

Research Report

The use of holmium-yttrium aluminum garnet laser as pit and fissure cleaner

Armasastra Bahar

Faculty of Dentistry, Universitas Indonesia
Jakarta - Indonesia

ABSTRACT

Background: The prevention and management of pit and fissure caries has become relatively more important in recent times. There is a need for an effective preventive measure against pit and fissure caries. **Purpose:** The purpose of this study was to investigate the effect of laser beam as a cleaning method of pits and fissures. **Methods:** Ho-YAG laser which has a wavelength of 2.1 μm was used in this experiment. The specimens were extracted human teeth. The effect of three cleaning methods was examined comparatively by scoring the cleaned area of fissure, namely laser irradiation with Ho-YAG laser, chemico-mechanical with combination of 10% NaOCl and ultrasonic scaler and mechanical with ultrasonic scaler. Vertico-bucco-lingual serial ground sections of each tooth were observed under light microscopy. Scoring the depth of cleaned area was performed by comparing the depth of fissure. **Result:** Progressive result was obtained on the cleaning effect of three methods laser irradiation methods which was the most effective compared to other methods but statistically was not significant. Cleaned area of laser irradiation method was 48.91%, chemico-mechanical method was 41.77% and mechanical method was 36.78%. **Conclusion:** Holmium -yttrium aluminum garnet laser is a relatively new method for pit and fissure cleaning even though the effectivity is not yet maximal. More research is needed to maximize the use of this laser.

Key words: laser, cleaning methods, pit and fissure

Correspondence: Armasastra Bahar, c/o: Fakultas Kedokteran Gigi Universitas Indonesia. Jl. Salemba Raya 4 Jakarta, Indonesia.
E-mail: armsbah@hotmail.com

INTRODUCTION

The factor concerned in the initial destruction of tooth is a biomechanical process resulting from the activity of microbiological agents existing in the environment concerned. Pit and fissure caries is therefore primarily of environmental origin, although its initial progression may be governed by the enamel structure.

Relative caries incidence is low on smooth, self cleaning surfaces but increase significantly on interproximal and occlusal surface. Several investigations have shown that the oral surfaces are especially susceptible to dental decay accounting for nearly 50% of all dental caries.

The prevention and management of pit and fissure caries has become relatively more important in recent times. There is a need for an effective preventive measure against pit and fissure caries, which now account for more than 90% of the total caries experience in some child populations.¹

The immature permanent teeth, especially the first molar shows a high caries rate prior to the start of their functioning as teeth.

Many previous studies have reported in prevention of pit and fissure caries such as drilled pit and fissure to have a better shape of pit and fissure. However, this method damaged to the tooth structures. Some investigators used fluoride application, but penetration was difficult to the area of pit and fissure. More recently various adhesive materials that act as agents to seal the fissures from oral environment have been investigated.

Pit and fissure sealant is known to prevent occlusal surface caries.² While a sealant is generally applied as part of the system for the prevention of caries, the cleaning of tooth surface, pit and fissure is very important. For obtaining the better retention of sealant, necessity of cleaning of pit and fissure is widely recognized. Aoki³ have used the solution of 1N HCl, 50% H₃PO₄, 1N NaOH and

10% NaOCl, ultrasonic and combination of ultrasonic and NaOCl to clean pit and fissure.

The use of CO₂ laser in dental caries prevention and the effects of CO₂ laser in combination with fluoride have been investigated.⁴ CO₂ laser irradiation can decrease enamel demineralization, it has still not been clarified which laser wavelength and which irradiation conditions represent the optimum parameters for application as preventive treatment. Scanning electron microscopy examination did not reveal any obvious damage caused by the laser irradiation.⁵

