminating the thin layer of substructural damage, exposing the collagen fibres, and creating a substrate for the formation of the hybrid layer; acid etching changes Silverstone class 2 and 3 enamel into class 1 enamel, allowing better composite adaptation.

Endodontics

The use of lasers with different wavelengths is well documented in adult endodontics, but literature on their use in paediatric endodontics is lacking. In endodontics, lasers are indicated for:

_pulp capping
_pulpotomy
_root canal disinfection.

A search of the literature indexed in PubMed found few studies that investigate the use of lasers in maintaining pulp tissue vitality.

In this field, low-level laser energy (from 0.5 to 1.0 W) is usually used, delivered in defocused mode, preferably with low repetition rate or/and in superpulsed mode. In 1997, Santucci, using an Nd:YAG laser for coagulation and glassionomeric cement as pulp capping agent, reported a 90 % success rate after six months.[41] The following year, similarly high success rates were obtained by Moritz *et al.*: 89 % and 93 % after 1 and 2 years, respectively, compared to 68 % and 66 % in the calcium hydroxide control group.[42,43] The CO_2 laser has a purely thermal effect on tissue, 90–95 % of the energy delivered to the tissue being absorbed by a fine tissue layer (100 microns) and transformed into heat. The wavelengths of Erbium lasers, too, are almost completely absorbed by the water in a superficial tissue layer and transformed into heat: however, these lasers do not have such a marked coagulating effect (Figs. 6–8) .

Olivi *et al.*, in 2006, showed the Er,Cr:YSGG laser with adjustable air-water spray to be, by itself, an excellent mini-invasive instrument for caries removal and pulp coagulation, which does not overprepare or overheat the residual dental tissue and is associated with 80 % tooth survival at 4 years.[44] The same author, in 2007, compared the efficacy of two laser systems, the Er,Cr:YSGG laser and the Er:YAG laser, with that of a conventional calcium hydroxide procedure, observing success rates of 80 % in the Er,Cr group, 75 % in the Er:YAG group, and 63 % in the control group at two years.[45]

Pulpotomy is a very common technique in primary teeth. Although pulpotomy with formocresol (1 : 5 dilution) is used successfully, in view of the carcinogenic and mutagenic potential of its formaldehyde compo-

nent, there is now a tendency to seek alternative techniques. Lasers have been proposed for this application and, in 2002, Pescheck *et al.* favourably compared CO_2 laser treatment to formocresol for pulpotomy in primary teeth, reporting a survival rate ranging from 91% to 98%.[46] The superpulsed mode recorded a markedly higher success rate than the continuous wave mode.

Elliot *et al.*, in 1999, also found a significant inverse correlation between the laser energy applied to the pulp and the degree of inflammation at 28 days; these authors reported a 99.4% clinical success rate at four years compared to 88.2% in the formocresol control group.[47] Instead, Guelmann *et al.*, in 2002, reported a correlation between healing and age and apex size of the primary teeth.[48] The Nd:YAG laser has also been used for pulpotomy on human primary teeth, but a recent study reported a clinical success rate of 85.71% and a radiographic success rate of 71.42% at 12 months, compared to the clinical and radiographic success rate of 90.47% recorded in the formocresol group.[49] While clinical reports in paediatric endodontics are lacking, it is known that permanent teeth can be treated with the Nd:YAG and diode lasers, which have a high bactericidal effect in root and lateral canals.

Only one study on laser use in primary teeth is indexed in PubMed. It compared the effects of different procedures (Er,Cr:YSGG laser, manual and rotary instrumentation techniques) on root canal wall cleaning and shaping in primary teeth. Treatment with the Er,Cr:YSGG laser provided cleanliness similar to that obtained using the rotary instrumentation technique and superior to that obtained with manual instrumentation; the laser technique required less time for completion of the cleaning and shaping procedures compared with both the other techniques.[50]

Clinical implications

In pulp capping procedures, attention must be paid to the level of energy applied. Low energy delivered in defocused mode and pulsed or superpulsed mode guarantees good superficial coagulation and good decontamination, and maintenance of the vitality of the residual pulp. Due to the characteristic anatomy of the apex and the penetration depth of near infrared lasers, particular care must be taken when introducing laser energy into primary root canals for root canal cleaning and disinfecting purposes.

_Laser applications in dental traumatology

Dental traumas in children, sometimes complex and occasionally genuine emergencies, are frequent events in which laser-assisted therapy offers new treatment possibilities.[31, 51, 52] There is very little on this topic in the international literature and there are no well-coded guidelines for the use of lasers in this field, although the advantages offered by laser techniques, already described by others, make them useful options in the treatment of hard and soft dental tissue and exposed pulp.

Hard-tissue traumatic injuries

A crown fracture involves the enamel and dentin and, if complicated, exposes the pulp. As underlined in the section on hard-tissue applications, only lasers belonging to the Erbium family can guarantee good results in tooth excavation, reducing post-operative discomfort and sensitivity as well as ensuring a minimally invasive approach. These lasers can be used for the entire procedure: tooth margin preparation and finishing, coagulation of the exposed pulp, pulpotomy or pulpectomy (if needed)[42, 43], and soft-tissue procedures (Figs. 9–10). A crown fracture exposes a large number of dentinal tubules: Erbium lasers, when used with only a little or no water spray, have the capacity to fuse and seal the dentinal tubules (to depths of up to 4 m), thereby reducing the tissue's permeability to fluids and reducing dentinal hypersensitivity.[53] The other laser wavelengths (diode, Nd:YAG, CO_2) also exert this beneficial therapeutic action.[54]

Soft-tissue traumatic injuries

Indirect traumas are lesions to the supporting structures, in particular the alveolar bone, gums, ligaments, fraenum and lips. Lasers are currently an available option for the manipulation of dental soft tissue and, as reported in the literature cited above, they provide good coagulation (with an extremely clean working area), effective decontamination, photobiostimulation and antalgic effects. For these reasons, they are indicated for the treatment of traumatic soft-tissue injuries, eliminating the need for sutures, allowing good and rapid healing by second intention and reducing patient discomfort to a minimum.

In the authors' own experience, the use of laser systems improves the following procedures:

_decontamination of the alveolus following a traumatic avulsion
_treatment of periodontal defects following dental luxations or subluxations
_microgingival surgery for the treatment of traumatic dental injuries
_gingivectomy and gingivoplasty
_surgical cutting (e.g. to remove tooth fragments).

CLINICAL IMPLICATIONS: all the advantages of laser applications (on hard and soft tissue and on exposed pulp tissue) make laser technology useful in this field.[56, 57, 58, 59, 60]

_Low-Level Laser Applications

Biostimulation and pain control (LLLT)

Low-level laser therapy (LLLT), or soft laser therapy, may provide a patient with a non-traumatic introduction to dentistry. There is a large body of literature on this topic, even though opinion on methods and doses still varies widely. Even though helium-neon lasers (632.8 nm) were the first lasers used for LLLT, they have now been replaced by semiconductor diode lasers (830 nm or 635 nm). These lasers exert a marked antalgic and biostimulating effect and speed up tissue repair processes. In short, they influence a large number of cell systems (fibroblasts, macrophages, lymphocytes, epithelial cells, endothelium), and can also have a series of benefits on the inflammatory mechanism, reducing the exudative phase and stimulating the healing process.

These are important clinical advantages, especially in youngsters with impaired defences (patients with insulin-dependent diabetes, a history of endocarditis, cardiac dysfunction or malformations, or who have undergone cardiac surgery or have prosthetic valves, oncological patients undergoing chemotherapy or radiation). In LLLT the power delivered is around 10/50 mW with an irradiation energy ranging from several millijoules to 1 or 2 Joules. After 1–3 days of biostimulation, it is already possible to observe a considerable reduction of swelling and an acceleration of the epithelisation and collagen deposition phase. LLLT has a number of applications in dentistry, both at soft-tissue level (biostimulation of lesions, aphthous lesions, stomatitis, herpetic lesions, mucosity, pulpotomy) and at hard-tissue level (acceleration of orthodontic movement); it also has important neural effects (analgesia, neural regeneration, reduction of temporo-mandibular pain, post-surgical pain, orthodontic pain).[61,62,63]

_Conclusions

The diverse parameters of use and different clinical and experimental results reported in the international literature tend to disorient the non-expert wishing to explore applications of laser technology in paediatric dentistry. The studies on soft-tissue applications are for the most part in line with each other, following similar protocols and recording reproducible results: this is due to the fact that the lasers involved (diode, Nd:YAG, CO_2) use a similar technology.

Instead, the studies on hard-tissue applications use the Erbium family of lasers, of which various types are available, differing not only in their wavelengths (2,780 and 2,940 nm), but also in their overall construction. The studies performed to date cannot be compared for various reasons: power density and fluence are only one aspect of the energy delivered to the target tissue. Above all, these lasers have different delivery systems: optical fibres (hollow fibres) and articulated arms transmit energy in substantially different ways and, as a result, the energy reaching the tissue can be very different from that selected on the display. Air/water spray flow and pressure, pulse length, and beam profile, are other parameters that affect the results of the laser-tissue interaction.

The success of minimally invasive laser therapy, in which it is crucial to apply the correct energy (the minimal effective level), is conditioned in part, by the operator's familiarity with laser technology. The operator must thus learn to act on the tissues with precision. Before using a contact-free instrument effectively, it is necessary to acquire the correct technique through a period of training with a more or less extended learning curve. Professionals also need to understand the physical characteristics of the different laser wavelengths and their interaction with biological tissues in order to ensure that they are used safely and that young patients reap the benefits of this technology.

Finally, a correct psychological approach to the patient also contributes considerably to the success of laser therapy, which is often seen by patients and their families as almost magical._

Editorial note: A list of references is available from the publisher.

Soft-Tissue lasers
KTP 532
Argon
Diode 810, 940, 980
Nd:YAG 1.064
CO_2 10.600
Hard- and Soft-Tissue lasers
Er,Cr:YSGG 2.780
Er:YAG 2.940
Low level lasers
Helium-Neon 635
Diode 810

Table I

carious detection
cavity preparation (enamel-dentin) and carious removal
hard and soft tissue traumatic injuries
surgery
endodontics
orthodontics
biostimulation and pain relief

Table II

Table I_Classification of lasers.
Table II_Laser dentistry procedures.

_contact laser

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