Assessment of Post Space Volume Change After Removal of Fiber Post by Two Techniques Using CBCT

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Abstract:

Aim: The aim of the study was to assess the post space volume change after the removal of the fiber post from endodontically treated teeth by ultrasonic and by the Er,Cr:YSGG laser and compare between them using cone-beam computed tomography (CBCT). **Materials and Methods:** This study used twenty-four extracted human single rooted teeth. They were mechanically prepared after their crowns were cut off near the cemento-enamel junction (CEJ). All roots were obturated with gutta-percha points and resin-based sealer. The post space preparation was made to all roots to receive the glass fiber posts. The post space volume was measured by CBCT before post cementation. The roots were divided into two groups (each = 12) according to the technique used in post removal. Group A: ultrasonic. Group B: Er,Cr:YSGG laser. CBCT was used to measure the difference between before post cementation and after post removal (dentin volume loss) was calculated, and the results were statistically analyzed. **Results:** In all groups, the post space volume after post removal was significantly higher than the post space volume before post cementation. Group B had a significantly higher mean value of dentin volume loss than group A. **Conclusions:** The post space volume after fiber post removal by the Er,Cr:YSGG laser or by ultrasonic was significantly higher than before post cementation. The use of the Er,Cr:YSGG laser in fiber post removal produced more dentin volume loss than ultrasonic.

Keywords: CBCT, Er,Cr:YSGG laser, Post space volume, Ultrasonic.

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Introduction:

Teeth that have undergone endodontic treatment are frequently repaired with a post and core prior to the manufacturing of a crown or other fixed restorations. [(1)] Inadequate disinfection during the chemo-mechanical preparation of the root canal can maintain bacterial infection levels in the canal at levels sufficient to sustain periapical inflammation after root canal therapy. [(2)] This situation call for root canal retreatment procedures, which can present difficulties during therapy, including removing intraradicular posts. [(3)]

Fiber posts and resin cores have become more popular due to their mechanical and cosmetic qualities, which blend well with permanent restorations. [(4)] The fiber post material is made up of filaments of zirconia, quartz, carbon, silica, or glass that have been encapsulated in an epoxy resin matrix. [(5)] Root fracture, the most common reason for failure with metallic posts, is substantially less likely with fiber glass posts since their modulus of elasticity is comparable to that of radicular dentin. Because stress at the interface between post and tooth can result in post dislodgment and subsequent failure if a post has a higher elastic modulus than dentin. [(6)] Glass fiber posts have a 95% yearly survival rate and have been in use for more than 20 years. [(7)] The high flexural strength of glass fiber posts helps sustain the core components. [(8)] The material's translucency also improves aesthetics. [(9)] With the recently produced self-adhesive composite resin, the mechanical characteristics and retention of glass fiber posts can be significantly improved. [(10)] An endodontically treated tooth with a glass fiber post may live longer if adhesive cement is used. As a result, there may be a reduction in tooth fracture failure rates of less than 5% annually. [(7)]

Whereas the bonding of the fiber post may increase the post and tooth survival, it creates a challenge during post retrieval when endodontic retreatment is necessary. Mechanical and ultrasonic post removal techniques are frequently used. [11] Mechanical removal of the post can be accomplished using rotary tools like trephine drills. However, removing a post using these mechanical techniques can result in substantial tooth structural loss as well as thermal damage. [12]

Another popular technique for removing the fiber post is ultrasonic. However, it can generate heat and tiny cracks in the nearby dentinal wall. Dentinal microcracks and tooth structure loss raise the possibility of further fractures. Additionally, prolonged chair time is required. [13] Therefore, a post removal procedure that preserves tooth structure, results in minimal temperature change, and does not harm the endodontic dentin wall is required.

