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(REVIEW ARTICLE)

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Effectiveness of CO_2 laser conjugation with topical fluoride for caries prevention through improved enamel microhardness

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Abstract

Background: Dental caries is a major global health problem. According to Basic Health Research 2018, the prevalence of caries in Indonesia reached 45.3%, therefore preventions are needed to reduce the prevalence of caries. One of the preventions that can be done is the use of CO_2 lasers combined with topical fluoride.

Objective: To determine the effectiveness of CO_2 laser conjugation with topical fluoride for caries prevention. Methods: In this article review, a method of finding theories and research articles was implemented using the keywords "CO_2 laser, topical fluoride, enamel caries, microhardness, prevention" on sites Google Scholar and PubMed.

Results: From the article search, 8 journals that met our requirements were found, included in them are 3 literature reviews and 5 research articles.

Discussion: In several studies, it was found that a CO_2 laser with a wavelength of 10.6 μm is effective to reduce the solubility of hydroxyapatite crystals on the enamel surface under acidic conditions. Meanwhile, the use of topical fluoride can also reduce demineralization and increase enamel remineralization through physical and chemical prevention. However, the effect of topical fluoride is partial and depends on its constant presence in the oral cavity.

Conclusion: CO_2 laser with the application of topical fluoride can work synergistically in increasing the microhardness of the enamel as an effort to prevent caries.

Keywords: CO_2 Laser; Topical Fluoride; Enamel Caries; Microhardness; Prevention

1. Introduction

Dental caries is a global burden with a high prevalence. In Indonesia, the results of the 2018 Basic Health Research showed that the prevalence of caries in Indonesia reached 45.3%, which is a consideration for preventive efforts to reduce the caries rate. Topical application of fluoride, use of fluoride toothpaste, and fluoridation of drinking water are methods for preventing dental caries. Lasers have been considered to have a potential effect on caries prevention since the 1930s. [1]

The use of a CO_2 laser with a wavelength of 10.6 m can demineralize enamel as a long-term preventive measure. [2] Although there are several conventional techniques in caries prevention, more effective interventions are needed in

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some cases. [3] CO_2 laser irradiation together with fluoride application is a new technique to increase the binding of fluoride to the enamel, thereby causing more fluoride to come into contact with the enamel. [4]

Therefore, this literature review was written to discuss more CO_2 laser conjugation with topical fluoride application for caries prevention through the process of increasing enamel microhardness. The purpose of this study was to analyze the effectiveness of CO_2 laser conjugation with topical fluoride for caries prevention by increasing enamel microhardness.

2. Material and methods

The study design used is a narrative review with research articles and journals from PubMed and ScienceDirect, using keywords "CO_2 laser, topical fluoride, enamel caries, microhardness, prevention". The inclusion criteria include related literature in English and Bahasa Indonesia in the last 10 years(2011-2021). Textbooks and journals that are chosen from the inclusion criteria were compiled and made into a summary that will be discussed according to the similarity and differences in the data.

3. Results and discussion

In the 8 journals that met the criteria to be discussed, included in them are 3 literature reviews and 5 research articles. The summary of the journals are compiled in the table below. (Tabel 4.1)

3.1. The use of CO_2 Laser and Topical Fluoride Separately

In a study conducted by Luk et al. [4], Valério et al. [7], Rechmann et al. [14], and Pagano et al. [15], it was found that the use of a laser with certain parameters (λ = 9.3 - 10.6 m) was able to increase the microhardness and resistance of enamel to cariogenic treatment, and according to Al- Maliky et al. [1] CO_2 lasers can be used as an alternative to fluoride.

CO_2 laser irradiation works by increasing the temperature of the external surface and subsurface layers of the enamel, resulting in chemical and structural changes including reduction of carbonate ions, fusion, and recrystallization of hydroxyapatite crystals, which makes the tooth surface more acid-resistant. [3, 7]

The use of lasers must comply with certain parameters. Several studies have shown that the application of high-powered lasers (30–100 h) can cause irregularities and cracks in the tooth surface, increase the brittleness of the enamel and reduce its surface hardness, making the enamel more susceptible to acid attack. Meanwhile, lasers with low power (3-21 h) can increase the enamel resistance to acid. [3, 16, 17]

