Lasers in dental traumatology

Author_Claudia Caprioglio, DDS

Introduction

Dental traumas occur frequently in children. They can be complex events and sometimes real emergencies. Traumatic injuries involve all the branches of dentistry (endodontics, restorative, periodontics, oral surgery, orthodontics) such that traumatology can be considered a multidisciplinary discipline.

Laser technology lends itself well to the problems encountered in dental traumatology (from simple crown fractures to replantation, root fractures and different types of luxation injury) because it is able to replace or complete, and also to simplify, traditional dental procedures. It contributes to the reduction of postoperative sensitivity through a minimally invasive and highly selective technique that has a positive psychological impact for the patients. In addition, it is an alternative technique for non-vital bleaching procedure to solve post-traumatic esthetic problems.

Working without anaesthesia through laser-induced analgesia is another challenge. Laser-assisted therapies drastically reduce the need for postoperative medications compared to conventional procedures. The international literature doesn’t report extensive references on laser-assisted dental trauma therapy, and there are no well-coded guidelines for specific laser application in this clinical field. Even though this challenging technology is ideal for trauma-related problems, the existing dental trauma guidelines and protocols should nevertheless be widely consulted (Andreasen et al. 2007).

Epidemiology and prevention

Dental traumas are sustained mainly during play (56 percent), sports activities (21 percent), road accidents (11 percent) or as a result of acts of violence (12 percent), which continue to be underestimated. In the literature, the high incidence of dental trauma is demonstrated by large-scale American studies that show that one in six adolescent boys is twice as likely as a girl to suffer a dental trauma, and the type of lesion varies depending on the age of the subject; in young age groups the incidence is usually equally high in both sexes (Glendor 2008).

Around 20 percent of children suffer a traumatic injury to their primary teeth and more than 15 percent to their permanent teeth (Andreasen et al. 2007). The teeth most frequently affected, both in primary and in permanent dentition, are the upper central incisors (50 percent) and the upper lateral incisors (30 percent). Pediatricians and dentists need to draw attention to the importance of prevention in this field. These injuries, together with tooth decay, are the

Figs. 1a, 1b_Complicated enamel-dentin crown fracture of 1.2 with complete detachment of the palatal tooth fragment. (Photo/ Courtesy of Prof. R. Grandini)
most frequent pathologies encountered in pediatric dentistry. Thus, specific training, adequate continuing education conventions, a high level of knowledge and updated guidelines for the management of traumatic dental injuries are needed.

Classification

In 1978, the World Health Organization created a classification of traumatic dental injuries. In 1992, this classification, revised and extended, was published. The following classification includes injuries to the teeth, supporting structures, gingival and oral mucosa. It is applicable both to primary and permanent dentition (Table I) (Andreasen et al. 2007).

Lasers application in dental traumatology

Taking a careful dental history report and doing a clinical examination are the basis of an accurate diagnosis. In order to save time and to be exhaustive, specific standardized charts are recommended. Every phase, both pre- and post-treatment, must be fully documented through radiographic and photographic examinations and pulp vitality tests, making it easier and quicker to monitor the evolution of the clinical case at subsequent visits and to compile a full medico-legal report, which is often required during and at the end of dental trauma treatment.

In dental trauma, pulp testing is a controversial issue; different tests have been proposed: the laser doppler flowmetry (LDF) is an experimental value method to diagnose the state of pulp revascularization; however, at this time this method cannot be of general use, but it looks promising.

Laser technology is an advancement that fits into the concepts of tooth preservation (microdentistry) and prevention. The use of lasers in many medical fields has become the standard treatment; this is not the case of dental traumatic injuries but this author is confident that these technologies will offer better quality treatments and will make our profession more enjoyable.

There are different types of lasers available to treat dental injuries. The properties of each type make them suitable for different tissues and procedures; each wavelength has a particular use determined by its specific tissue-interaction and affinities.

Due to their versatility, two types of lasers are more frequently used by pediatric dentists in dental traumatic injuries: Er:YAG and Er,Cr:YSGG because they can be used on hard and soft tissues (Gutknecht et al. 2005). In addition, other technologies are indicated: the KTP, the Nd:YAG laser, the Diode laser and the CO2 (Table II).

No randomized clinical studies exist concerning traumatic dental injuries and laser-assisted therapy, so in this article the author describes his own clinical experience and aims to stimulate more extensive scientific research.

