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Assessing Fluoride Absorption in Dentine Treated with Silver Diamine Fluoride: A Mini-Review on the Role of Nd:YAG and Diode Lasers

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Abstract

Background: Dental caries management has long relied on fluoride therapy as a cornerstone of preventive care. Silver diamine fluoride (SDF) has emerged as a promising material in clinical dentistry showcasing significant potential in caries control
Objective: This review aims to evaluate the influence on penetration depth and fluoride uptake in dentine treated with SDF solution as well as laser irradiation at sub-ablative energy levels. The objective is to explore how these lasers can enhance fluoride absorption and further protect the enamel from acid attacks. Accordingly, two types of laser were selected for this evaluation, namely Nd:YAG and Diode lasers.
Conclusions: Lasers have a greater potential to boost fluoride uptake of enamel while also protecting the enamel surface from acid attack. This study sheds light on the enhanced efficacy of laser-assisted protocols in bolstering the protective mechanisms of fluoride, potentially revolutionizing contemporary approaches to caries prevention and treatment in the realm of dental care.

Keywords— fluoride therapy, silver diamine fluoride, Nd:YAG laser, diode laser irradiation

I. INTRODUCTION

The predominant methods of topical fluoride administration are toothpaste, gel, varnishes, and mouth rinses. The protective action of fluoride arises from the creation of a superficial calcium fluoride (CaF_2) layer that shields the enamel from acid exposure and breakdown. Nonetheless, certain studies indicate that the effectiveness of fluoride therapy in mitigating tooth erosion is constrained, as it is dependent on the continuous presence of fluoride in the oral cavity [1]. Therefore, in order to obtain a protective effect, it is necessary to employ products with a longer retention time and a higher fluoride concentration. Consequently, the application of fluoride to mitigate erosive processes necessitates substantial patient adherence.

The mechanism of action of silver diamine fluoride (SDF) is illustrated in **fig. 1**. Silver (Ag) ions interact with bacterial DNA, inhibiting replication and preventing bacterial growth. Additionally, Ag ions bind to bacterial cell membranes, causing structural damage and eventual cell death. Meanwhile, fluoride ions play a key role in promoting enamel re-mineralization by forming fluorapatite, which exhibits greater resistance to acid erosion compared to hydroxyapatite. Furthermore, in the presence of calcium and phosphate ions found in saliva, calcium fluoride-like deposits form on the enamel and dentin, serving as long-term fluoride reservoirs. Lastly, the high pH of SDF induces protein denaturation and coagulation within demineralized dentin. These precipitated proteins seal exposed dentinal tubules, providing a protective barrier to safeguard soft dentin and minimize sensitivity.

Recently, lasers have been suggested as a novel approach to prevent dental caries or to augment traditional treatment [1]. The degradation of the organic matrix, loss of carbon and water, and the formation of refractory hydroxyapatite phases, such as calcium phosphate or calcium pyrophosphate are all caused by the heat generated by laser light, which also inhibits cavities development on enamel surfaces. Additionally, it enables the integration of fluoride into the hydroxyapatite matrix when used in conjunction with topical fluoridation. This results in the synthesis of fluorohydroxyapatite and CaF_2 on the enamel surface which serves as a fluoride reservoir to combat dental caries during demineralization [2].

1

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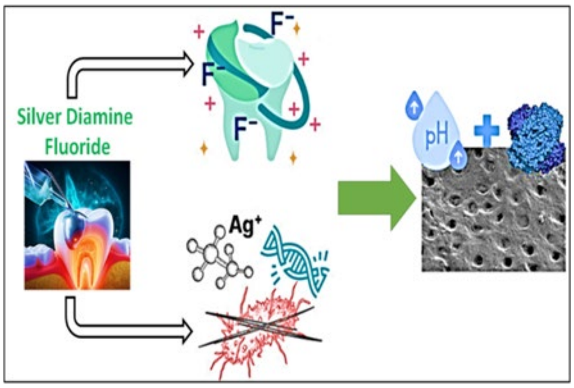

Figure 1. Impact of Fluoride, Silver Nitrate, and Silver Diamine Fluoride on Dental Structures and Bacterial Activity

