EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

VOL. 70, 979:986, JANUARY, 2024

PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360

CONSERVATIVE DENTISTRY AND ENDODONTICS

Submit Date : 18-12-2023 • Accept Date : 31-12-2023 • Available online: 10-01-2024 • DOI : 10.21608/EDJ.2023.256015.2828

EVALUATION OF FRACTURE RESISTANCE OF BIOCERAMIC SEALER WITH C POINTS WITH AND WITHOUT LASER ACTIVATION (AN IN-VITRO STUDY)

Nadia Saeed Hosny* *and* Fatma ElZahraa ElAbbasy*

ABSTRACT

Aim: The aim of this study was to evaluate effect of laser activation on fracture resistance after using different sealers and different obturating materials.

Materials and Methods: Fourty single rooted mandibular premolar teeth were used in this study. Teeth were decoronated and root length is standardized to 16 mm. Samples were instrumented using Protaper Next system reaching file size x4 as the final master apical file. Teeth were divided into 2 groups, each containing 20 teeth. Group 1: without laser activation, Group 2: with laser activation. Each group was subdivided into 2 groups, each containing 10 teeth. Subgroup A: teeth were obturated with AH plus sealer and Gutta Percha points, Subgroup B: teeth were obturated with Ceraseal sealer and C points. All teeth were embedded in acrylic resin blocks and fracture force was measured using a universal testing machine.

Results: Results showed that for diode laser activated and non-activated groups, Ceraseal + C-points had significantly higher strength values than Adseal + GP. Results also showed that regardless of the type of sealer used, laser activation significantly increased fracture resistance.

Conclusion: Within the limitation of this study, it can be concluded that, bioceramic sealer along with C-points significantly increased fracture resistance of endodontically treated teeth compared to Adseal combined with traditional gutta percha points whether treated with diode laser or not.

KEYWORDS: Fracture resistance; Bioceramic sealer; Adseal; Diode laser; C-points.

* Endodontic Department, Faculty of Dentistry, Cairo University

INTRODUCTION

Root fracture is considered to be one of the unpleasant complications of root canal treatment, it can be related to several factors including type of canal filling material, remaining dentin thickness, and also the type of irrigation protocol and intracanal medications used, as they may play a role in altering the mechanical and physical properties of dentin which in turn increases the possibility of root fracture[1,2]. Therefore, root canal treated teeth will be more subjected to root fracture and the resistance to load maybe reduced[1].

Accordingly, it is beneficial to use a root canal filling material that strengthen the root and improve its resistance to fracture. This could be achieved by using endodontic sealers that are able to provide good adhesion and seal between the core material and radicular dentin. Several studies have shown that by adhesion and mechanical interlocking between the radicular dentin and filling material, root fracture can be reduced [3,4].

Gutta percha with epoxy resin-based root canal sealer have been used in several studies, as it is considered a gold standard for obturating the root canal, however, the ability of these materials to reinforce root canal treated teeth is still a matter of debate because of controversial results[5-7]. Therefore, there is a continuous quest for alternative sealers or root filling materials to provide better sealing and adhesive properties.

In the wake of this concept, the use of bioceramic sealers has been popular in the recent years. Calcium silicate sealers based on dentin adhesion technology, which depend on the chemical interaction at the interfacial dentin and formation of hydroxyapatite along with the micromechanical tag-like structures result in effective adhesion of sealer to radicular dentin. This adhesion strengthens the endodontically treated teeth, and thus increases the fracture resistance[8].

In order to improve adhesion, it is important to remove the smear layer and open the dentinal tubules to obtain a superior field for adhesion[9]. For many years, the combination of sodium hypochlorite (NaOCl) and ethylene diamine tetraacetic acid (EDTA) is an effective irrigation protocol capable to dissolve the smear layer's organic and inorganic content[10]. However, the smear layer cannot be completely removed with irrigants alone. Many devices have been used and various methods have been applied till now[11]. However, lasers have begun to be used to progress the effectiveness of irrigating solutions. Diode laser was capable to remove smear layer and is recommended to be used in endodontics because it has a wavelength which is equivalent to the infrared range[12,13].

Thus, this study aimed to evaluate the effect of diode laser activation on the fracture resistance after using different sealers and obturating materials. The null hypothesis was that either activation with diode laser or not would not affect the resistance to fracture of teeth filled with two different obturating materials.