Recently, erbium lasers have been proposed as an alternate method for removing fiber posts since they almost completely preserve the walls of root canal dentin and produce relatively little heat. [14] The erbium, chromium-doped yttrium, scandium, gallium and garnet (Er,Cr:YSGG) laser has a wavelength of 2780 nm. It has been used to etch the enamel and dentin surfaces. [15] It has been demonstrated that the Er,Cr:YSGG laser can effectively remove the surface of dentin, enamel, and cementum without causing the pulp any appreciable thermal harm. [16] Additionally, it has the ability to remove orthodontic brackets, ceramic crowns, porcelain veneers, and fiber posts. [17] It has been established that Er,Cr:YSGG laser radiation causes thermal ablation, a process that causes the constituents of resin cements to evaporate. Debonding and post removal can occur as a result of the deterioration of resin cements caused by laser energy absorption. [18, 19] Additionally, the region of application doesn't see a significant increase in temperature due to their pulsed irradiation. [20]

Cone-beam computed tomography (CBCT) is a non-destructive and repeatable imaging technology that uses a series of two-dimensional (2D) projections to rebuild three-dimensional (3D) pictures. It generates 3D pictures of dentin thickness, canal morphology, and root canal space volume without causing any damage to the tooth structure. [21]

The aim of the study was to assess the post space volume change after the removal of the fiber post from endodontically treated teeth by ultrasonic and by the Er,Cr:YSGG laser and compare between them using CBCT.

Materials and methods:

Sample size calculation:

The sample size was determined using Arukaslan and Aydemir's [3] study as a guide. The minimum acceptable sample size per group based on this study was ten, when the mean ± standard deviation was 154.7 ± 18.49, the estimated mean of the other group was 25, the power was 80%, and the type I error probability was 0.05. The sample size was raised to twelve in order to recompense for a 20% dropout rate. The Independent t test was carried out using P.S.Power 3.1.6.

Ethical Approval:

The research was given approval on 3/10/2023 by the Research Ethical Committee (REC) of the National Institute of Laser Enhanced Sciences, and the approval reference was: NILES-EC-CU 23/10/20.

Selection of study samples:

This study used twenty-four extracted human teeth from patients who had their teeth removed for orthodontic treatment. The picked teeth met the requirements of having a single root, a mature apex, and being free of cracks or fractures. They were preserved in a saline solution.

Preparation of the teeth:

The crowns of the selected teeth were cut off near the cemento-enamel junction (CEJ) using a tapered diamond stone. The roots were made to be 14 mm length. The rotary system M-Pro (Innovative Material and Devices, Shanghai, China) was used to mechanically prepare the canals of the roots up to size 35. Following each file, irrigation was performed using 1 ml of 2% sodium hypochlorite (NaOCl). The last step was to rinse the canals with three ml of 17% ethylenediaminetetraacetic acid (EDTA), three ml of 2% NaOCl, and three ml of saline solution. All canals were obturated with gutta-percha points (Maillefer-Dentsply, Ballaigues, Switzerland) and resin-based sealer (ADSEAL, META BIOMED, Korea) using the lateral condensation technique.

Gutta-percha removal and post space preparation:

Gates Glidden drills size 1, 2, and 3 were used to remove the gutta-percha from the canals, approximately 8 mm in length from the coronal portion of the roots, leaving 6 mm from the apex. A size II drill with a 1.2 mm diameter (Harald Nordin sa, Montreux, Switzerland) was used to prepare the canals to receive the glass fiber posts of the same size and the same system.

CBCT scan before post cementation:

The roots were fixed in an acrylic bases (Acrostone, Egypt) with a diameter of 4 cm to match the diameter of the cone beam as shown in figure (1).

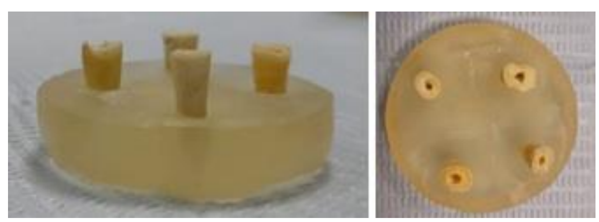

Figure 1: Fixation of the roots in an acrylic base.

The initial volume of post space of each root was measured with a CBCT (Photon-scan, Egypt). The roots were scanned with CBCT with a 75 µm3 voxel size under an identical scanning condition of 90 kV and 12 mA. The scanned images were reconstructed into a 3D

15-bit. The roots were aligned in the viewing software (Planmeca Romexis Viewer 6.1.1.105) to set the rotation axis with proper alignment in the sagittal, coronal, and axial planes. The slice thickness was adjusted to 0.075mm, and then the volume space was measured by using the Region-Growing tool (a manual segmentation tool) in the sagittal plane with the view port setting the 0.1 mm thickness of each slice.