An active solid component of a diode laser is semiconductor crystals of indium, gallium, as well as arsenide. It emits wavelengths among 800 and 980 nm, which are located in the non-ionizing invisible infrared spectrum. A diode laser's continuous wavelength renders it highly effective for soft tissue surgery. A significant benefit of diode lasers is their compactness and portability [3]. The effects of diode laser application with a λ of 809–960 nm on the enamel surface have been examined in only a few research. This λ is absorbed by the hydroxyapatite of the dental structure at low levels, while the remaining energy is transmitted as heat to the enamel surface and its surrounding structures. Nevertheless, such elevated enamel temperatures may result in significant modifications to its structure and ultrastructure, therefore reducing the enamel's susceptibility to acid dissolution. Such alterations may involve the degradation of its organic matrix, loss of carbonate and water, as well as the formation of acid-resistant hydroxyapatite layers [4]. There was some evidence that utilizing a diode laser in conjunction with sodium fluoride effectively increased the amount of fluoride absorbed by tooth enamel. However, different studies found that enamel-acid solubility was significantly reduced and carious lesion growth was inhibited in vitro [5].

This review seeks to assess the effects of SDF solution and sub-ablative laser irradiation (especially Nd:YAG and Diode Lasers) on fluoride uptake and penetration depth in dentin. It aims to investigate the potential of laser treatment to enhance fluoride absorption and provide additional protection against acid-induced demineralization.

II. Literature Review

1. Laser in promoting dentine fluoride uptake

Lasers have a significant impact on dental tissues due to their ability to modify surface morphology and enhance structural properties. When applied to dentin, laser irradiation can clean the surface by removing the smear layer and opening dentinal tubules, thereby improving permeability and facilitating the penetration of therapeutic agents. Additionally, lasers can induce thermal effects that lead to fusion and re-solidification of dentin, creating a smoother and more compact surface (see **Fig. 2**). This process reduces the susceptibility of dentin to acid attacks and microbial infiltration by sealing exposed tubules and strengthening the surface Sub-ablative laser energy can enhance the uptake of fluoride ions by altering the crystalline structure of dentin, promoting the formation of more stable and acid-resistant compounds, such as fluorapatite. The interaction between laser energy and dental tissues also contributes to protein coagulation and mineral deposition, which aids in protecting the dentin from further demineralization and sensitivity. These effects make lasers a valuable tool for improving the durability and effectiveness of dental treatments.

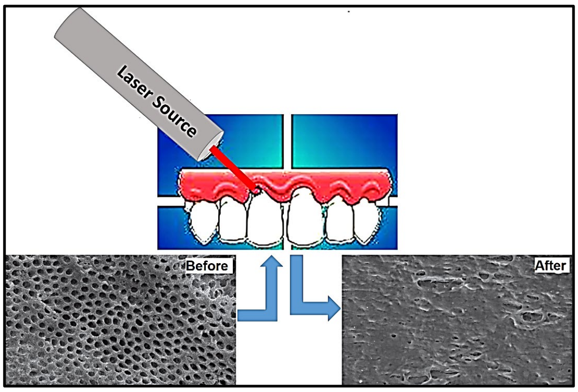

Figure 2. Dentinal surface showing open dentinal tubules and absence of smear layer before laser treatment, followed by dentin fusion and re-solidification after laser irradiation, with no smear layer or debris present

The literature on the use of lasers to improve dentine fluoride uptake is a rich tapestry of studies and findings. Studies have looked into the synergistic effects of laser irradiation, notably with Nd:YAG and diode lasers operating at sub-ablative energy levels, when combined with SDF treatment. These studies have found a possible avenue for increasing fluoride penetration within dentine, thereby strengthening the protective mechanisms against acid attacks. The availability of literature indicates a growing interest in using laser technologies to improve the efficacy of fluoride therapy in dental care, implying a paradigm shift towards more precise and effective techniques to increasing fluoride uptake and reinforcing enamel surfaces. The literature highlights the revolutionary potential of laser-assisted protocols in revolutionizing tactics for enhancing dentine fluoride uptake and advancing preventive dental care practices by synthesizing research findings and clinical insights.

