

*Original Research Article*

# Er:YAG laser applications in dental traumas of permanent teeth in childhood

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Abstract

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**Children suffer often from dental traumas. The clinical cases in traumatology can be an object of the different fields of dental medicine. In the last years laser technologies have been proposed and approved for using in dental practice. One of the most suitable laser for using in pediatric dentistry is the Er:YAG laser. The aim of this study is to describe the Er:YAG laser treatment possibilities in the field of traumatology and its advantages compared to the conventional techniques. The authors can suggest several appropriate clinical protocols when use this new technology in dental traumatology in children.**

**Keywords:** Children, Dental trauma, Er:YAG laser, Fractures, Pediatric dentistry, Permanent teeth

## INTRODUCTION

Dental traumas together with tooth decay are the most frequent pathologies encountered in pediatric dentistry. Around 20 % of children suffer a traumatic injury to their primary teeth and over 15 % to their permanent teeth (Andreasen et al. 2007).

Dental traumas are sustained mainly during play (56 %), sports activities (21 %), road accidents (11 %) or as a result of acts of violence (12 %). Traumatic dental injuries occur with great frequency in preschool, school age children and young adults comprising 5% of all injuries for which people seek treatment (Andreasen et al. 2007; Petersson et al. 1997). A twelve year review of the literature reports that 25% of all school children experience dental trauma and 33% of adults have experienced trauma to the permanent dentition with the majority of injuries occurring before age 19 (Glendor et al. 2008).

The teeth most frequently affected, both in primary and in permanent dentition, are the upper central incisors (50 %) and the upper lateral incisors (30 %) (Andreasen et al. 2007; Flores 2002; Kramer et al. 2003).

Traumatic injuries involve all the branches of dentistry (endodontics, restorative, periodontics, oral surgery, orthodontics) so that traumatology can be considered a multidisciplinary discipline (Caprioglio et al., 2010).

Luxation injuries are the most common dental injuries in the primary dentition, whereas crown fractures are more commonly reported for the permanent dentition (Andreasen et al., 2007; Flores 2002; Kramer et al., 2003). Sometimes traumatic injuries of teeth in young patients can result in pulp necrosis. Immature permanent teeth with open foramina present a challenge in root canal treatment. The absence of an apical constriction and the divergent apical architecture of the root canal hamper complete debridement, canal disinfection and filling (Andreasen et al., 2007).

An individual operative protocol, including a correct diagnosis, an effective control of pain, a rapid and correct intervention, is necessary to be applied in each clinical case of dental injury in order to reducing the risk of complications to the permanent teeth and providing a proper development of the dental arches. Management of a dental trauma in children can be complicated by their emotional status and inability to cooperate. The psychological approach towards the child is therefore of fundamental importance, and the use of new technologies that can simplify and improve both therapy and prognosis (Caprioglio et al., 2010).

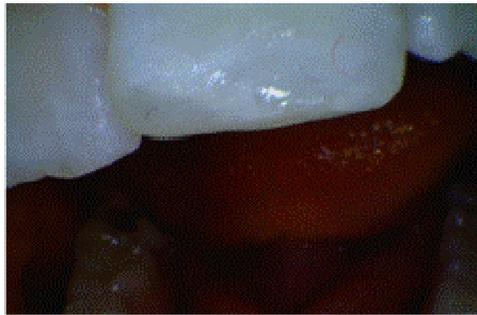
In this context, laser technologies are ideal for trauma-related problems and represent a real challenge for pediatric dentists.

**Table 1.** Er:YAG laser parameters for hard dental structures' treatment

Treatment	Surface treatment	Enamel edges beveling
<b>Parameters</b>		
Energy	300 mJ	100 mJ
Frequency	20 Hz	20 Hz
Theoretical fluence	22,61 J/cm <sup>2</sup>	12.74 J/cm <sup>2</sup>
Sapphire tip diameter	1.3 mm	1.0 mm



A. Before restoration

B. 300 mJ/20 Hz (22,61 J/cm<sup>2</sup>) + orthophosphoric acid

C. After restoration



D. 1 year later

**Figure 1.** Noncomplicated crown fracture of first maxillary permanent incisor

Lasers containing erbium are the most suitable lasers used in pediatric dentistry (Martens 2011). There are numerous benefits of using these types of lasers in pediatric dental traumatology.

