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Evaluation of various laser irradiations on the dentin tissue permeability

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Abstract--Background: Dental tissue that has been irradiated with a laser undergoes morphological and chemical changes. Because the magnitude of these changes is influenced by the absorption qualities of the tissue, it is possible that these alterations will vary depending on the kind of laser used and the dental tissue. Objective: The purpose of this research was to evaluate the mineral content of dentin irradiated with CO₂ 10600nm, Diode 980nm and Er:Cr: YSGG 2780nm. Material and method: One hundred extracted molars were utilised for the study, and the samples were split into five groups. Next, the enamel was scraped from the dentin surface using a standard bur while abundant coolant was applied. A low-speed diamond stone was used to prepare the teeth, resulting in the creation of two slabs for each tooth. The dentine of samples were irradiated to .5 watt of co₂, diode, Er:Cr: YSGG lasers with nano ZnO-HA and without. Calcium (Ca) and phosphorous (P) were measured and analysed using a Scanning Electron Microscope (SEM) in conjunction with Energy Dispersive X-ray (EDX). The data were analysed using One-way ANOVA, and then the Tukey post-hoc test was used in order to compare more than two groups within samples that were not related to one another in any manner. Results: the most effective laser on closure of dentinal tubules was Er: Cr: YSGG and the worst was ZnO-HA. ZnO-HA had improved the action of CO₂ laser by increasing the closure of dentinal tubules. But worsen the action of diode and Er:Cr: YSGG laser by decreasing the closure of dentinal tubules . The different types of lasers owe different effects on the patency of dentinal tubules and therefore, affect the permeability of dentin to various stimuli. The highest calcium and phosphorous weight ratio were in (Diode and Nanoparticles) group and the lowest calcium and phosphorous weight ratio were in (CO₂) group. Some lasers have

melting effects on peritubular dentin that alter organic to inorganic ratio and occlude dentinal tubules. Conclusion: We can conclude that the three types of laser induced different aspects of morphological alterations on dentine surfaces with and without Nano-particles of all teeth irradiated. These evident alterations on the surfaces of dentine of teeth irradiated with CO₂, Diode and Er: Cr: YSGG lasers , can suggest extrapolation for certain dental clinic.

Keywords--Laser irradiation, Dentine Tissue, Tooth sensitivity

Introduction

When dental tissue is irradiated with a laser, it causes morphological and chemical changes in the tissue. Because the absorption qualities of the tissue affect the magnitude of these changes, it is anticipated that these modifications will differ based on the kind of laser and dental tissue that is used. (1) Tooth sensitivity, also known as dentinal hypersensitivity, is one of the most frequent dental illnesses. Dentinal hypersensitivity is another term for tooth sensitivity. Dentinal hypersensitivity is another term that may be used to describe this disorder. It was discovered that dentin hypersensitivity manifested itself as a sudden and excruciating pain that was brought on by exposed dentin in response to a variety of stimuli, including those related to temperature, evaporation, touch, osmosis, electricity, and chemicals. (2) One of the hallmarks of dentinal hypersensitivity is an exaggerated response to sensory stimuli that under normal circumstances would not prompt a reaction in a tooth that is otherwise healthy and normal. Dentinal hypersensitivity demonstrates this quality in addition to its other characteristics. It's possible that DH may produce chronic discomfort, which might make it difficult to eat, drink, or breathe (3). The bulk of therapies for DH centre on covering up visible dentinal tubules in the affected teeth. However, none of these therapies have demonstrated results that are dependable in terms of their efficacy or that last for a considerable amount of time. (4) It has been demonstrated that a number of different substances, such as potassium oxalate, sodium fluoride, calcium phosphate, varnishes, cements, adhesive materials, and lasers, are capable of occluding dentinal tubules. Other substances that are capable of doing this include fluoride, calcium phosphate, and potassium. Lasers are one of these chemicals and tools that are included. Over the last several years, there has been a rise in the prevalence of the usage of laser technology, and many dental and Medicare applications for lasers have been proposed (5).

The first study to investigate the effectiveness of laser therapy in the management of DH was carried out by Mastomoto et al. (6). The area of dentistry makes use of a wide variety of lasers, some of which include carbon dioxide lasers, neodymium yttrium aluminium garnet lasers, diode lasers, and Erbium yttrium aluminium garnet lasers, amongst others. Because the light emitted by an Er:YAG laser has a wavelength of 2940 nm and is strongly absorbed by water but only moderately absorbed by hydroxyapatite, it is possible to cut by ablation using an Er:YAG laser. This is due to the fact that water strongly absorbs the light while

hydroxyapatite only moderately absorbs the light. This procedure includes the water droplets in the enamel sucking up the laser energy, which finally leads to a micro-expansion of the water and the expulsion of the hard tissues. (7,8). The treatment of DH using an Er:YAG laser may be very effective in lowering the diameter of the dentinal tubule, and it can even destroy the tubule below the ablation threshold in some situations (9). The components of dentin, both organic and inorganic, are used to determine its make-up in terms of their relative proportions. Calcium (Ca) and phosphorous (P) are the principal inorganic components of tooth hard tissue. [Ca] and [P] stand for calcium and phosphorous, respectively. Crystals of hydroxyapatite have been discovered to contain both of these elements. The calcium to phosphorous mineral ratio [Ca/P] of hydroxyapatite in dentin was discovered to be almost 1.67, which means that the fundamental makeup of the tooth hard tissue surface is calcium and phosphorous. This ratio may change based on the kind of crystal, the amount of Ca that is readily available, the anatomical location, and the method that is used to determine it. Nearly 1.67 calcium atoms for every 1 phosphorus atom may be found in dentin. (9). In addition to generating a change in the chemical structure of dentine, it has been found that a particular chemical agent also produces a change in the ratio of calcium to phosphorus on the surface of the dentine (9). Because of fluctuations in the Ca/P mineral ratio, dentin's permeability and solubility may be changed. These shifts, in turn, might create changes in the original ratio between organic and inorganic components. (9) In the oral cavity, CO₂ lasers are utilised to conduct procedures on soft tissues. (10) The therapy may lead to interactions between the laser and radiation, as well as the teeth. CO₂ laser light has the potential to cause damage to dentine, which is often exposed in the cervical area of the teeth. This tissue may be harmed even after the light has passed through the enamel and the enamel dentine junction (11). CO₂ lasers are a kind of therapy that is utilised for DH (12).

Irradiation of dental hard tissues with an infrared laser results in changes that are both chemical and morphological in nature. The degree to which these alterations take place is determined by the absorption capabilities of the dental tissues; hence, the nature of the modifications will most likely differ depending on the kind of dental tissue. The reactions of the dental tissues to the laser irradiation are impacted by the parameters of the laser (namely, the laser wavelength, pulse energy, repetition rate, and irradiation period), as well as by the optical characteristics of the dental tissues themselves (13).

Any material with a size that is less than 100 nanometers is referred to as "Hydroxy Apatite Nano Particles" (HANP), and this word is abbreviated as "HANP" (nm). In addition, HANP may be classified as a member of the family of compounds known as calcium phosphates. Both igneous and metamorphic rock types may include naturally occurring HA since it is a mineral that may be found in nature. In addition to this, it is the most important component of the inorganic structure that makes up bones and teeth. Hydroxyapatite (HA or HAP) of either a synthetic or a biological (produced from coral, bovine, or marine algae) origin is being used for the purposes of bone repair and bone regeneration (14, 15, 16).