Prior to the sealant therapy, it is also possible to clean up a pit and fissure with the yttrium aluminum garnet (YAG) laser to remove organic and inorganic debris. Myers & Myers used a pulsed YAG laser beam on the technique effectively vaporized the organic and debris.⁶ In reaching the depth of pit and fissure using laser irradiation is needed in order to remove fissure of the contents and to facilitate direct penetration without any alterations of size and shape of the fissure. There is no detailed study has been reported yet concerned about the effectiveness of laser irradiation through pits and fissures. Holmium-yttrium aluminum garnet (Ho-YAG) laser was saved used in the human teeth. Laboratory findings by Roy⁷ suggested that when used with collateral water spray, the Ho-YAG laser can ablate human dentine in a controlled manner without adverse thermal effects. Ho-YAG laser at a wavelength of 2.12 microns can be safely and effectively used for photoconditioning of the dental surfaces of teeth in clinical conditions.⁸ In this study, the effect of Ho-YAG laser on cleaning of pit and fissure was compared to other methods.

MATERIALS AND METHODS

Fifty extracted human teeth, particularly molars and premolars were used in this study. Samples without any lesions in the area of pit and fissure were carefully selected. Since we measure the percentage of cleaned area of fissure content, the depth and shape of fissures were exclusive criteria.

The tooth specimens were fixed with formalin and CaCO₃, washed in distilled water for 15 minutes, cleaned with brush cone and placed in ultrasonic bath for 15 minutes.

Samples were divided into 4 groups. Each 10 teeth treated with laser irradiation, chemico-mechanical with 10% NaOCl and ultrasonic scaler for 2 minutes, mechanical with ultrasonic scaler for 2 minutes and no treatment after cleaned with brush cone for control group. 200 µm diameter

of tip of scaler was used for chemico-mechanical and mechanical methods.

The longitudinal ground sections were prepared buccolingual from the fissure area of each group. The specimens were fixed into slide glass and processed for examinations under light microscope. Scoring the depth of cleaned area was performed by comparing to the depth of fissure.

Ho-YAG laser with a wavelength of 2.1 µm was used in this study. Cleaning of pit and fissure with Ho-YAG laser irradiation which has a repetition rates of 10 pps with an energy of 40 Joule/cm². The 200 µm diameter of fiber was used.

The direction of laser beam for irradiation was vertical to the occlusal surface, pit and fissure of enamel. Black ink was applied into the fissure before laser irradiation to have better absorption of laser beam.

The cleaning effect of pit and fissure was evaluated by determining the distance between the entrance of the pits and fissures and the top of residues. Percentage of cleaned area was calculated by comparison between length of cleaned area and depth of fissure × 100%. ANOVA test was used to reveal any significant differences in the cleaning effect of the pits and fissures among the four groups.

RESULT

Cleaning effects of pit and fissure with laser irradiation, chemico-mechanical and mechanical are presented in table 1 shows a cleaned area of control group. The comparison of cleaning effect of laser irradiation, chemico-mechanical method, mechanical method and cleaning with brush cone only as a control is shown in table 2.

Percentage of cleaned area of fissure after Ho-YAG laser irradiation (Mean = 48.91%), cleaning with 10% NaOCl and ultrasonic scaler (Mean = 41.77%), cleaning with ultrasonic scaler (36.78%) and cleaning with brush cone only as control (17.11%) (Tabel 1).

There are no significant different of cleaning effect of pit and fissure content between laser application and chemico-mechanical method ($p = 1.00$), laser application and mechanical method ($p = 0.85$), but significant different of cleaning effect of pit and fissure content between laser application and cleaning with brush cone only as control group ($p = 0.002$). There are no significant different of cleaning effect of pit and fissure content between chemico-mechanical method and mechanical method ($p = 1.00$), but significant different of cleaning effect of pit and fissure

Table 1. Cleaning effect of pit and fissure with laser irradiation, chemico-mechanical method, mechanical method compared to control

No.	Cleaning method	n	Mean of Cleaned Area	Standar Deviation
1.	Ho-YAG laser	10	48.91	22.60
2.	Chemico-mechanical method (10% NaOCl + Ultrasonic scaler)	10	41.77	16.96
3.	Mechanical method (Ultrasonic scaler)	10	36.78	19.25
4.	Control (Brush cone)	10	17.11	21.03

Table 2. The comparison of cleaning effect of laser irradiation, chemico-mechanical method, mechanical method and control group (cleaning with brush cone only)