Mei et al., (2014) [6] investigate the preventative effects of Er:YAG laser irradiation in conjunction with SDF therapy on dentine that has been subjected to a cariogenic biofilm challenge. From human third molars that had been extracted and were still intact, 24 dentine slices were created. Each slice was divided into four sections for the application of SDF, which was then followed by EYL irradiation (group SL), EYL irradiation (group L), SDF application (group S), and finally water (group W). There were laser melting traces visible on the specimen surfaces of groups SL and L, and the dentinal orifices were becoming more constricted. The group S showed signs of a partial obstruction of the tubules. Demineralization was identified in group W, which was characterized by a porous surface profile. Based on the findings of the research, it was discovered that the employment of SDF, followed by EYL irradiation on a dentine surface, resulted in an improvement in the latter's resistance to cariogenic biofilm problems.

The effects of carbon dioxide and diode lasers on the absorption of fluoride by primary tooth enamel were compared by Bahrololoomi et al., (2015) [2]. Forty primary molars from humans were divided into four equal groups. The experimental and control groups were formed by removing the roots and dividing the crowns mesiodistally into the buccal as well as lingual halves. Application of 5% sodium fluoride (NaF) varnish was performed on all samples. Fluoride uptake was evaluated by an ion-selective electrode after acid dissolving the specimens, and experimental samples from each of the four groups were compared to the controls after 15 seconds of irradiation with 5 or 7W diode lasers or 1 or 2W CO2 lasers. The conventional topical fluoridation group had significantly lower estimated fluoride uptake values contrasted with the 5W and 7W diodes and 1W and 2W CO2 lasers, correspondingly, which were 59.5± 16.31 ppm, 66.5± 14.9 ppm, 78.6± 12.43 ppm, as well as 90.4± 11.51 ppm. In accordance with the results, fluoride absorption is improved when the enamel surface is exposed to diode lasers and carbon dioxide.

Tosun et al., (2016) [7] compare the effects of using Clinpro® White Varnish (five percent sodium fluoride + tri-calcium phosphate) with and without the use of a Nd:YAG laser on the occlusion potential and dentinal tubule penetration. They randomly divided 75 dentine samples (n = 15) taken from 38 recently extracted human molars. Clinpro varnish was applied to groups A, B, D, and E, with group C serving as the control group that did not receive any therapy. An Nd:YAG laser (1.5 W, 10 Hz, 1 minute) was used to further irradiate groups B and E. Compared to group C, groups A and B had significantly higher tubular occlusion. Group B exhibited noticeably higher tubular occlusion compared to group A. Group D's penetration depth was noticeably greater than group E's. The effectiveness of Clinpro in tubular occlusion was improved by utilizing laser technology as the laser had the opposite effect reducing Clinpro's penetration.

The effectiveness of fluoride varnish in restoring root dentine permeability was investigated by Chiga et al., (2016) [8] utilizing an Er:YAG (100 mJ, 3 Hz) or Nd:YAG (70 mJ, 15 Hz) laser. A total of sixty 2 × 2 × 2-millimeter-thick slabs of bovine root dentine were eroded for two hours in a solution of 0.3% citric acid (pH 3.2) and then immersed in artificial saliva for twenty-four hours. One hundred and ten specimens were randomly assigned to one of six treatments: fluoride varnish alone, fluoride varnish plus Er:YAG laser, fluoride varnish plus Nd:YAG laser, non-fluoride varnish alone, non-fluoride varnish plus Er:YAG laser, and non-fluoride varnish plus Nd:YAG laser. Each of the two types of YAG, Er and Nd, were pulsed for ten seconds at 100 mJ and fifteen Hz, respectively. The permeability of damaged root dentine was greatly reduced by laser irradiation, regardless of the laser source, but the key factor, varnish, had no discernible effect. The results of this study show that Er:YAG and Nd:YAG lasers can control the permeability of damaged root dentine without the need for fluoride varnish.

The effectiveness of Diode (wave length = 980 nm; power = 5 Watt; fluence energy = 53 J/cm2; repetition rate = 16 Hz; for 15 s. A G6 tip, diameter = 600 µm) and Nd-YAG (1064 nm, peak power = 0.6 W, beam spot diameter = 10 µm, fluence= 14J/cm^2) lasers on enamel's acid resistance is assessed by Chand et al., (2016) [9] both separately and in conjunction with acidulated phosphate fluoride (APF) treatment. seventy-two enamel samples from 12 extracted human molars were randomly assigned to one of six groups: (1) Control (C); (2) APF gel exposure (F); (3) Diode laser (DL); (4) Diode laser and APF gel radiation (DL/F); (5) Nd-YAG laser (NL); and (6) Nd-YAG laser and APF gel radiation (NL/F). Group one through six had calcium ion values of 901, 757, 736, 592, 497, and 416 parts per million micrograms per gram on average. In contrast to the other groups, the NL/F group showed significantly less demineralization, according to the data, whereas the control group showed significantly more demineralization. When compared to the other groups, the results showed that Nd-YAG laser irradiation, both by itself and in conjunction with APF, was better in reducing enamel demineralization.