Therefore, the purpose of this research was to determine, via the use of energy dispersive spectroscopy, how the CO₂, diode, and Er: Cr: YSGG lasers affected the chemical composition of hard tissues as well as the morphological changes that occurred in those tissues (EDX).

Materials and methods

Students at the faculty of oral and dental medicine performed surgery to remove one hundred molars from patients with periodontal disease in order to improve their oral health. Following an examination, it was discovered that the teeth exhibited no signs of restorations, caries, fractures, or attrition. The samples were sterilized using gauze and a fine brush as soon as the extraction procedure was finished. After that, they were encased in distilled water and stored at room temperature until they were needed. After being divided into their respective geogroups, each of the hundred and fifty samples received twenty of its own. First, the enamel on the teeth was removed with a normal bur while the region was kept cool with water in order to expose the superficial dentin surface. After that, the dentin surface was exposed. Dentin slabs with a thickness of 0.7 millimetres were created by cutting the occlusal third of the crown using a slow-speed diamond saw section machine that was immersed in cooling water. This allowed for the dentin to remain intact throughout the cutting process. The incisions were made in a path that was perpendicular to the long axis of the tooth while it was being reshaped. Two dentin slabs were taken from the same tooth during the extraction process. Dentine slabs were divided up and given to each of the four groups in such a way that they each received two slabs of dentine.

The following is an outline of the therapy groups:

Group (I) (control): To produce the group's samples, an ethylene diamine tetraacetic ethylenediaminetetraacetic EDTA gel was used. (**Fig. 1**) for removal of smear layer and simulating hypersensitivity. The samples were washed with distilled water and dried.



Figure (1): Showing application of 17% EDTA

Group (II): The samples of the group were prepared using Ethelyne Diamine Tetra Acetic EDTA gel (**Fig. 1**) for removal of smear layer and simulating hypersensitivity. The samples were then dried after being cleaned with distilled water. The group divided into sub groups (ten samples for each): **Group IIa:** (n=1) apply EDTA 17% and rinse + ZnO HA + CO₂10600nm. **Group IIb:** (n=1) apply EDTA 17% and rinse + CO₂. **Group (III):** The samples of the group were prepared using Ethelyne Diamine Tetra Acetic EDTA gel (**Fig. 1**) for removal of smear layer and simulating hypersensitivity. The samples were then dried after being cleaned with distilled water. The group divided into sub groups (ten samples for each): **Group IIIa:** (n=1) apply EDTA 17% and rinse + ZnO HA + Er: Cr: YSGG2780nm. **Group IIIb:** (n=1) apply EDTA 17% and rinse + Er: Cr: YSGG2780nm. **Group (IV):** The samples of the group were prepared using Ethelyne Diamine Tetra Acetic EDTA gel (**Fig. 1**) for removal of smear layer and simulating hypersensitivity. The samples were then dried after being cleaned with distilled water. The group divided into sub groups (ten samples for each): **Group IVa:** (n=1) apply EDTA 17% and rinse + ZnO HA + Diode 980nm. **Group IV b:** (n=1) apply EDTA 17% and rinse + Diode 980 nm. **Group (V):** The samples of the group were prepared using Ethelyne Diamine Tetra Acetic EDTA gel (fig.1) for removal of smear layer and simulating hypersensitivity. The samples were then dried after being cleaned with distilled water. **V:** (n=1) apply EDTA 17% and rinse + ZnO HA

Table (1): Properties: Hydroxyapatite Nanoparticles

No.	Parameter	resilts
1	Appearance	Color
		White
		form
		powder
2	Solubility	Suspension in water/ ethanol
3	Size(D, nm)	100±30nm(L), 20±5nm(D)
4	Shape	Rod Like-Shape
5	Expiration Date	8/2023

Table (2): Properties: Zinc Oxide Nanoparticles

Appearance (color)	White
Appearance (form)	Powder
Solubility	Dispersed in water and suspension in ethanol /Mehanol
Avg.Size(TEM)	30±5nm

Shape(TEM)	Spherical like shape
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Data written on devices
Diode laser 980nm

Class 4 laser product, with maximum energy 25 W. continuous mode. Aiming beam Class 3R Diode Laser 4mW@635nm standard CEI-EN 60825: 2003-02 .Diode will be used as scanning, non-contact to cover more surface area. The power will be set as 1.5W because of the fiber optic delivery system is 1mm diameter and it should be 320 μ m. Exposure time will be 5 seconds on and 5 off to be repeated three times.



Figure (2): Showing perpendicular Application of diode980 hand piece



Figure (3): showing diode 980 screen with P=1.5 W

CO₂ laser 10600nm: Class 4 invisible laser. Maximum power at 10.6 μ m =30W. Maximum pulse length = 80ms. Maximum pilot laser power at 630 ÷ 670nm=5mW. Classified by IEC60825-1(2007-03). CO₂ will be used as scanning, non-contact to cover more surface area. The power will be set as 0.5W. Exposure time will be 5 seconds on and 5 off to be repeated three times.



Figure (4): showing CO₂ 10600 screen with P=0.5W



Figure (5): Showing perpendicular application of CO₂ 10600

Er:Cr:YSGG laser 2780 nm: Class 4 laser product. Wavelength = 2.78 μ m. Pulse rate = 5-100Hz. Pulse energy=600mJ. Pulse width =60 μ s/700 μ s. aiming beam is 1mW Max. C.W. @ 525-670nm. IEC 60825-1:2007. IEC 60601-2-22:2007. Er:Cr:YSGG will be used as scanning, non-contact to cover more surface area. The power will be set as 0.5W. The air spray = 100mL/min. The water spray = 100mL/min. Pulse frequency= 20Hz. Exposure time will be 5 seconds on and 5 off to be repeated three times.

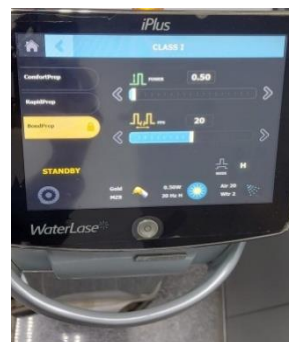


Figure (6): Showing Er:Cr:YSGG 2780 screen with p=0.5W and frequency=20Hz



Figure (7): Showing perpendicular application of Er:Cr:YSGG 2780

By using **Scanning Electron Microscope (SEM)** and **Energy Dispersive X-ray (EDX)** to identify diameters of dentinal tubules. The later to identify percentage of elements inside the tooth.

The first creates images by scanning the sample with high energy beam of electrons. The last used for analyzing the elemental and quantitative composition of solid surfaces.

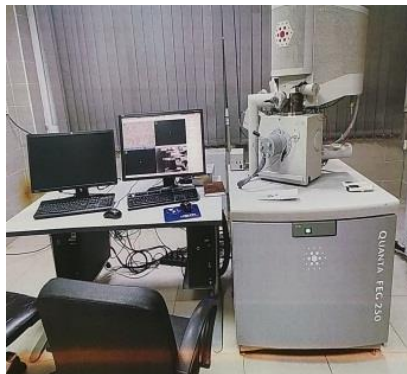


Figure (8): Showing Scanning Electron Microscope (SEM)

The Olley Classification System is what we use (17). No occlusion equals zero percent, mostly unoccluded equals zero to twenty-five percent of occluded tubules, partially occluded equals twenty-five to fifty percent of occluded tubules, mostly occluded equals fifty to one hundred percent of occluded tubules, and occluded equals one hundred percent of occluded tubules.

