ECRONICON OPEN ACCESS
EC DENTAL SCIENCE
Research Article

Relationship between Fracture Resistance and Ferrule Length in Teeth Restored with Different Types of Posts and Luting Cements

Rana M Mahjari[1], Latifah M Alfrihidi[2], Renad M Alawi[3], Saba A Lanqa[4], Salah A Yousief[5], Waleed M Alqahtani[6] and Ahmed M Elmarakby[7]*

[1]*Dental Intern, Alfarabi Colleges, Jeddah, Saudi Arabia*

[2]*General Practioner dentist, Alfarabi Colleges, Jeddah, Saudi Arabia*

[3]*5th Year Dental Student, Alfarabi Colleges, Jeddah, Saudi Arabia*

[4]*4th Year Dental Student, Alfarabi Colleges, Jeddah, Saudi Arabia*

[5]*Assistant Professor, Restorative Dentistry Department, AL-Farabi Dental College, Jeddah, Saudi Arabia*

[6]*Assistant professor, Department of prosthetic Dentistry, College of Dentistry, King Khalid University, Abha, Saudi Arabia*

[7]*Assistant Professor in the Department of Restorative Dental Sciences, Al-Farabi Colleges for Dentistry and Nursing, Riyadh, Saudi Arabia and Lecturer of Operative Dentistry Department, Faculty of Dental Medicine, Al-Azhar University, Assiute Branch, Egypt*

***Corresponding Author**: Ahmed M Elmarakby, Assistant Professor in the Department of Restorative Dental Sciences, Al-Farabi Colleges for Dentistry and Nursing, Riyadh, Saudi Arabia and Lecturer of Operative Dentistry Department, Faculty of Dental Medicine, Al-Azhar University, Assiute Branch, Egypt.

Received: September 27, 2018; **Published:** October 30, 2018

Abstract

Objectives: The aim of this study is to evaluate the effect of ferrule length on fracture resistance of teeth restored with two different types of posts luted with two different luting cements.

Materials: Eighty freshly extracted sound human non caries maxillary central incisors were collected and stored in normal saline solution (0.9% Na Cl) at room temperature. The teeth were randomly divided into two groups. Each group was subdivided into two subgroups according to type of cement used for its cementation, a composite resin and a zinc phosphate. Using a universal testing machine, a compressive force was applied at a cross head speed of 0.5 mm/min until fracture occurred to all samples.

Results: The cast post that cemented with resin cement in both cases "with and without ferrule effect" had higher load values than the others cemented with resin phosphate cement in both cases (with and without ferrule effect).

On the other hand the fraction resistance increased by increasing the ferrule length in both tested cement used for cementation of the different posts in its place of root canals.

Conclusion: The fracture resistance of endodentically treated teeth increased with increasing the coronal dentinal structure (Ferrule length). The fracture resistance of endodentically treated teeth restored by flexi post and cemented with composite resin was higher than others cemented with zinc phosphate. The fracture resistance of endodentically treated teeth restored with cast post and cemented with composite resin was higher than cast post cemented with zinc phosphate. The fracture resistance of endodentically treated teeth restored with flexi post and Ti core was higher than cast post and its core.

Keywords: *Ferrule Length; Fracture Resistance; Central Incisors*

Introduction

Natural dentine is superior in terms of fracture resistance than any post and core restoration. Tooth strength is directly related to the remaining tooth structure. This necessitates caution during tooth preparation for endodontic post insertion. Restoration of root filled teeth with endodontic posts should preserve tooth structure and reduce loss of dental tissues, allow and maintain a suitable apical seal and decrease damaging stresses. The amount of remaining tooth tissue around a post determines fracture resistance [1]. Although most reports have recommended retaining coronal tooth structure to improve retention and stress distribution, the effect of retained coronal dentine on the strength of root filled teeth remains controversial. Some studies had suggested that it increases resistance to tooth fracture, whilst others have concluded that it does not [2].

A post - core system is usually inserted to restore damaged teeth after endodontic treatment. The functions of a post placed in the root canal of the restored tooth are; (1) to disperse occlusal forces along the root, (2) to provide retention of the core substituting for coronal tooth structure and supporting or retaining the final restoration [3].

Flexi-Flange post has split shank, the presence of a split for the post system, reduces insertion and cementation stress, the split may act as a vent for release of hydrostatic pressure during cementation of the post into the canal. Flexi-Flange post with its multitier system maximizes dentin to metal contact to distribute functional stresses to the strongest part of root and coronal portion. Also, the threaded split shank design for the Flexi- Flange post offers high retention with minimal insertional and functional stresses [4].