The effects of diode laser at different power densities on dentine permeability and closure of exposed dentinal tubules were investigated by Lutfi et al., (2018) [10] with and without sodium fluoride. One hundred eighteen teeth were utilized. The samples were categorized into three primary groups. The initial set comprised 100 teeth utilized for the permeability test. The second component comprised 16 teeth for assessing the increase in external surface temperature during irradiation. The third component comprised a single pair of teeth examined using SEM for the examination of dentine surface morphology. The measurement of dentine permeability demonstrated a significant difference between the control group and the 2 and 3 W varnish groups. The results indicated that the external surface temperature increase for both the laser-only and laser with varnish groups ranged from 67 to 97.9 °C at 1.6 and 2 W. SEM examination indicated that nearly optimal sealing of tubules was achieved in the 2W varnish group. The study concluded that the simultaneous application of a 940 nm diode laser at 2W with a power density of 809.7 W/cm², in conjunction with sodium fluoride white varnish, significantly enhances the reduction of dentine permeability compared to each therapy administered independently.

In vitro studies on fluoride uptake by dentine were conducted by Al-Hasnawi et al., (2019) [11] using a variety of topical fluoride compounds, including APF, SDF, and stannous fluoride (SnF2), with or without the use of a Nd-YAG laser (1064 nm). For this investigation, 55 maxillary first premolar teeth were used as samples. The teeth were divided into 11 groups, with 5 specimens from each group. A pH cycling approach was used to produce a caries-like lesion in the dentine specimens of all eleven groups for five days before to the surface treatments. The specimens were subsequently immersed in re-mineralization solutions for two days. Following administration of various agents, the results showed that the groups treated with SDF+Laser, SnF2, Laser+SnF2, and Laser+APF had much higher fluoride uptake. Fluoride uptake was much higher in the group that received only SDF. In terms of topical fluoride application, the most effective treatment was SDF applied directly to the dentine surface. SDF alone may give a constant and extended fluoride release and facilitates sustained absorption, whereas laser treatment may speed up initial reactions but inhibit long-term fluoride diffusion. Without laser therapy, fluoride ions from SDF can travel naturally via the dentin tubules. However, laser irradiation may seal or partially block these tubules resulting in decreased ion transfer. While SDF alone increased fluoride uptake, coupled methods with laser still showed considerable benefits, particularly in terms of fluoride retention and antimicrobial properties.

Hendi et al., (2021) [12] evaluate the synergistic effects of silver nanoparticles and a diode laser with a wavelength of 940 nm on Enterococcus faecalis as antibacterial agents. They used rotary files to decoronate and prepare 90 human teeth with one root. There was an irrigation of the samples with sodium hypochlorite and 17% EDTA. After that, they were autoclaved and inoculated with a suspension of E. faecalis (1.5 × 108 CFU/mL) for a duration of 21 days. After micro-titrating the samples, they were randomly assigned to 1of 4 experimental groups (n=20) or a negative control group (n=10). First, 5% sodium hypochlorite; second, silver nanoparticles; third, diode lasers; and fourth, a combination of the two. Following treatments, colony levels dropped significantly across the board.

The colony counts of all groups were significantly lower than those of the negative control group. Group 1 demonstrated a significant decline in colony counts in contrast to the other groups, with an extreme decrease (RCC=100%). When comparing the two groups, the efficiency of the silver nanoparticles group (RCC=83.15%) was much higher than that of the diode laser group (RCC=41/33%). Group 4's RCC was 68%/52%. The most efficient antibacterial chemicals were silver nanoparticles, followed by sodium hypochlorite 5%. The antibacterial effect of the 940 nm laser diode was lower in contrast to its use in conjunction with silver nanoparticles due to the synergistic interaction. The nanoparticles act as plasmonic enhancers which amplify the laser's photothermal and photochemical effects. This results in increased bacterial cell damage unlike the laser's limited efficacy due to insufficient energy.

