AL-AZHAR
Dental Journal
For Girls

The Official Publication of The Faculty of Dental Medicine For Girls, Al-Azhar University Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 5, No. 2, April (2018) — PP. 135:143

Effect of Condensation Techniques on Fracture Resistance of Endodontically Treated Teeth Restored with Different Post Systems

El-Said Mahmoud Abd El-Hafiz[1]

Codex : 16/1804

azhardentj@azhar.edu.eg

http://adjg.journals.ekb.eg

ABSTRACT

The purpose of this study was to evaluate the fracture resistance of endodontically treated teeth with two obturating techniques supported with different post systems. A total of 90 sounds freshly extracted sound human single rooted teeth were included in the present study. The teeth were prepared by using the crown-down technique. The prepared specimens were divided randomly into three main groups (30 specimens each) .Group A1 used Titanium post),Group A2 used Glass fiber post), and Group A3 used Cast post. Each main group was divided into two subgroups (15 specimens each) according to the obturation techniques .Subgroup B1 used lateral condensation technique, and Subgroup B2 used Thermo plasticized injectable technique. Each subgroup was further subdivided into three minor subgroups each composed of 5 specimens .Subdivision S1 Post immediately placed after obturation, S2 (One month), and S3 (Three months). Failure loads were measured under a static loading. **The results** of fracture resistance of this study showed that at Immediate, 1 month, and 3 months; no statistical significant difference between vertical and lateral obturation technique. Post types showed that there were statistically significant differences in both obturation techniques. **Conclusions:** The Glass fiber post was more fracture resistance followed by Titanium post, then Cast post.

KEYWORDS

Condensation Techniques
Fracture Resistance of Endodontically Treated Teeth

INTRODUCTION

Endodontically treated teeth with flared roots or weakened root walls present a challenge to restorative dentistry. The extensive structural damage of the root can sometimes be as a result of immature development, dental caries, over instrumentation, previous restoration with an excessively large dowel and core, fractures or internal resorption[1]. Although the long-term functional survival of initial endodontically treated permanent teeth was reported as 97.1% after 8 years in a very large epidemiologic survey, coronal and/or radicular tooth fractures continue to remain important reasons for postendodontic tooth repairs and extractions [2].

1. Lecturer of endodontics, Faculty of Oral and Dental Medicine Future University in Egypt.

An endodontically treated tooth often has limited remaining tooth structure to provide retention for a definitive restoration, and the loss of radicular and coronal dentin increases susceptibility to fracture [3]. Posts are often required to restore these teeth and to provide retention and resistance for a core material and to provide a corono-radicular stabilization [4,5]. However this requires the partial removal of obturating material in the canal in order to prepare the post space and this procedure can affect the apical seal. 5 mm of obturating material is considered a safe margin, but a reduction of fillings to 3 mm produced unpredictable seal [6,7].

The ability of a dowel and core restoration to survive masticatory forces and remain firmly seated in the tooth is critical to the survival of a restoration. If either the dowel and/or the core material fail, the crown will ultimately fail [8]. Posts are primarily providing means for attachment of the core to the remaining tooth structure [9].

Generally, posts and cores may be fabricated using indirect or direct techniques. Indirect techniques require an impression and cast during the preparatory stages to produce a cast metal post-core build-up. Direct techniques involve the use of a prefabricated post in a radicular preparation. Metal posts and cores are associated with inferior aesthetics, as they do not allow light transmission. Nonmetal posts were developed as a result of advances in biomaterials, development in bonding and adhesive systems, and enhancement of aesthetic characteristics of dental restorations [10].

In vitro research has indicated that fracture resistance of teeth restored with prefabricated metallic posts was higher than that of teeth restored with cast metal posts. Clinical research also indicated similar findings with teeth restored with prefabricated posts having longer success rates than teeth restored with cast posts[11,12].

Thus this study aimed to evaluate the fracture resistance and failure mode of endodontically treated teeth by two obturating techniques and supported with different post systems.

MATERIALS AND METHODS

A total of 90 sound freshly extracted human single rooted teeth (maxillary anterior teeth) with no sign of cracks or structural anomalies under light microscope. A solution of 5.25% sodium hypochlorite* soaked into gauze was used to remove any soft tissue covering the root surface and any calculus was removed by the aid of ultrasonic scaler**. The selected teeth measured average thickness by caliber mesio- distally about 6mm and labio-palatlly about 7mm. The roots of all teeth were sectioned 15 mm from the root apex [13] by using a diamond tapered stone mounted on high speed hand piece*** with water spray. Flattening of the coronal portion of the roots was done with wheel stone.

k-File No. 10**** was introduced into the canal till the tip of the file is seen from the apex to ensured patency. The teeth were stored in distilled water at room temperature till the time of use.

