Iraqi J. Laser, issue 1, vol., 22, pp. 33-42 (2023)

IRAQI JOURNAL OF LASER

Effectiveness of 980nm diode Laser in reduction the diameters of exposed dentinal tubules for hypersensitive tooth

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(Received 12/11/2022; accepted 14/01/2023)

Abstracts:

Background: The oral cavity is a complex environment, both structurally and functionally, the hard and soft tissues are in close a proximity. Oral tissues subjected to wear throughout the life, that threatened the vitality of the pulp or increase the sensitivity of dentinal tubules. One of the common dental problems is loss of enamel or cementum, which stimulate the nerve ending in or near the pulp and manifested as pain sensation. **Aim of the study:** This study had done to evaluate the effects of 980nm diode Laser in diameters reduction of exposed dentinal tubules analyze the results and morphological changes of irradiated dentine surface by FE-SEM (field emission scanning electron microscope) analysis**. Material and Method**: Thirty-nine human extracted impacted 3rd molar teeth were tested in this study and divided into control Group (N=15), pilot study (N=9) and study group (N=15). The study group irradiated with 980nm diode Laser to the occlusal surface of the teeth after the application of 17% EDTA (Ethelyn diamine tetra acetic acid) for smear layer removal. The intra-pulpal temperature recorded for every second and monitored for 120s from the first second of irradiation by a thermometer (prośket MT-1820, 1st Edition, 2016, Taiwan), for detection the recovery time of initial tooth temperature. FE-SEM analysis to all teeth (control, pilot and study groups) for assessment the morphological changes after surface irradiation. **Results:** FE-SEM analysis to the irradiated surface show significant reduction in diameters of the exposed dentinal tubules irradiated by 980nm diode Laser. **Conclusion:** The selected parameters (1.5W/10s, 276.3W/cm^2) were able to seal exposed dentinal tubules without any sign of cracks or fissures. **Suggestion:** The parameters used with this study (1.5W, 10s, 276.3W/cm^2) can be utilize in the future treatment protocol to the management of dentinal hypersensitivity.

Key wards: Dentine hypersensitivity; etiological factors; Dental pain; Diode Laser; scanning electron microscope.

Introduction:

Dentine hypersensitivity (DH) is a most frequently encountered dentist in daily work and most widespread oral pathological problem (Amino shariae et al, 2021). Any procedure, that cause a change in the architecture of the protective enamel and dentine layers, may lead to pulpal inflammation and increased thermal sensitivity, Besides the procedures that increases dentine permeability through the alterations to the integrity of the enamel and dentine such as; decay, trauma, and tooth wear can give rise to symptoms of dentinal hypersensitivity (Ansari et al, 2013). DH is characterized by localized, short, sharp pain in exposed dentine in response to external thermal, mechanical, chemical, or osmotic stimuli, which cannot be attributed to any other form of dental defect or pathology, it may be associated with a number of factors including erosion, abrasion, attrition and may be associated with periodontal treatments or surgery (Bamise et al, 2011). DH manifested by an exaggerated response of exposed dentine to a nonharmful stimuli (mechanical, thermal, tactile, chemical or osmotic), that usually cause no response in a healthy tooth (Boreges et al, 2012). According to the hydrodynamic theory, as believed by [Brannström & Astrom [1963], the fluid movement in response to external stimuli can stimulate the pulpal afferent (Aδ) fibers in or near the pulp that produce pain sensation (Bordin et al, 2019). The velocity of fluids movement in dentinal tubules depends on the nature of stimuli, in thermal stimuli the cold applications cause contraction of fluids, that evoke rapid movement of fluids than hot stimuli, while hot stimuli cause expansion of fluids. So, the cold stimuli cause more painful sensation than hot one (Bubteina et al, 2015). The prevalence rate of dentinal hypersensitivity ranging (8-74%) among population, the appearance of the disease and prevalence distribution differs due to the differences in dietaries, populations and habits being more frequent in patients aged between 30 and 40 years (Borges et al, 2012). The treatment strategies of dentinal hypersensitivity either self-applied (in-home) or proficient-applied (in-office) depends on two ways; nerves blocking and/block the dentinal tubules to reduce the fluids movements in exposed dentine (Bamise et al, 2011). The conventional desensitizing agents with variables form (varnish, gels, or restorative materials) have a limit potential effect on dentinal hypersensitivity, that need frequent sessions or re-applied after a period of time (Chetan et al, 2022). Different laser types have been tested for dentinal hypersensitivity treatment. Laser can be applied in two levels, high level Laser therapy (HLLT) with energy density more than (4 J/cm^2) and Law level laser therapy (LLLT), so the optical effects on biological tissues differs accordingly (Cristina et al 2017). The HLLT occludes dentinal tubules by melting and re-solidifying effects. While, the LLLT have photo-biomodulation (PBM) effects on biological tissues (Cronshaw et al, 2022). PBM effects in dentine sensitivity are; analgesic effect and an increase in cellular metabolic activity of the odontoblasts. Thus, enhance the production of tertiary dentine or reparative dentine. So, reduce the symptoms of hypersensitivity. The bio-modulatory effects of LLLT through minimize pain sensation, and reduce inflammatory processes (Femiano et al, 2020). The applications of lasers can be used mainly in two forms, by means of direct and indirect method, respectively. The direct method involves only the use of lasers and indirect method involves application of certain chemical agents (NaF or SnF2) and then irradiating the area with the lasers (Chetan P. Raut et al, 2022). The combined laser treatment and fluoridation result in permanent integration of fluoride in the dentinal tubules that give immediate and prolong results, due to synergistic effects of Fluoride with Laser (Femiano et al, 2013). This research study was carried in an attempt to select more suitable parameters with 980nm diode Laser, that give powerful reduction in diameters of exposed dentinal tubules with tooth temperature elevation below the breakdown tolerance of the pulp (5.5^{0C}).

