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Er-YAG LASER AND DENTAL CARIES TREATMENT OF PERMANENT TEETH IN CHILDHOOD

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ABSTRACT

The **aim** of this study was elaboration, approbation in a clinical situation and monitoring of the optimized protocol for application of Er:YAG laser “Lite Touch” in dental caries treatment of permanent teeth in children.

Materials and methods: Fifty children between the age of 6 and 16 years with at least one bilateral matched pair of one type cavitated carious lesions in permanent teeth were included in the study. In each patient one of the 2 cavities was prepared conventionally, the other with the Er:YAG laser. All cavities were restored with light-cured composite resin following the application of acid etch and a bonding agent. Postoperative hypersensitivity, secondary caries and marginal morphology of restoration were evaluated.

Results: No postoperative sensitivity and secondary caries in all children at the 2-year follow-up examination were observed. It was found that 94.83 % of restorations in Er:YAG laser treated carious lesions were clinically acceptable and no one of the restorations was lost.

Conclusion: There is no difference with regard to the clinical success between laser and conventional treatment. The protocol with Er:YAG laser “Lite Touch” parameters used can be recommended in the dental practice for caries treatment of permanent teeth in childhood.

Key words: Er:YAG laser, dental caries treatment, children, permanent teeth

INTRODUCTION:

Er:YAG laser is one of the most suitable laser systems that could be used in dental caries treatment in childhood. Its higher safety compared to conventional techniques because it does not use rotating instruments in a small mouth which can move unpredictably [1], its minimally invasive nature because of the affinity of the laser beam for carious structures and decontamination of ablated dentin [2, 3], the possibility for achieving an effective ablation without thermal negative effects on underlying structures and tissues [4, 5], the increased children cooperativeness during the caries treatment process because of the non contact method used that induces less vibration and provides a painless and more comfortable treatment [6, 7, 8] are only a small part of the Er:YAG laser advantages described in the literature.

The laser ability to remove hard dental structures depends on different factors such as water and fluoride content of the target tissue, and laser parameters including energy, pulses per second, water spray, the tip material, shape and diameter [9, 10].

Different studies reported very good clinical results after using of Er:YAG laser in the caries treatment in adults [11, 12]. However, there is a lack of clinical studies in the literature with regard to the Er:YAG laser application in dental caries treatment in childhood.

The **aim** of the recent study was elaboration, approbation in a clinical situation and monitoring of the optimized protocol for application of Er:YAG laser “Lite Touch” in dental caries treatment of permanent teeth in children.

Tasks:

1. Proposal for a protocol with recommended Er:YAG laser parameters for cavity preparation and removal of carious hard dental structures in permanent teeth in children;

2. Assessment of the clinical success of Er:YAG laser caries treatment after applying of the same protocol in dental clinical practice.

MATERIALS AND METHODS:

Fifty children (21 male and 29 female) between the age of 6 and 16 years with a total of 116 cavitated carious dentinal lesions participated in this study. Of these, 24 children were aged from 6 up to 11 and had 48 cavitated carious dentinal lesions on first permanent molars and 26 children were aged from 12 up to 16 and had 68 carious dentinal lesions on first incisors, canines, first and second permanent molars.

Inclusion criteria:

- good general health;
- at least one bilateral matched pair of one type cavitated carious lesions with regard to:
- the tooth – incisors, canines, premolars or molars;
- location of the lesion – cervical, occlusal or proximal;
- cavity depth – less or more than second half of dentine.

Exclusion criteria:

- symptoms (evidence) of complicated caries (pulpitis or apical periodontitis);
- poor oral hygiene.

Informed written consent was obtained for the procedure of laser and conventional treatment from each patient’s parents, as required by the institution’s Ethics Board.

Ten permanent incisors, 6 upper permanent canines, 44 lower first permanent molars, 30 upper first permanent molars and 26 lower second permanent molars cavities were prepared. Sixteen of the lesions were in the cervical area of teeth, 38 were proximal lesions and 60 occlusal lesions. Thus, all three possible types of carious lesions were prepared using the laser. Ninety four of the lesions were at the dentin-enamel junction and the remaining 22 in the second half of the dentin.