The Er:YAG laser application on hard dental structures provides the opportunity of observing the rules for treatment with minimal intervention (Kornblit et al., 2008). On the other hand, non contact method used induces less vibration on hard dental surfaces reducing stress on injured tooth (Takamori et al., 2003). The possibility of avoiding the use of local anesthetics during Er:YAG laser treatment brings value of this new technology and makes it completely suitable for treatment in pediatric traumatology (Caprioglio et al., 2010; Olivi et al., 2009).

Er:YAG laser is indicated in crown fractures as well as in complications that require endodontic treatment (Caprioglio et al., 2010; Stefanovic et al., 2004).

The aim of this clinical study was to present some different clinical cases of dental injuries in pediatric patients with permanent teeth and to describe the Er:YAG laser treatment possibilities in this field and its advantages compared to the conventional techniques.

### Case Report 1

A 10 year-old female presented a uncomplicated crown fracture of the upper permanent central incisor 21 that

**Table 2.** Er:YAG laser parameters for hard dental structures treatment

Parameters	Treatment	Surface treatment	Enamel edges beveling
Energy		200 mJ	100 mJ
Frequency		20 Hz	20 Hz
Theoretical fluence		15,08 J/cm <sup>2</sup>	12.74 J/cm <sup>2</sup>
Sapphire tip diameter		1.3 mm	1.0 mm

involved the enamel and the outer half of dentin without exposure of the pulp (figure 1). Clinical examination did not reveal any accompanying damage to the soft tissue. Radiographic examination excluded any root fracture and after the positive vitality test an immediate restoration was performed.

Informed written consent was obtained from the patient's parents, as required by the institution's Ethics Board. For preparation of fractured hard dental structures an Er:YAG laser (Light Touch, Syneron, Israel) (wavelength 2940 nm and pulse duration 50  $\mu$ s) was used with the following parameters (Table 1).

Non contact mode with working distance 0.5 to 1.0 mm and air-water-spray cooling of 39 ml/min were applied. No local anesthetic was used either before or during the treatment.

The surfaces were further treated with 37% orthophosphoric acid. A bonding system 3M ESPE Scotch bond Multipurpose and a hybrid composite Calore GC for restoration were applied. (Figure 1)

The treated tooth was followed up for a period of 1 year each month until 6-th month and once until 12-th month and during this period positive tests vitality were found and no adverse events were observed.

### Case Report 2

A 6-year-old male presented a traumatic crown fracture of the lower permanent central incisor 41 (Figure 2). The fracture involved the enamel and the inner half of dentin. The patient came to our dental office a day after dental trauma with the avulsed tooth fragment kept in milk. No exposure of the pulp was found.

All the procedures were conducted in accordance with the guidelines established by the Bulgarian Ministry of Health's Code of Bioethics for Dentists and the Helsinki Declaration. Informed written consent was obtained from the patient's parents. An Er:YAG laser for preparing of both bonding surfaces was used. Table 2 shows the applied parameters:

Non contact mode with working distance 0.5 to 1.0 mm and air-water-spray cooling of 39 ml/min were used.

After Er:YAG laser preparing we applied Ca(OH)<sub>2</sub> on the deepest part of the dentin and then we treated the

surfaces with 37 % orthophosphoric acid and applied bonding 3M ESPE Scotch bond Multipurpose and subsequently flow composite resin Gradia LoFlo (GC).

No local anaesthetic was used. (Figure 2)

Check up of the tooth performed monthly until the 6-th month and once until 12-th month showed positive vitality tests and no complaints.

### Case Report 3

A 9 years old male presented a post traumatic periapical lesion on tooth 21 (first upper permanent immature incisor) (figure 3). The case history revealed a dental trauma- crown fracture of the enamel and the dentin without exposure of the pulp, restored via a composite resin 6 months ago, followed by a pulp necrosis, chronic periapical inflammation and an periapical abscess. Several times different dental practitioners realized unsuccessfully an endodontic treatment plus access cavity closure, followed by an abscess.