The primary objective of every post is to provide retention for the core. Prefabricated posts are classified according to geometry (shape and configuration) or by the method of retention [5].

Rohhmat., *et al.* [6] evaluated the effect of metal collars on resistance of endodontically treated teeth to root fracture. Twenty freshly extracted maxillary central incisors were used. The coronal portions of the teeth were removed to 1 mm or 2 mm above cemento-enamel junction perpendicular to the long axis of teeth. They concluded that the records of endodontically treated teeth suggest that there is no significant increase in resistance to fracture or dislodgment gained with intracoronal reinforcement for the six anatomic groups of teeth.

The effect of ferrule (retained coronal dentine) on the strength of root filled teeth remaining controversial. Many studies have suggested that it increases resistance to tooth fracture. While other authors have concluded that it does not increase fracture resistance [7].

Different studies [8] were conducted to determine the optimum length for the ferrule effect. The influence of ferrule length on resistance to preliminary failure showed that 1.5 mm should be the minimum ferrule length in a root of maxillary incisor with post and core retained crown because it increases fracture resistance.

An *in-vitro* study [9] was made to evaluate the fracture resistance of teeth restored with two different post-and-core designs (ferruled and none ferruled) cemented with two different cements (resin cement and zinc phosphate). Twenty samples were ferruled, and half of the posts and cores were cemented with zinc-phosphate cement, while the other half was cemented with resin cement. The same procedures were followed for the non-ferruled Group. Load was applied at 45º degrees and measured with universal testing machine. The results showed that ferruled samples showed greater resistance than non-ferruled ones regardless of the cement used. The non-ferruled Group with zinc-phosphate cement showed the poorest resistance. They concluded that 2 mm cervical ferrule is important for fracture resistance of restored teeth, and resin cement has a better performance.

In an *in-vitro* study [10] compared the effect of three different ferrule lengths (1 mm, 1.5 mm and 2 mm) on the fracture resistance patterns of crowned endodontically treated teeth restored with 4 different esthetic post systems (Quartz fiber, Glass fiber, Glass fiber plus zirconia, and zirconia). Fracture thresholds were higher for all 4 post systems when samples were prepared with a 2 mm ferrule length. The effect of different ferrule designs on the fracture resistance of teeth restored with prefabricated posts and composite cores was investigated [11]. They concluded that, no significant differences among the three groups as regard to the fracture resistance.

An *in-vitro* study [12] was made to evaluate that fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations. They concluded that central incisors restored with cast post/core and crowns with 2 mm uniform ferrule were more fracture resistant compared to central incisors with non-uniform ferrule (0.5 to 2 mm).

In this study, it was to evaluate the effect of ferrule length on fracture resistance of teeth restored with two different types of posts luted with two different luting cements.

Methods and Materials

Eighty freshly extracted sound human non caries maxillary central incisors were collected and stored in normal saline solution (0.9% Na Cl) at room temperature. The soft tissues and calculus deposits on the teeth surfaces were removed by using a surgical blade (No. 15) and ultrasonic sealer. The collected teeth were scrubbed with a hard tooth brush and soap under running water and finally dried with oil-free compressed air. Afterwards, teeth showing developmental abnormalities as cracks, caries, restoration, and/or roots shorter than 10mm were discarded and replaced by another one. Teeth with average length 23 mm were selected.

The teeth were randomly divided into two groups of 40 teeth each according to the type of post-core system. Group A: Restored with prefabricated flexi post and composite core. Group B: Restored with cast post and core. Each group was subdivided into two subgroups according to type of cement used for its cementation, a composite resin and a zinc phosphate. Each subgroup was further divided into four divisions according to ferrule length (0 mm, 1.5 mm, 2.5 mm, 3.5 mm) as illustrated in figure 1.