A split-mouth design was used. One of the cavities was prepared conventionally, the other with an Er:YAG laser in each patient.

For laser preparation, an Er:YAG laser (Lite Touch™, Syneron, Israel) with a wavelength of 2940 nm and pulse duration: 50 ìsec. tat is a solid-state crystal laser with the host crystal-Yttrium Aluminum Garnet doped with Erbium ions that replace the Yttrium ions was used.

Hard dental structures' ablation is getting performed with a sapphire tip, working distance of 0.5-1.0 mm and air-water cooling of 39 ml/min. The clinical protocol with recommended Er:YAG laser Lite Touch parameters was drawn on the base of our previous Scanning Electron Microscope (SEM) and Raman and Infrared reflection micro-spectroscopic study on permanent human enamel and dentin [13, 14]. Parameters of the laser used in carious lesions treatment of permanent teeth are presented on table 1:

Table 1. Protocol with Er:YAG laser (Lite Touch) parameters for cavitated dentinal carious lesions treatment in permanent teeth

Manipulations \ Parameters			Energy (mJ)	Energy fluence (J/cm^2)	Pulse repetition rate(Hz)	Sapphire tipdiameter (mm)	Working angle
Exposing of the carious lesion	Occlusal location		300	22.61	20	1,3	I-25° towardthe axial axis of the tooth
	Proximal location		300-400	22.61-30.15	20	1,3	II-90-100° towardenamel occlusal surface
	Cervical location		200-300	15.08-22.61	20	1,3	110-120° towardenamel surface
Carious dentin excavation	DEJ*- occlusal, proximallocation		200	15.08	20	1,3	45° towardthe axial axis of the tooth
	DEJ- cervical location		200	15.08	20	1,3	135-145° towardthe axial axis of the tooth
	Cavity wall		200	15.08	20	1,3	30-45° toward the irradiated surface
	Cavity floor	D3a	200	15.08	20	1,3	90-100° toward the
		D3b	100	12.74	20	1,0	irradiated surface
Enamel edges fining			100	12.74	20	1,0	45° towardenamel cavity edges

*DEJ- dentin enamel junction

The exposing of carious lesions with occlusal location (small pit and fissure carious lesions) starts with a sapphire tip tilted toward fissure at angle of 25 ° to the axial axis of the tooth. Once the ablation occurs, the tip is pointed toward the carious fissure perpendicularly (angle of 90 - 100 ° to the occlusal surface). At wide fissure carious lesions the exposing is conducted with an angle of 90 - 100 ° toward the fissure. The interproximal location requires the sapphire tip to be pointed at angle of 90 ° to the occlusal surface of the enamel that has to be removed. Er:YAG laser exposing of carious lesions with cervical location is getting conduct with a working angle of 110 -120 ° to the cervical enamel surface.

In mechanically prepared cavities, high-speed and low-speed water-cooled handpieces with burs were used.

The excavation in both groups was carried out under visual control with intermittent testing of hardness of the remaining hard structure by means of a dental probe [15] observing the principle of dental caries treatment with minimal intervention- removing of the infected layer leaving the affected one only on the pulpal wall of the cavity prepared.

All cavities were restored with a nanohybrid composite (Calore GC) and adhesive system 3M ESPE Scotchbond Multi-purpose (SBMP) in accordance with manufacture recommendations. In the deepest carious lesions, calcium hydroxide liner was used prior to placing one of the filling materials.

The two cavities (one prepared conventionally, the other with an Er:YAG laser) were completed at two separate appointments, on different days.

No local anesthetic was used either before or during the treatment.

The evaluation of clinical effect of Er:YAG laser application in dental caries treatment of permanent teeth was conducted at baseline, 6, 12, 18 and 24 months using FDI Recommendations for Conducting Controlled Clinical Studies of Dental Restorative Materials, updated in 2008 (table 2). The application of these criteria provides the opportunity of the clinical evaluation of restorations not only involving the restorative material per se but also different operative techniques [16].

