

Original Research Article

Efficacy of Er:YAG laser dental caries treatment in children

Galia Zhegova^{1*} and Maya Rashkova²

Abstract

¹PhD, Assistant Professor,
Department of Pediatric Dentistry,
Faculty of Dental Medicine, Medical
University- Sofia, Bulgaria

²PhD, Professor, Department of
Pediatric Dentistry, Faculty of Dental
Medicine, Medical University- Sofia,
Bulgaria

*Corresponding author's E-mail:
drjegova@abv.bg;
Tel: +359 888 363 312

Er:YAG laser is one of the most suitable laser systems used in pediatric dentistry. The objective of the study was to estimate the duration of cavity preparation by an Er:YAG laser versus conventional techniques and to compare the time required for Er:YAG laser cavity preparation and a combined preparation by Er:YAG laser and a hand excavator. Eighty four children between the age of 3 and 16 years with bilateral matched pairs of carious deciduous or permanent molars participated in this study. In each patient one of the 2 cavities was prepared conventionally, the other with an Er:YAG laser or combined Er:YAG laser plus hand excavator. A stopwatch was used for recording of the time spent on cavity preparation for each treatment. In permanent teeth the mean duration of Er:YAG laser treatment (6.04 min) was longer than the conventional treatment (3.55 min) ($p < 0.001$) and the combined treatment by the Er:YAG laser plus excavator (4.47 min) consumed more time than the conventional techniques (3.85 min) ($p < 0.05$). In deciduous teeth no statistically significant difference between the mean duration of laser preparation (4.98 min) and the mechanical means (5.61 min) was observed ($p = 0.05$) and the combined treatment (2.87 min) was shorter than the mechanical means (4.14 min) ($p < 0.05$). Therefore using of a hand excavator can be recommended as an additional instrument in order to reduce the duration of Er:YAG laser cavity preparation in dental caries treatment of children.

Keywords: Caries treatment, children, Er:YAG laser, hand excavator

INTRODUCTION

Substituting of conventional mechanical techniques by Erbium lasers in dental caries treatment provides the possibility of painless and more comfortable dental manipulations performance (Genovese 2008).

The ability of the Er:YAG laser (2940 nm) to provide precise ablation of both sound and carious enamel and dentin with a shallow thermal penetration depth (Hibst 1990) with no injury to the pulp and no thermal side effects, such as melting and charring to the surrounding tooth structure (Hibst et al., 1989; Visuri et al., 1996) is only a small part of this new technology's advantages.

Modern dentistry requires a minimally invasive approach with the focus on maximum conservation of the tooth structures (Peters et al., 2001). Er:YAG laser

irradiation results in a selective ablation of hard dental structures according to their water content (Cozean et al. 1998; Matsumoto et al. 2007). Additionally, the decontamination of Er:YAG laser irradiated dental surfaces during the cavity preparation is a prerequisite for the prevention of recurrent caries and a condition for a minimally invasive removal of infected carious dentin and preserving of the affected (demineralised) dentin (Sharon-Buller et al., 2003).

All Er:YAG laser properties described above make this technology ideal for paediatric dentistry (Visuri et al., 1996; Martens LC 2011).

However, some problems are still limiting its clinical application in dental caries treatment, such as longer

Table 1. Distribution of children according to the treatment method

Types of treatment	n	Er-YAG Laser	Conventional treatment	Total	n	Er-YAG Laser+ excavator	Conventional treatment	Total
		n ₁	n ₁			n ₂	n ₂	
Permanent teeth	24	24	24	48	24	24	24	48
Deciduous teeth	18	18	18	36	18	18	18	36
Total	42			84	42			84

Legend: n- number of children, n_{1,2}- number of carious lesions

preparation time compared to the use of a conventional bur (Keller et al., 1998). Giusti suggested using higher parameters of laser energy in order to reduce the ablation time (Giusti et al., 2002). The short duration of the procedure seems to be an important condition in children caries treatment. However it should be matched with the choice of the optimal laser parameters in order to prevent possible negative effects of Er:YAG laser ablation (Delme et al., 2007; Freitas et al., 2007). Some authors recommend using of a hand excavator for removal of the carious dentin during the Er:YAG laser cavity preparation of small carious lesions in order to avoid not only the negative effects but also the excessive removal of healthy dental structures (Vitale et al. 2010).

Therefore, there should be an individually tailored approach in each clinical case. This study aimed to evaluate the duration of cavity preparation with an Er:YAG laser "Lite Touch Syneron" versus conventional techniques. Additionally a comparison between the duration of the Er:YAG laser preparation alone and a combined preparation with the Er:YAG laser and a hand excavator was made.

METHODS

Selection of patients

Eighty four children (40 male and 44 female) between the age of 3 and 16 years with a total of 168 opened dentinal carious lesions participated in this study. Of these, 36 children were aged from 3 to 5 and the rest 48 children were aged between 6 and 16.