Post cementation:

The glass fiber post surface was coated with silane coupling agent. 37% phosphoric acid was applied to the post space for 15 seconds. After this period, the post space was washed thoroughly and then dried with paper point size 35. Self-adhesive resin cement (Breeze™, USA) was injected into the post space starting with depth, to prevent bubbles. The post was inserted into its place by finger pressure, and the excess was removed with a micro-brush and then light cured for 40 seconds as shown in figure (2).

Figure 2: Roots after post cementation.

Classification of the roots:

The roots were classified randomly into two groups according to the technique used in post removal. Each group consisted of twelve roots.

Group A: posts were removed by ultrasonic.

Group B: posts were removed by the Er,Cr:YSGG laser.

Post removal:

After 48 hours, all posts were removed. The posts in group A were removed by ultrasonic instrumentation (woodpecker, China). The E14 ultrasonic tip was installed on the ultrasonic device with a power indicator pointing to 5. The tip was moved around the fiber post in counterclockwise.

While the posts in group B were removed by the Er,Cr:YSGG laser at 2780 nm wavelength. We used the sapphire tip MX7 (700 µm in diameter), which creates an energy concentration extending from 3 mm to 5 mm from the tip's end, and the MZ5-5mm endo tip (5mm in length and 500µm). A pilot study was conducted to determine the proper laser parameter, tip, and direction with the most effective and least harmful effect.

These are the laser tips, parameters, and directions that were tested:

1-Sapphire tip MX7 was used at H mode, 20 HZ, and 2.5 watt under a 40/20 (air/water) spray setting in a perpendicular direction and produced no effect.

2- MZ5 tip was used at H mode, 20 HZ, and 2.5 watt under a 40/20 (air/water) spray setting in a perpendicular direction and produced no effect.

3- MZ5 tip was used at H mode, 25 HZ, and 4 watt under a 60/80 (air/water) spray setting in 45 degree and produced some burning smell.

4- MZ5 tip was used at S mode, 25 HZ, and 5 watt under a 40/20 (air/water) spray setting in 45 degree and produced some burning smell.

5-Sapphire tip MX7 was used at H mode, 25 HZ, and 4 watt under a 60/80 (air/water) spray setting in 45 degree and produced some burning smell, and the post was teared into fibrils.

6-Sapphire tip MX7 was used at H mode, 15 HZ, and 3.5 watt under a 20/10 (air/water) spray setting in 45 degree and produced some burning smell, and the post was teared into fibrils.

7-Sapphire tip MX7 was used at H mode, 15 HZ, and 2.5 watt under a 20/10 (air/water) spray setting in a perpendicular direction toward the cement and produced some burning smell.

8-MZ5 tip was used at H mode, 20 HZ, and 4 watt under a 30/10 (air/water) spray setting in a circular motion moving around the post and leading to destruction and removing the post. Therefore, this was the proper parameter used in this study as shown in figure (3).

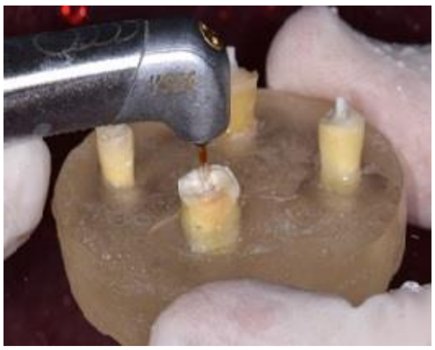

Figure 3: Removal of the fiber post by the MZ5 endo tip.

CBCT scan after post removal:

The final volume of post space after post removal of each root was measured with a CBCT as described before, and then the difference between before post cementation and after post removal (dentin volume loss) was calculated.