Table 2. Evaluation criteria and clinical rates

Code	Evaluation criteria	Clinical evaluation	
		First step	**Second step**
	Postoperative hypersensitivity		
1	No postoperative hypersensitivity	Clinically acceptable	Clinically excellent
2	Postoperative hypersensitivity of short duration (less than one week) and no longer present at the baseline assessment	Clinically acceptable	Clinically good
3	Intense postoperative hypersensitivity of duration greater than one week but less than six-months.	Clinically acceptable	Clinically satisfactory
4	Persistent postoperative hypersensitivity	Clinically unacceptable	Clinically unsatisfactory
5	Severe pain is noted and immediate root canal treatment is required	Clinically unacceptable	Clinically bad
	Recurrence of initial pathology		
1	No recurrence of initial pathology and no other pathology present.	Clinically acceptable	Clinically excellent
2	Presence of small marginal areas with transparency changes but no operative treatment required.	Clinically acceptable	Clinically satisfactory
3	Areas of demineralization in the enamel with noexposure of dentine.	Clinically unacceptable	Clinically satisfactory
4	Presence of cavitated caries or suspected undermining caries in dentine that can be restored / repaired by operative intervention.	Clinically unacceptable	Clinically unsatisfactory
5	Generalized or localized deep caries or exposed dentine that is not accessible for repair and requires immediate restoration replacement.	Clinically unacceptable	Clinically bad
	Marginal morphology of restoration		
1	No clinically detectable gap. Margins represent a harmonious continuation of the outline at the tooth/restoration transition	Clinically acceptable	Clinically excellent
2	Small marginal chip fracture of the restoration that can be eliminated by polishing.	Clinically acceptable	Clinically satisfactory
3	Presence of discoloration limited to the border areaof the marginsor several small marginal fractures. Minimal intervention is necessary.	Clinically unacceptable	Clinically satisfactory
4	Marginal fractures that may result in exposure of dentine or base. Repair is necessary.	Clinically unacceptable	Clinically unsatisfactory
5	Tooth- restoration bond destroying or the restoration is loose.	Clinically unacceptable	Clinically bad

Two step approach for assigning scores for each parameter was used: the first step was to assess the restoration and to determine the level of clinical acceptability for each parameter in each of the categories (the result becomes unacceptable whenever re-treatment is necessary or highly advisable with exception of secondary caries and marginal adaptation where even a minimally-invasive approach need requires score unacceptable); as a second step a further distinction was made between an excellent, good and clinically satisfactory result [17, 18].

Postoperative hypersensitivity was recorded at the time of restoration placement, at baseline and at all recalls visits, and included type of pain, discomfort and duration on dry ice stimulus at clinical assessment. Intensity was assessed with a Wong-Baker scale [19]. Clinical evaluation of secondary caries and marginal adaptation was done with a loop (magnification 4 X), after tooth brushing with a paste.

Evaluation was done by two independent investigators not involved in the treatment procedures using a mirror, explorer and air stream.

The statistical analysis was performed using the Sp-comparison.

RESULTS:

Postoperative sensitivity

No postoperative sensitivity in all children at the 2-year follow-up examination was observed. All treated carious lesions were evaluated as clinically ideal (code 1).

Secondary caries

No secondary caries was observed during the 2-year period of examination neither in the group treated with Er:YAG laser nor in conventional treatment group.

Marginal adaptation

The results of the marginal adaptation's assessment are presented on the table 3.

Table 3. Clinical assessment of marginal adaptation

Groups	**Experimental**					**Control**				
Code	1	2	3	4	5	1	2	3	4	5
Baseline	58	0	0	0	0	58	0	0	0	0
6 m	58	0	0	0	0	58	0	0	0	0
12 m	55	3	0	0	0	56	2	0	0	0
18 m	55	2	1	0	0	55	2	1	0	0
24 m	54	2	2	0	0	54	3	1	0	0

During the two- year study period 55 (94.83 %) of total 58 restorations in Er:YAG laser treated carious lesions and 56 (96.55 %) of conventionally treated lesions were clinically acceptable (code 1 + code 2). No statistically significant difference between the two groups was found ($T=0.46$; $p>0.05$). One of the restorations (1.72%) in Er:YAG laser treated carious lesions assessed as clinically unacceptable at 18-th month and 2 (3.45%) at 24-th month because of several small marginal fractures (code 3) were registered with no statistically significant differences between the groups.