MATERIAL AND METHODS

Sample selection

Forty single-rooted human mandibular premolar teeth with completely formed apices were selected in this study. Initial digital radiographs (Belray II 097, Belmont, Japan) were taken in a bucco-lingually and mesio-distal directions. Only premolars presenting Type I of Vertucci's root canal configuration with straight roots (canal curvature angle ≤5°, calculated using the methodology of Scheider) were included. Teeth with incomplete root formation, root fracture, previously endodontically treated, cracked roots, calcifications, and internal and external root resorptions were excluded. Calculus and soft tissue deposits on the surface of the teeth were removed using ultrasonic tips, then the teeth were disinfected by immersing in 5.25% sodium hypochlorite (Clorox CO. Cairo, Egypt) for 30 minutes, then stored in saline till further usage.

Teeth were then de-coronated at a length of 16 mm from anatomic apex to ensure standardization using a low speed diamond precision saw with water cooling (Isomet 1000; Buehler, Lake Bluff, IL). The working length was obtained using K-file size #10 (MANI, Inc, Utsunomiya, Tochigi, Japan). The file was inserted into the root canal until the tip of the file was observable at the apex (tooth length) and then the working length was obtained after subtracting 1 mm from the tooth length. Instrumentation was carried out using Protaper Next system (Dentsply Maillefer, Ballaigues, Switzerland) till file size X4 (#40/0.06) with speed and torque adjusted according to manufaturer's instructions using an electric motor (X Smart; Dentsply, Maillefer, Ballaigues, Switzerland). A 3 ml of 2.5% NaOCl was used between each file size with a 30-gauge max-i-Probe needle tip (Dentsply Maillefer, Ballaigues, Switzerland) that was positioned 1mm away from the working length with a rate of 1ml/min.

After cleaning and shaping, teeth were then distributed into two groups each containing 20 teeth according to final irrigation technique:

Group I (CG): conventional irrigation protocol without diode laser activation (Control group). Teeth were irrigated with 5 ml 2.5 % NaOCl followed by 5 ml 17% EDTA with 5 ml distilled water between NaOCl and EDTA and as a final flush with no activation.

Group II (DL): Diode laser activation (940 nm). Biolase Epic XTM (Biolase, Irvine, California, USA) was applied using a tip number E2-14 (Biolase, Irvine, California, USA); endo 200-µm malleable laser tip and a length of 14 mm, being short of the apex by 1 mm, with wave length 940nm ± 10nm with consistent settings of 2 watt. The laser tip was detached in gentle, helical movements, in an apical-coronal path to guarantee even light diffusion inside the root canal wall at a speed of about 2 mm/sec. The irrigation/activation protocol was as follows: 1.25 ml 2.5% NaOCl for 5 seconds time periods, then diode laser activation for another 5 seconds. This lasing cycle was repeated for 4 times. Radiation lasted for a total of 20 seconds. After rinsing the canals with 2.5 ml distilled water (DW), same protocol of irradiation was applied with the 17% EDTA. Thus, 1.25 mL of EDTA was used at each lasing cycle and the procedure was repeated four times. Consequently, the total radiation exposure for both irrigants was 40 seconds. Finally, the canals were rinsed with 2.5 mL distilled water[14].

Teeth in each group were then subdivided into two subgroups (n = 10) according to the type of sealer and obturating material that was used for obturation as follows:

Subgroup A: teeth were filled with Adseal resin sealer (Dentsply, Konstanz, Germany) and a single gutta perch (GP) cone size X4 (Dentsply Maillefer, Ballaigues, Switzerland).

Subgroup 2: teeth were filled with Ceraseal bioceramic sealer (MetaBiomed, Cheongju, Republic of Korea) and a perfectly fit single C-point cone size F4 (Endo Technologies, LLC, Shrewsbury, MA, USA).

All teeth were stored at 37°C with 100% moisture for two weeks to confirm that the sealer was completely set.

Testing resistance to fracture

The root surface of all the samples was concealed with two layers of glue tape and inserted in a block of acrylic resin with a long axis perpendicular to the base of the acrylic block and exposing approximately 5 mm of the coronal portion of each root. The glue tape was then removed and the space was occupied with light body silicone impression material to simulate periodontal ligament. To guarantee vertical alignment of the long axis of the root, a protractor was used. The blocks were then mounted on the lower immovable partition of the Instron testing machine (Model 3345; Instron, UK). Over the canal opening of each root, a 5kN vertical force was applied. Force was increased by using a cylindrical steel rod with round tip, and a diameter of 2 mm being attached to the upper part of the universal testing machine at a rate of 1.0 mm/min, until the root was fractured. This point of fracture was documented by the computer monitoring software (BlueHill, Instron) and measured in Newton as shown in figure (1).