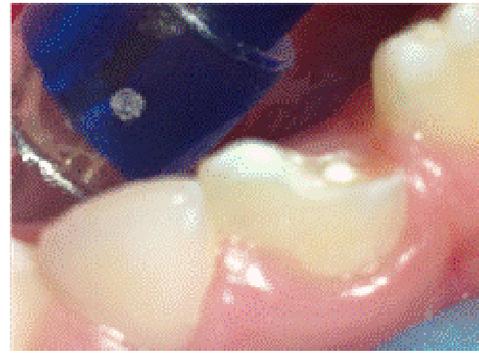
The treatment plan was explained to the parents and it was conducted with their written consent. During the first consultation radiolucency was observed in the periapical region and the treatment was engaged following different steps:

- access cavity re-designed;
- root canal preparation (NaOCl-5,25%);
- decontamination via Er:YAG laser 50 mJ, 10 Hz, sapphire tip diameter 0.6 mm inserted until 6 mm inside the root canal two times 5 sec. each plus NaOCl as irrigating solution. The theoretical fluence was 17,69 J/cm<sup>2</sup>.
- temporary root canal filling was conducted with Ca(OH)<sub>2</sub> paste;
- same protocol canal filling with Ca(OH)<sub>2</sub> paste was applied after 1 week, 1 month and each month until the 8-th month. (Figure 3)

Symptoms disappeared after first application of Er:YAG laser, in synergy with NaOCl as irrigating solution plus filling of Ca(OH)<sub>2</sub> paste. Once radiolucency disappeared in the periapical region and apexification was observed, then the root canal was filled using conventional method.



A. Before restoration



B. Application of Ca(OH)<sub>2</sub>



C. After restoration



D. 1 year later

**Figure 2.** Noncomplicated crown fracture of first mandibular permanent incisor



A. Before treatment



B. Final result 8 months later

**Figure 3.** X-ray examination

## DISCUSSION

Since the introduction of the Er:YAG laser in dental practice in 1989, pediatric dentistry disposes of a safe and enough effective technology for treatment of different dental diseases (Martens 2011). Er:YAG laser system is indicated for both hard and soft dental tissue treatment, thus it can be used successfully in dental traumatology.

With regard to hard dental structure treatment after crown fractures different advantages of Er-YAG laser application can be pointed out. Er:YAG laser beam action is minimally invasive to enamel and dentin due to the selective ablation of tissues according to their water content (Kornblit et al 2008). Authors demonstrate clean and microretentive surfaces produced by Er:YAG laser irradiation. Enamel surfaces showed Silverstone class 3

patterns with fractured enamel prisms, prisms edges not supported by any enamel structure that look “ready to be broken” (Borsatto et al., 2009; Kornblit et al., 2009). Analyses of Er:YAG laser irradiated dentinal surfaces revealed opened dentinal tubules, protruded peritubular dentin and loosely bound particles (Kornblit et al., 2009; Ortolan et al., 2009).

In the recent study the lower mineralization rate and higher water content of hard dental structures was the reason of application of low Er:YAG laser energy- 200 mJ (fluence-  $15.08 \text{ J/cm}^2$ ) while treating the surfaces of the fractured immature permanent incisor of 6 year old child (case 2). Moreover, proximity to dental pulp in this case requires using of lower energy in order to avoiding thermal damages on the pulp tissue as well as pain during the manipulation.

It is well known that the choice of Er:YAG laser parameters such as energy density, pulse repetition rate and air-water spray is very important factor for achieving of an optimal ablation without causing thermal damages on surrounding tissues (Borsatto et al., 2009; Delme et al., 2007). Various studies demonstrated that the temperature rise in pulp chamber during Er:YAG laser preparation is lower compared to the conventional treatment (Krmek et al., 2009). Lower temperature rise in pulp tissue, already stressed by the trauma, is also an important factor for a successful dental trauma treatment.