Traumatic injuries to hard dental tissue and the pulp

Uncomplicated and complicated crown fracture

This type of fracture involves the enamel and dentin and exposes the pulp (if complicated).

The examination should be preceded by cleaning the injured area and doing a careful search for pulp exposure.

Take an X-ray, perform vitality tests because sometimes there is accompanying damage to the soft tissue (tongue and lips: look for tooth fragments).

The use of modern bonding agents and laser technology has considerably changed our clinical practice. Erbium lasers can guarantee good results in reducing postoperative discomfort and sensitivity as well as providing minimally invasive dentistry (Genovese et al. 2008).

Erbium lasers are indicated for the treatment of crown fractures, both complicated and uncomplicated, and whether not the tooth fragment is available. 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: the results obtained with the laser were the same as those achieved with orthophosphoric acid (Moritz et al. 2006).

Various studies and clinical reports show how the laser, used by numerous operators as an alternative to rotary instruments in pediatric restorative dentistry, brings an added measure of safety even when used in the treatment of very young children, is a new possibility for minimal interventions (Kornblit et al. 2008) and overall has better acceptance compared to traditional techniques (Keller et al. 1998).

Laser cavity preparation is closely related to different variables. Fluence, power density and pulse length, but also laser angulation, focus mode and 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.

The action of Erbium lasers on hard tissues and pulp is extremely precise: the surfaces treated are cleansed and sterilized. Temperature increase during treatment is minimal and may decrease while working with water-spray cooling.

Due to bactericidal capacities, there is no production of smear layer nor opening of dentinal tubules or allowing hybrid layer formation, these lasers can be used to perform the entire procedure: excavation, coagulation of the exposed pulps (if needed), pulpotomy or pulpectomy (Figs. 1–4).

Another feature is the very superficial thermal effect, therefore, the necrotic zone is likely to be very small. This kind of injury exposes a large number of dentinal tubules: 1 mm² of dentin exposes 20,000 to 45,000 dentinal tubules. They constitute a pathway for bacteria, thermal and chemical irritants that can determine pulpal inflammation. Erbium lasers are effective at removing organic material and the smear layer, and can achieve a bactericidal effect, but the Nd:YAG laser and the diode laser can provide an effective decontamination action as well.

The Erbium laser’s fusion and sealing capacity of the dentinal tubules (depth of up to 4 µm) can result in a reduction of the tissues’ permeability to fluids, thus reducing dentinal hypersensitivity.

Another structural change induced by these lasers is the phenomenon of vitrification, which can be very useful because it increases hard-tissue resistance to acid remineralization, dental hardness and dental abrasion.

The Nd:YAG and the diode laser have a beneficial therapeutic action in direct traumas. By exploiting their photothermic effect, these lasers can be used to treat both pulp and dentin. They can be applied:

- to treat dentinal hypersensitivity,
- to perform indirect or direct pulp capping,
- to remove endodontic material and
- to treat infected root canals.

The CO2 laser has a purely thermal effect on the tissue, 90–95 percent of the energy it delivers to tissue is absorbed by a fine tissue layer and transformed into heat. It’s indicated for:

- pulp capping (following dentin fracture),
- pulpotomy (following crown or root-crown fractures) and
- surgical cutting (e.g., to remove a tooth fragment) (Figs. 3–5, 15).

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 super-pulsed mode.

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 this formaldehyde component. Lasers have been proposed...
This laser rocks!

NVOrtho. The laser that tops the charts!

The NV Ortho diode laser has become the new standard for soft tissue surgery, winning some of the most prestigious awards in dentistry over the past two years. Nothing even comes close to its star performance.

- Completely cordless, battery operated
- Disposable tips – no stripping or cleaving
- Wireless foot pedal activation
- Preprogrammed settings
- 8 CE unit training course included
- Excellent balance and ergonomics

Experience NV today!
(800) 217-8822
discusdental.com/lasers.php

NOW $5,995!
for pulpotomy, and one study compared favorably CO\textsuperscript{2} laser treatment to formocresol for pulpotomy in primary teeth, with a survival rate from 91 to 98 percent (Pescheck et al. 2002). Other studies reported that the superpulsed mode produced a markedly higher success rate than the continuous wave mode.

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 (Olivi et al. 2007).

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 (Soares et al. 2008).