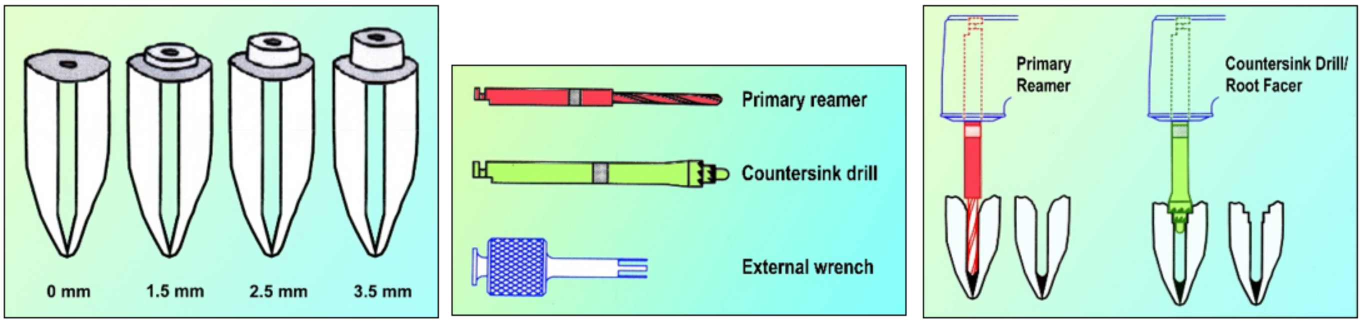


Figure 1: *Diagram showing different ferrule length used, and tools.*

The coronal portion of all teeth were (amputated) sectioned horizontally to its long axis at 0 mm, 1.5 mm, 2.5 mm and 3.5 mm coronal to the level of the cemento-enamel junction by using diamond stones. Teeth were inserted in blocks of self cure acrylic resin mold, 2 mm below cervical line. Then teeth were endodontically treated with step-back technique and filled with gutta-percha and epoxy Root Canal Cement (eugenol free-sealer) using lateral condensation technique.

All teeth were prepared with diamond tapered stone with flat end to obtain 1.2 mm shoulder finish line. The preparation had a wall of convergence of approximately 6°. Gutta-percha was removed from the root canals with a peso reamer leaving 4 mm of root canal filling in the apical portion. The root canal was enlarged to receive the posts using the kit of Flexi post system.

Cementation of the post A was done with Flexi-Flow resin cement which mixed according to the manufactures instructions. Cement was spun down the channels with spiral paste filler (lentulo spiral). Post B (flexi post) was cemented using the zinc phosphate cement (Figure 2).

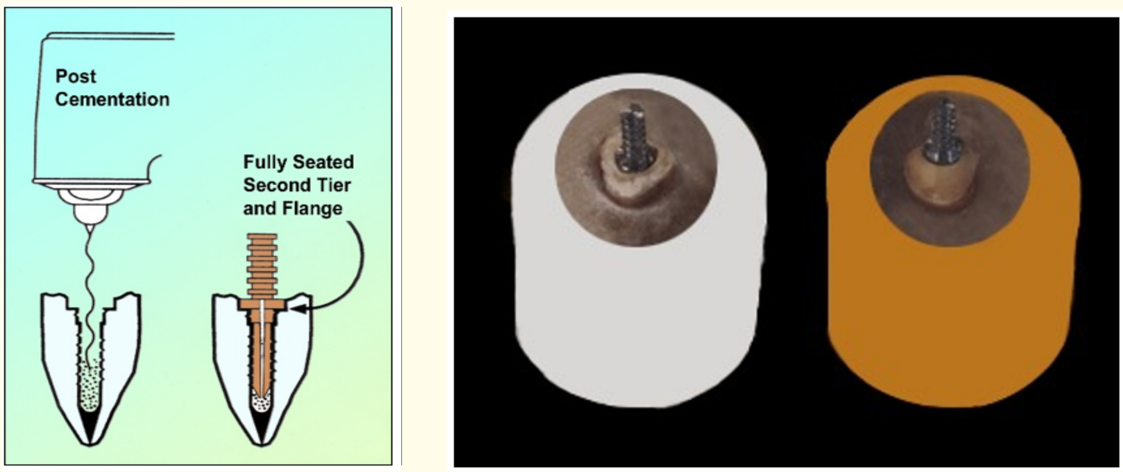


Figure 2: *Cementation of post.*

Core fabrication: Ti-Core was used according to manufacture instructions, and presenting standard core dimensions and applied on the coronal part of the post head.

Fabrication of cast post and core specimen, a plastic post with the same dimension of the flexi post was inserted into the prepared root canal space for taken the impression using auto polymerzing resin (Duralay). After complete set of pattern, additional mix is applied over the coronal part of plastic burn out post to make core. The pattern was cast using nickel chromium alloys with aid of a centrifugal casting machine, cementation of cast post and core was done by using a composite resin cement (flexi-flow) and a zinc phosphate cement following the same steps for cementation of the flexi-post. Fabrication of full crown (Cast Crown Fabrication): All patterns were casted using Nicr base alloy and finished then polished.

Samples were secured in a universal testing machine with use of device that allowed loading of the tooth lingually at 130 degree to the long axis as shown in figure 3. A compressive force was applied at a cross head speed of 0.5mm/min until fracture occurred by using a computerized testing machine.