Hassan et al., (2021) [13] investigate the impact of dental curing light and laser treatments on dentine hardness in primary molars that have developed cavities after being treated with SDF. Thirty removed primary molars with pulpal-free, dentinal-extending caries were used in this in-vitro study. Three groups were formed from the collected teeth at random: group 1: SDF plus sub-ablative low-energy Er,Cr:YSGG laser (The output power = with 0.5 W, 5 Hz, without water cooling, and 55% of air); group 2: SDF plus 40 seconds of curative light; and group 3: SDF alone. All groups utilized 38% Ag (NH3)2F SDF. In comparison to the other two groups, the laser+SDF group had noticeably greater surface hardness of healthy dentine beneath the carious lesion. While photo-polymerization of SDF does raise the surface hardness of healthy dentine beneath the carious lesion, the greatest surface hardness is achieved by sub-ablating dentine with a laser after SDF.

The effectiveness of the 980 nm diode, Nd:YAG, and Er:YAG lasers in conjunction with fluoride for dentinal tubule obstruction is evaluated and compared by Aghayan et al., (2021) [14]. This in vitro investigation utilized twenty healthy, single-rooted human teeth. After preparing the roots, forty dentinal discs were etched with 6% citric acid. Their surface was coated with one coat of fluoride varnish. Each part was divided into four equal groups at random. There was no laser treatment for the control group. Irradiation with a 0.5 W power 980 nm diode laser was performed on Group 2. The third group was exposed to 0.5 W of Nd:YAG laser irradiation, whereas the fourth group was exposed to 0.5 W of Er:YAG laser irradiation. When compared to a control group, all three laser modalities dramatically reduced the amount of open dentinal tubules. In terms of dentinal tubule blockage, none of the three laser groups differed significantly. There was no significant variation between the control group and the three laser groups with respect to the diameter of open tubules.

Atef et al., (2022) [15] investigate microstructural changes and the impact of diode laser (980 nm, 2 W for 15 sec, in a CW and contact modes via 320-μm optical fiber) and two re-mineralizing agent types on the micro-hardness of primary tooth enamel. For this experiment, twenty primary molars were cut in half lengthwise in a mesiodistal direction. The resulting forty specimens were then distributed at random into five groups. None of the five participants in Group 1 (Control Negative) received radiation or any kind of treatment. The second group, the control positive group (n = 5), was subjected to 60 Gy of gamma radiation. Subgroups A and B were created with five specimens each for Groups 3, 4, and 5. Different surface treatments were applied to Subgroup A after gamma irradiation. Treatment 3A involved 10% nano-hydroxyapatite (nHA) paste, treatment 4A involved 5% sodium fluoride varnish (FV), and treatment 5A involved a 980 nm diode laser. A surface treatment of 10% nHA was applied to 3B, 5% FV to 4B, and a diode laser at 980 nm to 5B before gamma irradiation to subgroup B. The mean micro-hardness was lowest in Group 2 (G) specimens, and it was most noticeably greater in nHA-G (3B), G-Fl (4A), and L-G (5B). Group G had a change, and re-mineralizing agents obliterated enamel micropores, according to ESEM study. Enamel subgroups also showed signs of melting and fusing. The results showed that the micro-hardness was increased and the microstructure integrity was maintained while employing FV, nHA, or a diode laser. The inflammatory response, dentinogenesis, silver penetration, pulp cell activity and bacterial presence in the dental pulp are all considered in the systematic analysis of the dental pulp's response to SDF treatment by Zaeneldin et al., (2022) [16]. After conducting a preliminary search, 1,433 publications were identified, five of which met the inclusion criteria. In total, these five publications examined the effects of direct and indirect SDF administration on the essential pulp of 30 teeth. Pulp necrosis was the consequence of the direct application of SDF to vital pulp. The tooth pulp experienced minimal or no inflammatory response as a consequence of the indirect administration of

SDF. Within the dental pulp, the odontoblasts demonstrated increased cellular activity. Tertiary dentine was produced on the pulpal aspect of the cavity as a result of the indirect administration of SDF. Mineralization disruptions were indicated by prominent incremental lines of tertiary dentine. Silver ions were observed to infiltrate the dentinal tubules, but they were not detected within the pulp. Pulp necrosis is the consequence of immediate administration of SDF, as evidenced by the existing literature. The indirect administration of SDF is generally biocompatible with dental pulp tissue, resulting in a moderate inflammatory response, increased odontoblastic activity, in addition to increased tertiary dentine production.