Topical fluoride is a material that is conventionally used in the process of preventing dental caries. Based on research conducted by Valério et al. [7], the use of 1.23% acidulated phosphate fluoride is effective in preventing caries in primary teeth by forming calcium fluoride (CaF2) bonds wherein, fluorine ions will be released as a liquid phase which causes a decrease in enamel demineralization. In addition, fluoride is able to inhibit the production of intracellular carbohydrates in the oral cavity by binding to metalloenzymes to form fluor-metallo complexes, which inhibit the formation of phosphoenolpyruvate from 2- phosphoglycerate in the Krebs cycle. This prevents the demineralization process and enhances the enamel remineralization process so as to prevent the development of carious lesions. [6]

The amount of fluoride formed on the enamel also depends on the concentration and pH of the topical fluoride applied and the length of contact with the enamel. Topical application of fluoride with fluoride compounds with higher acid concentrations has a higher level of effectiveness in preventing enamel demineralization. [7]

3.2. Combination of CO_2 Laser and Topical Fluoride

Al-Maliky et al. [1], Kasraei et al. [3], Luk et al. [4], Oliveira et al. [18], and Xue et al. [19] found that the use of a laser in combination with topical fluoride could have an additional effect on preventing enamel demineralization. Moreover, Kasraei et al. [3] found that the order of administration of laser irradiation and topical fluoride can also affect the effectiveness of caries prevention, namely the use of CPP-ACFP followed by CO_2 laser irradiation can significantly increase the surface hardness of the enamel, and prove to be more effective than using the method and material separately. for enamel remineralization.

Table 1 Summary of the journals

Author(s)/Year	Title	Sample Amount	Control Group	Intervention Group	Methods	Results
Mohammed Abbood Al-Maliky & Matthias Frentzen & Jörg Meister. (2019).	Laser-assisted prevention of enamel caries: a 10-year review of the literature	-	-	-	Narrative review	Laser irradiation can he used as an alternative or being a synergic system with topical fluoridation to prevent enamel caries in the long term.
Shahin Kasraei, Parmis Kasraei, Sara Valizadeh, & Mohadeseh Azarsina (2021)	Rehardening of Eroded Enamel with CPP-ACFP Paste and CO_2 Laser Treatment	46 healthy human premolars sliced mesiodistally to achieve 84 samples.	14 positive control samples (G1)	60 samples divided into 5 groups: eroded teeth without prevention (G2). eroded teeth given CO_2 laser irradiation (G3), teeth given CPP-ACF paste prevention (G4), teeth being irradiated by CO_2 lasers that is followed by application of paste (G5), paste application followed by irradiation with a CO_2 (G6) laser	Randomized controlled trial; 60 samples submerged into 500mL soda for 2 minutes and continued with rinsing in distilled water for 10 seconds. The procedure was done three times to produce caries lesions. Afterward, the teeth were divided into 5 groups according to the interventions. The mean surface microhardness was calculated in each group.	The highest and lowest microhardness value are in groups G1 and G2 respectively. The second highest value is located in G6, followed by G5, G4, and G3.
Kenneth Luk. John Yun Niu, Norbert Gutknecht. Irene Shuping Zhao, Chun Hung Chu. (2021).	Preventing Enamel Caries Using Carbon Dioxide Laser and Silver Diamine Fluoride	Random human enamel specimens allocated into 4 groups (n=10 per group).	Group 4: Control group	1. Group 1 specimens given SDF 2. Group 2 specimens given CO_2 laser irradiation 3. Group 3 specimens irradiated by CO_2 lasers followed by SDF.	Randomized controlled trial; All specimens were subjects to pH cycling for a cariogenic challenge. The depth of the morphology, and elemental analysis were calculated.	1. The use of CO_2 lasers or SDF separately causes enamel resistance towards a cariogenic challenge. 2. Other than that, there are additional effects from the combination of CO_2 lasers and SDF to prevent