Done by calculating the oclusal dentinal tubules divided by the total number of tubules in the slice. Then, multiply it by 100 (17).

The IBM® SPSS® Statistics Version 20 for Windows software was used to carry out the statistical analysis.

Results

The study group consists of 226 males (55.9%) and 178 females (44.1%). Mean age of cases was 61.7 ± 12.5 years and range from 24 to 93 years. Table (1)

Table (3):

Olley Classification System⁽¹⁷⁾	
Control	No occlusion
CO2	Mostly occluded
Diode	Mostly occluded
Er:Cr:YSGG	Occluded
Er:Cr:YSGG + nanoparticles	Mostly occluded
Nanoparticles	Partially occluded
CO ₂ + nanoparticles	Partially occluded
Diode+ nanoparticles	Mostly occluded

Er:Cr:YSGG showing average diameter of: 0.418 μ m

CO₂+ZnO-HA showing average diameter of: 0.716 μ m

Diode showing average diameter of: 0.88 μ m

CO₂ showing average diameter of: 1.030 μ m

Diode+ZnO-HA showing average diameter of: 1.0366 μ m

Er:Cr:YSGG+ZnO-HA showing average diameter of: 1.384 μ m

ZnO-HA showing average diameter of: 2.037 μ m

Control showing average diameter of: 2.136 μ m

The most effective laser on closure of dentinal tubules is Er:Cr:YSGG and the worst is ZnO-HA.

ZnO-HA has improved the action of CO₂ laser. But worsen the action of diode and Er:Cr:YSGG.

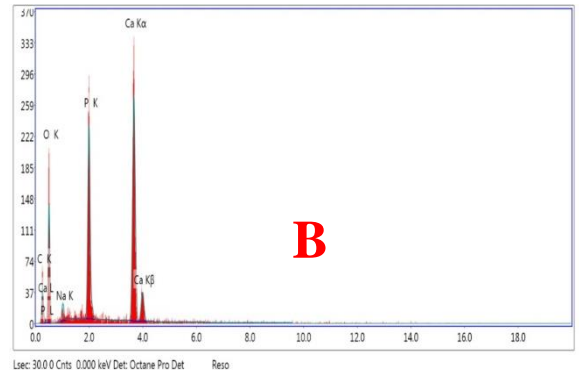
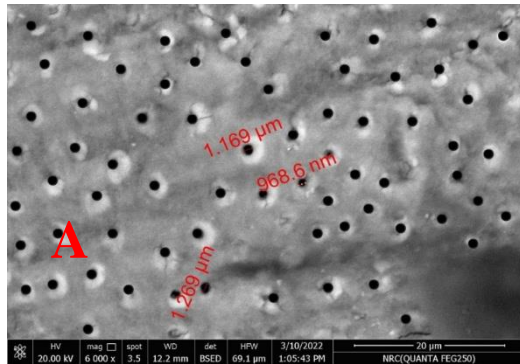


Figure 9: A) Showing cross sectional image of molar tooth by (SEM) with no occlusion of dentinal tubules of control group B) showing (EDX) with Ca weight 25.14 and P weight 12.3

Element	Weight %	Atomic %	Net Int.	Error %
C K	15.77	25.17	9.36	16.11
O K	44.43	53.23	36.71	13.18
NaK	2.36	1.96	5.52	20.88
P K	12.3	7.61	76.73	5.14
CaK	25.14	12.03	108.61	3.59

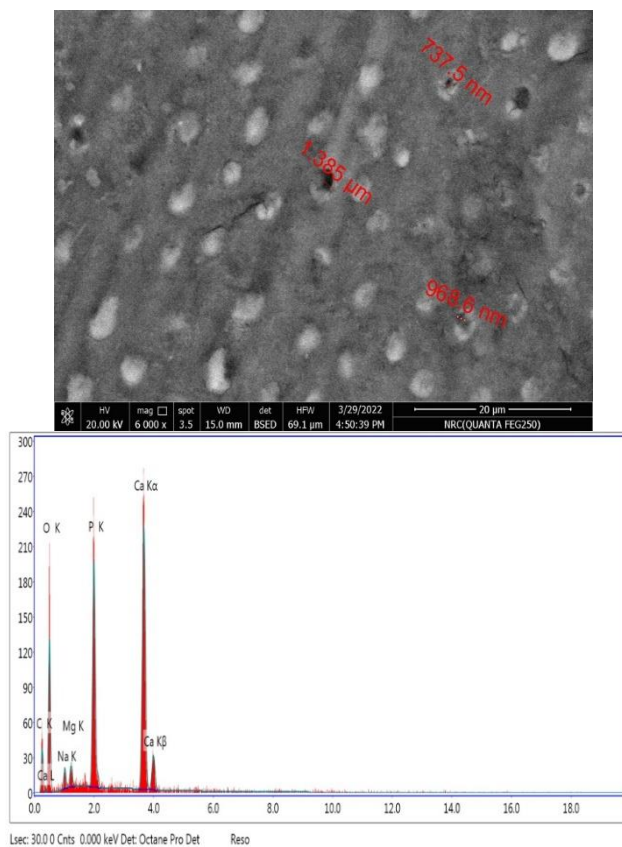
A**B**

Figure 10: A) showing cross sectional image of molar tooth by (SEM) with mostly occluded dentinal tubules of CO₂ group B) showing (EDX) with Ca weight 24.02 and P weight 11.97

Element	Weight %	Atomic %	Net Int.	Error %
C K	15.01	23.97	7.72	16.75
O K	44.79	53.69	33.99	13.25
NaK	2.48	2.07	5.22	21.25
MgK	1.73	1.36	6.72	18.04
P K	11.97	7.41	65.32	5.44
CaK	24.02	11.5	91.85	3.84

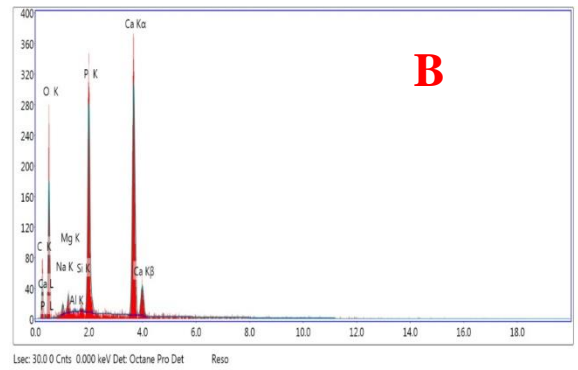
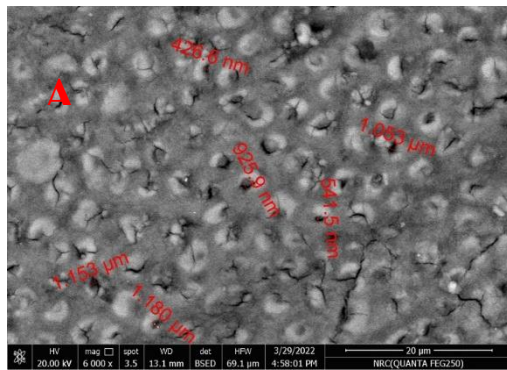