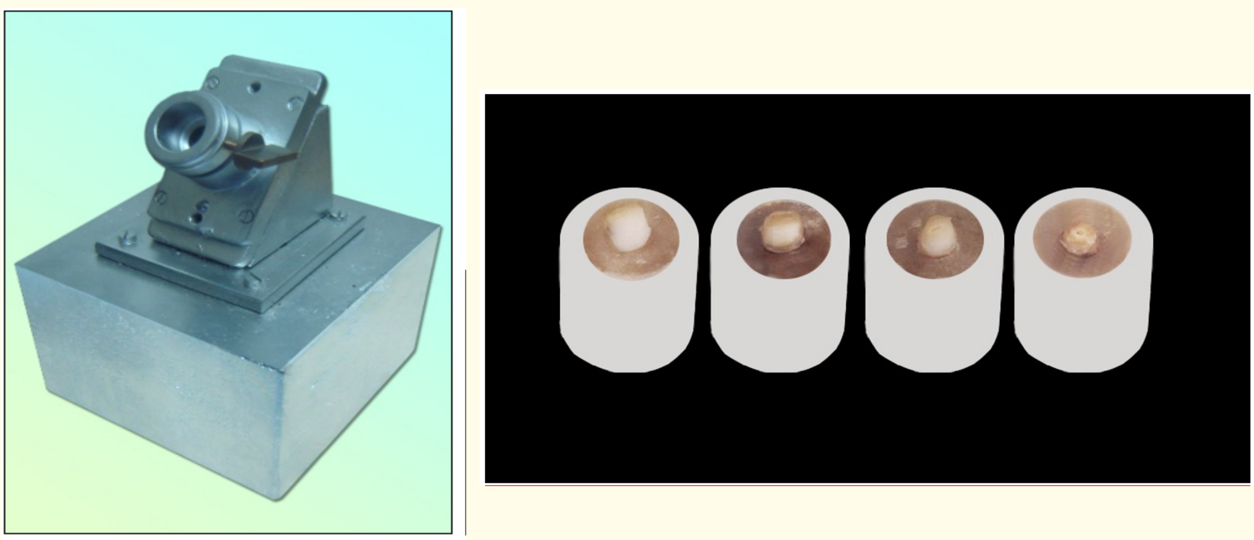


Figure 3: *Fixture and picture of samples of 0mm, 1.5 mm, 2.5 mm, 3.5 mm.*

Results

The cast post that cemented with resin cement "in both with and without ferrule effect" had high at (0) was (1126.6100), at (3.5) was (3737.2900 ± 206.19). Values than the others cemented with resin phosphate cement "in both with and without ferrule effect". On the other hand the fraction resistance uncreased by increasing the ferrule length in both tested cement used for cementation of the different posts in its place of root canals at (0) was (645.9760) and at (3.5) was (2772.2680). The flexi-post that cemented with resin cement "in both with and without ferrule effect" had high at (0) was (1216.3200), at (3.5) was (4411.4320). Values than the others cemented with resin phosphate cement "in both with and without ferrule effect".

On the other hand the fracture resistance increased by increasing the ferrule length in both tested cement used for cementation of the different posts in its place of root canals at (0) was (1076.3400) and at (3.5) was (3200.00) tables 1-5 revealed the Statically analysis with Standard deviations and Standard. Error Mean. Table 6 was ANOVA table for analysis of Cast-post and Flexi-post. Bar chart in figure 4 showed comparison in fracture resistance values between Cast-post and Flexi-post cemented with (a) Zinc phosphate, (b) composite resin, in group I and group II. While bar chart in figure 5 represented the mean values of all experimental groups.

Statically analysis	Group I Cast-post	0 mm	1.5 mm	2.5 mm	3.5 mm
Mean	Zinc phosphate	645.9760	1340.3200	2200.2000	2772.2680
± S.D		± 135.44	± 171.96	± 147.23	± 385.09
SEM		60.57	76.90	65.85	172.22
P-value		NS	NS	NS	NS
Mean	Composite resin	1126.6100	1700.9100	2483.0000	3737.2900
± S.D		± 123.89	± 185.84	± 174.59	± 206.19
SEM		55.40	83.11	78.08	92.21
P-value		NS	NS	NS	VHS***

Table 1: *Group I Cast-post cemented with zinc phosphate cement and composite resin.*

*S.D.: Standard Deviations; SEM: Standard Error Mean; NS: Not Significant; VHS***: Very High Significant at P < 0.001.*

Statically analysis	Group II Flexi-post	0 mm	1.5 mm	2.5 mm	3.5 mm
Mean	Zinc phosphate	1076.3400	1660.9700	2694.5600	3200.00
±S.D		±102.89	±270.15	±403.23	±433.56
SEM		46.02	120.82	180.33	193.89
P-value		NS	NS	NS	NS
Mean	Composite resin	1216.3200	1958.4500	2887.1100	4411.4320
±S.D		±159.58	±244.23	±402.64	±1211.72
SEM		71.37	109.23	180.07	541.89
P-value		NS	NS	NS	VHS***