Material and Method;

1.Sample collection and preparation:

Thirty-nine Human, extracted, impacted 3rd teeth were used in this study. Any fractured, carious or cracked teeth were excluded. The outer surface of the teeth cleaned from debris and remnant cementum with ultrasonic scaler and then the teeth had immersed in thymol solution (0.1%) for 24 hours to prevent bacterial growth and perceived the lubrication of the samples. The teeth were suctioned transversely (1mm) apical to cementoenamel junction with a double-faced diamond bur (22mm) under water cooling with contra-angled handpiece at law speed (300 rpm), the contra-angled handpiece fixed to Surveyor holding by a clamp and the tooth fixed to the tooth holder (Prośket PD-376, Taiwan) for cutting, then one canal prepared with SX-file V-Taper, irrigated with distilled water and then dried with paper points, the probe of thermocouple inserted in prepared canal opposite to the irradiated surface and the other end of thermocouple was fixed to the apical orifice of the root with light cure composite resin for proper sealing from the outer environments. The suctioned surface of teeth polished with non-Fluoride paste for (30s) and dried with air blast for (30s), then the surface coated with 17% EDTA (Ethylene diamine tetra acidic acid) for (three min.) according to manufactured of smear layer removal, then the teeth immersed in ultrasonic cleaner for (two min.) and dried with air blast for (30s), then the samples are ready for irradiation with (980nm) diode Laser. The teeth are fixed in water path with temperature fixed at 37°C to approximate the temperature of the oral cavity, the other end of thermocouple connected to the thermometer for monitoring the tooth temperature while irradiated the dentine surface. The initial temperature recorded, that represents the pulp roof temperature is (τ_1) and the maximum temperature recoded at the exposure time is (τ_2), the change in tooth temperature during irradiation is calculated by ($\Delta\tau = \tau_2 - \tau_1$). Pulp chamber temperature monitored for 120s from the first second of irradiation time to record the time of temperature recovery of the tooth.

2.Irradiation and temperature measurement for the study group:

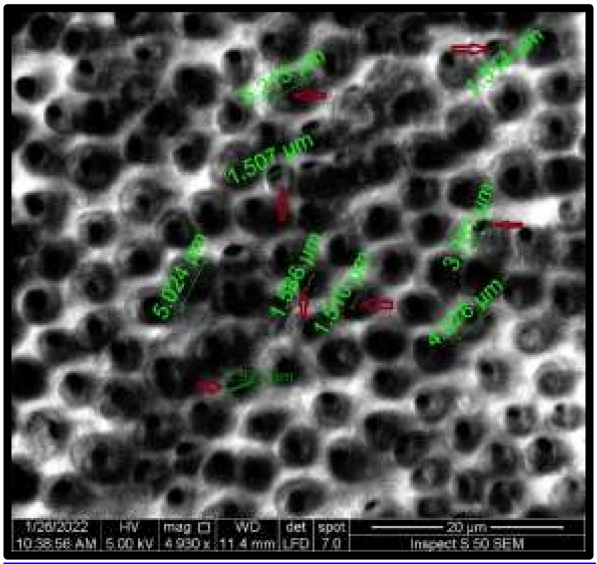
This study done on 15 teeth for the study Group (G1), the root of the teeth immersed in water path with the probe of thermocouple in position, the teeth fixed with a stainless- steel rack, the handpiece of diode Laser fixed with a clamp 1mm from the irradiated dentine surface. According to the previous two pilot studies the selected parameters were (1.5W/10s), that are used in this study, the power density was (276.3W/cm^2), that had determined by measuring the spot size which was (542723.690μm^2), then after 40s when the pulp roof temperature reaches the steady state in water path, the teeth irradiated with 980nm diode Laser and the temperature recorded every second for 120s, which was (10s) exposure time and (110s) observation time, for recording the maximum temperature elevation within exposure time and the recovery time for the irradiated tooth within observation period.