	P value	Laser	Chemico-mechanical	Mechanical	Control
Laser		-	1.00	0.85	0.002*
Chemico-mechanical			-	1.00	0.025*
Mechanical				-	0.12
Control					-

$\alpha = 0.05$

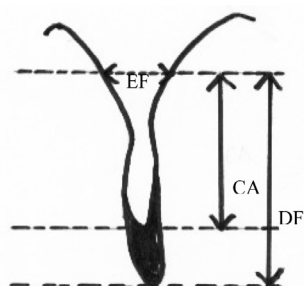


Figure 1. A schematic of comparison between cleaned area and depth of fissure.

EF = Entrance of fissure;
CA = Cleaned area;
DF = Depth of fissure.



Figure 2. Cleaning of fissure content.



Figure 3. Cleaning of fissure content with 10% with laser irradiation. NaOCl + Ultrasonic scaler.



Figure 4. Cleaning of fissure content.



Figure 5. Cleaning with brush cone (control), with Ultrasonic scaler.

content between chemico-mechanical method and cleaning with brush cone only as control group ($p = 0.025$). There is no significant different of cleaning effect of pit and fissure content between mechanical and cleaning with brush cone only as control group ($p = 0.12$).

The findings showed that the cleaning effect of laser irradiation resulted was seemingly most effective than other methods. The findings showed that the cleaning effect of laser irradiation resulted 48.91% of cleaned area. Chemico-mechanical method was 41.77% and mechanical method was 36.78% compared to control was 17.11%.

Condition of fissure's content after exposure to laser irradiation, cleaning with chemico-mechanical, mechanical and control were demonstrated in Figure 2, 3, 4, and 5

Cleaning effect of laser irradiation was seemingly more effective than other methods, however, laser irradiation and other methods was not statistically different.

DISCUSSION

Since Stern and Sognaes⁹ showed in their pioneering work that laser irradiation of enamel with a ruby laser increased its acid resistance, many attempts have been made to apply lasers in preventive dentistry. Stern and Sognaes¹⁰ also demonstrated in vivo that enamel subjected to 10 to 15 J/cm² showed a greater resistant to dental caries than the controls.

Pit and fissure sealant is known to prevent occlusal surface caries. While a sealant is generally applied as part of the system for the prevention of caries, the cleaning of tooth surface, pit and fissure is very important. For obtaining the better retention of sealant, necessity of cleaning of pit and fissure is widely recognized. Prior to the sealant therapy, it is also possible to clean up a pit and fissure with the YAG laser to remove organic and inorganic debris.⁶

Most of researcher investigated the effect of laser irradiation in the smooth surface of enamel. The prevention of pits and fissures caries has become relatively important to be investigated. Lenz *et al.*¹¹ has been suggested the CO₂ laser irradiation for sealing of enamel defects. Walsh and Perkins¹² demonstrated the technique for enamel fusion using CO₂ laser has potential application for sealing pits and fissures and producing physico chemical alterations in enamel which may have preventive benefits. Preliminary findings by Myers⁶ showed that the YAG laser has the potential to remove organic and inorganic debris from pits and fissures without causing pulpal or enamel injury due to minimal laser energy.

Ho-YAG laser were used in this study for cleaning of pits and fissures and tried to compare with chemico-mechanical and mechanical methods. The progressive results were obtained that the cleaning effects of three approaches, laser irradiation was seemingly most effective compared to other methods and control (Table 2). Scoring the depth of cleaned area was performed by comparing to the depth of fissure. The differences of cleaned area of chemico-mechanical and mechanical method was not significant compared to laser irradiation method. However, cleaning method with chemico-mechanical and mechanical had consequence in the alteration of the shape of fissure and damage the enamel surfaces of fissures. The cleaned area supposed to be higher in percentage if the black ink as a removable absorptive coating which was used in this study could penetrates deeply into the fissure to have better absorption of laser beam. The study by Tagomori and Morioka¹³ has shows that the use of black ink on enamel greatly enhances Nd-YAG laser absorption in it. Because of the shape of fissures, application of black paint into the enamel surface of fissure in this study may be was not penetrate deeply into the fissures.