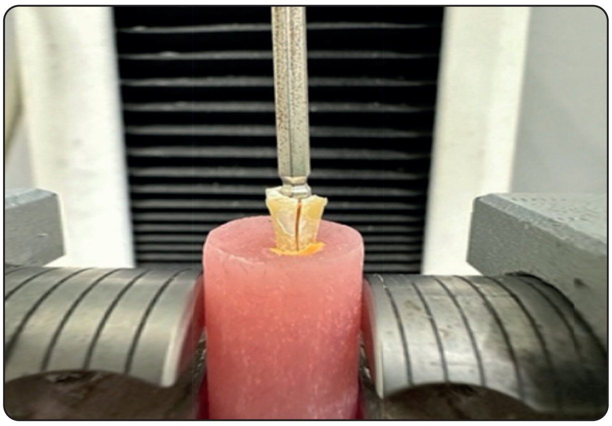

Fig. (1): Fracture resistance test setup.

Statistical analysis:

Numerical data were represented as mean and standard deviation (SD) values. Shapiro- Wilk's test was used to test for normality. Homogeneity of variances was tested using Levene's test. Data showed parametric distribution and variance homogeneity and were analyzed using two-way ANOVA. Comparison of simple main effects was done utilizing the error term of the two-way model with p-values adjustment using Bonferroni correction. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.3.0 for Windows.

RESULTS

Results of two-way ANOVA presented in table (1) to determine the difference between the groups and showed that there was a significant interaction between sealer type and laser activation on fracture resistance ($p<0.001$). Mean and standard deviation (SD) values for the effect of the two different root canal filling materials with and without diode laser activation on root fracture resistance were presented in table (2) figure (2). Results showed that for diode laser activated and non-activated groups, Ceraseal + C-points had significantly higher strength values than Adseal + GP ($p<0.001$). Results also showed that regardless of the type of sealer used, laser activation significantly increased fracture resistance ($p<0.001$).

TABLE (1): Two-way ANOVA test results.

Parameter	*Sum of squares*	*df*	*Mean square*	*p-value*
Sealer type	332755.21	1	332755.21	**<0.001***
Activation	874867.10	1	874867.10	**<0.001***
*Sealer type *activation*	22402.11	1	22402.11	**<0.001***

significant (p<0.05)

TABLE (2): Mean and standard deviation values for the effect of diode laser activation on root fracture resistance between the compared groups.

Group	*Fracture resistance (N) (Mean±SD)*		*p-value*
	Without diode laser activation	**With diode laser activation**	
Adseal + GP	305.65±22.85	524.16±9.96	**<0.001***
Ceraseal + C-points	433.35±31.95	734.16±13.35	**<0.001***
p-value	**<0.001***	**<0.001***	

significant (p<0.05)

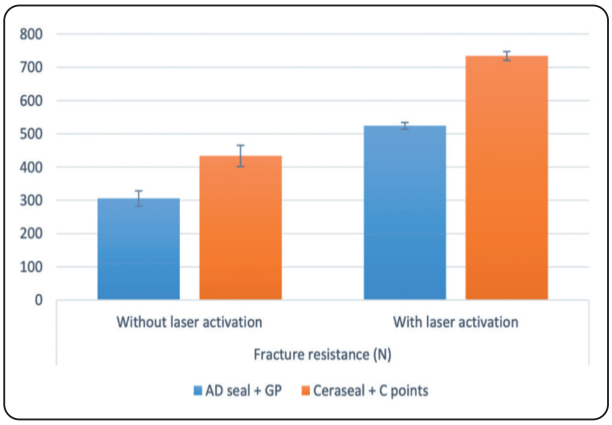

Fig. (2) Bar chart showing mean and standard deviation values for the effect of diode laser activation on root fracture resistance between the compared groups.

DISCUSSION

The results of the following study did not support the null hypothesis as activation with diode laser affected the resistance to fracture of teeth filled with different root canal obturating materials.