3.SEM measurement:

An SEM study was conducted to evaluate the extent to which the applied treatment method blocked the exposed dentinal tubules. All the teeth in this study (control, pilot and study group) analyzed with FE-SEM from (Inspect™ F50, FEI, Europe) to evaluate the morphological changes to the irradiated dentine surface. First, the specimens were numbered and attached to the single target plasma coater under pressure 18 Pa, 11mA for 20s, then the samples were placed in FE-SEM device for evaluation the morphologic changes in dentine surface with comparison to the morphology of control group and under magnification taken to each sample at (2500X, 5000X and 10000X).

Results: In the present study, the diameters of exposed dentinal tubules assessed for control and the irradiated dentine surface for G1, with FE-SEM analysis as show in figure (1) in page (4). Statistical analysis was performed using the SPSS (v 20, France) for Windows. Post hoc test shows significant reduction (P value≤ 0.05) in diameter for study group (G1) after irradiation with (1.5W, 10s, 273.6W/cm^2) 980nm diode Laser, the mean value of diameters for G1 was (0.66μm), while for control group was (1.79μm).

There was very high significant difference between control group and G1 regarding the diameters mean values (P≤0.001) as in Table (1), Figure (2).



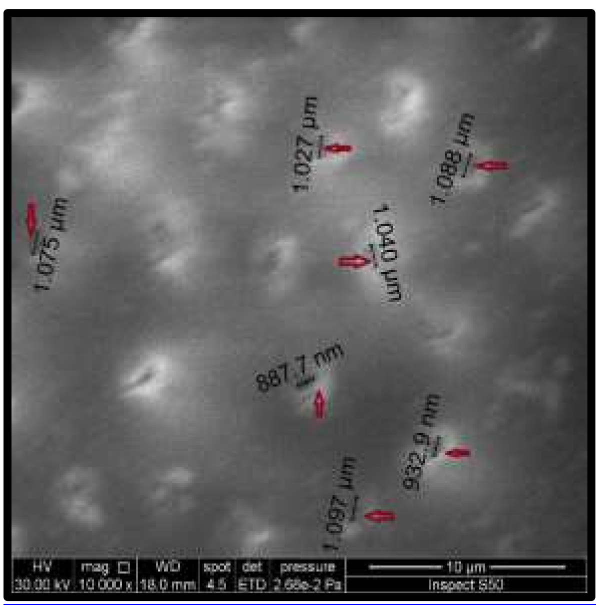


Fig. 1: shows FE-SEM analysis A-control group B-study group mag. 10000X

Table (1): post hoc test G1 with control group

DIAMETER	Tested group		
	CONTROL	G1	P VALUE
N	15	15	0.001
Mean	B 1.79	A 0.66	
Std. Error of Mean	0.02	0.13	
Post hoc test was used to calculate the significant differences between tested mean, the letters (A, B) represented the levels of significant, highly significant start from the letter (A) and decreasing with the last one. Similar letters mean there are no significant differences between tested mean			