Table 2: *Group II of flexi-post Group II cemented with zinc phosphate cement and composite resin.*

*S.D.: Standard Deviations; SEM: Standard Error Mean; NS: Not Significant; VHS***: Very High Significant at P < 0.001.*

Statically analysis	Cast-post and Flexi-post	0 mm	1.5 mm	2.5 mm	3.5 mm
Mean	Zinc phosphate in group I	1076.3400	1660.9700	2200.2000	2772.2680
±S.D		±135.44	±171.96	±147.24	±385.09
SEM		60.57	76.90	65.86	172.22
P-value		NS	NS	NS	NS
Mean	Zinc phosphate in group II	645.9760	1340.3200	2694.5600	3200.00
±S.D		±102.89	±270.15	±403.23	±433.56
SEM		46.02	120.82	180.33	193.89
P-value		NS	NS	NS	NS

Table 3: *Cast-post and Flexi-post cemented with Zinc phosphate in group I and group II.*

*S.D.: Standard Deviations; SEM: Standard Error Mean; NS: Not Significant; VHS***: Very High Significant at P < 0.001.*

Statically analysis	Cast-post and Flexi-post	0	1.5	2.5	3.5
Mean	Composite resin in group I	1126.6100	1700.9100	2483.0000	3737.2900
±S.D		±123.89	±185.84	±174.59	±206.19
SEM		55.40	83.11	78.08	92.21
P-value		NS	NS	NS	NS
Mean	Resin in group II	1216.3200	1958.4500	2887.1100	4411.4320
±S.D		±159.58	±244.23	±402.64	±1211.72
SEM		71.37	109.23	180.07	541.89
P-value		NS	NS	NS	VHS***

Table 4: *Cast-post and Flexi-post cemented with composite resin In group I and group II.*

*S.D.: Standard Deviations; SEM: Standard Error Mean; NS: Not Significant; VHS***: Very High Significant at P < 0.001.*

Statically analysis	Groups	0	1.5	2.5	3.5
Mean	Zinc phosphate in group I	645.9760	1340.3200	2200.2000	2772.2680
±S.D		±135.44	±171.96	±147.23	±385.09
SEM		60.57	76.90	65.85	172.22
P-value		NS	NS	NS	NS
	Zinc phosphate in group II	1076.3400	1660.9700	2694.5600	3200.00
		±102.89	±270.15	±403.23	±433.56
		46.02	120.82	180.33	193.89
		NS	NS	NS	NS
Mean	Composite resin in group I	1126.6100	1700.9100	2483.0000	3737.2900
±S.D		±123.89	±185.84	±174.59	±206.19
SEM		55.40	83.11	78.08	92.21
P-value		NS	NS	NS	VHS***
	Composite resin in group II	1216.3200	1958.4500	2887.1100	4411.4320
		±159.58	±244.23	±402.64	±1211.72
		71.37	109.23	180.07	541.89
		NS	NS	NS	VHS***

Table 5: *Group I and group II (mean value + Standard Deviations).*

*S.D.: Standard Deviations; SEM: Standard Error Mean; NS: Not Significant; VHS***: Very High Significant at P < 0.001.*

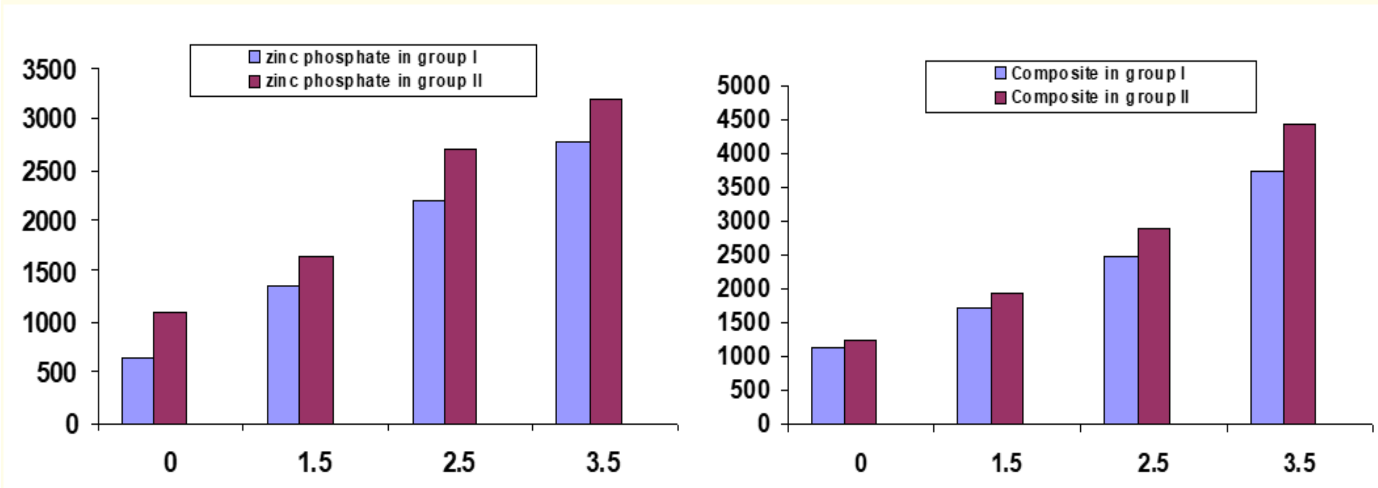
Analysis of Variance Procedure					
Source	**DF**	**Sum of squares**	**Mean square**	**F value**	**Pr > F**
Between groups	3	8614015.691	2871338.564	26.2386	.001
Within groups	16	175090.775	10943.173		
Corrected total	19	8789106.466			