Statistical analysis:

All data were displayed as mean, standard deviation, percentage of change, mean difference, minimum, and maximum. Statistical analysis was executed by SPSS 16® (Statistical Package for Scientific Studies), Graph pad prism, and windows excel. The qualitative data was explored by the Shapiro-Wilk test and the Kolmogorov-Smirnov test for normality, which showed that the P-value was significant as a P-value > 0.05, which denoted that all data arose from no-parametric data. So the Mann Whiteny`s t test was used for comparing between two different groups, whereas the Wilcoxon signed rank test was used for comparing between before and after.

Results:

Effect of post removal (comparison of post space volume before post cementation and after post removal):

In ultrasonic group (Group A), there was a significant increase in post space volume from (0.053 ± 0.035) before post cementation to (0.073 ± 0.031) after post removal, with a 0.02 mean difference and 51.18% percent of change as P = 0.002, as shown in table (1) and figures (4, 5 and 8).

Table 1: Comparison of post space volume before post cementation and after post removal:

	Post space volume	Min	Mix	M	SD	Difference (Wilcoxon signed rank test test)					
						MD	SD	% of change	95% CI		*P value*
									L	U	
Group A (Ultrasonic)	Before	0.027	0.110	0.053	0.035	0.020	0.008	51.188	0.014	0.025	0.002**
	After	0.044	0.120	0.073	0.031						
Group B (Er,Cr:YSGG laser)	Before	0.035	0.041	0.038	0.002	0.047	0.027	121.309	0.030	0.064	0.002**
	After	0.063	0.131	0.085	0.029						

Min: minimum Max: maximum M: mean SD: standard deviation
MD: mean difference SD: standard error of difference
*CI: confidence intervals L:lower arm U:upper arm **Highly significant difference as P<0.001.*

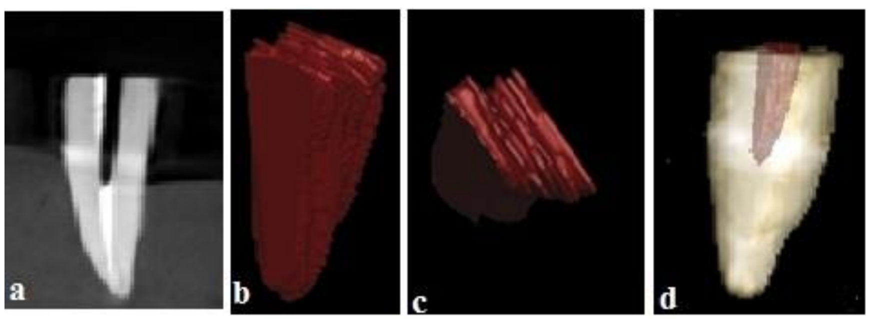

Figure 4: 3D image of ultrasonic group before post cementation, where (a): post prepared tooth sample, (b): sagittal view of isolated root space, (C): top view of isolated root space, (d): isolated root space with hard tissue.

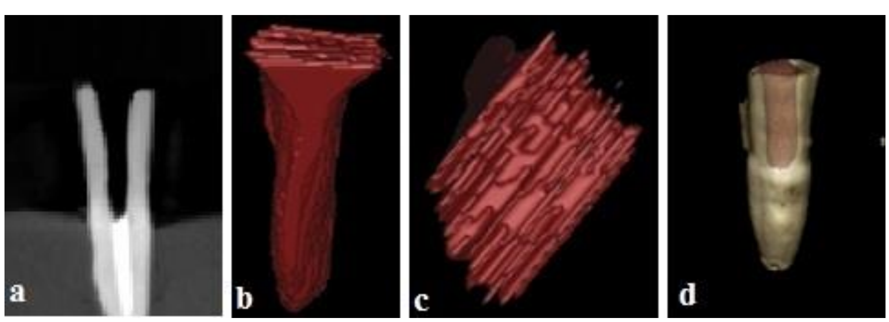

Figure 5: 3D image of ultrasonic group after post removal, where (a): post prepared tooth sample, (b): sagittal view of isolated root space, (C): top view of isolated root space, (d): isolated root space with hard tissue.

In Er,Cr:YSGG laser group (Group B), there was a significant increase in post space volume from (0.038 ± 0.002) before post cementation to (0.085 ± 0.029) after post removal, with a 0.04 mean difference and 121.309% percent of change as P = 0.002, as shown in table (1) and figures (6-8).