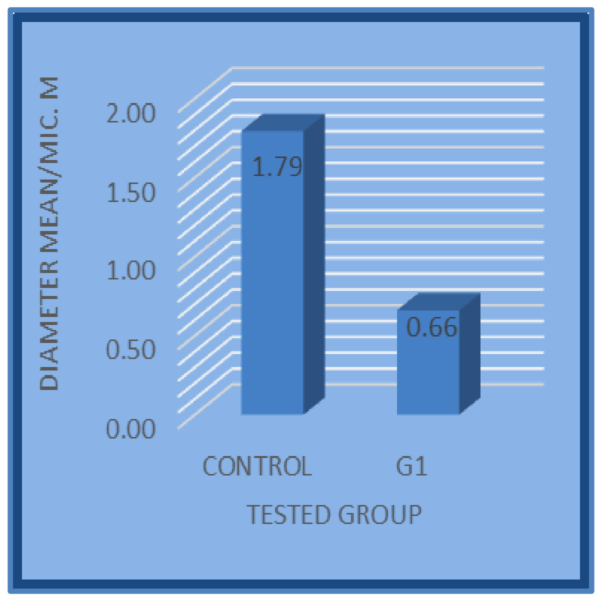


Fig. 2: shows FE-SEM analysis A- control group mag 5000X B-study group mag. 10000X.

Test of Normality done by Kolmogorov-Smirnov[a] and Shapiro-Wilk tests for the exposure time (10s) and the observation time (110s) for G1, which were normally distributed data. Descriptive statistics for observation time (110s) was done and Post hoc test for comparison between tested mean. There was significant tooth temperature elevation in time duration (11-20s) within the observation time and gradual reduction in temperature mean values as in table (2).

Table (2): post hoc test for observation time (110s)

G1:980nm Diode Laser	DESCRIPTIVE STATISTICS G1											*P value
	Exposure time	Observation time										
	G1 S1-S10	G1 S11-20	G1 S21-30	G1 S31-40	G1 S41-50	G1 S51-60	G1 S61-70	G1 S71-80	G1 S81-90	G1 S91-100	G1 S101-110	G1 S111-120	
N	150	150	150	150	150	150	150	150	150	150	150	150	0.01
Mean	37.65	**A 38.05**	**B 37.78**	**C 37.51**	**D 37.24**	**D 37.13**	**D 37.05**	**E 36.94**	**E 36.89**	**E 36.89**	**E 36.89**	**E 36.89**	
Std. Error of Mean	0.04	0.02	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	
Median	37.76	38.11	37.83	37.46	37.23	37.13	37.10	37.00	36.99	37.00	37.00	37.00	
Std. Deviation	0.48	0.24	0.20	0.14	0.04	0.04	0.07	0.12	0.12	0.12	0.12	0.12	
Minimum	36.47	37.52	**37**.43	37.31	37.15	37.04	36.83	36.69	36.69	36.70	36.70	36.70	
Maximum	38.36	38.37	38.07	37.77	37.33	37.20	37.11	37.08	37.00	37.00	37.00	37.00	

***Calculate the significant value of the observation time only, the exposure time not involved //Post hoc test was used to calculate the significant differences between tested mean, the letters (A, B, C, D, and E) represented the levels of significant, highly significant start from the letter (A) and decreasing with the last one. Similar letters mean there are no significant differences between tested mean.**

Dunnett test was done for the exposure time (10s) in comparisons of the tested mean with the initial tooth temperature, there were significant differences in tooth temperature mean values from the initial temperature mean values. Table (3) shows the differences in page (6), and post hoc test for (10s) was done to determine the significant time in which maximum tooth temperature reaches within exposure time, which were in (S8, S9 AND S10) as in table (4) in page (6).

Table (3): Dunnett test (2 sided) for multiple comparisons depended variables: Temp.

(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
G1S2	G1S1 INITIAL TIME	.31790*	.05938	.000	.1563	.4795
G1S3	G1S1 INITIAL TIME	.58426*	.05938	.000	.4227	.7458
G1S4	G1S1 INITIAL TIME	.80413*	.05938	.000	.6425	.9657
G1S5	G1S1 INITIAL TIME	.98229*	.05938	.000	.8207	1.1439
G1S6	G1S1 INITIAL TIME	1.12329*	.05938	.000	.9617	1.2849
G1S7	G1S1 INITIAL TIME	1.23145*	.05938	.000	1.0699	1.3930
G1S8	G1S1 INITIAL TIME	1.31082*	.05938	.000	1.1492	1.4724
G1S9	G1S1 INITIAL TIME	1.36524*	.05938	.000	1.2037	1.5268
G1S10	G1S1 INITIAL TIME	1.39828*	.05938	.000	1.2367	1.5599

G1:980 nm without Graphite paste//*The mean difference s significant at the 0.05 level.

