Lasers in Pediatric Dentistry – A Review

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Abstract: This review presents the current knowledge of laser therapy in pediatric dentistry, including examples of clinical cases. Agreeing with Martens that "children are the first in line to receive dental laser treatment" and based on the microdentistry motto "filling without drilling", we are of the opinion that laser-supported dental diagnosis and treatment is basic to treating children successfully according to the latest standards in dentistry.[1]

Keywords: primary teeth, pediatric dentistry, laser, review, diagnostic, caries diagnosis, caries therapy, dental cavity preparation, oral surgery, frenectomy.

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The most common chronic disease of childhood is early childhood caries (dental caries in children younger than six years). It is five times more prevalent than asthma. Most children do not receive dental care until they are three years old, but by that time, more than 30 percent of children from lower socio-economic groups already have caries. Caries typically presents in children as white spots or lines on the maxillary incisors, which are among the first teeth to erupt and the least protected by saliva.[2]

The infant oral health care visit, described by the clinical guidelines on infant oral health care,[3] should be seen as the foundation on which a lifetime of preventive education and dental care can be built to help assure optimal oral health into childhood. Oral examination, anticipatory guidance including preventive education, and appropriate therapeutic intervention for the child can enhance the opportunity for a lifetime of freedom from preventable oral disease.[3] This infant oral health care starts ideally with prenatal health counseling for parents, and initial oral evaluation within 6 months of the eruption of the first primary tooth but no later than 12 months of age.[2-4]

Since 1965, when Sognaes and Stern[5] first suggested the use of lasers for caries prevention, the effects of different wavelengths in general dental treatment have been widely evaluated.[1] The introduction of

Fig 1 Molar caries.

Fig 2 Diagnodent device.

Fig 3 Caries diagnosis using Diagnodent.

lasers in pediatric dentistry has led to an enormous broadening of the different treatment possibilities for children. Preventive dental treatment for children begins at the earliest possible stage, includes traditional caries management, and incorporates developmental milestones and functional considerations to avoid any oral risk factors in children.[4] The use of the laser in pediatric dentistry allows the dentist to perform minimally invasive dentistry, removing only the diseased dental tissue and preserving the remaining healthy tooth structure. Dental diseases can be diagnosed early on by using dental radiography or laser-assisted diagnosis of dental decay.[6] In the last few years, new techniques for the prevention of caries lesions have been developed and many investigations related to the applications of lasers in the field of pediatric dentistry have been conducted.

DIAGNOSIS

Using the argon laser with a wavelength of 488 nm, the detection of occlusal caries and interproximal lesions is possible using different techniques, such as QLF (quantitative light-induced fluorescence) or DELF (dye-enhanced laser fluorescence).[7-9]

As today's traditional clinical methods for diagnosing caries are not sensitive enough, detection tools based on fluorescence may supplant them, as described in an overview.[10] There are now commercial detection technologies available for the diagnosis of dental diseases, eg, Diagnodent (Kavo) – a diode laser with a wavelength of 655 nm.[10,11] The device analyzes the emitted fluorescence on the occlusal surface of the tooth, which correlates with the degree of demineralization in the tooth and, when quantified, indicates the relative amount of caries present.[10,12-15] Detection of caries under pit and fissure sealants is thus greatly simplified.[10,16-18] Diagnodent for diagnosis of occlusal caries in deciduous teeth shows promising results in comparison with conventional clinical methods in in vitro studies;[14,19] however, Diagnodent tends to overscore discolored fissures.[20] Other in vitro studies on primary teeth show reduced efficacy in the presence of plaque or changes in the organic content.[21-24] Further, the detection success of Diagnodent can depend on the examiner's experience.[25] Clinical studies show positive results in monitoring occlusal caries in primary molars,[26] although the quantification of mineral loss seemed undesirable,[27] or visual inspection showed better values.[28] The use of Diagnodent seems limited in terms of detecting early signs of enamel caries[29] and occlusal lesions.[30] Demineralization around brackets can also be measured by Diagnodent, as shown in an in vitro study.[31]

A pilot study described a photon undulatory nonlinear conversion diagnostic method for caries detection using a diode laser 633-nm system, which shows a high accuracy in detecting caries in clinical practice (98%) in comparison with classical methods.[33]