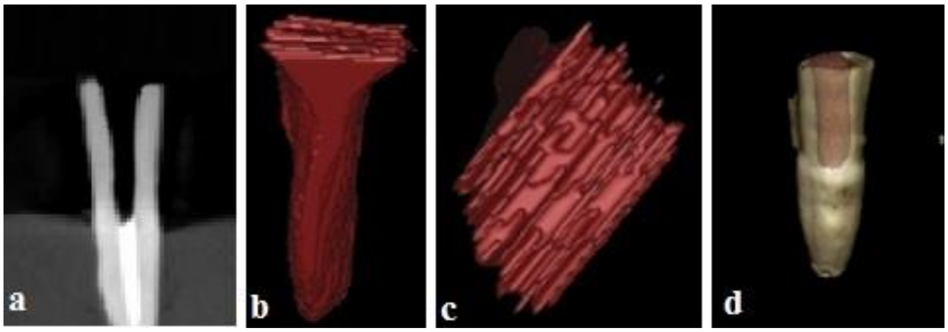

Figure 6: Figure 4: 3D image of Er,Cr:YSGG laser group before post cementation, where (a): post prepared tooth sample, (b): sagittal view of isolated root space, (C): top view of isolated root space, (d): isolated root space with hard tissue.

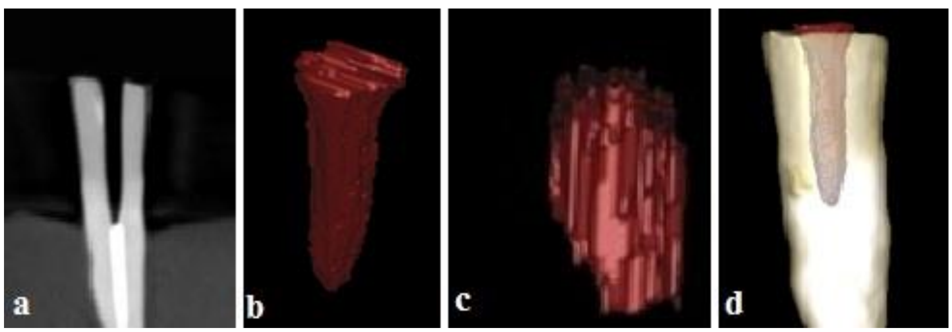

Figure 7: 3D image of Er,Cr:YSGG laser group after post removal, where (a): post prepared tooth sample, (b): sagittal view of isolated root space, (C): top view of isolated root space, (d): isolated root space with hard tissue.

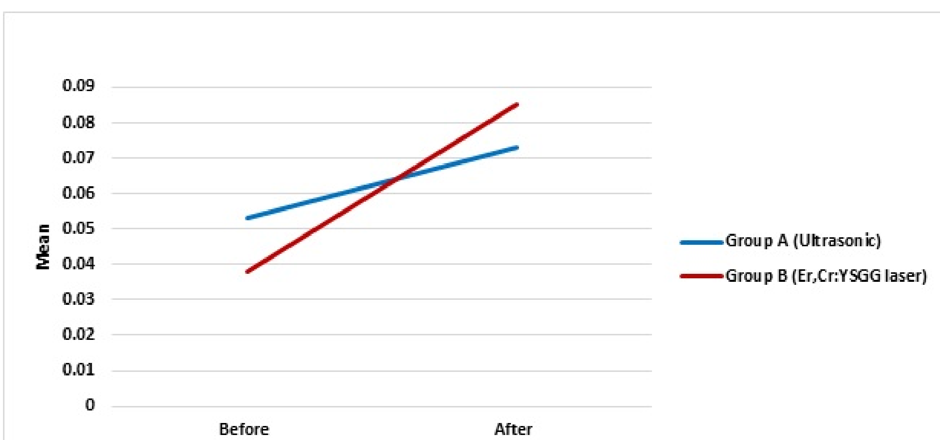

Figure 8: line chart showing effect of post removal in group A and B.

Effect of technique (comparison between groups A and B) (table 2 and figure 9):

Before post cementation: there was an insignificant difference in post space volume between group A (0.053 ± 0.035) and group B (0.038 ± 0.002), with a 0.015 mean difference as P = 0.99.