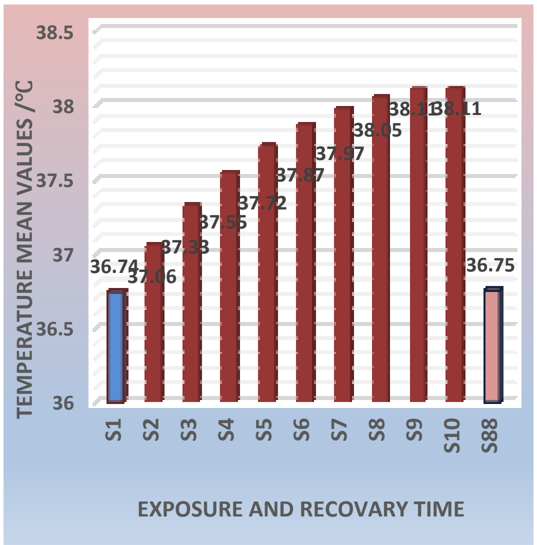
Dunnett t-tests treat one group (INITIAL TIME) as a control, and compare all other groups against it.

Table (4): Post hoc test between tested mean for exposure time (10s)

G1:980 nm without Graphite paste	G1S1	G1S2	G1S3	G1S4	G1S5	G1S6	G1S7	G1S8	G1S9	G1S10	P value
Mean	**E 36.74**	**D 37.06**	**C 37.33**	**C 37.55**	**B 37.72**	**B 37.87**	**B 37.97**	**A 38.05**	**A 38.11**	**A 38.11**	**0.001**
Std. Error of Mean	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	
Median	36.81	37.12	37.38	37.58	37.75	37.89	37.99	38.07	38.13	38.16	
Std. Deviation	0.15	0.14	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.19	
Minimum	36.47	36.78	37.03	37.24	37.40	37.54	37.64	37.71	37.76	37.79	
Maximum	36.92	37.23	37.48	37.71	37.91	38.07	38.19	38.27	38.33	38.36	

Post hoc test was used to calculate the significant differences between tested mean, the letters (A, B, C, D, and E) represented the levels of significant, highly significant start from the letter (A) and decreasing with the last one. Similar letters mean there are no significant differences between tested mean

The mean value of temperature elevation for G1 component of tooth structure (Ying Liu et al within exposure time was (1.37℃) and recovery time was at (88s) as seen in figure (3) and (4).



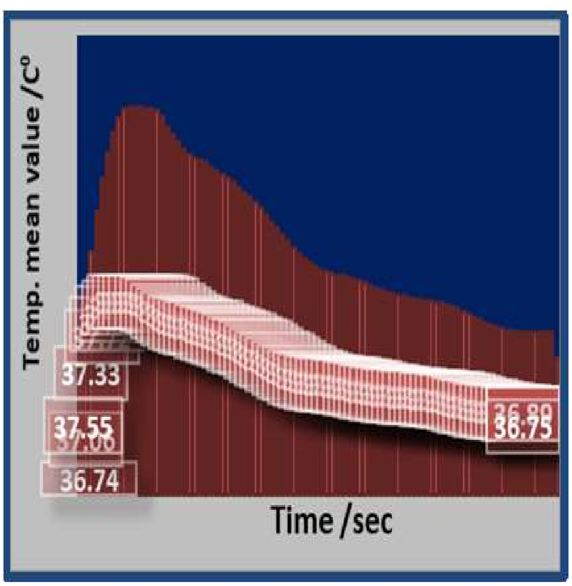


Fig. 4: shows temp. mean value within exposure and recovery time.

Discussion:

For dentinal hypersensitivity, many different treatments and techniques have been studied and proposed with identical objectives: to seal dentinal tubules (Hu et al 2019). The prevalence of dentine hypersensitivity is site-specific showed increased predilection in premolars followed by incisors, canines and molars, and more in female than male (Cronshaw et al 2020). Many conventional desensitizing products have been tested to relieve the symptoms of dentine hypersensitivity either by interfering with pulse transmission or by occluding the exposed dentinal tubules to reduce the fluid movements, that have a limitation in time and longevity in treatment of DH, the ideal treatment for DH does not exist, but this is true in case of combination of different protocols (Femiano et al,2020). Laser applications in dentistry come with appositives results in many fields and give a sign in treatment strategies of dentinal hypersensitivity (Hasan Guney Yilmaz et al 2011), many studies have been approved the action mechanisms of diode lasers in dentine hypersensitivity treatments (Mendes et al, 2021). The low output power lasers mediate an analgesic effect related to depressed nerve transmission. Furthermore, it stimulates the dentine forming cell to produce tertiary (Reparative) dentine (Rekha Bilichodmath et al 2018). While, the high-level laser therapy minimize the symptoms of dentine hypersensitivity by modifying the morphology of dentine surface “melting and re-solidification” (Ruaa M. Al-Mafrachi , 2018). In the current study the effects of 980nm diode Laser with the selected parameters (continuous, non-contact mode, 1.5W, 10s, 276.3W/cm2) have a more effective and significant reduction in the diameters of dentinal tubules. The mechanisms by which the diode Laser occlude exposed dentinal tubules, through the photothermal effects on irradiated dentine surface that results in melting of the organic component of tooth structure (Ying Liu et al 2013). science, the wavelength (800-980nm) diode Laser have poor absorption spectrum in water and hydroxy appetite crystals, so the effects of 980nm diode Laser on dentine surface depending on the absorbing chromophores in dentine surface that absorbed the wavelength 980nm. The main effect of 980nm diode laser is photothermal effect on the collagen fiber (the organic part of dentinal tubules. Furthermore, it has a slight absorption in water, that increase its photothermal effects on dentine surface (*Rajeev Ranjan1* et al 2021). The mean value of temperature elevation was (1.37℃), that below the injury temperature of the pulp (3℃) and the recovery time was at (88s). Previous studies approved that, diode lasers have a multiple role in dentinal hypersensitivity, their occluding effects by making dentine cells degenerate, cause calcium salt deposition, and calcify the closure of dentine tubules (Ruaa M. Al-Mafrachi et al, 2018). Besides, it can stimulate the dentine forming cells (odontoblast) and induces them to produce secondary dentine by the production of secondary reaction (Rekha et al, 2018). Moreover, the analgesic effects through the change in nerve fiber membrane permeability to potassium and sodium (Rajeev Ranjan et al, 2013), increase the peripheral nerve action potentials, and stimulates the formation of neural axon endorphins, which have an analgesic effect (Tabibzadeh et al, 2018). The results of this study a great agreement with that of (Ying Liu et al,2013) and (Umana et al 2013).

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فعالية (٩٨٠ نانومتر) دايود ليزر على انحسار القطر للاوعية السنية المكشوفة لسن فرط الحساسية العاجية

رنا هاشم حيدر * ، كريم محمد ظاهر، صلاح عبد الامير القرطاس

معهد الليزر للدراسات العليا - جامعة بغداد

الخلاصة :

تتضمن الدراسة تحضير (٣٩ سن) من أسنان العقل المقلوعة جراحياً وأزالة طبقة الميناء كلياً عن سطح الاطباق، وعندما تتم إزالة المينا يؤدي ذلك إلى أن تكون الأنابيب السنية داخل طبقة العاج مكشوفة مما يؤدي الى زيادة حركة السوائل داخل الأنابيب وتحفيز النهايات العصبية القريبة من لب السن وزيادة الأحساس بالألم. حيث تم تقسيم الاسنان الى ثلاث مجاميع المجموعة الاولى هي المجموعة التجربية لأختيار معملات مناسبة للتشعيع بالدايود ليزر واستخدم فيها (٩أسنان) والمجموعة الثانية هي المجموعة الظابطة واستخدم فيها (١٥سن) والمجموعة الثالثة هي مجموعة الاختبار المشععة بالدايود ليزر وأستخدم فيها (١٥سنة).

حيث تم تشعيع العينات بالدايود ليزر ذو الطول الموجي ٩٨٠ نانومتر مع معاملات تم اختيارها بأجراء دراستين تجريبية قبل بدء التشعيع لمجموعة الاختبار وقد استخدم (١,٥ واط), (١٠ ثانية) وكثافة طاقة (٢٧٦,٣ واط/سم ٢) تم اختيرها بقياس مساحة نقطة التشعيع. وبعد مرور (٤٠ ثانية) عن وضع اسنان مجموعة الاختبار داخل الحمام المائي بدأ تشعيع اسنان مجموعة الاختبار.

أظهر فحص المايكروسكوب الماسح الالكتروني أنسداد واضح في الأنابيب السنية المفتوحة بعد التشعيع لمجموعة الاختبار وأظهر التحليل الأحصائي أنحسار كبير بقطر الأنابيب السنية المكشوفة مقارنة مع قطر المجموعة الظابطة ،وكان ارتفاع درجة حرارة السن نتيجة التشعيع ضمن الحدود المسموح بها للحفاظ على حيوية السن أما وقت انتعاش السن فقد سجل يالثانية (٨٨) من الثانية الاولى لبدأ التشعيع.