Single-rooted human mandibular premolar teeth were used in this study; as the oval cross section of the single canal cannot be prepared and cleaned using the rounded cross sectional design of most endodontic files, leaving areas of untouched canal walls which lead to the accumulation of tissue debris in the irregularities found within the root canal [15]. Therefore, activation of irrigants is mandatory in such canals to optimize cleaning and to progress the adhesion of root canal filling materials to root dentin.

In the current study, ProTaper Next (PTN) system was used to clean the root canal, which is the second generation of ProTaper Universal system manufactured from M-Wire nickel-titanium alloy to improve flexibility and resistance to cyclic fatigue[16]. PTN comes with desirable design features as offset rectangular cross-section to diminish the contact between the file and dentin and also for reducing the undesirable taper lock and screwing effect, thus minimizing stress on dentinal walls. Hence, these files are concomitant to less micro-cracks[17].

Obturation was carried out in this study with a single cone technique in-order to eliminate the wedging force of the spreader during lateral compaction and to avoid unnecessary removal of coronal dentin to facilitate insertion of pluggers during vertical compaction. Moreover, some studies showed that single cone technique increase the resistance of teeth to fracture, compared to other techniques of obturation[18].

In-order to overcome the limitations of hydrophilic obturating systems and to improve consequences of endodontic treatment, C-Point with bioceramic sealer were used as a hydrophilic obturating system in this study. Ceraseal is a calcium silicate based bio-ceramic sealer which is free of resin and monomer to ensure better biocompatibility and zero shrinkage. It helps re-mineralization by formation of hydroxy apatite due to its high pH and bioactive properties. Bioceramic sealer was used with C-point, as the bioceramic particles in the sealer can bond to the outer layer of C-Points as well as to the dentin through formation of hydroxyapatite and water as byproduct. C-point contains a hydrophilic polymer coating around a central core that expands in spaces available and allow sealer to penetrate into dentinal tubules and lateral canals only upon absorbing water, which in turn helps in achieving better seal and adhesion of the obturating material to radicular dentin[19,20].

Smear layer perform an obstacle which may inhibit the penetration of irrigants, intra-canal medicaments and sealers inside dentinal tubules. Following the innovation of the laser techniques and devices, the diode laser is recommended in the field of endodontics due to its compactness, favorable antibacterial effect, relatively safe wavelength, minimal temperature rise and low cost[21]. Diode laser has an excellent depth of penetration into dentinal tubules (500 μm) in comparison to chemical solutions (100 μm)[22]. In the present study, 940 nm diode laser activation was used as it showed promising results in removing the smear layer without massive loss of mineral contents of dentin along with NaOCl and EDTA irrigation[23,24].

The results of the current study showed that Ceraseal bioceramic sealer combined with C-points cones had a higher resistance to fracture when compared to Adseal resin sealer combined with traditional gutta percha points.

These results may be attributed to the fact that bioceramic sealer has a hydrophilic nature which results in higher intimate contact with root canal walls than AH Plus hydrophobic sealer[25]. Furthermore, bioceramic sealer has slow setting and when it is combined with the sluggish expansion of C-points when subjected to moisture, may have possibly pushed the sealer into spaces that AH Plus sealer with gutta-percha could not reach[26].

This came in agreement with Nagas et al [25], Patil et al [27] and Elfaramawy and Abdelrahman[28] who reported that the calcium silicate composition of bioceramic sealer helps in minimizing contraction during the setting procedure. Also, its bonding effectiveness to root canal dentin might be due to the extremely small particle size and the low level of viscosity of bioceramic sealer which improves its flow. Moreover, the integration of Ca and Si in dentin with subsequent alteration in the physical and chemical structure of dentin, results in higher resistance to fracture and increase the strength of the root.

On the other hand, Mandava et al[29], Mittal et al[30] and Abdallah et al [31] reported that resin-based sealers had the highest resistance to fracture values compared to other bioceramic sealers. They clarified such results by the formation of a covalent bond epoxy resin sealer and amino groups of the dentinal collagen which results in a strong bond of Adseal to root canal dentin.

In this study, the fracture resistance of root was found to be high after diode laser activation. This came in agreement with Quteifan et al[32] and Barakat et al[33] that accredited it to the fact that laser can glaze, melt, and recrystallize dentin, where such molten dentin layer solidifies and close slight transient surface cracking. In the opposite side a study by Ayrancı et al[34] stated that laser decreased the fracture resistance of dentin, this may be attributed to the difference in the study design and methods as the vertical root fracture resistance test was done on apicoected teeth, also they claimed that the decrease of fracture resistance might be due to alteration in structural composition of dentin.