						demineralization of enamel.
Peter Rechmann. Daniel A Charland, Beate M T Rechmann, Charles Q Le, John D B Featherstone(2013)	In-vivo occlusal caries prevention by pulsed CO_2-laser and fluoride varnish treatment--a clinical pilot studv	Second molars of 20 childrens with the average age of 14 vears old.	Groups that only received fluoride varnish in the baseline and recall after 6 months of research.	Groups that were given CO_2 laser irradiation	Randomized controlled trial; 20 second molars were divided into 2 groups. The test group teeth were irradiated with laser of 9.6 um wavelength. Caries was detected on the 3rd, 6th, and 12th months with International Caries Detection & Assessment Svstem (ICDAS-II); SOPROLIFE light-induced fluorescence evaluator in daylight mode and blue-fluorescence; and diagnodent.	The lower the score. the better the condition of the teeth. There were a decrease of ICDAS scores on the test group and an increase in the score of the control group. Assessment using SOPROLIFE daylight shows an increase of scores in both Groups but the highest increase was in the control group.
R. A. Valério, C. T. Rocha, R. Galo, M. C. Borsatto, M. C. P. Saraiva, & S. A. M. Corona (2014)	CO_2 Laser and Topical Fluoride Therapy in the Control of Caries Lesions on Demineralized Primary Enamel	30 primary canine fragments (3x3x2mm)	C: 10 samples that were only given artificial saliva.	20 samples divided into 2 groups: 1. L: CO_2 laser 2. APF: 1.23% acidulated phosphate fluoride	30 samples were submerged into the demineralization solution for 3 hours and followed into the remineralization solution for 21 hours Intervention was given according to the grouping. After the intervention. Another pH cvcling was done again. The process was repeated for 5 days. Knoop microhardness (KHN) of the subsurface was calculated in each group.	L Group shows the highest microhardness score, but not too different from the APF Group statistically. The 2 groups have a significantly different score from Group C. which has the lowest score.
Pagano, S., Lombardo, G., Orso, M., Abraha, I., Capobianco, B., & Cianetti, S. (2020).	Lasers to prevent dental caries: a systematic review	-	-	-	Systematic review from 7 Randomized Controlled Trial (RCT) dan 2 Controlled Clinical Trial (CCT)	In permanent teeth. The combination of each lasers (CO_2, Er:YAG, Er,Cr:YSGG and argon lasers) and

						TPI are effective in reducing caries compared to teeth without interventions. Lasers are safe to use and can be well-tolerated by patients.
Xue, V. W., Zhao, I. S., Yin, I. X., Niu, J. Y., Lo, E. C. M., & Chu, C. H. (2021).	Effects of Treatment Combining 9300 nm Carhon Dioxide Lasers and Fluoride on Prevention of Enamel Caries: A Systematic Review and Meta-Analysis	-	-	-	Systematic review	CO_2 laser irradiation with vavelength of 9300 nm that is ombined with topical fluoride roduces a letter result than CO_2 laser or topical fluoride alone to prevent enamel caries in-vitro
Marcia Regina Cabral Oliveira Pedro Henrique Cabral Oliveira, Luiz Henrique Cabral Oliveira, Ravana Angelini Sfalcin, Renato Arauio Prates. Ricardo Scarnaro Navarro, Paulo Francisco Cesar, Alessandro Melo Deana . Maria Cristina Chavantes, Sandra Kalil Bussadori & Anna Carolina	Influence of Ultrapulsed CO_2 Laser, before Application of Different Tves of Fluoride. on the Increase of Microhardness of Enamel In Vitro	50 bovine teeth	Irradiated by laser (n=10)	40 samples divided into 4 groups: laser + neutral fluoride gel 2% (LNF); laser + acidulated phosphate fluoride gel 1.23% (LAFG); laser+ acidulated fluoride mousse 1.23% (LAFM) ; laser+ fluoride varnish 5% (LFV)	Randomized controlled trial; 50 bovine teeth was given artificial caries lesions and was given different interventions. Microhardness was calculated at baseline, after CO_2 laser irradiation and fluoride application in the 1st week, and at the 3rd and 5th week after fluoride application.	1.There is a decrease in microhardness after the induction of caries in all of the grouns 2.There are no increase of microhardness inte Ist and 3rd week of intervention 3.There is an increase in microhardness at the 5th week in all of the groups.

Ratto Tempestini Horliana (2018)						

CO_2 laser irradiation together with fluoride application is a new technique to enhance fluoride incorporation into hydroxyapatite structures. The process of melting and hardening of the tooth structure by laser light is able to form globular granules on the enamel surface, and when calcium, phosphate, and fluoride ions are saturated on the enamel surface, the penetration of ions in the intergranular microscopic space and precipitation on the subsurface of the enamel will be better. and reduces enamel permeability. [3] The binding of enamel with topical fluoride results in the formation of fluorohydroxyapatite and calcium fluoride (CaF2) on the enamel surface. These two components serve as fluoride reservoirs for dental caries. [5, 20]

4. Conclusion

CO_2 laser conjugation with topical fluoride is effective to prevent caries by increasing the microhardness of the enamel.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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