CARIES PREVENTION

Several in vitro and initial in vivo studies have shown that argon laser irradiation provides a certain degree of protection against enamel caries initiation and progression. Studies with different argon laser delivery systems showed similar results, ie, that this type of laser is effective in reducing caries susceptibility of sound enamel and white spot lesions.[32,34] More recent in vitro studies showed reductions in lesion depth in primary tooth surfaces using argon laser irradiation combined with topical acidulated phosphate fluoride treatment (APF). This combination provides a protective surface coating against caries and results in significant decreases in lesion depth.[35,36] No statistical difference was seen in lesion depth between fluoride treatment before or after laser irradiation.[36] An in vitro study to assess the caries preventive potential of 809-nm diode laser treatment of the enamel of primary teeth compared with topical fluoride application showed that diode laser irradiation was less effective than topical fluoride treatment (APF) in improving the acid resistance of sound enamel of primary teeth.[37]

The CO_2 laser has also been used for caries prevention. Investigations show the beneficial effect of CO_2 laser irradiation on the acid resistance of enamel.[38-40] Kato[41] evaluated the effect of carbon dioxide laser irradiation in the prevention of pit and fissure caries in immature molars with covering opercula. The operculum cut takes less than 2 minutes and there is no bleeding, and the laser irradiation imparted acid resistance to the teeth without any discomfort to the children. The patients did not complain about any pain after the procedure, and Kato concludes that a CO_2 laser might be an effective mode of treatment in the prevention of pit and fissure caries. Using a 9.6-µm TEA CO_2 laser on erupted caries- and restoration-free third molars to render the enamel more caries resistant, the laser was found to cause no damage to the pulp.[42]

HARD TISSUE TREATMENTS

Caries Therapy

Some clinical investigations showed an improved treatment of early childhood caries (ECC) by selective removal of surface enamel caries with the Nd:YAG laser, which is absorbed by carious but not by healthy enamel.[43,44] This type of laser treatment provides well-known clinical advantages for children, such as pain reduction, sterilization of the lased surface, and fluoride penetration into the teeth.[44] A randomized clinical trial showed safe and effective Nd:YAG-laser caries removal without removing the sound enamel below the lesion. Clinical and histological evaluations of pulp vitality showed no abnormalities arising from Nd:YAG ablation.[43] A significantly higher number of preparations in groups treated with rotating instruments vs laser-treated groups entered the dentin.[43] Micromorphological aspects of the laser-tooth interaction using a Nd:YAG picosecond pulsed laser on primary teeth showed that collateral effects in enamel were more pronounced than in dentin. Specific ablation characteristics were observed in both dentin and enamel.[45]

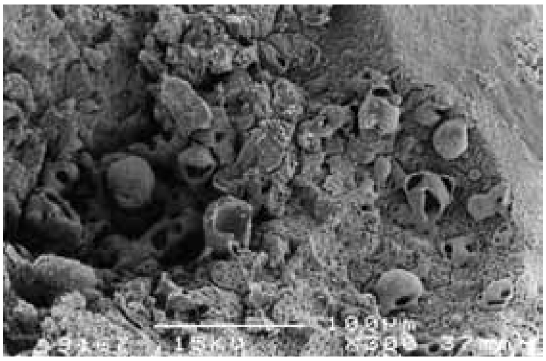

Fig 4 Caries ablation by Nd:YAG irradiation in vitro.

There are two wavelengths, Er:YAG at 2940 nm and Er,Cr:YSGG at 2790 nm, which are similarly active in treating hard- and soft-tissue lesions. Er:YAG and Er,Cr:YSGG lasers are used successfully in all classes of cavity preparation, but the publications about Er:YAG lasers are more numerous. After initial reports of the effects of Er:YAG lasers on dental hard tissues by Keller and Hibst,[46,49] many authors have shown the efficient ablation of dental hard tissues with little or no thermal effects on the pulp.[50,52,54] Other studies showed the minimal vibration and noise of the Er:YAG during cavity preparation, and no or minimal need for local anesthesia; enamel surfaces thus treated have been reported to be similar to those of acid-etched enamel surfaces.[46-48,52]

Several publications show that Er:YAG laser-ablated dentin surfaces have no smear layer and open, clearly visible dentin tubules.[46-48] A morphological study showed that cavity surfaces of primary teeth prepared by Er:YAG laser are irregular, and that the microleakage of such cavities after filling with composite resin is less than when a mechanical bur is used, as shown by the dye penetration method.[53]

Fig 5

Fig 6

Figs 5 to 7 Primary teeth (nursing bottle syndrome). Caries excavation and surface modification by Er:YAG laser and final filling.

Fig 7

Fig 8 Pediatric dental treatment with an Er,Cr:YSGG laser: making friends.

Fig 9 Simple explanation of what to expect during treatment.

Fig 10 Intra-oral situation.

Fig 11 No treatment without safety goggles.