Table 6: *ANOVA table for analysis of Cast-post and Flexi-post.*

Number of groups = 2.

Number of observations in data set= 20.

Dependent variable: Cast-post and Flexi-post in length of (0, 1.5, 2.5 and 3.5).



(a) *(b)*

Figure 4: *Cast-post and Flexi-post cemented with (a) Zinc phosphate, (b) composite resin, in group I and group II.*

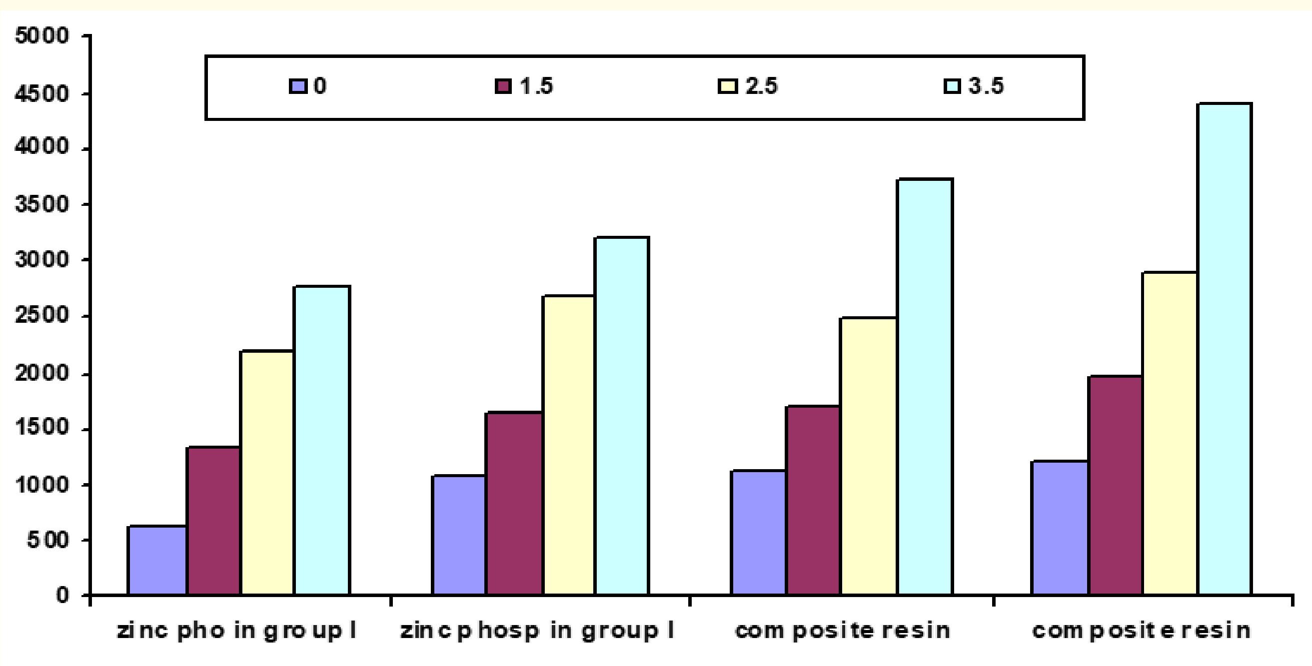


Figure 5: *Mean values of all experimental groups.*

Discussion

The endodontically treated teeth are a challenge when in sufficient coronal tooth structure remains to support a restoration. In such cases different post and core systems may be used to provide solid foundation for the final restoration [13].