Figure 11: A) showing cross sectional image of molar tooth by (SEM) with mostly occluded dentinal tubules of Diode group B) showing (EDX) with Ca weight 23.53 and P weight 12.26

Element	Weight %	Atomic %	Net Int.	Error %
C K	15.81	25.07	11.09	15.52
O K	44.93	53.49	46.86	12.47
NaK	1.43	1.19	4.15	26.32
MgK	1.39	1.09	7.57	21.18
P K	0.21	0.14	1.42	70.84
SiK	0.44	0.3	3.7	40.06
CaK	12.26	7.54	92.36	5.04
CaK	23.53	11.18	123.95	3.49

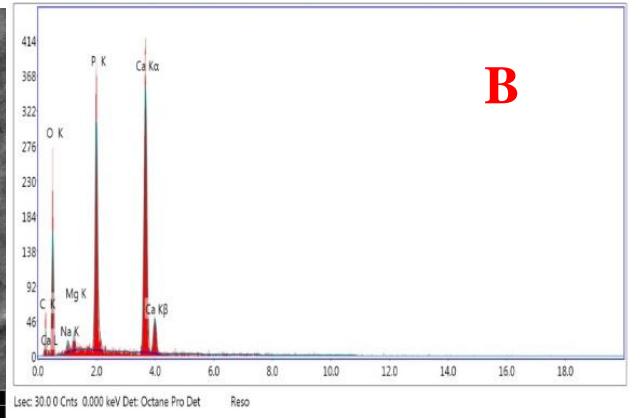
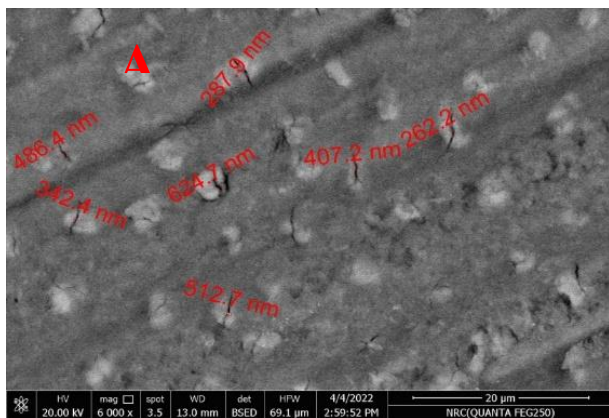


Figure 12: A) showing cross sectional image of molar tooth by (SEM) with all occluded dentinal tubules of Er:Cr:YSGG B) showing (EDX) with Ca weight 28.05 and P weight 13.94

Element	Weight %	Atomic %	Net Int.	Error %
C K	10.47	17.69	6.71	18.09
O K	44.41	56.3	42.79	12.67
NaK	1.71	1.51	4.7	25.81
MgK	1.42	1.18	7.34	21.29
P K	13.94	9.13	101.57	4.98
CaK	28.05	14.19	142.23	3.36

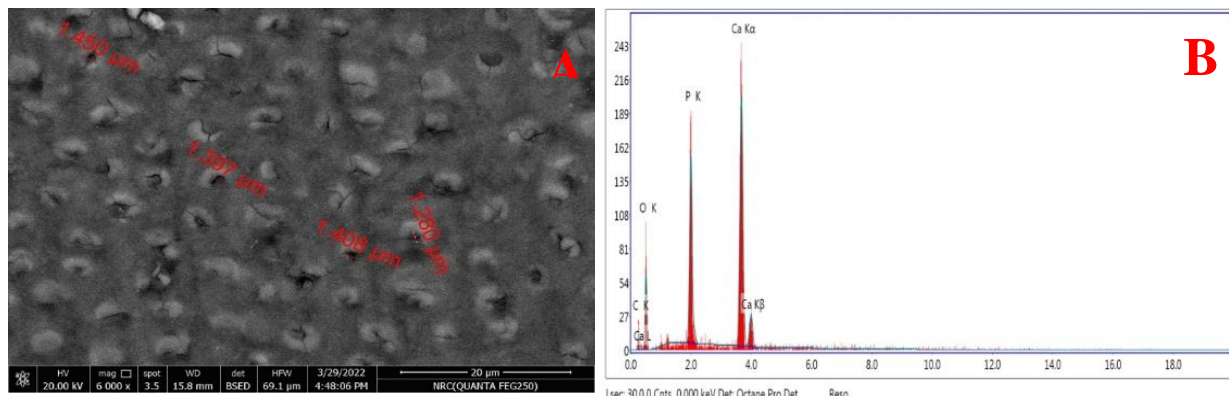


Figure 13: A) showing cross sectional image of molar tooth by (SEM) with mostly occluded dentinal tubules of Er:Cr:YSGG +ZnO HA group B) showing (EDX) with Ca weight 35.26 and P weight 14.95

Element	Weight %	Atomic %	Net Int.	Error %
C K	9.15	16.33	2.7	24.6
O K	40.64	54.46	15.49	15.87
P K	14.95	10.35	50.62	6.23
CaK	35.26	18.86	81.63	4.12

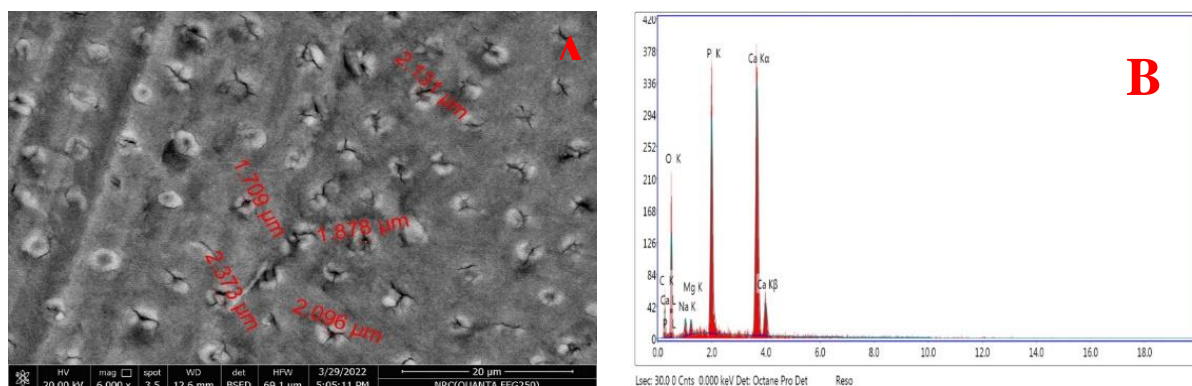


Figure 14: A) showing cross sectional image of molar tooth by (SEM) with partially occluded dentinal tubules of ZnOHA group B) showing (EDX) with Ca weight 28.83 and P weight 14.05.