Fig 12 During treatment.

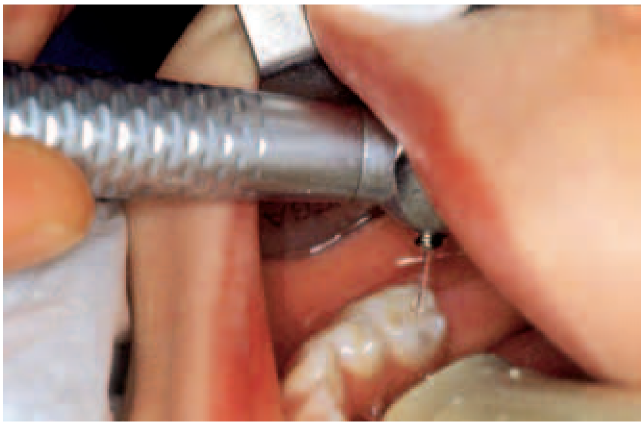

Fig 13 During treatment.

Fig 14 Prepared cavity.

Fig 15 Final filling.

Fig 16 A happy patient after treatment.

Fig 17

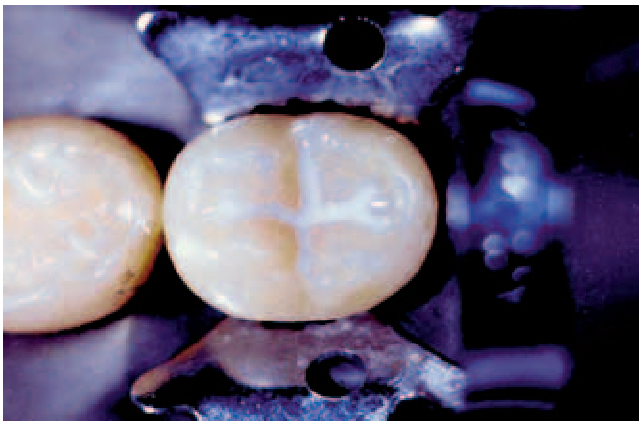

Fig 18

Figs 17 and 18 Laser supported pit and fissure sealing.

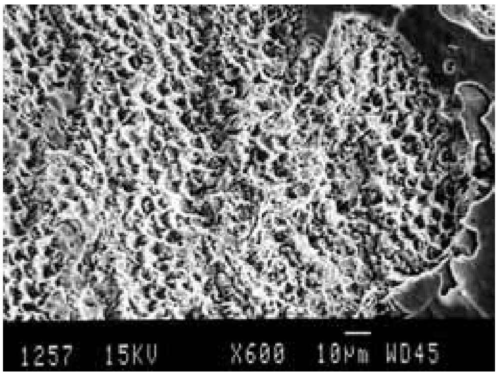

Fig 19 Retentive surface in enamel created by an Er:YAG laser.

Fig 20 Bond strength test after laser conditioning.

These advantages of the Er:YAG laser have prompted a great increase in the use of this wavelength for cavity preparation due to caries in children. In cavity treatment of pediatric patients, it is generally difficult for the dentist to control the child's behavior. Cavity preparation by Er:YAG lasers produces less or almost no noise, less vibration, and no need for local anesthesia. Some Er:YAG laser systems are even as fast as burs in terms of preparation time. Up to now, the reports about clinically successful laser cavity preparation in children are few.[54] Kato describes the ablation with Er:YAG in enamel and dentin in both deciduous and immature permanent teeth in children, and confirms patient cooperation with almost no pain. In the 3-year observation period of this clinical study, no tooth showed undesirable effects due to laser treatment.[55] A clinical case with Er,Cr:YSGG laser preparation of pediatric crowns without anesthesia showed optimal patient comfort and compliance.[56] In our investigations of cavity preparation in children, we see these special advantages in the treatment of children confirmed.

CLINICAL CASES

Pit and Fissure Sealing

A study to assess microleakage at the sealant/enamel interface of primary teeth found the highest degree of microleakage where Er:YAG irradiation was used alone, and concluded that laser treatment does not eliminate the need for acid etching prior to the placement of pit and fissure sealants.[57] This was also stated in other studies.[58] The only exception was described in a study with an experimental tip.[59]

Fig 21

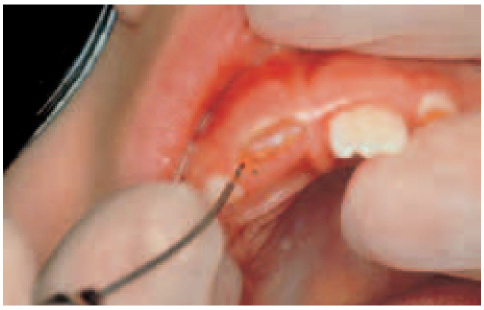

Fig 22

Fig 23

Fig 24

Figs 21 to 24 Exposure of impacted permanent first incisor with a short pulsed high-repetition Nd:YAG laser.