In this study the effect of ferrule length on the fracture resistance of endodontically treated teeth which restored with different types of posts (Flexi-post, cast post). Cemented with different types of composite resin and zinc phosphate was investigated. The upper central incisors were selected and chosen due to the ideal form and length of its roots. Their roots were long, straight and had a sufficient around the circular root canal.

The post must be made from material with high strength, corrosion resistance and stress distribution [1,5,13]. All selected posts used in this study has high strength and corrosion resistance. The flexi-post was designed to solve the old-age problem of root fracture potential due to the presence of the unusual patent split-shank which absorbs the insertional stresses by gradually closing during placement while combining both parallel and tapered designs to epically conform the natural external root anatomy [6,9,14].

The cores of the specimens of this study would carried out with standardized manner which the external metal crown follow the requirements of full crown restorations. Samples were secured in universal testing machine with use of a device that allowed loading of tooth at palatal surface at angle 130^o to long axis of the teeth, this angle of loading was chosen to simulate a contact angle in class I occlusion between maxillary and mandibular anterior teeth.

The results of this study showed that the highest fracture resistance values were obtained with flexi-post and cast post cemented with composite resin or zinc phosphate cement at ferrule length 3.5 this is in agreement with many researches [7,12,15-19]. This may be attributed to the amount of remaining dentinal tooth structure (Ferrule length), ferrule length is important in the restoration of endodontically treated teeth because it increase the fracture resistance [12,20,21]. Also this may be attributed to natural dentine because it's superior in terms of fracture resistance than any post and core due to distrusting the stress to surrounding structure. The fracture resistance of endodontically treated teeth is directly related to the remaining tooth structure and preventing the tooth from splitting and distributing the occlusal forces in a uniform manner, this necessitates caution during tooth preparation for endodontic post insertion [22].

In contrast, other researchers found no benefits of adding of ferrule to the preparation of endodontically treated teeth [23-26] this may be attributed to differences in their experimental techniques.

The consensus is that a properly constructed ferrule significantly reduces the incidence of fracture in non-vital teeth by reinforcing the tooth and its external surface and redistributing applied forces which concentrate at the narrowest point around the circumference of the tooth, in addition, it helps to maintain the integrity of the cement seal of the crown [22].

Results of this study showed minimum ferrule length in the root of maxillary central incisor should be (1.5 mm) coronal to cemento enamel junction to resist fracture resistance, this is in agreement with the results and explanation of another studies [7,15].

Different type of the posts results during the present study showed highest fracture resistance of teeth restored with flexi-post and cemented with composite resin, this is in agreement with the result and explanation of some other studies [2,27,28]. Also it showed lowest fracture resistance of teeth restored with posts and cemented by zinc phosphate cement, this result is in agreement with the result of several investigators [2,16,17]. This results may be attributed the high to compressive and tensile strength of resin luting cement approach, beside the strength and elasticity of dentin, as well as the adhesive capacity of the resin cement. This factors leads to reduce the potential stress and increasing fracture resistance, that may be due to the resin cement layer provides a buffer zone that contributes to uniform stress distribution between the post and the canal, therefore when filling the space between the channel wall and post, resin serves as a sealant that not easily destroyed against the vertical displacement and fracture resistance was increased [26].

Conclusion

Within the limitation of this *in vitro* study the following conclusions may be drown:

- The fracture resistance of endodentically treated teeth increased with increasing the coronal dentinal structure (Ferrule length).
- The fracture resistance of endodentically treated teeth restored by flexi post and cemented with composite resin was higher than others cemented with zinc phosphate.
- The fracture resistance of endodentically treated teeth restored with cast post and cemented with composite resin was higher than cast post cemented with zinc phosphate.
- The fracture resistance of endodentically treated teeth restored with flexi post and Ti core was higher than cast post and its core.

Acknowledgment

I would like to express my deep appreciation and thanks to Prof. DR. ALLAN DEUTSCH H D.M.D, Executive vice a President and Co-Director of Dental Research and Essential Dental System Inc, in Hackensack city (U.S.A.) for supply me with the materials used in this study.

Bibliography

1. Asmussen E., *et al*. "Stiffness, elastic limit, and strength of newer types of endodontic posts". *Journal of Dentistry* 27.4 (1999): 275-278.

2. Butz F., *et al*. "Survival rate and fracture strength of endodontically treated maxillary incisors with moderate defects restored with different post and core systems. an in-vitro study". *International Journal of Prosthodontics* 14.1 (2001): 58-64.