Crown-fracture and root fracture
In contrast to root fractures where the fracture is located entirely within the alveolous, fracture healing cannot be expected in crown-fractures. The coronal fragment is usually removed and the treatment should be focused on the possibility of using the remaining fragment.

On a superficial fracture without pulp exposure, it's suggested to remove loose fragments, smoothing the rough subgingival fracture surface, and covering the exposed dentin. When the coronal fragment comprises one-third or less of the clinical root after the removal of loose fragments, a pulpectomy and root canal filling is recommended.

The fracture surface has to be exposed with a gingivectomy or osteotomy and subsequently a prosthetic restoration (Figs. 5–8).

Laser-assisted therapy can be useful not only for the coronal fragment restoration but also for supporting tissue surgery and endodontic therapy (gingivoplasty, gingivectomy, crown lengthening) (Sarver and Yanosky, 2005). Lasers are effectively used in these soft-tissue procedures because they can easily incise, cut, ablate and reshape the soft tissue with no or minimal bleeding, less pain and have a bactericidal effect.

In these clinical events, deeply penetrating lasers, such as Nd:YAG and diode-lasers, show a thicker coagulation layer than superficially-absorbed ones, such as CO\textsuperscript{2}-Erbiium lasers. The technique used with the first pair is similar to removing the tissue with electrosurgery.

Treatment factors such as optimal repositioning and flexible splinting have a positive influence upon healing, such as immature root formation, lower age and less displacement of the coronal fragment.

Because a splint has to be kept in situ for at least several weeks, anesthetic orthodontic splint can also be used (ceramic brackets).

Debonding procedures can beatraumatic when using a Nd:YAG laser. Intra-pulpal temperature rises less than using conventional high-low speed instruments for orthodontic brackets removal.

Therefore the laser-assisted procedure is safer, quicker and more comfortable (Figs. 3–5, 15).

Traumatic injuries to the periodontal tissues
Indirect traumas are lesions to the supporting structures, in particular the alveolar bone, the periodontum, the gingiva, the ligaments, the fraenum and the lips. The Nd:YAG laser and the diode laser have a beneficial therapeutic action in traumatic injuries to the periodontal tissues. These lasers have a decontaminating effect, as well as a biostimulating and reparative effect, with no suture, good and rapid healing by second intention and minor discomfort for the patient.

They are useful for:
- decontamination of the alveolous following a traumatic avulsion,
- treatment of a periodontal defect following a dental luxation or sub-luxation,
- microgingival surgery for the treatment of a traumatic dental injury,
Injuries to developing teeth

Disorders of permanent teeth caused by traumatic injury to primary teeth can be divided into two groups according to the type of dental trauma: direct traumatic impact or indirect lesion. The prevalence of these disturbances ranges from 12 to 69 percent depending on the study. Avulsion and intrusive luxation are injuries associated with very high frequencies of developmental complications.

Laser-assisted therapy can be useful in:

- enamel discoloration: treatable with Erbium laser
- circular enamel hypoplasia: treatable with Erbium laser and
doctoral eruption: treatable with surgical exposure or soft-tissue laser surgeries (all the wavelengths of the near-medium and far infrared spectrum of light).
Low-level laser therapy (LLLT) or soft-laser therapy

A non-traumatic introduction to dentistry can be represented by low-level laser therapy or soft-laser therapy. There is a large body of literature on this particular topic even though methodologically and in terms of doses, there is still a considerable difference of opinions.

Even though helium-neon lasers were initially used (632.8 nm = λ), the ones in use today are the semiconductor diode type (830 nm or 635 nm = λ). The water absorption coefficient of the wavelengths used for this purpose is reduced and the beams are able to penetrate both soft and hard tissues from a distance of 3 to 15 mm.

LLLT has a number of applications in dentistry, both at the soft-tissue level (biostimulation of lesions, aphthous stomatitis, herpetic lesions, mucositis, pulpotomy) and neurally (analgesia, neural regeneration, temporo-mandibular pain, post-surgical pain, orthodontic pain).

Between one and three days after biostimulation it is already possible to observe a considerable reduction of swelling and an acceleration of the epithelization and collagen deposition phase.

The clinical importance of this acceleration of the reparative processes is considerable, especially when the general defense system of the patient is compromised (young patients but also older patients with insulin dependent diabetes, valvar dysfunction or malformations, history of endocarditis, patients with prosthetic cardiac valves and cardiac surgical reconstruction).