CONCLUSION

It can be concluded that bioceramic sealer along with C-points increased resistance to fracture of endodontically treated teeth more than Adseal combined with traditional gutta percha points whether treated with diode laser or not. Also, activation of root canal dentin with 940 nm diode laser, using NaOCl and EDTA as irrigation, resulted in increasing the resistance to fracture of endodontically treated teeth compared to the using NaOCl and EDTA alone.

REFERENCES

1. Sayin TC, Serper A, Cehreli ZC, Otlu HG. The effect of EDTA, EGTA, EDTAC, and tetracycline-HCl with and without subsequent NaOCl treatment on the microhardness of root canal dentin. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104(3):418-424.
2. Zandbiglari T, Davids H, Schafer E. Influence of instrument taper on the resistance to fracture of endodontically treated roots. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101(1):126-131.
3. Yendrembam B, Mittal A, Sharma N, Dhaundiyal A, Kumari S, Abraham A. Relative assessment of fracture resistance of endodontically treated teeth with epoxy resin-based sealers, AH Plus, MTA Fillapex, and Bioceramic sealer: An In vitro study. Indian J Dent Sci. 2019;11(1):46-50.
4. Dibaji F, Afkhami F, Bidkhori B, Kharazifard J. Fracture resistance of roots after application of different sealers. Iran Endod J. 2017;12(1):50-54.

5. Bhat SS, Hegde SK, Rao A, Mohammed AS. Evaluation of resistance of teeth subjected to fracture after endodontic treatment using different root canal sealers: an in vitro study. J Indian Soc Pedod Prev Dent. 2012; 30(4):305.

6. Hegde V, Arora S. Fracture resistance of roots obturated with novel hydrophilic obturation systems. J Conserv Dent. 2015; 18(3):261-264.

7. Topçuoğlu HS, Tuncay Ö, Karataş E, Arslan H, Yeter K. In vitro fracture resistance of roots obturated with epoxy resin–based, mineral trioxide aggregate–based, and bio-ceramic root canal sealers. J Endod. 2013; 39(12): 1630-1633.

8. Torabinejad M, Parirokh M, Dummer PMH. Mineral trioxide aggregate and other bioactive endodontic cements: an updated overview - part II: other clinical applications and complications. Int Endod J. 2018;51(3):284-317.

9. Özcan M, Volpato CAM. Current perspectives on dental adhesion: (3) Adhesion to intraradicular dentin: Concepts and applications. Jpn Dent Sci Rev. 2020; 56(1):216-223

10. Mohammadi Z, Shalavi S, Yaripour S, Kinoshita JI, Manabe A, Kobayashi M. Smear layer removing ability of root canal irrigation solutions: a review. J Contemp Dent Pract. 2019; 20(3):395–402.

11. Ahmetoglu F, Keles A, Yalcin M, Simsek N. Effectiveness of different irrigation systems on smear layer removal: A scanning electron microscopic study. Eur J Dent. 2014; 8(1):53-57.

12. Wang X, Sun Y, Kimura Y, Kinoshita J, Ishizaki NT, Matsumoto K. Effects of diode laser irradiation on smear layer removal from root canal walls and apical leakage after obturation. Photomed Laser Surg. 2005;23(6):575-581

13. Anagnostaki E, Mylona V, Parker S, Lynch E & Grootveld M. Systematic review on the role of lasers in endodontic therapy: valuable adjunct treatment? Dent J. 2020;8(3): 1-18.

14. Mehrvarzfar P, Saghiri MA, Asatourian A. Additive effect of a diode laser on the antibacterial activity of 2.5% NaOCl, 2% CHX and MTAD against Enterococcus faecalis contaminating root canals: an in vitro study. J Oral Sci. 2011;53(3):355-360.

15. Peters OA, Schönenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J. 2001;34(3):221-230.

16. Gambarini G, Galli M, Seracchiani M, Di Nardo D, Versiani MA, Piasecki L. In vivo evaluation of operative torque generated by two nickel-titanium rotary instruments during root canal preparation. Eur J Dent. 2019;13(4):556–562.