3. Abou-Rass M. "Post and core restoration of endodontically treated teeth". *Current Opinion in Dentistry* 2 (1992): 99-107.

4. de Castro AR., *et al*. "Stress analysis of an upper central incisor restored with different posts". *Journal of Oral Rehabilitation* 30.9 (2003): 936-943.

5. Caputo AA and Standlee JP. "Pins and posts--Why, when, and how". *Dental Clinics of North America* 20.2 (1976): 299-311.

6. Sorensen JA and Engelman MJ. "Effect of post adaptation on fracture resistance of endodontically treated teeth". *Journal of Prosthetic Dentistry* 64.4 (1990): 419-424.

7. Sorensn JA and Engelman MJ. "Ferrule design and fracture resistance of endodontically treated teeth". *Journal of Prosthetic Dentistry* 63.5 (1990): 529-536.

8. Cohen BI., *et al*. "A 10-year literature review of a split-shanked threaded post". *Compendium of Continuing Education in Dentistry* 16.6 (1995): 630-631.

9. Mezzomo E., *et al*. "Fracture resistance of teeth restored with two different post-and-core designs cemented with two different cements: an in vitro study. Part I". *Quintessence International* 34.4 (2003): 301-306.

10. Akkayan D. "An in vitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems". *Journal of Prosthetic Dentistry* 92.2 (2004): 155-162.

11. Kutesa-Mutebi A and Osman YI. "Effect of the ferrule on fracture resistance of teeth restored with prefabricated posts and composite core". *African Health Sciences* 4.2 (2004): 131-135.

12. Tan PL., *et al*. "In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations". *Journal of Prosthetic Dentistry* 93.4 (2005): 331-336.

13. Sorensen JA. "Preservation of tooth structure". *Journal of the California Dental Association* 16.11 (1988): 15-22.

14. Deutsch AS., *et al*. "Root fracture during insertion of prefabricated posts related to root size". *Journal of Prosthetic Dentistry* 53.6 (1985): 786-789.

15. Stankiewicz NR and Wilson PR. "The ferrule effect: a literature review". *International Endodontic Journal* 35.7 (2002): 575-581.

16. Schmitter M., *et al*. "Fracture resistance of incisor teeth restored using fibre-reinforced posts and threaded metal posts: effect of post length, location, pretreatment and cementation of the final restoration". *International Endodontic Journal* 43.5 (2010): 436-442.

17. Standlee JP., *et al*. "Analysis of stress distributions by endodontic posts". *Oral Surgery, Oral Medicine, Oral Pathology* 33.6 (1972): 952-960.

18. Pereira JR., *et al*. "Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts". *Journal of Prosthetic Dentistry* 95.1 (2006): 50-54.

19. Wahadni A and Gutteridge DL. "An in vitro investigation into the effects of retained coronal dentine on the strength of a tooth restored with a cemented post and partial core restoration". *International Endodontic Journal* 35.11 (2002): 913-918.

20. Gegauff AG. "Effect of crown lengthening and ferrule placement on static load failure of cemented cast post-cores and crowns". *Journal of Prosthetic Dentistry* 84.2 (2000): 169-179.

21. Assif D., *et al*. "Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns". *Journal of Prosthetic Dentistry* 69.1 (1993): 36-40.

22. Standlee JP and Caputo AA. "Interaction of endodontic posts with tooth structure". In: Kurer P, ed. Kurer anchor system. Chicago: Quintessence Publishing Co. Inc. (1984): 160-140.

23. Schmitter M., *et al*. "Fracture resistance of upper and lower incisors restored with glass fiber reinforced posts". *Journal of Endodontics* 32.4 (2006): 328-330.

24. Al-Hazaimeh N and Gutteridge DL. "An in vitro study into the effect of the ferrule preparation on the fracture resistance of crowned teeth incorporating prefabricated post and composite core restorations". *International Endodontic Journal* 34.1 (2001): 40-46.

25. Zhi-Yue L and Yu-Xing Z. "Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors". *Journal of Prosthetic Dentistry* 89.4 (2003): 368-373.

26. Sendhilnathan D and Nayar S. "The effect of post-core and ferrule on the fracture resistance of endodontically treated maxillary central incisors". *Indian Journal of Dental Research* 19.1 (2008): 17-21.

27. Khaledi AA., *et al*. "Evaluation of Retention of two Different Cast Post-Core Systems and Fracture Resistance of the Restored Teeth". *Journal of Dentistry* 16.2 (2015): 121-128.

28. Cohen BI., *et al*. "Comparison of the photoelastic stress for a split-shank threaded post versus a threaded post". *Journal of Prosthodontics* 3.1 (1994): 53-55.

Volume 17 Issue 11 November 2018