In short, LLLT stimulates tissue repair processes and, influencing a large number of cell systems, can have a series of benefits on inflammatory mechanism. (antalgic, biostimulating and anti-inflammatory effects) (Nascimento et al. 2004, Weber et al. 2006) (Figs. 13–15). These effects are specific to some wavelengths and they cannot be obtained with non-polarized and non-coherent light sources.

**Fig. 11** Once 1.1 and 2.1 had been repositioned, they were restored with an Er:YAG laser.

**Fig. 12** Final clinical appearance.

**Table 1** Classification of traumatic injuries.

<table>
<thead>
<tr>
<th>Traumatic Injuries to hard dental tissue and pulp</th>
</tr>
</thead>
<tbody>
<tr>
<td>crown infraction</td>
</tr>
<tr>
<td>complicated crown fracture</td>
</tr>
<tr>
<td>complicated crown-root fracture</td>
</tr>
<tr>
<td>root fracture: middle third</td>
</tr>
</tbody>
</table>

**Table 2** Laser classification of hard and soft tissues.

<table>
<thead>
<tr>
<th>Hard and soft tissues</th>
<th>Er/YAG 2,940</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Er,Cr:YSGG 2,780</td>
</tr>
<tr>
<td>Soft tissues</td>
<td>KTF 632</td>
</tr>
<tr>
<td></td>
<td>Argon</td>
</tr>
<tr>
<td></td>
<td>Diode 810, 940, 980</td>
</tr>
<tr>
<td></td>
<td>Na:YAG 1,064</td>
</tr>
<tr>
<td></td>
<td>CD, 10,600</td>
</tr>
<tr>
<td>Low Level Laser</td>
<td>Ellum neon 635</td>
</tr>
<tr>
<td></td>
<td>Diode 810</td>
</tr>
</tbody>
</table>

**3. Injuries to the supporting bone**

| not described as they are related to maxillo-facial surgery |

**4. Injuries to gingiva or oral mucosa**

| laceration of gingival or oral mucosa |
| contusion of gingival or oral mucosa |
| abrasion of gingival or oral mucosa |
such as LEDs.

The author hopes that the pursuit of these new horizons might lead to the definition of protocols containing more specific indications in regards to times, doses and sites of application.

LLLT has the main indication in dental traumatology (Caprioglio C. and Caprioglio A. 2010, Tuner and Hode 2004): Brief analgesic effect in the mucosa allowing painless injection with a needle or treatment without anesthesia.

Direct application into the exposed cavity of a deciduous tooth can be used for pain reduction. Also, the trans-mucosal irradiation in the apical portion and a reticular irradiation to the cervical area of the tooth has an analgesic effect in post-traumatic treatment after lip and front-tooth trauma to reduce swelling and pain, and for post-endodontic therapy, after pulp capping and after apicogenesis or apicification. There is also an analgesic effect for orthodontic movements, TMJ disorders and pain, traumatic mucosal lesions (ulcers) and aphthous or herpetic lesions.

Knowing that the analgesic effect of light at 800–900 nm is 30 joules x cm² and the biostimulating effect is 50 joules x cm², it becomes possible to develop operating protocols that can be compared, standardized and repeated (Benedicenti 2005).

**Conclusions**

Lasers are very effective not only in pediatric dentistry but also in traumatic dental injuries. They enable 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. Therefore, a period of education and training is highly recommended before applying this technology, especially to pediatric patients.

A complete list of references is available from the publisher.

---

Claudia Caprioglio, DDS
Post-graduate in orthodontics
Visiting professor University of Parma (Italy)
Director Centro Internazionale di Aggiornamento Odontoiatrico (C.I.A.G. s.r.l.)
Via San Zeno 1, 27100 Pavia, Italy
E-mail: ac.caprioglio@tin.it

**Fig. 13** Patient aged 16.2 years. Avulsion of 2.1. Deep abrasion of upper lip oral mucosa, nose and chin. (Photo/Courtesy of Dr. V. Lazzarini).

**Fig. 14** The soft-tissue injuries are treated every day for seven days with a Nd:YAG laser.

**Fig. 15** Final clinical outcome of the face and smile. A removable orthodontic space maintainer is placed to temporarily restore the frontal tooth loss.