17. Capar ID, Arslan H, Akcay M, Uysal B. Effects of ProTaper Universal, ProTaper Next, and HyFlex instruments on crack formation in dentin. J Endod. 2014;40(9):1482–1484.

18. Pereira A, Nishiyama C, Pinto L. Single-cone obturation technique: a literature review. Rev Sout-Braz Odontol J. 2012; 9(4):442-447.

19. Jain P, Ranjan M. The Rise of Bioceramics in Endodontic: A Review. Int J Pharm Bio Sci. 2015; 6(4):416 - 22.

20. Janavathi, Basavanagowda N, Reddy G, Praveen M. Apical Sealing Ability of Four Different Root Canal Sealers: An In Vitro Study. J Int Oral Health. 2016; 7(6):47-50.

21. Ashofteh K, Sohrabi K, Iranparvar K, Chiniforush N. In vitro comparison of the antibacterial effect of three intracanal irrigants and diode laser on root canals infected with Enterococcus faecalis. Iran J Microbiol. 2014;6(1):26-30.

22. Schoop U, Kluger W, Dervisbegovic S, Goharkhay K, Wernisch J, Georgopoulos A. Innovative wavelengths in endodontic treatment. Lasers Surg Med 2006;38(6): 624-630.

23. Saraswathi, M., Ballal, N., Padinjaral, I., & Bhat, S. (2012). Ultra-morphological changes of root canal dentin induced by 940 nm diode laser: An in-vitro study. Saud Endod J.2012; 2(3):131-135

24. Otaify RR, Roshdy NN, Ezzat N. Evaluation of competency of diode laser and er: yag laser activation on sodium hypochlorite capability for biofilm eradication and smear layer removal : a comparative in vitro study. Acta Sci Dent Sci. 2020; 4(2):28-36.

25. Nagas E. Uyanik MO. Eymirli A, Cehreli ZC,Vallittu PK, Lassila LVJ, Durmaz, V. Dentin moisture conditions affect the adhesion of root canal sealers. J Endod. 2012; 38(2):240–244.

26. Ibrahim NK, Nayif MM. Bond Strength of Endosequence Bioceramic Sealer to Root Canal Dentine Irrigated with Different Solutions. Int J Enhanc Res in Sci Techno and Eng. 2015;4(5):136–139

27. Patil P, Banga K, Pawar A, Pimple S, Ganeshan R. Influence of root canal obturation using gutta-percha with three different sealers on root reinforcement of endodontically treated teeth. An in vitro comparative study of mandibular incisors. J Conserv Dent. 2017;20(4):241-244

28. Elfaramawy MT. and Abdelrahman TY. The Effect of Bioceramic Sealers on the Fracture Resistance of Endodontically Treated Teeth (In Vitro Study). Egy Dent J. 2021;67(1):857–860.

29. Mandava J, Chang P, Roopesh B, Faruddin M, Anupreeta A, Uma C. Comparative evaluation of fracture resistance of root dentin to resin sealers and a MTA sealer: An in vitro study. J Conserv Dent. 2014;17(1):53-56.

30. Mittal A, Dadu S, Garg P, Yendrembam B, Abraham A, Singh K. Comparative evaluation of fracture resistance of endodontically treated teeth with epoxy resin-based sealers ah plus and mineral trioxide aggregate fillapex: An in vitro study. Indian J Dent Sci. 2017;9(1):8.

31. Abdallah Y, Nagi M, Hussein S. fracture resistance of two different sealers (in vitro study). Egy Dent J, 2023; 69(1):793-800.

32. Quteifan MQ, Madarati AA, Layous K, AL Tayyan M. A Comparative ex-vivo Study of Effects of Different Irrigation Protocols with/without Laser Activation on the Root Dentine's Micro-Hardness. Eur Endod J 2019;3:127-32.

33. Barakat D, Hassanein, E, Elbatouty K, Evaluation of The Effect of Diode Laser on Root Canal Disinfection Canal Cleanliness Fracture Resistance of Tooth Structure and Bond Strength to Root Canal Dentin. An in Vitro Study. Ain Shams Dent J. 2021; 21(1): 20-28.

34. Ayrancı F, Ayrancı, LB, Özdoğan A. Resistance to vertical root fracture of apicoected teeth using different devices during two root canal irrigation procedures Lasers Med Sci. 2018;33(8):1685-1691.