Paediatric laser dentistry. Part 2: Hard tissue laser applications

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ABSTRACT

Erbium lasers can provide effective and minimally invasive caries removal in children. The bonding phase remains a critic step as well as the choice of material. Glass ionomers exhibits lower bonding properties in laser irradiated teeth compared to the conventional method or to composite and resin modified glass ionomer. Laser can also provide effective decontamination and coagulation effects in vital and non vital pulp therapy of primary teeth, improving and simplifying the cleaning and disinfecting steps.

Keywords *Laser caries removal; Laser pulpotomy; Paediatric dental care.*

Introduction

Lasers can be used as a suitable alternative or complementary tool to many conventional diagnostic and therapeutic procedures in preventive and restorative dentistry, as well as in endodontics. As reported by Martens [2003] children are the first in line to receive dental laser treatment according to micro-dentistry's motto "filling without drilling".

Some of the clinical advantages of lasers (Table 1) are very important for minimally invasive dentistry in paediatric dental care. Among other advantages, the absence of contact and vibration and the different noise produced during cavity preparation are few of the reasons for the higher acceptance of laser therapy when compared to conventional techniques for caries removal [Takamori et al., 2003]. Despite the patient's subjective experience during laser cavity preparation, reported by some adolescents as unpleasant due to smell and longer chair time, laser was preferred by the majority (62.9%) of adolescents [Mosskull Hjertton and Bågesund, 2013]. In addition, the application of "laser analgesia" before caries removal can be more comfortable for children [Olivi et al., 2011].

Laser in preventive dentistry

Laser for caries prevention

Many studies have investigated the use of different laser wavelengths alone or in combination with fluoride gel or varnish, to modify the superficial enamel ultra-structure in order to increase the acid resistance of the tooth [Delbem et al., 2003; Zezell et al., 2009; Vitale et al., 2011; Ana et al., 2012; Rechmann et al., 2011-2013]. Results were positive but several long term clinical studies are necessary to validate this application before extensive diffusion of the procedure in preventive dentistry.

Laser for fissure sealant and preventive resin restoration

Despite the significant body of evidence of high fissure sealant retention without the use of any unnecessary and undesirable removal of sound enamel when the teeth are diagnosed as sound [Welbury et al., 2004; van Loveren and van Palenstein Helderman, 2015], the use of different laser wavelengths can be considered in addition to conventional protocols for pit and fissure treatments, for several reasons.

The combination of laser diagnosis (laser fluorescence, LF, at 655nm) and erbium laser irradiation (2780nm and 2940nm) of pits and fissures is promising for a truly minimally invasive treatment. When LF detects a healthy enamel (scores 0-10/0-13), erbium lasers can be used (low energy: 40>70mJ) for selective enamel cleaning [Hossain et al., 2012], disinfection and conditioning (macro-roughening) [Olivi et al., 2011]. When LF scores

Minimally invasive	Selective for carious tissue
Decontaminating effect	In carious lesion and root canal
Microretentive surface	Rough, cleansed and debrided surface; no smear layer
Soft tissue application	Easy gingivectomy close to decayed proximal surface, pulp vaporisation and coagulation

TABLE 1 Clinical advantages of laser in conservative dentistry and endodontics.

indicate an initial carious lesion (11-20/13-24), erbium lasers are effective (at higher energy: 180>200mJ) for a minimally invasive preparation (ablation) of demineralised fissures [Olivi and Olivi, 2015]. Many studies concluded that laser irradiation does not eliminate the need for acid etching of the enamel prior to placement of a sealant or composite filling [Borsatto et al., 2004, 2007; Youssef et al., 2006; Lupi-Pégurier et al., 2007; Sungurtekin et al., 2009; Baygin et al., 2012; Shahabi et al., 2012; Memarpour et al., 2014; Unal et al., 2014]. More recent studies reported, however, that laser pre-treatment is comparable to the conventional acid etching technique [Karaman et al., 2013; Topaloglu-Ak et al., 2013; Sungurtekin-Ekci et al., 2015; Ciucchi et al., 2015]. Furthermore, comparative tensile bond strength and SEM analysis of enamel etched with Er:YAG laser and phosphoric acid indicated that this protocol can be used to increase bond strength to laser-prepared enamel [Sasaki et al., 2008] and to decrease microleakage at the enamel-sealant interface [Khogli et al., 2013].

Laser in conservative dentistry

Erbium lasers for molar-incisor hypomineralisation (MIH) treatment

There is no specific literature on laser application on this topic, except for a few case reports. The minimally invasive approach consists in reinforcing and protecting the existing dental structure and in a restorative treatment in the most severe cases [Mast et al., 2013]. Accordingly, the possibility to increase the uptake of fluoride and the enamel resistance with laser exists and should be explored [Delbem et al., 2003; Zezell et al., 2009; Vitale et al., 2011; Ana et al., 2012; Rechmann et al., 2011-2013]. Furthermore, treatment of severe MIH lesions can take advantage of erbium laser preparation due to the minimal and favourable modifications of dental tissues and to the minor discomfort produced, making this procedure elective for children [Olivi and Olivi, 2015].