On the other hand, effect of laser irradiation also has the potential to increase acid resistance of the enamel. Many previous studies have reported that the lased enamel surface was more resistant to demineralization of the enamel.^{9,10,14,15} Consequently besides effect of cleansing, laser irradiation has also increasing acid resistance on the area of pit and fissure.

Two hundred μm diameter of fiber of laser beam was used in this study, whereas generally width of fissure's entrance is less than 200 μm . The result should be better if its possible to use fiber with diameter smaller than 200 μm , because there will be better adaptation to the entrance of fissure.

Cleaning effects of laser irradiation was seemingly more effective compared to chemico-mechanical method.

Cleaned area of chemico-mechanical and mechanical method was not statistically significant different compared to laser irradiation method. However, cleaning method with chemico-mechanical and mechanical had consequence in the alteration of the shape of fissure and damage the enamel surfaces of fissures. Laser irradiation has also increasing acid resistance on the area of pit and fissure. The cleaned area supposed to be higher in percentage of the black ink as removable absorptive coating could penetrates deeply into the fissure to have better absorption of laser beam. For better adaptation to the entrance of fissure, using fiber with a diameter smaller than 200 μm is recommended. In conclusion, holmium-yttrium aluminum garnet laser is a relatively new method for pit and fissure cleaning even though the effectivity is not yet maximal. More research is needed to maximize the use of this laser.

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REFERENCES

- Brunelle JA, Carlos JP. Changes in the prevalence of dental caries in US schoolchildren. *J Dent Res* 1982; 61(Sp.Iss):1346–51.
- Weintraub JA. The effectiveness of pit and fissure sealant. *J. Public Health Dent* 1989; 49:317–30.
- Aoki K. A study on cleansing of fissure. *J Oral Pathology (in Japanese)* 1974; 41(3):225–32.
- Rodriguesa LKA, Santosb MN, Pereira D, Assafb AV, Pardib V. Carbon dioxide laser in dental caries prevention. *Journal of Dentistry* 2004; 32(7):531–40.
- Oliveira ME, Zezell DM, Meister J, Franzen R, Stanzel S, Lampert F, *et al.* CO₂ laser (10.6 μm) parameters for caries prevention in dental enamel. *Caries Res* 2009; 43:261–8.
- Myers TD, Myers WD. The use of laser for debridement of incipient caries. *J of Prosthet Dent* 1985; 53(6):776–9.
- Roy G, Walsh, Laurence J. Coaxial water mist spray alters the ablation properties of human radicular dentin for the Holmium: YAG laser. *Journal of Oral Laser Application* 2007; 7(4):225–31.
- Raleigh AH, Robert NE. Holmium: YAG laser in dentistry: Photoconditioning of dental surfaces. *Proc SPIE* 2009; 2128: 308–18.
- Stern RH, Soggnaes RF. Laser beam effect on dental hard tissue. A preliminary report. *JS Calcif. Dent Assoc* 1965; 33:17–9.
- Stern RH, Soggnaes RF. Laser irradiation of dental caries suggested by first test in vivo. *J Am Dent Assoc* 1972; 85:1087.
- Lenz P, Gilde H, Walz R. Untersuchungen zur Schmelzversiegelung mit dem CO₂ laser. *Dtsh Zahnarzt Z* 1982; 37:469–78.
- Walsh LJ, Perham SJ. Enamel fusion using a carbon dioxide laser. A technique for sealing pits and fissures. *Clinical Prevent Dent* 1991; 13(3):16–20.
- Tagomori S, Morioka T. Combined effect of laser and fluoride on acid resistance of human dental enamel. *Caries Res* 1989; 23:225–31.
- Oho T, Morioka T. A possible mechanism of acquired acid resistance of human dental enamel by laser irradiation. *Caries Res* 1990; 24:86–92.
- Yamamoto H, Ooya K. Potential of yttrium aluminum garnet laser in caries prevention. *J Oral Pathol* 1974; 3:715.