Element	Weight %	Atomic %	Net Int.	Error %
C K	12.07	20.37	7.21	17.88
O K	41.86	53.07	35.95	13.3
NaK	2.16	1.9	5.57	23.09
MgK	1.04	0.86	4.99	25.37
P K	14.05	9.2	95.41	5.03
CaK	28.83	14.59	135.76	3.4

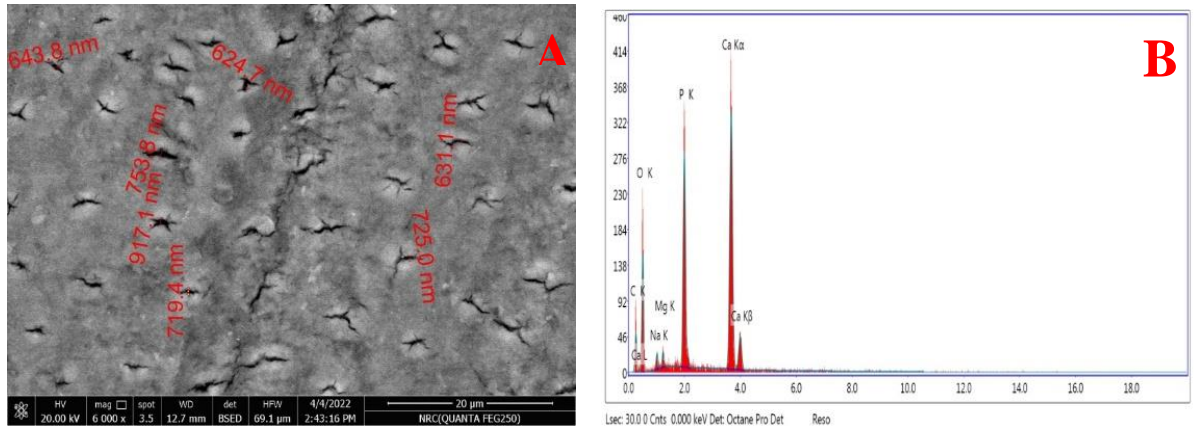


Figure 15: A) showing cross sectional image of molar tooth by (SEM) with partially occluded dentinal tubules of CO₂+ZnOHA group B) showing (EDX) with Ca weight 26.59 and P weight 12.69

Element	Weight %	Atomic %	Net Int.	Error %
C K	15.72	25.5	10.75	15.65
O K	41.9	51.02	39.35	13.14
NaK	1.99	1.68	5.58	23.01
MgK	1.11	0.89	5.83	22.18
P K	12.69	7.98	93.33	4.99
CaK	26.59	12.92	135.7	3.34

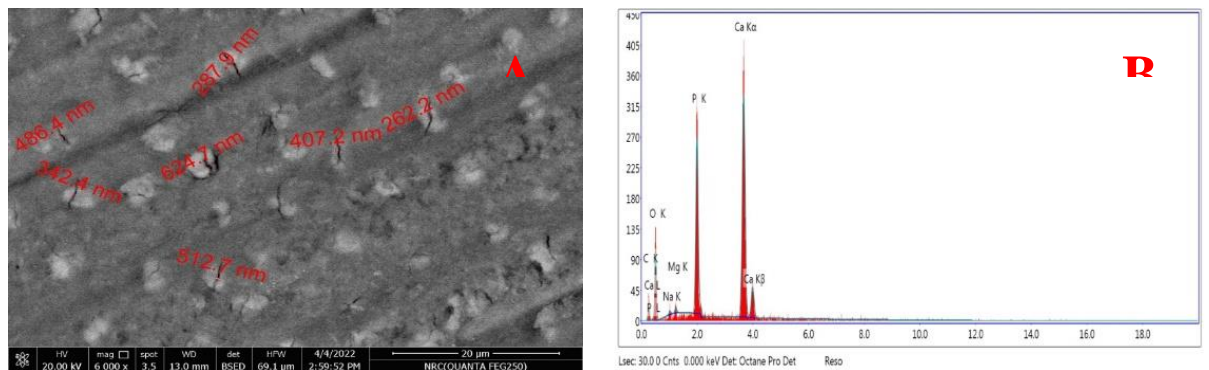


Figure 16: A) showing cross sectional image of molar tooth by (SEM) with mostly occluded dentinal tubules of Diode+znOHA group B) showing (EDX) with Ca weight 33.77 and P weight 15.27

Element	Weight %	Atomic %	Net Int.	Error %
C K	10.06	17.86	4.89	20.06
O K	39.01	51.96	25.59	14.04
NaK	1.17	1.08	2.49	43.2
MgK	0.72	0.63	2.9	46.89
P K	15.27	10.51	87.23	5.08
CaK	33.77	17.96	132.59	3.52

Statistical Results of Energy Dispersive X-ray (EDX)

The mean and standard deviation of the data for each group's data were computed and published in each experiment. Using the Kolmogorov-Smirnov and Shapiro-Wilk procedures, the data were investigated to determine whether they followed a normal distribution, and the results revealed that the data followed a parametric distribution (normal).

When comparing more than two groups using independent samples, a one-way analysis of variance (ANOVA) was performed first, followed by a Tukey post-hoc test. The statistical significance level was selected to be P less than 0.05. The software utilised for the statistical analysis was IBM® SPSS® Statistics Version 20 for Windows.

I- Calcium:

(CO₂), (Control), (Diode), (Er:Cr;YSGG), (Er:Cr;YSGG and Nano), (CO₂ and Nano), (Nano) and (Diode and Nano) all had a statistically significant difference at ($p < 0.001$).

Where ($p = 0.647$) was established, there was no statistically significant difference between (CO₂) and any of the (Control) and (Diode) groups and ($p = 0.997$), while a statistically significant difference was found between (CO₂) and each of (Er:Cr;YSGG), (Er:Cr;YSGG and Nano), (CO₂ and Nano), (Nano) and (Diode and Nano) where ($p = 0.014$), ($p < 0.001$), ($p = 0.002$), ($p < 0.001$) and ($p < 0.001$).

No statistically significant difference was found between (Control) and each of (Diode), (Er:Cr;YSGG) and (CO₂ and Nano) groups where the p values were respectively ($p = 0.948$), ($p = 0.316$), and ($p = 0.061$), whereas a statistically significant difference was detected between the Control group and each of (Er:Cr;YSGG and Nano), (Nano), and (Diode and Nano) where the p value was (< 0.001).

(Diode) was found to have a statistically significant difference from each of (Er:Cr;YSGG), (Er:Cr;YSGG and Nano), (CO₂ and Nano), (Nano), and (Diode and Nano) where ($p = 0.045$), ($p < 0.001$), ($p = 0.007$), and ($p < 0.001$) respectively.

Also a statistically significant difference was found between (Er:Cr;YSGG) and each of (Er:Cr;YSGG and Nano), (Nano) and (Diode and Nano) where ($p < 0.001$), ($p = 0.046$) and ($p < 0.001$). While ($p = 0.971$) indicates that there is not a statistically significant difference identified between the groups (Er:Cr;YSGG) and (CO₂ and Nano).

It was discovered that there is a statistically significant difference between (Er:Cr;YSGG and Nano) and both (CO₂ and Nano) and (Er:Cr;YSGG and Nano) (Nano) where the p -values were ($p < 0.001$) and ($p = 0.027$), respectively. On the other hand, there was found to be no statistically significant difference between (Er:Cr;YSGG and Nano) and (Diode and Nano) where the p -value was (0.995).

It was discovered that there was not a statistically significant difference between (CO₂ and Nano) and (Nano), where the value of ($p = 0.253$). On the other hand, it was discovered that there was a statistically significant difference between (CO₂ and Nano) and (Diode and Nano), where the value was ($p < 0.001$).