Vazirizadeh et al., (2022) [17] examine the efficacy of a 940 nanometer diode laser, Gluma, and a five percent NaF varnish in the treatment of dentinal tubule occlusion. The enamel of forty healthy human premolars was removed from the buccal surface's cervical midline, with a measurement of 2×2 millimeters in area and 2 millimeters in depth. The samples were divided into four categories: control, 940 nm diode laser, NaF varnish, and Gluma. The samples were subjected to field emission scanning electron microscopy (FE-SEM) analysis subsequent to the interventions. The number of open, fully occluded, as well as semi-occluded dentinal tubules was counted in their totality. The control group (15.03% ± 3.39), those treated with Gluma (74.4 percent), those treated with NaF varnish (61.78% ± 15.25 percent), and those treated with a 940 nm laser (84.01% ± 12.08%) exhibited the highest rates of dentinal tubule occlusion. The rate of the control group was markedly different from that of the groups that received Gluma, NaF varnish, or 940 nm laser treatment. The Gluma group did not exhibit any significant distinctions from the NaF varnish and 940 nm laser groups. The NaF varnish group was significantly more prominent than the 940 nm laser group. The results of this investigation provide evidence in favor of the use of a 940 nm diode laser, 5% NaF varnish, and Gluma for dentinal tubule sealing. The effects of Gluma were comparable to those of the other two modalities; however, the 940-nanometer diode laser had a more significant impact than NaF varnish.

Salem et al., (2022) [18] used SDF or a diode laser to eliminate pathogens in carious lesions with the Hall method to improve its success rate for carious primary molars. Random assignments were made to three equal groups of 159 children, ages 4 to 8: diode laser with Hall technique, SDF with Hall technique, and Hall technique application. Children get together on a regular basis all year round. Findings: At the end of the follow-up, Group I had the lowest clinical and radiographic success rates (88.7% and 86.8%, respectively), while Group III had the highest clinical success rate (94.3 percent), followed by Group II (96.2 percent). However, these differences were not statistically significant. The Hall approach was enhanced in primary teeth by treating carious lesions with SDF or Diode Laser.

Mohsen et al., (2022) [19] investigate the impact of pretreating primary molars with SDF and potassium iodide (SDF + KI) on fluoride absorption in dentine when using resin modified glass ionomer restoration (RMGI). Twenty extracted primary molars were sectioned mesio-distally, resulting in two equivalent halves, totaling forty pieces. Each tooth was positioned in an individual container alongside its two halves. Teeth were subsequently assigned at random to either the control or therapeutic group. The caries was dug in both halves of each tooth. The control group received resin-modified glass ionomer. SDF and potassium iodide were followed with resin-modified glass ionomer in the intervention group. Energy dispersive X-ray analysis measured dentine fluoride % by weight in both groups after two weeks. Following repair implantation, the RMGI control group experienced a considerable rise in fluoride weight percentage, from 0.81±0.47 to 3.49±1.88%. After repair, the SDF + KI intervention group showed a significant increase in fluoride weight % from 0.47±0.44 to 4.14±1.45. In the control group, the mean fluoride weight % (3.49±1.88) was not significantly different from the intervention group (4.14±1.45). The use of SDF and potassium iodide beneath resin-modified glass ionomer restorations does not prevent fluoride absorption into dentine.

The effect of a light-emitting diode (LED) healing light on the extent to which SDF penetrates carious lesions is examined by Crystal et al., (2023) [20]. Twenty-four primary teeth were prepared for treatment within five minutes of extraction based on the number of untreated caries lesions: (1) six subjects were treated with one drop of SDF for one minute, then rinsed with tap water for ten seconds. (2) six subjects were treated with one drop of SDF for ten seconds, then exposed to LED light for twenty seconds (30 seconds total SDF exposure). (3) six subjects were treated with one drop of SDF for ten seconds, then rinsed with tap water for ten seconds. (4) three subjects were left untreated, and (5) three subjects were left untreated but exposed to LED light for twenty seconds. Groups 1 and 2 were statistically comparable to Group 3 and distinct from it. There was no silver present in Groups 4 and 5. Silver penetration appears to be facilitated by the use of LED light for 20 seconds following a 10-second SDF application, which is comparable to a one-minute SDF technique.