No one of the restorations was lost in the 2-year period of evaluation.

DISCUSSION:

The recent study showed very good results with regard to the clinical success rate of Er:YAG laser dental caries treatment in permanent teeth in children after applying of the recommended by us protocol for using of the Er:YAG laser in dental clinical practice. These results can be explained with the adequate choice of Er:YAG laser parameters – laser energy, pulse repetition rate, energy fluence, working distance, working angle and air-water cooling, as well as the suitable clinical protocol applying.

In the process of Er:YAG laser assisted dental caries treatment "fine tuning" of the laser is one of the most important factors for a success treatment with no complications [20]. No post operative sensitivity and secondary caries were observed in our study during the period of 2 years after applying of the protocol with recommended by us Er:YAG laser Lite Touch parameters. Postoperative hypersensitivity evaluated can be related to thermal pulp changes [21]. It is well known that the temperature rise in the pulp chamber during cavity preparation with appropriate Er:YAG laser parameters is significantly lower than that with conventional mechanical methods [5].

The correct choice of laser parameters is a prerequisite for a safe and effective ablation of hard dental structures and enamel and dentin surfaces that provide a good adhesion of composite materials [9, 22]. Marginal morphology of restorations in Er:YAG laser Lite Touch treated carious lesions evaluated in the recent study showed excellent results compared to conventionally treated lesions. No one of restorations was lost and no one the evaluated clinical cases needed re-treatment. The only one of the restorations in Er:YAG laser treated carious lesions that showed several small marginal fractures at 18-th month and the two 2 of the restorations at 24-th month with the same defects were corrected by polishing of the edges and addition of composite material after acid etching and bonding.

Criterion "marginal morphology of restorations" is related to the adaptation of composite materials to the cavity edges and walls [23]. In Er:YAG laser prepared cavities both the quality of ablated enamel and dentin surfaces and the type of adhesive system play crucial role in the marginal adaptation of restorations and are a prerequisite for a good final restoration [20, 24]. It has been demonstrated in the literature that enamel and dentin surfaces prepared by laser should be followed by acid etching with 35-37% orthophosphoric acid [24]. It allows regularization of ablated enamel prisms and less microleakage at the interface enamel composite as well as formation of hybrid layer and resin tag hybridisation into the opened dentinal tubules resulting in a better retention of the adhesive composites.

Using of a working angle conformed to the orientation of the enamel prisms and dentinal tubules provides the opportunity of observing the rules for hard dental structure's treatment with minimal intervention [2, 25]. In the recent study, observing the rules for micro-invasive cavity preparation, carious dentin excavation in the area of DEJ and cavity walls expanded to sound dentin, in contrast to cavity bottom where dentin excavation was limited to vaporizing of the infected layer leaving the affected dentin on the pulp wall of the cavity prepared. Calcium hydroxide liners should be applied to stimulate a possible remineralisation of the affected dentin.

Er:YAG laser beveling of the enamel edges with parameters 100 mJ/20 Hz and working angle of 45° provides a regularization of the enamel prisms before acid etching and good adhesion of the restorative material and a microleakage-free interface [20, 26].

Secondary caries appearance depends on many factors such as oral hygiene, caries activity, the potential of adhesion system to provide a good sealing between enamel margins and filling material [27]. With regard to the Er:YAG laser application in dental caries treatment the potential of erbium-lasers for increasing of the enamel and dentin acid resistance has been demonstrated in the literature [28]. The good results in our study are likely to be due to the described above effects.

It seems that the Er:YAG laser is a promising technology and it can be successfully used in dental caries treatment of permanent teeth. The manual ability of the operator to act on the structures with precision has been demonstrated to be of great importance [1, 25].

In the near future this new technology could replace the conventional techniques used in pediatric cariology.

CONCLUSION:

The results of our study showed that the clinical success of the Er:YAG laser treatment did not differ from the conventional treatment. The protocol with Er:YAG laser Lite Touch parameters used can be recommended in the dental practice for caries treatment of permanent teeth in childhood.

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