A statistically significant difference was found between (Nano) and (Diode and Nano) where ($p = 0.007$).

The area had the highest mean value overall (Diode and Nano), while the least mean value was found in (CO₂).

Table (4): The mean, standard deviation (SD) values of calcium of different groups

Variables	Calcium	
	Mean	SD
CO ₂	22.67 ^d	1.47
Control	24.35 ^{cd}	0.72
Diode	23.30 ^d	0.86
ErCr	26.60 ^c	1.27
ErCr and Nano	33.53 ^a	1.83
CO ₂ and Nano	27.53 ^{bc}	0.82
Nano	29.93 ^b	1.14
Diode and Nano	34.21 ^a	0.69
p-value	<0.001*	

*; significant at ($p < 0.05$) ns; nonsignificant at ($p > 0.05$)

Significant differences are shown by the presence of means with different letters in the same column.

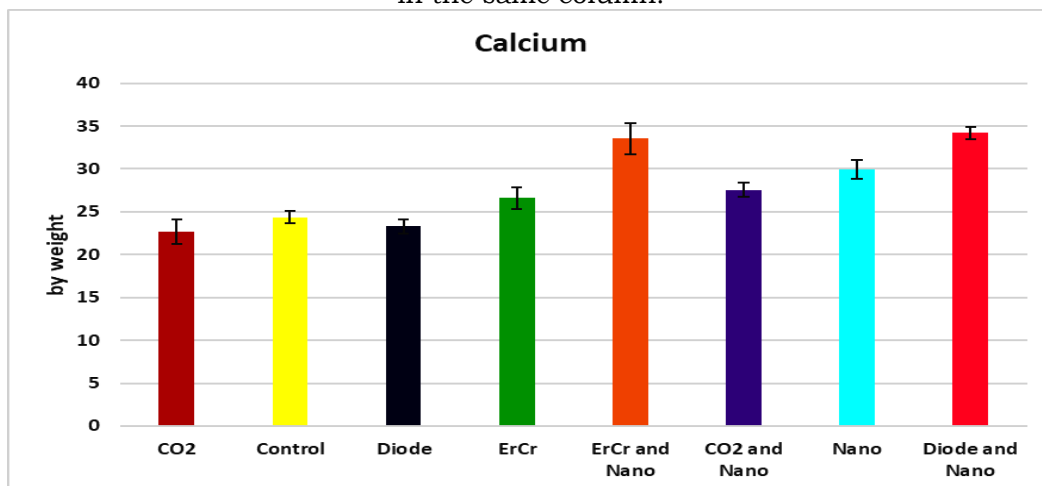


Figure (17): Bar chart representing Calcium for different groups

II- Phosphorus:

There was a statistically significant difference between (CO₂), (Control), (Diode), (Er:Cr;YSGG), (Er:Cr;YSGG and Nano), (CO₂ and Nano), (Nano) and (Diode and Nano) where ($p < 0.001$).

There was not a statistically significant difference discovered between the CO₂ group and either the Control group or the Diode group when ($p = 0.922$) was used. and ($p = 0.908$), while a statistically significant difference was found between (CO₂) and each of (Er:Cr;YSGG), (Er:Cr;YSGG and Nano), (CO₂ and Nano), (Nano) and (Diode and Nano) where ($p = 0.008$), ($p < 0.001$), ($p = 0.032$), ($p = 0.002$) and ($p < 0.001$).

No statistically significant difference was found between (Control) and each of (Diode), (Er:Cr;YSGG) and (CO₂ and Nano) groups where (p=0.999), (p=0.080) and (p=0.259), whereas a statistically significant difference was detected between (Control) and each of (Er:Cr;YSGG and Nano), (Nano), and (Diode and Nano), where the respective p-values were (p=0.001), (p=0.022), and (p<0.001) respectively.

There was shown to be a statistically significant difference between (Diode) and each of (Er:Cr;YSGG and Nano), (Nano), and (Diode and Nano) where the p-values were (0.001), (0.024), and (<0.001) respectively. Although there was not a statistically significant difference discovered between (Diode) and either (Er:Cr;YSGG) or (CO₂ and Nano), where the p-values were (0.086) and (0.276), respectively.

There was found to be no statistically significant difference between (Er:Cr;YSGG) and each of (Er:Cr;YSGG and Nano), (CO₂ and Nano), and (Nano) where the p values were (0.327), (0.996), and (0.996), respectively. While it was discovered that there is a statistically significant difference between (Er:Cr;YSGG) and (Diode and Nano) where (p=0.020), the former is the more prevalent of the two.

There was not a discovered a statistically significant difference between (Er:Cr;YSGG and Nano) and each of the following: (CO₂ and Nano), (Nano), and (Diode and Nano) where the p-values were respectively (0.106), (0.713), and (0.750).

While there was not a statistically significant difference identified between CO₂ and Nano and Nano alone (p=0.848), there was found to be a statistically significant difference between CO₂ and Nano and (Diode and Nano) (p=0.005).

No statistically significant difference was found between (Nano) and (Diode and Nano) where (p=0.075).

The mean value was determined to be the greatest in (Diode and Nano), whereas the mean value was determined to be the lowest in (CO₂).

Table (5): The values of mean and standard deviation (SD) for the element phosphorus across the various groupings.

Variables	Phosphorus	
	Mean	SD
CO₂	11.58 ^d	1.06
Control	12.12 ^{cd}	0.53
Diode	12.14 ^{cd}	0.52
ErCr	13.59 ^{bc}	0.54
ErCr and Nano	14.66 ^{ab}	0.33
CO₂ and Nano	13.27 ^{bc}	0.52
Nano	13.91 ^{ab}	0.13

Diode and Nano	15.39 ^a	0.39
p-value	<0.001*	

*, significant at ($p < 0.05$) ns; nonsignificant at ($p > 0.05$)

Significant differences are shown by the presence of means with different letters in the same column.

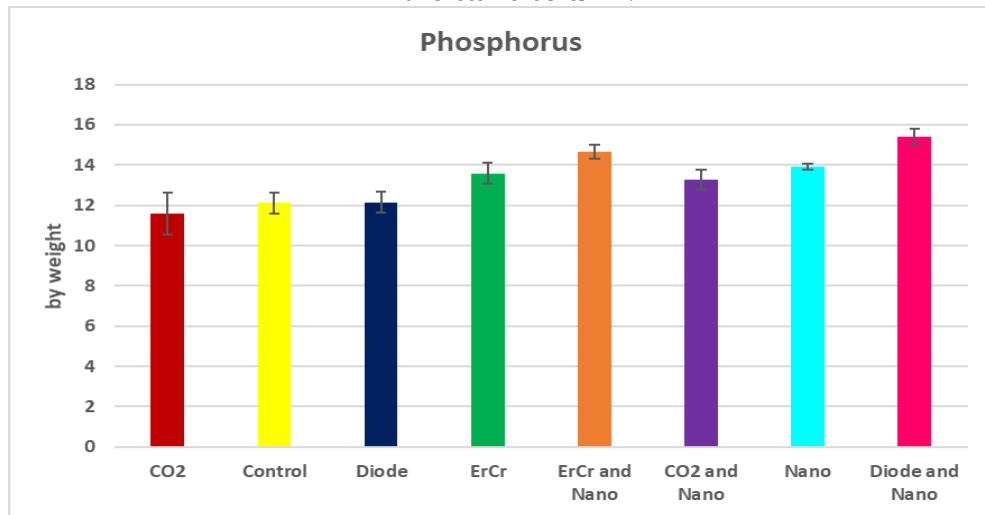


Figure (18): Bar chart representing Phosphorus for different groups
Discussion

SEM and EDX were used to analyse the compositional changes in the dentin surface irradiated by CO₂ laser, Diode laser, and Er:Cr:YSSG laser.