A final laser conditioning with low energy fluences both on dentin and enamel is advisable during Er:YAG laser treatment (Bader et al., 2006). The results of our previous study (Zhegova G. 2014) (unpublished data) that are in agreement with other studies, revealed that Er:YAG laser conditioning ( $12.74 \text{ J/cm}^2$ ) performed after cavity preparation led to smoothing the preparation cavity margins. The subsequent treatment with ortho-phosphoric acid both on enamel and dentin demineralises a thin layer of hard tissue, exposing the collagen fibres and creating a substrate for the formation of the hybrid layer; acid etching of the enamel changes the Silverstone class 3 patterns to class 1 allowing a better composite adaptation and adhesion increase (Bertrand et al., 2004).

Erbium lasers can guarantee good results reducing dentinal sensitivity as well as post-operative discomfort. According to Genovese laser therapy may improve the psychological approach and the compliance of the patient, positively influencing both the objective and the subjective factors of pain, by raising the threshold of pain (inducing laser analgesia) and reducing discomfort (Genovese et al., 2008).

In the case of pulp necrosis, followed by chronic periapical inflammation (case 3) using Er-YAG laser in synergy with NaOCl plus  $\text{Ca(OH)}_2$  we successfully achieved an apexification.

Apexification is a procedure creating a barrier with hard tissue at the end of the root. It is defined by the American Association of Endodontics (AAE) as “a

method inducing a calcified apical barrier or the continued apical development of an incompletely formed root in which the pulp is necrotic”. Calcium hydroxide ( $\text{Ca(OH)}_2$ ) is currently the most widely accepted material recommended to induce root-end barrier formation (American Association of Endodontists 2003).

It is very important that during treatment the root canal system can be efficiently and predictably cleaned, shaped and filled. There is agreement that cleaning and shaping go hand-in-hand, referring to the combination of chemical cleansing using irrigants, and mechanical debridement or root canal enlargement by means of hand or rotary instruments; hence the term chemomechanical preparation is used. Although instrumentation alone may reduce bacterial load by mechanical removal of microorganisms, it does not provide a bacteria-free root canal (Robotta 2011). As the persistence of microorganisms is one of the main causes of endodontic failure, additional disinfection measures are necessary in order to eliminate and neutralise these microorganisms and their endotoxins. Irrigation with an antibacterial agent during and after preparation provides additional disinfection. In addition to this, irrigants also remove organic tissue, dentine debris and the smear layer (thereby products of instrumentation from the root canal system as well as lubricate the canal walls and instruments (American Association of Endodontists 2003).

In this respect, sodium hypochlorite (NaOCl) at 0.5 to 5.25% is still considered to be the gold standard (Kimura et al., 2000). It is the most effective endodontic irrigant because it is a strong oxidising agent and, therefore, a good solvent of organic tissue. It has good antimicrobial properties, inactivates endotoxins, acts as a lubricant and is non-toxic at lower concentrations (Baumgartner et al., 1992).

The conventional chemo-mechanical treatment for canal preparation, enlargement and removal of necrotic soft tissue is not always complete, and neither is bacteria removal (Stefanovic et al., 2004). Endodontic instrumentation produces organic and mineral debris on the wall of the root canal (Kimura et al., 2000). Although this smear layer may be beneficial, in that it provides an obstruction of tubules and decreases dentine permeability, it also may harbor bacteria and bacterial products (Fogel et al., 1990). Very often the apical third of the root canal remains insufficiently prepared, meaning that a smear layer made of dentin debris, pulp residue and bacteria may be found in it.

Many studies have been performed in an attempt to find ways of removing the smear layer, some of them using laser systems (De Moor et al., 2009). In addition, the bactericidal effects of Er:YAG laser make this technology suitable for endodontic use (Stefanovic et al., 2004).

## CONCLUSION

Er:YAG laser is very effective in paediatric dental traumatology and may be used as alternative to conventional techniques in dental fracture of permanent teeth with numerous advantages.

Er:YAG laser, in synergy with NaOCl plus Ca(OH)<sub>2</sub> may help to heal such complex clinical endodontic problem in immature permanent teeth.

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