Bonding

Er:YAG laser energy favorably influenced shear bond strength of a total-etch adhesive system to lased enamel of primary teeth, as demonstrated by the morphological appearance of the laser-ablated enamel surfaces. Shear bond strengths to laser-irradiated surfaces were superior to those obtained only with acid etching. SEM analysis of lased surfaces resulted in more uneven and microroughened surfaces.[60]

Lasers in Oral Surgery

All laser wavelengths used in dentistry can also be used in soft and hard tissue treatment. Depending on the indication, different wavelengths and power settings have to be selected. Nd:YAG, argon, CO_2, and diode lasers are useful for cutting, coagulation, and decontamination of soft tissue. Modern Er:YAG lasers, with their modifiable pulse lengths (up to 1000 µs), are also suitable for soft tissue management. Indications described by various authors are as follows: removal of fibroma, operculectomy, gingival hyperplasia, herpes labialis, aphtosis ulcerus, and hemangioma.[6,61-64]

Ankyloglossia

Ankyloglossia is a relatively common finding in the newborn population and is responsible for a significant proportion of breast-feeding problems. Ankyloglossia can be diagnosed in 3.2% of pediatric patients. The abnormal attachment of the lingual frenum is one of the most misdiagnosed and overlooked congenital abnormalities observed in children. There is no consensus, nor are there many current studies or recommendations on what constitutes abnormal lingual attachments which could lead to the diagnosis and treatment of ankyloglossia.[6]

After treatment is completed, children can begin nursing, and nursing mothers report immediate relief of pain, extended nursing intervals, and improved infant sleep duration. Older children and adults are prepared in the usual manner using a local anesthesia. It is important to avoid the glands on the floor of the

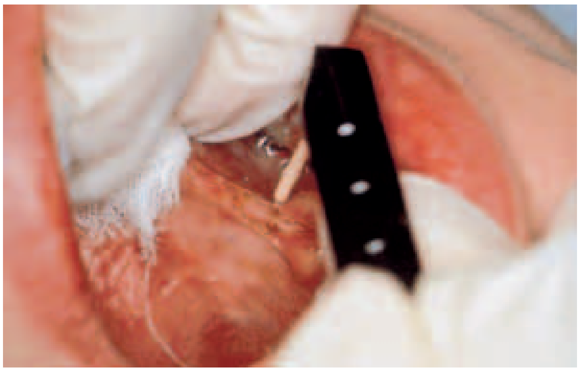

Fig 25

Fig 26

Figs 25 and 26 Bloodless treatment of ankyloglossia with a CO_2 laser.

Fig 27

Fig 28

Figs 27 and 28 Frenectomy with a very long pulsed Er:YAG laser.

Fig 29 Situation 10 days after frenectomy.

mouth. A suture can be placed at the junction of the frenum when using an Er:YAG or Er,Cr:YSGG laser.[6] If using a CO_2, Nd:YAG, or diode laser, no additional sutures are necessary (see clinical case documentation).

Maxillary frenum in infants and in mixed dentition

In some infants, the maxillary frenum may insert into the alveolar ridge and, in severe cases, extend between the central incisors and insert into the palate. A diastema may consequently develop between the central incisors. In the newborn, a tight maxillary frenum may interfere with proper latching-on to the breast and create difficulty with breast-feeding.[6] These problems can