First: dentine surface was irradiated by CO₂ laser which was used as scanning, non-contact to cover more surface area. The power was set as 0.5W. Exposure time was 5 seconds on and 5 off to be repeated three times. Research by Romano et al has demonstrated that the application of CO₂ at 0.5 W is safe for pulp. It does not cause increase in temperature greater than 5 °C⁽¹⁸⁾

The use of lasers in treatment of dentine hypersensitivity, in which the impact of CO₂ laser on the anti- erosive dentine potential needs to be considered as the results to date have not been promising. **Wegehaupt et al.**⁽¹⁹⁾ estimated the greatest anti -erosive potential of dentine occurs after the synergetic application of cerium fluoride and amino fluoride without laser radiation. In present study, no positive effect of laser radiation on dentine was observed. Unlike enamel, the greater content of water in dentine causes tissues contraction following laser radiation. Dehydration leads to the disintegration of organic mold, which takes the places of the lost phase of mineral dentine.⁽²⁰⁾

These findings back up the findings of the current investigation, which show that CO₂ lasers reduce mineral formation more than diode and Er:Cr: YSSG lasers. The calcium and phosphorus content of enamel that had been ablated by a carbon dioxide laser was much lower than that of a control group, according to one study's results. (21). These findings are consistent with those of the current investigation.

Second, a non-contact scanning diode laser was employed to cover a larger surface area. Because the fibre optic delivery system had a 1mm diameter and should have been 320µm, the power was set to 1.5 W. The exposure period was set to 5 seconds on and 5 seconds off, which was repeated three times. The absorption rates of diode lasers into tissues are enamel 5%, dentine 30%, and decay tissues 35%, respectively, while the reaction rates are enamel 15%, dentine 20%, and decay tissues 3%. (22) The diode laser wavelength's weak absorption coefficient in enamel and dentine caused a fast elevation of surface energy during exposure while also creating a rapid decay of temperature. As a consequence, there were tremendous benefits. As a result, the needed activity was completed; however, it did not penetrate deeply enough to have an impact on the pulp and tissues under the surface. (23) The changed ultrastructure of the dentine as a consequence of diode laser irradiation is largely reliant on the laser settings (24).

The laser's wavelength and the applied power density have a significant role in determining how the laser interacts with tissue. **Kiomarsi et al.**, (24) which agree with parameters of the present study. On the other hand, one may hazard a guess that the interaction between the laser energy and the dentin may have resulted in the denaturation of proteins, which can lead to the blocking of the diffusion channel in the dentin. (25)

Diode laser irradiation in present study showed adjunct SEM irregular dentin surface without carbonization but with melted and sealed dentinal tubule especially with Nano Zn HA application. These results agree with results of **Souza et al.**, (26) which explains the blockage of dentinal tubules with diode laser and Nano particles.

Third, the Er:Cr:YSGG was employed as a non-contact scanning device to cover a larger surface area. The power level was set at 0.5 watts. The air spray rate is 100 mL per minute. The water spray rate is 100 mL per minute. The frequency of the pulses is 20Hz. The exposure duration was set to five seconds on, five seconds off, and then repeated three times. Evaporation of dentinal fluid may result in the deposition of insoluble ions from exposed tubules due to the large level of absorption of the Er: Cr: YSGG laser emission wavelength (2780 nm) in water. It's possible that this deposition is to blame for the obturation of the dentinal tubules, which results in a reduction in dentinal hypersensitivity. As a result, it is reasonable to conclude that this deposition is to fault. Scanning electron microscopy (SEM) revealed that irradiating the peritubular dentin with an Er, Cr:YSGG laser caused the dentin to melt in an uneven manner, resulting in a decrease of up to 52 percent in the mean entry diameter of the tubules. (27) These conclusions are consistent with the results of the current investigation.

The Er, Cr:YSGG laser's high bactericidal action is particularly important since bacteria have the ability to reduce the pain threshold in sensitive teeth as a result of enhanced inflammatory mediators. This is because bacteria have this ability. This is possible due to the capabilities that bacteria possess in this regard. Dentin surfaces that were irradiated with an Er,Cr:YSGG laser set at 0.25 watts revealed a decrease in the amount of bacteria without causing any melting to take place (28). Dentin's permeability may be decreased by treating it with a laser with a

wavelength of Er,Cr:YSGG 2780 nm, for example. (29) The use of toothpaste containing biomimetic hydroxyapatite nanocrystals helps reduce dentine hypersensitivity and promotes a remineralizing process (30). When used twice a day, toothpaste with nano-hydroxyapatite (less than 20 percent nano-HAP) has been shown to have a beneficial impact in lowering DHS (31).

The combination of CO₂ 10600 nm and nano hydroxyapatite resulted in the blockage of dentinal tubules and a reduction in permeability, leading in a novel DHS treatment method (32). The CO₂ laser with 0.65 W and nano-HA crystals paste reduced dentinal permeability to an acceptable level at a lower power setting (33). The CO₂ laser with a wavelength of 10600 nm has a high absorption coefficient in dentin (800 cm⁻¹) due to its strong absorption in both hydroxyapatite and water, indicating appropriate superficial contact. Sealing DTs to minimise fluid flow across the dentin and, as a result, DH pain alleviation, requires this kind of interaction. (34) and (35)

Conclusion

We can conclude that the three types of laser induced different aspects of morphological alterations on dentine surfaces with and without Nano-particles of all teeth irradiated. These evident alterations on the surfaces of dentine of teeth irradiated with CO₂, Diode and Er:Cr: YSGG lasers , can suggest extrapolation for certain dental clinic.

Acknowledgments

Disclosure

In this study, the author declares no conflicts of interest.

Ethical Considerations:

Ethical approval was obtained from the Research ethical Committee at Faculty of Medicine, Beni-Suef University (The FM – BSU).

Ethical approval number: FMBSUREC/03052020/Ahmed.

Abbreviations:

COVID-19	coronavirus disease-2019
EDX	Energy Dispersive X-ray
SEM	Scanning Electron Microscope
Ca	Calcium
Ca/P	calcium to phosphorous
SD	standard deviation

References

1. Rohanizadeh, LeGeros R, Fan D, Jean A, Daculsi G, Ultra structure properties of laser irradiating and heat treatment dentin . J dent res, 1999; 78:1827-1835.
2. Ozen T, Orhan k, Aversh, H. Dentin hypersensitivity; a randomized clinical comparison three different agents in a short term treatment period. J oper. Dent.2009; 34 (4) 392-398.