After post removal: there was an insignificant difference in post space volume between group A (0.073 ± 0.031) and group B (0.085 ± 0.029), with a 0.012 mean difference as P = 0.15.

The difference between before post cementation and after post removal (dentin volume loss): group B (0.047 ± 0.027) had a significantly higher mean value of dentin volume loss than group A (0.020 ± 0.008), with a 0.028 mean difference as P = 0.001.

The percentage of change: there was a significant difference between group A (51.188 ± 25.778) and group B (121.309 ± 63.151), with a 70.121 mean difference as P = 0.0001.

Table 2: Effect of technique (comparison between groups A and B):

Post space volume	Group A (Ultrasonic)		Group B (Er,Cr:YSGG laser)		Difference (Mann Whiteny`s test)				
					MD	SED	95% CI		*P value*
	M	SD	M	SD			L	U	
Before	0.053	0.035	0.038	0.002	0.015	0.010	-0.006	0.036	0.99
After	0.073	0.031	0.085	0.029	0.012	0.012	-0.037	0.013	0.15
Difference (dentin volume loss)	0.020	0.008	0.047	0.027	0.028	0.008	-0.044	-0.011	0.001**
% of change	51.188	25.778	121.309	63.151	70.121	19.690	-110.956	-29.286	0.0001**

Min: minimum Max: maximum M: mean SD: standard deviation
MD: mean difference SD: standard error of difference
*CI: confidence intervals L:lower arm U:upper arm **Highly significant difference as P<0.001.*

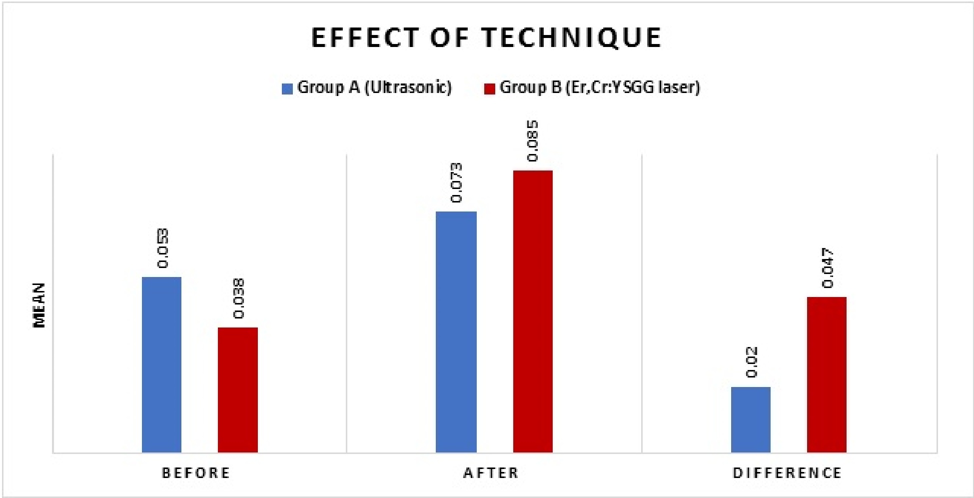

Figure 9: bar chart showing Effect of technique.

Discussion:

New therapies in the fields of endodontics, prosthodontics, and periodontics are enabling an extended favorable prognosis despite the difficulties in restoring severely affected teeth. As a result, fiber posts are frequently utilized in these situations to assure the durability of restorations through better adhesion of fiber posts to the root canals. (22) However, this characteristic makes post retrieval difficult when endodontic retreatment is necessary. (10)

When compared to metallic posts, the usage of fiber posts has significantly increased, either as a result of aesthetic improvements or because of their compatibility with the elastic properties of dentin. (10) However, debonding from root canals continues to be the main reason for these materials' failure. (23) Dentists may find difficulty in removing the translucent glass fiber posts that closely resemble the dentin and have a similar appearance to it while conserving as much of the root canal dentin as they can (13), because the removal techniques may cause dentin micro or macrocracks and tooth fractures. (12)

The amount of residual tooth structure after fiber post removal is a crucial factor for adequate root resistance and for long-term tooth retention. [24] So the aim of the study was to assess the post space volume change after the removal of the fiber post from endodontically treated teeth by ultrasonic and by the Er,Cr:YSGG laser and compare between them using CBCT.