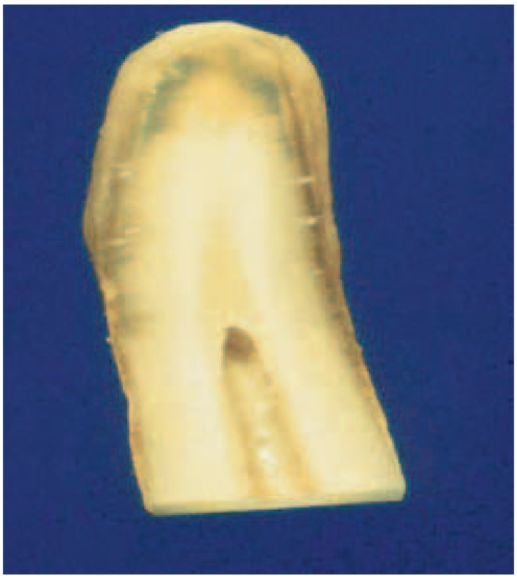

Fig 30

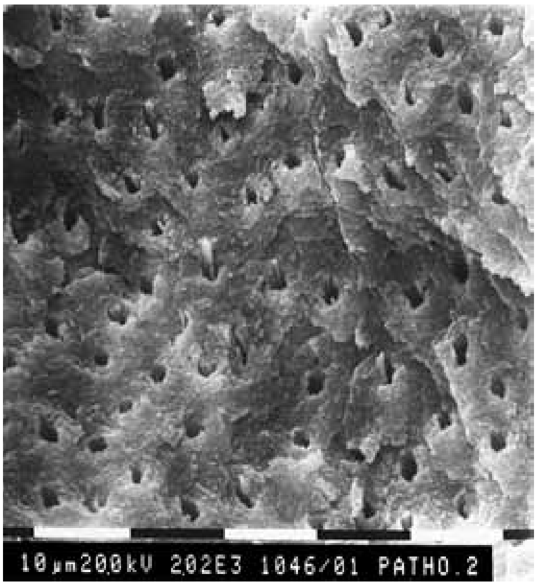

Fig 31

Figs 30 and 31 Removal of organic material and smear layer by Er:YAG and Er,Cr:YSGG lasers.

be diagnosed and corrected with little discomfort to the infant or young child in dental office.[6]

In the mixed dentition, in addition to soft-tissue revision, the procedure may require the lasing of bone between the two central maxillary incisors. In that case, the erbium lasers are an ideal choice of instrument, and a water spray must be used. In the author's experience, the optimal time to correct the frenum – if it is not done in the early primary dentition – is when the two central incisors have erupted about 2 to 3 mm. Frenum areas in other areas of the mouth are treated similarly, and other wavelengths may be used, such as Nd:YAG laser with a setting of 80 Hz, 25 mJ, and 2 W for the ablation of the soft tissue.[6]

Endodontics

Although there are no clinical studies in pediatric endodontics, it is obvious that, similar to the treatment of adults, Nd:YAG or diode lasers can be used for the treatment of infected root canals. The bactericidal effect within the root canal is around 99%, and in the lateral root canal wall dentin, the bactericidal effect is between 63% for the diode laser and 84% for the Nd:YAG laser. Er:YAG and Er,Cr:YSGG laser are effective for removing organic materials and smear layer within the root canal.[65-69]

Pulpotomy in pediatric endodontics is a very common procedure. Especially CO_2 lasers are described to be very effective, but pulsed Nd:YAG lasers can also be employed to perform pulpotomies. In a clinical study, it was shown that after a follow-up of 4 years, 99.4% were clinically successfully treated. In contrast, the formocresol control group had a success rate of only 88.2%.[70-72]

Low-Level Laser Therapy

Treating children with the LLLT laser is not different from treating adults. However, a nontraumatic introduction to dentistry is very important. To a child a laser is not a threat; it's "cool".

According to Tuner and Hode,[73] five main indications in pediatric dentistry are given:

1. The eruption of both deciduous and permanent teeth is sometimes painful. Therefore, irradiating the lymph nodes in the area is recommended for relief.
2. A radiation dose of 2 J has a brief anesthetic effect in the mucosa, allowing painless injection with a needle.
3. Direct application of a dose of 4 to 6 J into an exposed cavity of a deciduous tooth can be used for pain reduction.

4. Post-traumatic treatment after lip and front-tooth trauma to reduce swelling and pain can be achieved by applying a dose of 3 to 4 J.
5. A dose of 0.5 to 2 J as an additional treatment in pulp capping will improve the outcome of treatment.[73]

OUTLOOK

Laser-supported pediatric dentistry is one of the most promising fields in modern minimally invasive dentistry. Especially in the fields of pit and fissure sealing, caries treatment, and cavity preparation, Er:YAG and Er,Cr:YSGG lasers are very useful. In the fields of soft-tissue surgery, CO_2 lasers and very long pulsed Er:YAG lasers play a dominant role. In addition, the diode and Nd:YAG lasers are indicated. Despite the fact that no randomized clinical studies exist concerning pain management during laser-supported cavity preparations, numerous clinical case reports have found that in most cases, the whole procedure can be achieved without anesthesia.

RECOMMENDATION

Because laser treatment done with little or no knowledge risks causing great damage, it is strongly recommended – especially for the use of lasers in pediatric dentistry – that the dentist receive sufficient skill and safety training in laser use to make the laser treatment provided successful and safe.

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