Erbium lasers for carious removal and cavity preparation

Laser settings for tooth preparation have been studied for more than 25 years, evaluating the morphological effects produced on the hard dental tissues [Keller and Hibst, 1989; Armengol et al., 1999; Tokonabe et al., 1999; Shigetani et al., 2002; Olivi and Genovese, 2007; Olivi et al., 2010;], as well as on the pulp [Dostalova et al., 1997; Rizoiu et al., 1998; Glockner et al., 1998; Armengol et al., 2000; Cavalcanti et al., 2003; Mollica et al., 2008]. In recent years, new studies have revived the 9,300nm wavelength of CO_2 laser for ablation of both hard and soft tissues [Fan et al., 2006; Nguyen et al., 2011], but further studies are needed to validate this new technology before introduction in paediatric dental care.

Interaction between erbium lasers and primary enamel and dentin depends on the water and minerals composition of these tissues; accordingly, the lower presence of hydroxyhapatite and higher water content of primary teeth requires less energy for laser ablation of primary enamel and dentin [Olivi et al., 2011; Zhegova et al., 2014; Al-Batayneh et al., 2014]. Ablation effectiveness of the Er:YAG laser for caries removal in children and its safety for the pulp in primary and permanent teeth were assessed by Al-Batayneh et al. [2014]. Due to the laser ability to deeply decontaminate the infected dentin, it was supposed that deeper and softer layer of dentin can be left to remineralise dental tissue, allowing for maximum conservation of dental structure [Kornblit et al., 2008]. Comparing different dentin excavation methods in deciduous teeth, lower level of over-preparation was found in the erbium laser group compared to steel bur group, confirming the minimally invasive approach of laser. In comparison the Er:YAG laser was found less effective but with the same efficacy of bur preparation during caries removal at the pulpal wall of primary molars [Celiberti et al., 2006]. Level of decontamination in affected dentin in the pulpal wall was also found similar for all methods [Valério et al., 2016].

Erbium lasers and composite adhesion

Several studies investigated – with conflicting results – the adhesion of composites and glass-ionomers to laser-irradiated dentin and enamel of primary teeth [Monghini et al., 2004; Wanderley et al., 2005; Lessa et al., 2007; Yildiz et al., 2013; Oznurhan and Olmez, 2013; Bahrololoomi et al., 2014]. In short, the use of orthophosphoric acid remains a crucial and mandatory step for bonding.

FIG. 1 Low speed drill on a first lower primary molar. Contact, vibration and production of the smear layer can be avoided by using erbium laser (a). Er:YAG laser (2940nm) with a 600 μ tip is used in non-contact mode to remove carious tissues in proximal decays of both primary molars. See the absence of smear layer (b).

FIG. 2 Restorative treatment (tooth N. 64) and endodontic therapy (tooth N. 65) completely performed by means of Er,Cr:YSGG laser (2780nm) (a). Restorative liner in deep cavity (tooth N. 64) (b)and resorbable sealer in the root canal of a primary tooth (tooth N. 65) prior of composite restorations (c).

Self-etch bonding agents can be improved by the use of a chemical pre-treatment with sodium hypochlorite. Glass ionomer restorations prepared with erbium lasers showed higher microleakage than those prepared with diamond burs [Arapostathis, 2014].

Laser in endodontics

The use of different laser wavelengths in endodontics is widely reported in adults, but few studies refer to primary teeth. Lasers can be used for vital and non-vital pulp therapies: pulp capping, pulpotomy and pulpectomy.

Laser pulpotomy

Pulpotomy is a very common technique in primary teeth and laser was proposed as an alternative to formocresol and ferric sulfate. Several studies reported conflicting results [Elliot et al., 1999; Pescheck et al., 2002; Saltzman et al., 2005; Odabas et al., 2007], but more recent clinical studies progressively showed more favourable results. A randomised clinical trial on 30 primary molar teeth pulpotomies showed better clinical and radiographical outcomes for laser pulpotomy than other techniques investigated [Gupta et al., 2015]. Also, *in vitro* investigations of antimicrobial efficacy of diode laser, compared to triphala and sodium hypochlorite against Enterococcus faecalis contaminated primary root canals, showed significant reduction in colony count in the laser group compared to other groups [Durmus and Tanboga, 2014; Seby et al., 2017]. Laser pulpotomy was also found superior in terms of operating time, patient cooperation, ease of use and pain. The role of different capping materials still remains fundamental [Niranjani et al., 2015; Uloopi et al., 2016].

Laser pulpectomy

Few studies on laser use for pulpectomy in primary teeth are indexed on PubMed. Soares et al., [2008] compared root canal wall cleaning and shaping of different techniques in primary teeth, using Er,Cr:YSGG laser, and manual or rotary instruments. The laser technique required less time for completion of cleaning and shaping when compared with both rotary or hand instruments, yieding similar cleaning results when compared with rotary instruments preparation, and was superior to manual instrumentation.

Conclusion

Erbium laser is an effective tool for carious removal in primary teeth, for its higher acceptance by the patients and high decontamination of the cavity. Lower energy output and longer times are needed when using laser in children. Acid etching is required to achieve bonding results similar to the conventional drill method when using composite resins. Glass ionomers present lower bonding results in laser-irradiated teeth compared with conventional method or to composite and resin modified glass ionomer. Care must be taken during root canal procedures, delivering low energy in the pulp chamber and at the coronal third of the canals due to the anatomy of the apex in primary teeth and to the penetration depth of different infrared lasers.

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