Alsherif et al., (2023) [21] compared the anti-cariogenic effects of nano silver fluoride varnish around orthodontic brackets with those of diode laser irradiation. Group I consisted of 20 premolars treated with nano silver fluoride, Group II of 20 premolars treated with diode laser, and Group III of 20 premolars treated with a combination of nano silver fluoride and diode laser. All 60 premolars were free of caries and in good condition. The results of the PLM and SEM analyses showed that there were some demineralized spots in group I. Group II had considerably more demineralization. In Group III, we saw enamel with a very uniform surface. There was a significant distinction between Groups III and I, and a highly significant variance among Groups II and III, according to the elemental analysis. When comparing the shear bond strengths of groups I and II, as well as groups III and II, statistically significant differences were found. There was no statistically significant difference between groups I and III. Dental enamel appeared to benefit from both the diode laser and the nano-silver fluoride, according to the results. After pretreatment with a mix of diode laser irradiation and nano silver fluoride varnish, the enamel criterion showed the maximum improvement.

Alghazali et al., (2023) [22] evaluate the efficacy of a 940 nanometer diode laser at different power levels in addressing dentine hypersensitivity. The desensitizing efficacy of a 10-second continuous mode diode laser at 940 nm was evaluated for the treatment of dentine hypersensitivity in six individuals, including a total of 38 teeth. The laser was applied at two different power levels. A statistically significant reduction in dentine hypersensitivity was found immediately after the initial treatment session and following a 14-day follow-up period. The application of a diode laser (940 nanometer) was found to effectively reduce both acute and chronic dentine hypersensitivity discomfort.

The effects of SDF, APF, LASER-activated SDF, and LASER-activated APF on the surface of the enamel are studied and compared by Singh et al., (2023) [23]. The sample was made up of seventy-two non-corrupt, normal human premolar teeth that had recently been extracted for orthodontic reasons. Group 1 consisted of SDF, Group 2 of APF, Group 3 of LASER-activated SDF, and Group 4 of LASER-activated APF were the four groups into which the selected samples were randomly assigned (n = 18). Following demineralization and re-mineralization, all samples were evaluated for DIAGNOdent values. Spectrophotometry, Scanning Electron Microscopy, and Energy Dispersive X-ray Spectrometry were used to further classify and analyze the samples for color variations, surface alterations, and fluoride concentration in the surface enamel, respectively. The third group showed the most noticeable changes in surface enamel color and the highest re-mineralizing capacity. At magnifications of 2000× and 5000×, Scanning Electron Micrographs from Groups 3 and 4 showed consistent globular structures of enamel, whereas Groups 1 and 2 showed uneven globular surfaces of enamel. The surface enamel fluoride absorption was highest in Group 4, followed by Group 3. They found that topical fluorides triggered by lasers help prevent cavities more effectively. Because it shows better fluoride absorption on the enamel surface without discoloration, LASER activated APF is an appealing substitute to SDF.