The results of the study showed that the post space volume after fiber post removal by the Er,Cr:YSGG laser was increased significantly than before post cementation. Furthermore, the measured dentin volume loss after post removal by the Er,Cr:YSGG laser was significantly higher than the measured dentin volume loss after post removal by ultrasonic. This may be attributed to the fact that the diameter of the laser application tip was more than the thickness of the resin cement surrounding the post. Thus, the dentinal walls are undoubtedly exposed to some laser radiation. So, the active point of the laser was in close proximity to the root canal walls despite being as perpendicular to the interface between the dentin and post as possible. In general, dentin can interact with the light energy from a laser beam in four different ways: absorption, transmission, reflection, and scattering. Depending on the amount of water in the tissue, laser energy absorption raises the temperature and causes photochemical reactions. Thermo-mechanical ablation, which can result in a massive increase in dentin subsurface pressure and explosive destruction of the surrounding dentin mineral matrix, is a process that happens when the temperature surpasses 100°C and occurs when water vaporizes. [25] Moreover, denaturation of the dentin proteins starts without water evaporation when the temperature is over 60°C but below 100°C. Additionally, the tissue burns at temperatures exceeding 200°C after being dehydrated, which causes an unfavorable side effect known as carbonization. [26]

In spite of the use of ultrasonic in fiber post removal produced less dentin volume loss than the Er,Cr:YSGG laser, but post space volume after fiber post removal by ultrasonic was increased significantly than before post cementation. This may be related to tiny dentin fractures caused by the repetitive stress generated by the ultrasonic tip's vibration. [3] Also dentin tissue is frequently affected during the removal of the fiber post because it is challenging for the dental professional to discriminate between resin cement and dentin. This also raises the temperature within the canal. [27] The dentin structure degrades more quickly as a result of this transfer of kinetic energy, which also causes heat to be generated in nearby areas of the tip application and, ultimately, dentin volume loss. [13]

The results of Cho *et al.* [14] were similar to our results in that the post space volume after fiber post removal either by ultrasonic or Er,Cr:YSGG laser was increased significantly than before post cementation. But it was different from our results in that the measured dentin volume loss after post removal by the Er,Cr:YSGG laser was significantly lower than the measured dentin volume loss after post removal by ultrasonic. This may be attributed to using different laser parameters and using small sample size.

Also, the results of Papoulidou *et al.* [20] stated that the post space volume was significantly increased as a result of the loss of dentin after fiber post removal by ultrasonic or Er,Cr:YSGG laser, and there were no significant differences in the dentin volume loss between the ultrasonic group and the Er,Cr:YSGG laser group.

Arukaslan and Aydemir [3] proved that the post space volume after fiber post removal by ultrasonic was higher than before post cementation and there was more dentin volume loss in the ultrasonic group in comparison to the removal kit group using the micro-computed tomography technique. Lindemann and Herrero [28] had the same results. But these contradict the results of Alsafra *et al.* [29], which stated that the changes that occurred in post space volume after fiber post removal by ultrasonic were insignificant in comparison to the removal kit. This could be explained by the fact that this study used a two-dimensional technique in the assessment process, which was insufficient to determine the precise amount of three-dimensional dentin volume loss that resulted from the removal of fiber posts from the root canals.

This research can be helpful in estimating the retrieval and amount of dentin volume loss, which can help dentists to determine the treatment plane for a retrieval and replacement of post or take alternative choices, like extraction and dental implant. In vivo investigations showed that the mean yearly failure rate for fiber posts was rather high in long-term follow-up, coming in at 8.6% after 6.5 years and 4.6% within 10 years. [7] However, the failure was primarily caused by the residual root canal walls. As a result, while removing a broken post, residual root canal structure must be taken into consideration. [30]

Conclusions:

The post space volume after fiber post removal by the Er,Cr:YSGG laser or by ultrasonic was significantly higher than before post cementation. The removal of the fiber post from an endodontically treated teeth by the Er,Cr:YSGG laser produced more dentin volume loss than ultrasonic.

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