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.

The children were divided in two groups: (L) treated by the Er-YAG laser alone and (EL) treated by a combined method- the Er-YAG laser and a hand excavator (table. 1).

The children presented bilateral matched pairs of carious Class I and / or II permanent and primary molars. The cavities were matched according to tooth type

(permanent or primary), cavity type (occlusal or approximal) and cavity depth (less than or more than half way through dentine).

All teeth were clinically free of any pathological condition other than dental caries.

Clinical procedure

Cavity preparation was performed on two first or second deciduous or permanent molars in each patient. One cavity was prepared conventionally, the other with the Er-YAG laser alone or combined- the Er-YAG laser plus a hand excavator according to the group.

In the group of combined treatment approach, the carious lesion was exposed using the Er:YAG laser, followed by the removal of soft dentin with a hand excavator. The final cavity preparation was performed with the laser.

For laser preparation, an Er-YAG laser (Syneron, Lite Touch™, Israel) was used with applied parameters as follows: energy ranging from 100 mJ to 400 mJ for permanent teeth and 100 mJ - 300 mJ for deciduous teeth, pulse repetition rate: 20 Hz, sapphire tip diameter: 1.3 mm, 1.0 mm, pulse duration: 50 µsec, theoretical fluence: 15.05 J/cm² for the dentin, 30.15 J/cm² for the permanent enamel and 22.61 J/cm² for primary enamel and 12.74 J/cm² for cavities' edges bevelling, non-contact mode distance: 0.5 to 1.0 mm, air-water-spray cooling: 39 ml/min.

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

All cavities in permanent teeth were restored with light-cured composite resin (Kalore GC) following the application of acid etch (37 % orthophosphoric acid) and a bonding agent (3M ESPE Scotchbond Multipurpose). All cavities in deciduous teeth were restored with a Compomer (Glasiosite Voco). In the deepest carious lesions, calcium hydroxide liner was used prior to placing one of these filling materials.

The two cavities in each patient were completed at two separate appointments, on different days.

Table 2. The mean time (in min) for Er:YAG laser and conventional cavity preparation

Types of treatment	n	Er-YAG Laser	Control group	Paired-samples T-test	n	Er-YAG Laser+ excavator	Control group	Paired-samples T-test
		Mean±SD	Mean±SD			Mean±SD	Mean±SD	
Permanent teeth	24	6.04±2.27	3.55±1.37	T=3.184 P=0.000	24	4.47±1.44	3.85±1.21	T=3.096 P=0.005
Deciduous teeth	18	4.98±2.49	5.61±3.16	T=2.138 P=0.047	18	2.87±1.96	4.14±3.83	T=2.410 P=0.028

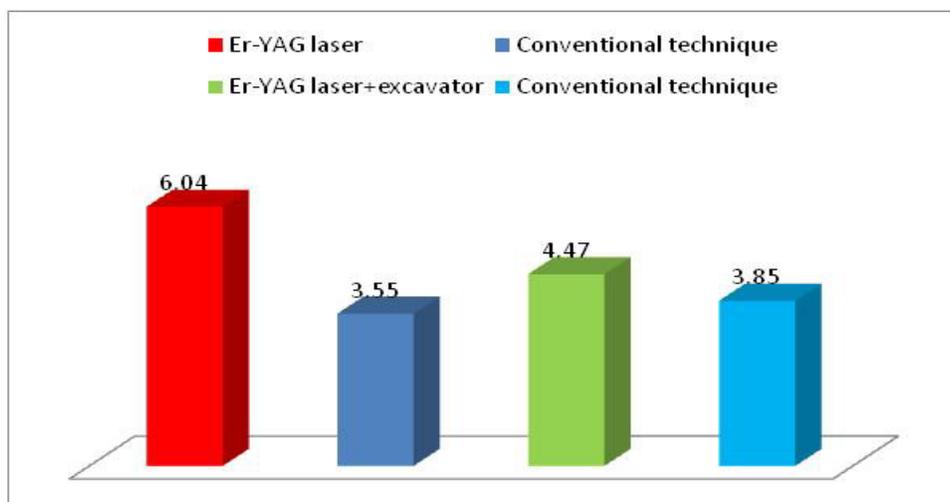


Figure 1. Duration (in min) of carious lesions treatment in permanent teeth

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

Evaluation of caries excavation

The preparation was carried out under visual control with intermittent testing of the hardness of the remaining hard structure by means of a dental probe (Bjorndal et al., 1995).

Evaluation of treatment duration

The time spent on cavity preparation was recorded for each treatment, including the working time for the inspection of the residual lesion, using a stopwatch starting with the first contact to tooth until the last contact with the preparation.

Data analysis

Data were collected and evaluated using statistical soft-

ware SPSS (Statistical Package version 19.0).