3. Tonque M, Ozat Y, Sert T, Sonmiz y, Kirzioglu F, tooth sensitivity flourotic teeth. *Euro J dent.* 2011; 5: 273-280.
4. Jacobsen P, Bruce G. Clinical dentine hypersensitivity understanding the causing and prescribing a treatment. *J contemp dent pract.* 2001; 2:1-12.
5. Miglani S, Aggarwal V, Ahja B. Dentine hypersensitivity recent trends in mangment *J Conserv Dent.* 2010;13(4):218-24.
6. Mastumoto KFunai H, Shirasukat T, Wakata Y, Ashi H. Eeffects of Nd:YAG laser in treatment of cervical hypersensitivity dentine *J consev dent* 1985a; 28:760-765.
7. Meshini A, Mikaem L, Saqat R. The effective of Er.Cr,YSSG laser in sustained dentinal tubules occlusion using scanning electron microscopy . *J dent health disord ther* 2017; 7:368-373.
8. Seka W, Featherstone J, Fried D, Visuri S, Walsh J. laser ablation of dental hard tissues, explosive ablationto plasmas –mediated ablation. *ProcSPIE*2672,144,1996; doi :10 1117.
9. Arnmaha A, Domingues F, France V, Gutrech N, Edurodecde P. Effects of Er:YAG and Nd:YAG lasers on dentin permeability in root surface in vitro study. *J photo med laser surgery* 2005; 23:504-508.
10. Calvalcanti S, Nascimento D, saavedra G, Kimpara E, Borges A, Niccolu F, et al. CO2 laser surgery and prosthetic management for the treatment of epulis fissuratum *ISRN Dent,* 2011.
11. Ching Y, Lee B, Wang D, Lin C. Microstracural changes of enamel, dentin–enamel junction and dentin induced by irradiating oute enamel surface with CO2 laser *Med. Sci,* 2007,22,21-24.
12. Romano A, Aranha A, Silverar B. Evaluation of carbon dioxide laser irradiation associated with calcium hydroxide in thr treatment of dentinal hypersensitivity .A preliminary study . *lasers MedSci* 2011, 26, 35-42.
13. Rohanizadeh R, LeGeros D, Fan A, Ultra structureral properties of laser irradiated heat treated dentine1999, *dental research J* 87 (12):1829-1835.
14. Cong T, Xie J, Liao J, Zhang T, Lin S, Lin Y. Nanomaterials and bone regeneration. *Bone Res.* 2015; 3:15029.
15. Shanmuganathan R, Edison T, LewisOscar F, Kumar P, Shanmugam S, Pugazhendhi A. Chitosan nanopolymers: an overview of drug delivery against cancer. *Int J Biol Macromol.* 2019; 130:727–736.
16. Pugazhendhi A, Edison T, Karuppusamy I, Kathirvel B. Inorganic nanoparticles: a potential cancer therapy for human welfare. *Int J Pharm.* 2018; 539(1-2):104–111.
17. Pathan AB, Bolla N, Kavuri SR, Sunil CR, Damaraju B, Pattan SK. Ability of three desensitizing agents in dentinal tubule obliteration and durability: an in vitro study. *J Conserv Dent.* 2016 Jan-Feb; 19 (1):31-6.
18. Romano A. Aranha A. Silvera B. Baldchi S. Edurodo P. Evaluation of CO2 laser irradiation associated with calcium hydroxide in the treatment of dentine hypersensitivity. preliminary study *lasers med. Sci.* 2011, 26, 35-42.
19. Weghaupt F, Sener B, Attin T, Schmidlin P. Antierosive potential of amin fluoride, cerium chloride and laser irradiation application on dentine. *Arch. Oral. Biol.* 2011, 56, 1541-1547.
20. Diaz J. Contereas B. Olea M. Garica F. Rodriguez V. Snachez F. Centeno P. Chemical changes associated with increase acid reestenceof Er:YAG laser irradiated enamel. *Scintific world J* 2014, DOI: 10.1155.

21. Vicky W, Irena S, Iris X, John Y, Edward C, Chun C. Effects of 9,300nm carbon dioxide laser on dental hard tissues: a concise review. *J clinical cosmetic and investigational dentistry*. 2021;13, 155-161.
22. Yukna R. Lasers in periodontal therapy. *Today FDA*. 2011; 23(3): 40-41.
23. Nermin M, Ali M, Saafan, Saah S. Posterior irradiation of pit and fissure sealant by diode laser. Part (II) laser int Mag. *Las Dent*. 2013; 2: 16-21.
24. Kiomarsi N, Salim S, Sarraf P, Kharazifard M, Chiniforush N. Evaluation of diode laser (810nm, 980nm) on dentine tubular diameter following internal bleaching; *J clin exp dent* 2016;8(3) e241-5.
25. Fleming S, Tawashi R. Dissolution retardation of dental enamel with special reference to protein matrix; *J can phamaceut. sci*; 1977; 12:55-59.
26. Souza A, Curylofo- Zotti F, Scatolin R, Corona S. Post treatment with high power laser to improve bond strength of adhesive system to bleached dentin. *J. adhesion science and technology*; 2017;31(17):1888-99.
27. Gholami GA, Fekrazad R, Esmaiel-Nejad A, Kalhori KA. An evaluation of the occluding effects of Er; Cr: YSGG, Nd: YAG, CO-and diode lasers on dentinal tubules: A scanning electron microscope in vitro study. *Photomed Laser Surg*. 2011;29:115-21.
28. Franzen R, Esteves-Oliveira M, Meister J, Wallerang A, Vanweersch L, Lampert F, et al. Decontamination of deep dentin by means of erbium, chromium: yttrium-scandium-gallium-garnet laser irradiation. *Lasers Med Sci*. 2007; 24:75-80. doi 10.1007/s10103-007-0522-2.
29. Lenzi TL, Guglielmi C, Arana-Chavez V, Raggio D. Tubule density and diameter in coronal dentin from primary and permanent human teeth. *Microsc. Microanal*. 2013; 19:1445-1449.
30. Orsini G, Procaccini M, Manzoli L, Sparabombe S, Tiriduzzi P, Bambini F, et al. A 3-day randomized clinical trial to investigate the desensitizing properties of three dentifrices. *J Periodontol*. 2013; 84(11): 65-73.
31. Amaechi B, Mathews S, Ramalingam K, Mensinkai P. Evaluation of nanohydroxyapatite-containing toothpaste for occluding dentin tubules. *Am. J. Dent*. 2021; 28:33-39.
32. Almaliky A, Mohamed A, Al karadaghi T, Kurzmann C, Laky M, Franz A, et al. the effect of CO2 laser with or without nanhydroxyapatite paste in the occlusion of dentinal tubule *J scientific world*; 2014; 4:1-8
33. Bonin P, Boivin R, Poulard J. Dentinal permeability of the dog canine after exposure of a cervical cavity to the beam of a CO2 laser. *Journal of Endodontics*. 1991; 17(3):116-118. doi: 10.1016/S0099-2399(06)81741-3
34. Romano A, Aranha A, Da Silveira B, Baldochi S, de Paula Eduardo C. Evaluation of carbon dioxide laser irradiation associated with calcium hydroxide in the treatment of dentinal hypersensitivity. A preliminary study. *Lasers in Medical Science*. 2011;26(1):35-42. doi: 10.1007/s10103-009-0746-4.
35. Fried D, Zuerlein MJ, Le C, Featherstone J. Thermal and chemical modification of dentin by 9-11-µm CO2 laser pulses of 5-100-µs duration. *Lasers in Surgery and Medicine*. 2002;31(4):275-282. doi: 10.1002/lsm.10100.