Working length was determined by subtracting 1 mm from a K file size 15 just visible at the apical foramen. All root canals were then prepared by using the step-down technique according to the specific manufacture's instruction, using ProTaper™ Rotary System•. The sequence used was ProTaper S1, S2, F1, F2, F3, F4, and F5. The preparation was accomplished using (DENTA PORT ZX)•• torque

* *Egyptian Detergant Company, Egypt.*

** *wood packer china.*

*** *W&H Burmoos, Austria.*

**** *Dentsply, Maillefer, Tulsa,OK.*

• *Dentsply-Maillefer, Ballaigues, Switzerland.*

•• *J.MORITA MFG. CORP. 680 HIGASHIHAMA, MINAMI-CHO.*

control motor at the rotational speed 250 rpm. One milliliter NaOCl of 2.6% concentration was the irrigant solution used after each file. The specimens received a final rinse with 17% EDTA solution••• in order to remove the smear layer then were rinsed with sterile water.

The prepared specimens were divided randomly into three main groups with 30 specimens each according to the type of post systems A1 (titanium), A2 (glass fiber), and A3 (custom made of chromium – nickel alloy). Each main group was divided into two subgroups with 15 specimens each according to the obturation techniques B1 (lateral), and B2 (Thermo plasticized injectable). Each subgroup was divided into three minor subgroups with 5 specimens each according to the storage time (time of post space preparation) S1 (immediate), S2 (one month), and S3 (three months).

After grouping the specimens, the obturation was done using AH Plus sealer. Each main group contain 30 specimens, half of specimens in each main group were obturated by lateral condensation technique (B1) using F5 points (size 50) 0.04 ProTaper gutta-percha cones [14], and the other half of specimens were obturated by Thermo plasticized injectable technique (B2) using obtura II with gutta-percha pieces [15].

A circumferential ferrule 2 mm in height and at least 1 mm shoulder finish line width was prepared in the coronal portion of all specimens by a flat-ended tapered diamond bur with 1.2 mm diameter••••[16].

Post space preparation was done by removing 9mm[17] of the gutta-percha in each specimen leaving only 5mm [18] of the apical filling at the following times;

1- ***Immediate after obturation (S1).***

2- ***One month after obturation (S2).***

3- ***Three months after obturation (S3).***

Post cementation was made by CEMENT – POST (Chemically cured resin cement). The procedures were done according to manufacture instruction.

Group A1 (Titanium post);-

Unimetrc 0.8 mm Titanium posts were used in this group. 9mm of the coronal gutta-percha in each specimen was removed leaving only 5mm of the apical filling by using penetrating drill (Dentsply) of the same size of the post (308 S of 13mm legnth), work at low speed with micro motor••••• (800-1200 r.p.m.). The final size of the canal was made by using the precision calibration drill (Dentsply) at the same speed. Standardization was achieved with the help of rubber stoppers placed on the drill.

Group A2 (Glass fiber post);

Nine mm of the coronal gutta-percha in each specimen was removed leaving only 5mm of the apical filling by using hot endodontic plugger. The final size of the canal was made by using the precision calibration drill (EXACTO bur) of the same size of the post. Standardization was achieved with the help of rubber stoppers placed on special drill.

Group A3 (Custom made post);

Nine mm of the coronal gutta-percha in each specimen was removed leaving only 5mm of the apical filling by using Gates-Glidden bur size 3, and 4 rotating at 8,000 r.p.m. (Dentsply Maillefer; Ballaigues, Switzerland). Standardization was achieved with the help of rubber stoppers placed on special drill. An anti-rotational box was created on the lingual surface [19].

••• *Dentsply, Latin America, Brazil*

•••• *SS White USA.*

••••• *W&H Burmoos, Austria*

Fabrication of the cast post:

A direct technique was used to fabricate the cast post in acrylic resin. The post was made up of hard plastic post*. The post has length of 13mm. This post can be modified with the self-cure acrylic resin for perfect adaptation** before sending to laboratory for casting procedure. A precise impression of the root canal was taken by applying self-cure material over the selected post. Excess acrylic was trimmed. