Evidence-based dentistry on laser paediatric dentistry: review and outlook

G. OLIVI*, M.D. GENOVESE**, C. CAPRIOGLIO***

ABSTRACT. Aim The goal of paediatric dentistry is to provide preventive education to parents and patients as well as interception and therapy of dental diseases in a minimally invasive way using a stress-free approach. Different laser wavelengths are used for different applications following these minimally invasive concepts: argon, KTP, diode; Nd:YAG, and CO2 lasers are used for soft tissue applications and the erbium family is used for both soft and hard tissue procedures. This paper offers a revision and a discussion of the international literature, showing also some clinical procedures, related to these scientific studies. Soft tissues laser applications in Pediatric Dentistry include application in oral surgery as well as in periodontics and orthodontics. Laser applications on hard tissues include caries prevention and detection and application for sealing of pits and fissures. Also application for cavity preparation, carious removal and pulp therapy are discussed.

KEYWORDS: Paediatric dentistry; Laser surgery; Frenectomy; Gingivectomy; Impacted tooth; Caries prevention; Caries diagnosis; Dental caries preparation; Dental trauma.

Introduction

The goal of paediatric dentistry is to educate both children and parents about prevention in order to reduce dental pathologies in early and late childhood as well as in adolescence. The common objective is tissue preservation (preferably by preventing disease and intercepting its progress), this means performing treatment with as little tissue loss as possible. With the new techniques available (digital radiology with low radiation emission, diagnostic laser and the dental operative microscope) we can aim for both an early diagnosis and a minimally invasive therapy (ozone therapy, air abrasion, rotary instruments for micro-preparation and the laser). As reported by Martens and underlined by Gutknecht [Martens, 2003; Gutknecht et al., 2005] «children are the first in line to receive dental laser treatment» and based on the micro dentistry motto filling without drilling, we agree with the philosophy that laser-supported dental diagnosis and treatment is crucial for treating children successfully according to the latest research in dentistry.

This paper will present a review of the international literature that provides scientific evidence (EBD) on the use of laser and its various possible applications in paediatric dentistry, and will attempt a discussion and a correct interpretation of the different results reported. A selection of clinical cases will document the clinical applications related to these scientific studies.

Laser applications in paediatric dentistry

Laser in paediatric dentistry is an alternative instrument that sometimes complements, and other times substitutes, traditional techniques: various applications are possible on both soft and hard tissues using different laser wavelengths (Tables 1, 2; Fig. 1).

Leaving the discussion on the physical basis of laser therapy to other works and publications, it should however be remembered that different wavelengths do not have a similar interaction with the different chromophores (haemoglobin, water, hydroxyapatite) contained in the target tissue (mucosa, gingiva, dental tissue) and therefore the therapy is influenced by the different optical affinity and absorption coefficients of the tissues for each particular wavelength.

Soft tissue applications

Laser application in oral surgery

The use of laser for the removal of oral diseases and the therapy of lesions of the oral mucosa has specific applications in the field of paediatric dentistry.
All the laser wavelengths with optical affinity for haemoglobin and water (chromophores contained in the gingiva and mucosa) can be used for these applications: argon, KTP, diode, Nd:YAG and CO2 lasers are useful for cutting, vaporisation and decontamination of the soft tissue, performing a very good coagulation and haemostasis, and are ideal for vascular lesions [Baggett et al., 1999; Barak et al., 1991]; Er,Cr:YSGG and Er:YAG lasers are also effective for these applications due to the good absorption by the water content of gingiva and mucosa, but with less bleeding control.

The use of an air-water jet delivered through the handpiece of the erbium laser allows a clean incision and vaporisation of the soft tissues with limited rise in the temperature, and the absence of peripheral necrotic tissue allows the performance of very accurate biopsies [Boj et al., 2007; Olivi et al., 2007].

Many authors agree with the advantages of laser application on soft tissues: quick and easy to use, less use of local anaesthesia, excellent control of bleeding during incision, sutureless technique, post-operative recovery often asymptomatic due to the decontaminating effects, and antalgic and biostimulant effects.

Moreover, the excellent clinical results improve the patient acceptance of the therapy and facilitate the operator’s intervention, which at times can be very complicated when using traditional techniques [Boj et al., 2005; Genovese and Olivi, 2008]. Furthermore the need for analgesics and anti-inflammatory medications is drastically reduced compared to conventional procedures.

Table 3 lists the treatable conditions as reported by various authors.

### Laser application in periodontics and orthodontics

The decontaminating effect of different lasers in the pockets of patients with periodontal disease has been widely documented in adults, but there is little documentation of laser-assisted therapy of periodontitis in young patients. Instead there are many clinical situations that require intervention on soft tissue before, during and after the orthodontic treatment, and the laser can be used in the procedures reported in Table 4. These procedures, needed for the orthodontic treatment or its completion, become extremely simple, safe and rapid, and can be performed by the orthodontic specialist himself.

<table>
<thead>
<tr>
<th>Soft tissues</th>
<th>Hard tissues</th>
<th>Dental Traumatology</th>
<th>Low level laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral surgery</td>
<td>Caries prevention/detection</td>
<td>Dental injuries</td>
<td>Biostimulation and pain control</td>
</tr>
<tr>
<td>Periodontics</td>
<td>Sealing of pits and fissures</td>
<td>Soft tissue injuries</td>
<td></td>
</tr>
<tr>
<td>Orthodontics</td>
<td>Cavity preparation, caries removal</td>
<td>Endodontics</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3 - Conditions that can be treated with laser.**

- Herpes labialis
- Aphthosis
- Haemangioma
- Fibroma
- Papilloma
- Epulis
- Pyogenic granuloma
- Mucocele
- Eruption cyst
- Dentigerous cyst
- Foreign body
Different wavelengths can be used in these procedures, employing different techniques, according to the different laser-tissue interaction [Kravitz and Kusnoto, 2008]. Among the most effective laser applications in orthodontics, and the most widely performed and documented are frenectomies: several authors reported less post-operative pain, discomfort and fewer functional complications (speaking and chewing) compared to the traditional techniques, where diode, Nd:YAG, Er:YAG, Er,Cr:YSGG and CO2 lasers were used, resulting in a better perception of the therapy by the patient [Haytac and Ozcelik, 2006; Kara, 2008]. Labial upper and lower frenectomies can be performed: the laser is extremely simple and effective even in newborns, in cases of severe ankiloglossia or tight maxillary frenum that make breastfeeding difficult [Kotlow, 2004].

Gingivectomy, gingivoplasty, and opercolectomy can be easily performed without anaesthesia with all wavelengths, and brackets can be immediately attached [Sarver and Yanosky, 2005; Fornaini et al., 2007]. Other authors have reported positive results with the application of LLLT to speed teeth’s orthodontic movement, stimulating the modulation of the initial inflammatory response, thus obtaining the results in a shorter period [Cruz et al., 2004; Youssef et al., 2008; Pretel et al., 2007], while other studies reported the CO2 laser local effect in reducing pain associated with orthodontic force application, without interfering with the tooth’s movement [Fujiyama, 2008].

Clinical implication

Laser is an alternative, valuable technique for soft tissue applications. Lesions of oral mucosa as well as soft tissue orthodontic problems are effectively treated with laser. The treatment of paediatric patients requires the application of the minimal effective power for these procedures (Fig. 2, 3, 4).

<table>
<thead>
<tr>
<th>Table 4 - Procedures that can be performed using a laser.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frenectomy</td>
</tr>
<tr>
<td>Gingivectomy</td>
</tr>
<tr>
<td>Gingivoplasty</td>
</tr>
<tr>
<td>Opercolectomy</td>
</tr>
<tr>
<td>Laser enamel etching</td>
</tr>
<tr>
<td>Biostimulation and pain relief during orthodontic movement</td>
</tr>
</tbody>
</table>

**Table 4 - Procedures that can be performed using a laser.**

**Fig. 2** - Female, 6 years old; lingual frenectomy: diode 810nm laser; parameters used: 1.0 to 1.5W c.w. topic anaesthesia.

**Fig. 3** - Female, 13 years old; impacted maxillary cuspid: Erbium:YAG laser vaporization of the mucosa, no bleeding (parameters used: 10pps-75mJ-0.75W- water spray- no anhestesia); laser conditioning of the exposed enamel (parameters used: 20pps-75mJ-1.5W).

**Fig. 4** - Female, 14 years old; orthodontic therapy: Erbium:YAG laser gingivectomy for early bonding of the bracket, absolutely no bleeding (parameters used: 10 to 20pps-75mJ-0.75-1.5W- water spray- no anaesthesia).
Hard tissue applications

**Laser application for caries prevention**

The *in vitro* studies to verify the possibility of an increase of acid resistance and of micro-hardness of the enamel surface following laser radiation started at the end of the 1980s.

As of today, several studies on these applications have been done with more or less uniform results but the clinical evidence is extremely limited.

The studies of this application fall into two broad categories based on the use of different laser wavelengths: Argon laser at 488-514 nm and CO₂ laser at 9300, 9600, 10600 nm. Also the erbium laser at 2780 and 2940 nm was investigated in modifying the physical-chemical characteristics of the enamel surface: the results of these studies were assessed by testing cross-sectional micro-hardness and enamel solubility.

In 1995 Flaitz et al. reported that Argon laser irradiation combined with acidulated phosphate fluoride treatment (APF) resulted in a decrease of lesion depth by more than 50% compared with control lesions, and by 26% to 32% when compared with lased-only lesions.

In 1999 other authors reported a significant reduction of white spotting or etching, using a zinc fluoride and Argon laser combination. It seems that this treatment stabilises the hydroxyapatite crystals and restores its structural defects.

The possibility of providing a protective barrier against a cariogenic attack in primary teeth using Argon laser irradiation combined with APF was investigated; the surface coatings associated with this treatment may contain fluoride-rich calcium and phosphate mineral phases that could act as reservoirs for fluoride, calcium, and phosphate, thus providing a certain degree of protection from caries.

Another study reported that the micro-hardness of the enamel surface was higher when exposed to low Argon laser irradiation only or Argon laser irradiation combined with APF vs. no treatment (control) [Westerman et al., 2003].

The other line of research dates 1998, when Featherstone et al. reported 70% inhibition of caries progression by using 9.300 nm and 9.600 nm laser (fluence from 1 to 3 J/cm²), comparable with the inhibition produced by the daily use of fluoride toothpaste. The subsurface temperature increase was minimal (<1°C at 2 mm depth), and another study reported no thermal damage to the pulp. Also the latest study confirmed that the CO₂ laser was efficient in reducing the subsurface enamel demineralisation and that its association with a high-frequency fluoride treatment may enhance this protective effect [Steiner-Oliveira et al., 2008].

A more recent research reported that the erbium laser wavelengths also apparently have the potential to increase acid resistance: subablative erbium energies can reduce enamel solubility increasing caries resistance without severe alterations of the enamel, but without reaching statistical significance [Apel et al., 2004].

**Clinical implications**

Subablative CO₂ laser irradiation of young healthy teeth could be an effective method for caries prevention; long term clinical studies are needed to validate this application. Further studies are also needed to evaluate the erbium family’s ability to increase the acid resistance of permanent teeth.

**Laser for carious detection**

This is the application most frequently and extensively investigated in paediatric dentistry. Of the 79 papers indexed under Laser Paediatric Dentistry in the PubMed as of July 31, 2008, 31 studied the use of this device for carious detection.

This non-ablative laser emits fluorescence light, visible in the red spectrum at 655 nm (LF), which proved useful as an additional method for occlusal caries detection.

Several studies compared different caries detection methods: visual inspection alone, visual inspection with magnification, bite-wing x-ray and laser fluorescence. Lussi et al., in 2003 stated that LF could be used as an additional tool in the detection of occlusal caries in deciduous teeth and its good reproducibility should enable monitoring of the carious process over time.

Burin et al. [2005], Mendes et al. [2006], and Barberia et al. [2008] considered the fluorescence device better than bite-wing x-ray for occlusal caries detection.

Other authors reported that the reliability and the diagnostic validity (sum of sensitivity and specificity) of LF are very high, and also higher than bite-wing radiography for proximal caries detection in primary teeth. Also caries detection of proximal tooth surfaces might be influenced by the condition of the adjacent tooth [Lussi et al., 2006]. Some studies investigated the impact of the operator on the results and concluded that the reliability, predictability and the reproducibility of the results did not depend on the operator factor [Bengtson et al., 2005].

Other studies reported that LF methods for occlusal caries detection are more efficient in deciduous than in permanent teeth, but concluded that LF was not able either to detect in vitro remineralisation of natural incipient caries lesions of primary teeth nor to monitor the mineral loss in caries lesions development in primary teeth [Mendes et al., 2003]. A recent study [Braga et al., 2008] reported that the LF performs better at the dentin threshold than at the...
enamel threshold; they therefore concluded that this method does not perform well in detecting initial enamel caries lesions, confirming what found in previous studies that demonstrated a good performance of LF in predicting the extension of the caries lesions.

The LF presents a better correlation with the lesion depth than with mineral loss in smooth-surface caries lesions and the assessment of mineral loss was unreliable. Several studies investigated particular situations that could affect the results: the presence of brown or dark spots on fissures tended to overscore discolored surfaces, while the presence of plaque worsened the performance of the LF method. Also the presence of toothpaste residual after teeth cleaning can modify the detection with false readings. Caries detection under dental sealants was unreliable and not recommended due to a high likelihood of inaccurate readings caused by the intrinsic fluorescence of sealant material.

Clinical implications

In daily practice, dentists can consider the LF system a reliable complementary tool for the visual inspection of occlusal surfaces, both in primary molars and permanent first molars.

New device tips also enable the detection of proximal lesions.

Laser application for sealing of pits and fissures

The use of laser for pre-treatment of pits and fissures, before application of sealant on the occlusal surface of young teeth, was investigated.

Several in vitro studies were performed to evaluate the bond strength and the microleakage of pit and fissure sealants, comparing invasive techniques and laser irradiation, with or without acid etching. Most of these studies reported no significant difference between the two types of enamel preparation when etching was performed.

In fact, preparing and treating the enamel surface exclusively by means of Er:YAG laser resulted in the highest degree of leakage [Youssef et al., 2006; Lupi-Pégurier et al., 2007].

On the contrary, Moshonov et al. [2005] found no difference in microleakage between laser and acid etching, suggesting that the technique may be effective.

Also the pre-treatment with Er,Cr:YSGG laser had no influence on the resistance to microleakage of bonded fissure sealants in primary teeth [Cehreli et al., 2006].

A study by Francescut and Lussi [2006] reported important considerations about the energy applied for this application: they concluded that mechanical preparation prior to fissure sealing did not enhance the final performance of the sealant, reporting that laser at 600 mJ and bur removed most of the hard tissue.

Clinical implications

Laser irradiation did not eliminate the need for acid etching prior to fissure sealant placement. Laser irradiation may be considered an additional tool in the sealant application procedure, for the overall cleansing and disinfecting effect: care must be taken with the energy applied so as not to over-prepare pit and fissure surfaces.

Laser application for cavity preparation and caries removal

Different laser wavelengths were studied for cavity preparation: the CO₂ laser was investigated first, but the results were not good, due to the thermal damage that affected the irradiated dental tissues; other clinical and experimental investigations showed the therapeutic possibility of treating early childhood caries of the enamel with Nd:YAG laser [Birardi et al., 2004], but the micro-morphological analysis showed collateral damage of the dental tissues.

Today two wavelengths, the Er,Cr:YSGG at 2780 nm and Er:YAG at 2940 nm are successfully used for treating dental hard tissues.

The initial 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 cutting ability of the Er:YAG laser on hard tissue of human teeth.

In the first decade of research, various authors studied the parameters and variables for using the erbium laser, evaluating the morphological effects on hard and pulp tissues: the effects of energy density, pulse repetition rate, and air-water jet were reported.

Moritz et al., in 1998 studied the possibility of etching the enamel, reporting that the results obtained with the laser were the same as those achieved with orthophosphoric acid.

The Authors [Olivi and Genovese, 2007] confirmed the efficacy of the erbium laser in cavity preparation and removal of carious tissue, researching the optimal parameters of use.

The idea of substituting the drill with a laser instrument which has less impact on the patient (the laser works on hard tissue with no contact, no vibration, no noise and less pain) has brought about the introduction of this device in paediatric dentistry.

Various studies and clinical reports showed how the laser, used by numerous operators as an alternative to rotary instruments in paediatric restorative dentistry, brings an added measure of safety even when used in the treatment of very young children, a new possibility for minimal interventions [Kornblit et al., 2008], and an overall better acceptance compared to traditional techniques [Keller et al., 1998; Liu et al., 2006; Takamori et al., 2003].
A study tested the laser efficacy on treating primary teeth, comparing the performance of four different dentin excavation methods in deciduous teeth: steel bur, polymer bur, Er:YAG laser, and manual excavator [Celiberti et al., 2006], evaluating different parameters, indicating both the efficacy and the potential for minimally invasive therapy.

The use of manual excavators seemed the most suitable method for carious dentin removal in deciduous teeth, combining good treatment time with effective caries removal, while the steel bur appeared the fastest but with the highest level of over-preparation. The laser produced intermediate results, among the slowest but with a low level of over-preparation according to the minimally invasive concepts (Fig. 5).

**Laser and composite adhesion**

The problem of the composite adhesion to lased surfaces is still controversial.

Many authors reported how adhesion to laser-ablated or laser-etched dentin and enamel of permanent teeth is lower compared to conventional rotary preparation and acid etching. These studies highlight the importance of energy output, avoidance of substructural damage, the need for standards for laser energy output in relation to the different tooth substrates and the need of acid-etching both for dentin and enamel even after laser conditioning [Brulat et al., 2007; Ceballo et al., 2002; De Moor and Delmè, 2006; Dunn et al., 2005].

Even studies on primary teeth reported how Er:YAG laser irradiation of dentin, at 60 mJ/2Hz, 80 mJ/2Hz and 100mJ/2Hz prior to adhesive protocol, adversely affected bond strength [Monghini et al., 2004].

On the opposite side, other authors reported that primary dentin treated with Er,Cr:YSGG laser at the lower wattage of 0.5 Watt (50 mJ) did not require etching for bonding, while as the energy level increases, the addition of etching as part of the conditioning provides adequate bonding [Sung et al., 2006].

Some studies on shear bond strength to the enamel of primary teeth reported superior results for the Er:YAG laser group compared with the control group, using 60 and 80 mJ, or similar results to the control group mechanically prepared and acid-etched using 100 mJ energy [Lessa et al., 2007; Wanderley et al., 2005].

Other studies investigated the microleakage of cavities prepared by the laser and here again different results were reported: some authors, using the dye penetration method, found that the microleakage of GIC and composite materials of laser-prepared cavities is lower than that those prepared by burs [Yamada et al., 2002; Quo et al., 2002].

Comparative studies on different methods of cavity preparation, drill, air abrasion and laser, reported that Er:YAG laser-prepared cavities at 300 mJ/4Hz and 400 mJ/4Hz showed the highest degree of infiltration [Borsatto et al., 2006; Kohara et al., 2002], and better composite resin marginal adaptation was obtained when Er:YAG laser preparation was followed by a total acid etching [Bertrand et al., 2006].

**Clinical implications**

Laser cavity preparation is closely related to different variables. Fluence, power density and pulse length, but also laser angulation, focus mode, the
amount of air-water jet are all factors that can cause substructural damage to the dentin. A final conditioning at low wattage 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 fibers and creating a substrate for the formation of the hybrid layer; acid etching modifies the Silverstone enamel class 2 and 3 into class 1, allowing better composite adaptation.

Laser application in endodontics

The use of lasers with different wavelengths in endodontics is well documented for adults but there are few studies on paediatric endodontics. Lasers are indicated for:

1. pulp capping;
2. pulpotomy;
3. root canal disinfection.

Few studies that investigate laser performance in maintaining pulp tissue vitality are indexed in the PubMed library. Different laser wavelengths and parameters related to the different devices were used. The common delineator was the low laser energy applied (from 0.5 to 1.0 W), delivered in defocused mode, preferably using low repetition rate or superpulsed mode.

Santucci [1997] first reported a high success rate of 90% after 6 months, using Nd:YAG laser for coagulation and glass ionomer cement as pulp capping agent.

Studies from Moritz et al. in 1998 reported success rates of 89% and 93% after 1 and 2 years compared to 68% and 66% of the calcium hydroxide control group. The CO2 laser has a purely thermal effect on the tissue; 90-95% of the energy delivered to the tissue is absorbed by a fine tissue layer (100 µ) and transformed into heat.

Also the erbium wavelengths are almost completely absorbed by the water in a superficial layer and transformed into heat; however, these lasers have less coagulating effect. Jayawaedena et al. [2001] demonstrated, in an animal model, good healing capacity with the formation of a dentin bridge and reparative dentin using 150 mJ - 10 pulses.

Olivi and Genovese in 2006 reported the importance of the use of the Er,Cr:YSGG laser with adjustable air-water jet as a single minimally invasive instrument for carious removal and pulp coagulation to avoid over-preparation and overheating of the residual dental tissue, with tooth survival of 80% after 4 years. The same author compared the efficacy of two laser systems, Er,Cr:YSGG laser and Er:YAG laser, with conventional calcium hydroxide procedure, and reported 80% success in the Er,Cr group, 75% in the Er:YAG group, while the control group had 63% success rate at 2 years [Olivi et al., 2007].

Pulpotomy is a very common technique in primary teeth; although pulpotomy with formocresol (1:5 dilution) is used with success, there is a tendency today to seek alternative techniques, considering the carcinogenic and mutagenic potential of its formaldehyde component. Lasers have been proposed for pulpotomy, and a study from Pescheck et al. [2002] compared favourably CO2 laser treatment to formocresol for pulpotomy in primary teeth, with a survival rate from 91% to 98%. Other studies reported that the superpulsed mode produced 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 and a 99.4% clinical success after 4 years compared to 88.2% of the formocresol control group. Guellmann et al., in 2002 instead reported the correlation of the healing with the age and the apex size of the primary teeth. The Nd:YAG laser was also used for pulpotomy on human primary teeth, but a recent study showed a clinical success rate of 85.71% and a radiographic success rate 71.42% at 12 months, compared to the formocresol group that presented a clinical and radiographic success rate of 90.47% at 12 months [Odabas et al., 2007].

Although there are no clinical reports on paediatric endodontics, permanent teeth can be treated with Nd:YAG and diode laser, for their high bactericidal effect in root and lateral canals.

Only one study on laser used in primary teeth is indexed in PubMed. It compared the root canal walls cleaning and shaping effect of different procedures in primary teeth, using Er,Cr:YSGG laser with manual or rotary instrumentation techniques. It reported that treatment with Er,Cr:YSGG laser provided similar cleanliness when compared with the rotary instrumentation technique and was superior to manual instrumentation, while the laser technique required less time for completion of the cleaning and shaping procedures when compared with both rotary or hand instrumentation [Soares et al., 2008].

Clinical implications

During this procedure, attention must be given to the energy applied. Low energy delivered in defocused mode and pulse or superpulsed mode guarantees good superficial coagulation and good decontamination to maintain the vitality of the residual pulp in pulp capping application.

Particular care must be taken with the application of laser energy into primary root canals for root canal cleaning and disinfecting, due to the characteristic anatomy of the apex and to the penetration depth of near infrared lasers.
Laser application in dental traumatology

Dental traumas are frequent in children. They can be complex events, and at times real emergencies in which laser-assisted therapy can offer new treatment possibilities [Caprioglio D. and Caprioglio C., 2006]. Very little attention is devoted to this topic in the international literature and there are no well–coded guidelines for laser applications in these specific clinical events. The advantages correlated to laser applications on hard and soft tissue and on the exposed pulp make laser technology useful in this field as already reported by the authors.

Laser application in dental traumatic injuries

Crown fracture involves the enamel and dentin and exposes the pulp, if complicated. As underlined in the hard tissue paragraph, only erbium family lasers can guarantee good results in tooth excavation, reducing post-operative discomfort and sensitivity as well as providing minimally invasive dentistry. These lasers can be used to perform the entire procedure: tooth margin preparation and finishing, coagulation of the exposed pulp, pulpotomy or pulpectomy (if needed) [Caprioglio et al., 2003], as well as soft tissue procedures.

Crown fracture exposes a large number of dentinal tubules: erbium-chromium and erbium lasers, when used with only a little amount or no water jet, have the capacity to produce fusion and sealing of the dentinal tubules (depth up to 4 μm), resulting in a reduction of the tissues’s permeability to fluids, thus reducing dentinal hypersensitivity (Fig. 6).

The other laser wavelengths (diode, Nd:YAG, CO2) also have this beneficial therapeutic action for this application. As reported in the previous paragraphs, they can also be applied:
- to perform indirect or direct pulp capping;
- to decontaminate infected root canals;
- to treat soft tissue defects.

Laser application in soft tissue traumatic injuries

Indirect traumas are lesions to the supporting structures, in particular the alveolar bone, the gum, the ligament, the fraenum and the lips.

Lasers are currently an available option for the treatment of dental soft tissue and, as reported in the literature cited above, they provide good coagulation (with extremely clean working area), effective decontamination, photobiostimulation and pain reduction effect for the treatment of traumatic injuries, with no suture, good and rapid healing by second intention and minor discomfort for the patient (Fig. 5).

The authors have experienced and reported an improvement in these procedures by using lasers in the following applications:
- decontamination of the alveolus following traumatic avulsion;
- treatment of a periodontal defect following dental luxation or sub-luxation;
- microgingival surgery for the treatment of traumatic dental injury;
- gingivectomy and gingivoplasty;
- surgical cutting (e.g. to remove a tooth fragment).

Clinical implications

All the exposed advantages related to laser applications on hard and soft tissue and on exposed pulp tissue make laser technology useful in this field.

Low level laser application

Laser application in biostimulation and pain control (LLLT)

A non-traumatic introduction to dentistry can be represented by low level laser therapy (LLLT) or soft laser therapy. There is a large body of literature on this particular topic, even if both methodologically and in terms of doses, there is still considerable difference of opinion [Benedicenti, 2005]. Even...
though helium-neon lasers were initially used (632.8 nm), the ones in use today are the semiconductor diode lasers (830 nm or 635 nm).

The LLLT has an important pain-reducing and biostimulating effect with acceleration of the reparative processes that have a considerable clinical importance, especially in those patients with a compromised immune system (young patients affected by insulin dependent diabetes, history of endocarditis, cardiac dysfunction or malformations or cardiac surgical and prosthetic valves reconstruction, oncological patients undergoing chemotherapy or radiation). In short, LLLT stimulates the tissue repair processes, influencing a large number of cell systems (fibroblasts, macrophages, lymphocytes, epithelial cells, endothelium), and can also have a series of benefits on inflammatory mechanism, reducing the exudative phase and stimulating the reparative process [Mendez et al., 2000; Whelan et al., 2001].

In LLLT the power is delivered with an irradiation energy ranging from 30 to 50 Joules for cm² and a total energy from 300 to 350 J daily. After 3-5 days of biostimulation, it is already possible to observe a considerable reduction of swelling and an acceleration of the epithelisation and collagen deposition phase.

The LLLT has a number of applications in dentistry, both at the soft tissue level (biostimulation of lesions, aphthous stomatitis, herpetic lesions, mucositis, pulpotomy), and the hard tissue level (acceleration of orthodontic movement) as well as neurally (analgesia, neural regeneration, temporo-mandibular pain, post-surgical pain, orthodontic pain). According to Tuner and Hode [2004], and to Gutknecht et al. [2005], LLLT has five main indications in paediatric dentistry.

- The eruption of both deciduous and permanent teeth is sometimes painful: the irradiation of the lymph nodes in the area is advisable for pain relief.
- A laser radiation dose of 2 J has a brief anaesthetic effect of the mucosa, allowing painless injection with a needle.
- Direct application of a laser radiation dose of 4 to 6 J into an exposed cavity of a deciduous tooth can be used for pain reduction.
- Post-traumatic treatment after lip and front-tooth trauma to reduce swelling and pain can be achieved by applying a laser radiation dose of 3 to 4 J.
- A laser radiation dose of 1 to 2 J as an additional treatment in pulp capping improves treatment outcome. According to the author’s clinical experience a daily irradiation of 1-2 J/cm² (repeated for 3-4 days) can bring good results.

Further clinical studies are needed to establish suitable irradiation conditions.

**Discussion**

The diverse parameters of use and clinical and experimental results reported in the international literature may mislead the non-expert wishing to explore this field of application of laser technology.

The studies on soft tissue are for the most part in line, with similar protocols and reproducible results: this is due to the fact that the lasers involved (diode, Nd:YAG, CO2) make use of a similar technology, allowing the same operative protocols.

The studies on hard tissue utilize the erbium family of lasers: here there is a variety of types available, not only with different wavelengths (2780 and 2940 nm), but also with different overall construction. The studies done cannot be compared for various reasons: power density and fluence are only one aspect of the energy delivered to the target tissue. Above all the delivery systems are different: optical fibers (hollow fibers) or articulated arms transmit energy in a substantially different way so that the energy delivered to the tissue is very different from that selected on the display.

Air/water flow and pressure of the integrated spray, the pulse length, the beam profile, are other parameters that affect the results of the laser tissue interaction.

Beyond a presentation of the literature that validates the proposed therapies, it is important to underline that the operator factor is fundamental, even with laser therapy.

The resulting minimally invasive therapy is conditioned both by the knowledge of laser technology as well as the application of the correct energy (the minimal effective), which also depends on the manual ability of the operator who must learn to act on the tissues with precision. Using an instrument that works without contact requires learning the correct operating technique and a period of training with a more or less extended learning curve.

A correct psychological approach to the patient also contributes considerably to the success of the therapy, which is often felt by patients and their families as very comfortable and acceptable, sometimes even magical.

**Conclusion**

Laser is very effective in paediatric dentistry and represents a good treatment option. It enables optimal preventive, interceptive, and minimally invasive interventions for both hard and soft tissue procedures.

It is important for the professional to understand the physical characteristics of the different laser
wavelengths and their interaction with the biological tissues to ensure that they are used in a safe way, in order to provide the benefits of this technology to young patients. Therefore a period of education and training is highly recommended before applying this technology on paediatric patients.

References