RESULTS

Mean values of time for cavity preparation conducted in the groups of the experiment are presented on table 2. In permanent teeth the preparation time ranged from 3.50 to 12.00 minutes. The mean time of Er:YAG laser treatment was longer than the conventional mean time treatment for both groups- treated by the Er-YAG laser alone (respectively 6.04 min versus 3.55 min) ($p < 0.001$) and treated by the Er:YAG laser plus excavator (4.47 min versus 3.85 min) ($p < 0.05$).

A recorded range of treatment times in deciduous teeth was from 50 sec up to 18 min. The mean time for Er:YAG laser preparation (4.98 min) compared to that for the mechanical means (5.61 min) was similar ($p = 0.05$). In the group with the combined treatment- laser and excavator the cavity preparation (2.87 min) was shorter compared to that for the mechanical means (4.14 min). The difference was statistically significant ($p < 0.05$). (Figure 1)

In permanent teeth conventional treatments for both groups required identical duration of the cavity

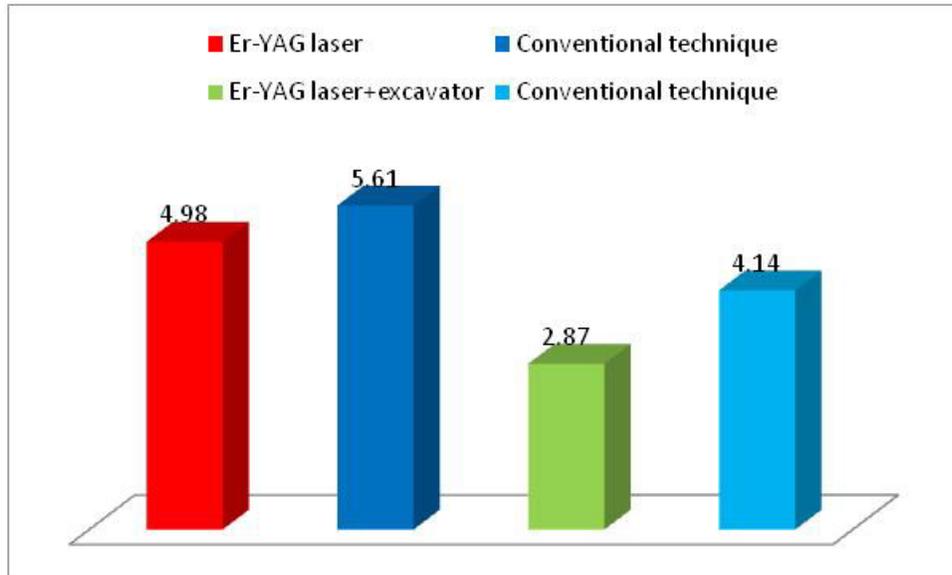


Figure 2. Duration (in min) of carious lesions treatment in deciduous teeth



Figure 3. Er:YAG laser treatment of opened dentinal carious lesion class II of a deciduous molar

preparation ($T=1.028$; $p=0.315$) which is a prerequisite for objectivity of comparative analysis between both studied groups. The combined treatment included Er:YAG laser + excavator compared to Er:YAG laser treatment alone resulted in a shorter duration of the cavity preparation ($T=4.654$; $p=0.000$). (Figure 2)

In deciduous teeth conventional treatments for both groups required identical duration of the cavity preparation ($T=1.219$; $p=0.239$). The combined treatment of deciduous teeth included Er-YAG + excavator compared to Er-YAG laser treatment alone resulted in a shorter duration of the cavity preparation ($T=2.575$; $p=0.020$).

The results are illustrated on figure 3.

DISCUSSION

The The results of the present study demonstrate considerably longer duration of Er:YAG laser preparation,

compared to the conventional procedure (6.04 min vs. 3.55 min). Liu reported that the Er:YAG laser cavity preparation in permanent teeth of children was two times longer than the conventional preparation (Liu et al., 2006).

The difference in duration between laser and mechanical preparation is mainly due to the amount of the enamel that has to be removed; especially in approximal localized carious lesions. Aoki demonstrated that there was no difference in the time required for removal of carious dentin in permanent teeth with Er:YAG laser and conventional techniques (Aoki et al., 1998).

The results of the recent study showed that using of a hand excavator during the Er:YAG laser treatment of permanent teeth resulted in a shorter cavity preparation (4.47 min) compared to the Er-YAG laser application alone (6.04 min).

With regard to deciduous teeth the duration of Er:YAG laser preparation (4.98 min) was similar to that for the mechanical means (5.61 min).

In contradiction with our results, Yamada reported in an *in vitro* study that the average required treatment time in primary teeth for Er:YAG laser treatment was longer than that for bur treatment (Yamada et al., 2001).