Cifuentes-Jiménez et al., (2023) [24] assess the demineralizing capacity of SDF/NaF products by analyzing the physicochemical and mechanical properties of the treated dentine surfaces, and (2) determine the effects of SDF and NaF on demineralized dentine subjected to acid challenge through pH-cycling. There were three phases to the experiment that involved 57 human molars: the first was a negative control using sound dentine; the second was a positive control utilizing demineralized dentin; and the third was a dentine treatment using SDF/NaF products + pH-c. The dentine + pH-c groups treated with SDF/NaF (Stage 3) had a larger mineral/organic content compared to the positive control groups, indicating a change in chemical composition. In comparison to the positive control, the XRD data demonstrated that the hydroxyapatite crystallite size increased in the SDF/NaF treated dentin + pH-c groups, ranging from +63% in RivaStar to +108% in Saforide. Images captured by scanning electron microscopy revealed the formation of a crystalline precipitate on the dentine surface and partial filling of the dentine tubules following the administration of the SDF/NaF products. Stage 3 dentine treated with SDF/NaF + pH-c had higher flexural strength (MPa) values than the positive control groups. Demineralized dentine's physicochemical and mechanical characteristics were impacted by the application of SDF/NaF. The results showed that even when exposed to acid, the dentine surface exhibited a re-mineralizing action after utilizing SFD/NaF. In order to determine whether or not APF is necessary to prevent dentine hypersensitivity after an erosive challenge, Corrêa et al., (2024) [25] evaluate the effectiveness of Er:YAG and Nd:YAG lasers. The following thirteen groups were formed from the 104 samples taken from bovine dentine: All eight groups were treated in the same way: G1 with Er:YAG, G2 with Er:YAG and APF, G3 with APF and Er:YAG simultaneously, G4 with Nd:YAG, G5 with Nd:YAG and APF, G6 with APF and Nd:YAG simultaneously, G7 with APF, and G8 without treatment. For the Er:YAG experiment, the following parameters were used: 10 seconds, 4 mm distance, 2 mL/min water cooling flow, 2 Hz frequency, and 3.92 J/cm² energy density. 10 seconds at a distance of 1 millimeter without cooling, 10 Hz, and 70.7 J/cm² were measured for Nd:YAG. In terms of roughness, there was no discernible difference across the categories. The groups that were exposed to Er:YAG radiation showed less fluid loss. Values for G6 were higher than those of the Er:YAG irradiation groups but lower than all of the others. Wear results in the other Nd:YAG-exposed groups were similar to those in the control group. Wear investigation showed that the Er:YAG laser caused the least amount of volume loss, which means that dentine is more resistant to acid.

The effects of Er,Cr:YSGG irradiation and 980 nm diode lasers on dentine surface roughness and volumetric loss under cariogenic stress are examined by Guarato et al., (2024) [26]. Thirteen categories were created from 130 bovine dentine specimens: no medical intervention; FG: fluoride gel; FV: fluoride varnish; Di: diode laser operating at 980 nm; Di + FG; Di + FV; FG + Di; FV + Di; Er: Er,Cr:YSGG laser; Er + FG; Er + FV; FG + Er; FV + Er The Er,Cr:YSGG laser settings were as follows: Without water and with 55% air, 0.25 W, 5.0 Hz, and 4.46 J/cm². The 980 nm diode laser's specifications were 2.0 W, 2.0 Hz, and 21.41 J/cm². The samples in each group were pH-cycled. The cariogenic challenge and 1807-3107-bor-38-e025 therapy did not cause a statistically significant response in the reference area's SR. VL in the FV + Er and FV + Di groups differed considerably from regions exposed to different cariogenic stimuli and treatment regimens. When bovine teeth were subjected to cariogenic stress, dentine susceptibility to lesions was decreased by fluoride varnishes, Er,Cr:YSGG, and 980 nm diode lasers.

2. Potential limitations of laser-assisted fluoride techniques

One of the key concerns of laser-assisted fluoride procedures is the cost of implementing laser technologies into dental practices which may pose financial hurdles for practitioners and impede the general acceptance of these advanced treatments [27]. Furthermore, the availability of laser equipment and the necessary training for dental professionals to use these technologies are substantial impediments to deployment, especially in small practices in areas with limited accessibility [28]. In addition, laser-assisted fluoride treatments in dental care may pose potential hazards. One significant concern is thermal injury to surrounding tissues during laser treatments, which can occur if laser energy levels are not carefully managed or suitable cooling systems are not in operation [29]. This heat degradation may cause discomfort for individuals and damage the integrity of adjacent tooth structures. Furthermore, there is a possibility of inadvertently exposing the patient's eyes or skin to laser radiation, highlighting the significance of rigid safety regulations and preventive measures to prevent any harmful consequences [30].

III. Conclusion

Combining SDF treatment with sub-ablative energy laser technologies such as Nd:YAG and Diode lasers offers a convincing way to improve fluoride absorption in dentine. Our analysis highlights the great potential of laser-assisted methods to increase fluoride's protective benefits, especially in enhancing enamel's resistance to acid erosion. These results underline the critical role that lasers play in boosting the effectiveness of fluoride therapy and point to a significant change in preventive dental care. Future developments indicate that the use of laser-assisted SDF therapies has the potential to revolutionize current dental caries prevention techniques and herald in a new era of accurate and successful oral health interventions.

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