In a clinical situation during the caries treatment in small children, on one hand most of the time is spent to convince the child for the treatment need. On the other hand, the characteristics of primary dental structures such as higher water content facilitate the action of Er:YAG laser radiation that could explain the described results.

In like manner as permanent teeth the application of the hand excavator as an additional instrument for removal of only the soft dentin in deciduous teeth reduced the duration of the Er:YAG laser treatment.

In our previous SEM study (Zhegova 2014) (unpublished data) the removal of permanent and primary carious dentin with a hand excavator resulted in a smear layer that covered the treated surface. However a following Er:YAG laser treatment can remove that smear layer. Therefore, the combined application of Er:YAG laser and a hand excavator improves the quality of the treated surfaces, but also can be used for additionally reducing of the treatment duration.

CONCLUSION

It can be concluded that, in permanent teeth both Er:YAG laser alone and combined with a hand excavator required longer time for cavity preparation compared to the conventional techniques. In deciduous teeth the duration of Er:YAG laser cavity preparation did not differ from that conducted by mechanical means. Using of a hand excavator as an additional instrument can reduce the duration of Er:YAG laser cavity preparation in dental caries treatment in small children.

REFERENCES

Aoki A, Ishikawa I, Yamada T, Otsuki M, Watanabe H, Tagami J, Ando Y, Yamamoto H (1998). *Comparison between Er:YAG laser and conventional technique for root caries treatment in vitro*. J Dent Res 77 (6): 1404-1414.

- Bjorndal L, Thylstrup A (1995). *A structural analysis of approximal enamel caries lesions and subjacent dentin reactions*. Eur. J. Oral Sci. 103 (1): 25-31
- Cozean CD, Powell GL (1998). *Er:YAG clinical results on hard tissue: Phase II*. Lasers in dentistry; 3248 (4): 33-39.
- Delme KIM, De Moor R (2007). *Scanning electron microscopic Evaluation of Enamel and Dentin Surfaces after Er:YAG Laser Preparation and Laser Conditioning*. Photomedicine and Laser Surgery 25 (5): 393-401.
- Freitas P, Navaro R, Barros J, Eduardo C (2007). *The use of Er-YAG laser for cavity preparation: an SEM evaluation*. Microsc Res Tech 70 (9): 803-808.
- Genovese MD, Olivi G (2008). *Laser in paediatric dentistry: patient acceptance of hard and soft tissue therapy*. Eur J Paediatr Dent. 9 (1): 13-17.
- Giusti JSM, Pinto L, Lizarelli R, Bagnato VS (2002). *Ablation rates and morphological patterns of deciduous tooth- enamel after Er:YAG Laser Irradiation- An in vitro study*. J Oral Las Appl 2 (3): 159-164.
- Hibst R and Keller U. (1989). *Experimental studies of the application of the Er:YAG laser on dental hard substances: I. Measurement of the ablation rate*. Lasers Surg Med. 9: 338-344.
- Keller U, Hibst R, Geurtsen W, Schilke R, Heidemann D, Klaiber B, Raab WHM (1998). *Erbium:YAG laser application in caries therapy. Evaluation of patient perception and acceptance*. J. Dentistry; 26 (8): 649-656.
- Liu JF, Lai YL, Shu WY, Lee SY (2006 Aug). *Acceptance and efficiency of Er:YAG laser for cavity preparation in children*. Photomed Laser Surg 24 (4): 489-493.
- Martens LC (2011 Apr). *Laser physics and a review of laser applications in dentistry for children*. European Archives of Paediatric Dentistry 12 (2): 61-67.
- Matsumoto K, Wang X, Zhang C, Kinoshita J (2007 Mar). *Effect of a novel Er:YAG laser in caries removal and cavity preparation: a clinical observation*. Photomed Laser Surgery. 25 (1): 8-13.
- Peters MC, McLean ME (2001). *Minimally invasive operative care. I. Minimal intervention and concepts for minimally invasive cavity preparations*. J Adhes Dent. 3 (1): 17-31.
- Sharon-Buller A, Block C, Savion I, Sela M (2003). *Reduced bacterial levels in cavities prepared by Er:YAG laser*. J Oral Laser Applic, 3 (3): 153-155.
- Visuri SR, Walsh JT, Wigdor HA. (1996). *Erbium laser ablation of dental hard tissue: effect of water cooling*. Lasers in Surgery and Medicine. 18 (3): 294-300.
- Vitale M, C Caprioglio. *Paediatric dentistry*. In: Vitale M, C Caprioglio. Lasers in dentistry-Practical text book; Martina Ed, Bologna, 2010: 85-104.
- Yamada Y, Hossain M, Nakamura Y, Suzuki N, Matsumoto K (2001). *Removal of Carious Dentin by Mechanical, Chemomechanical and Er:YAG Laser in Deciduous Teeth*. Oral laser Applications, 1 (2): 103-114.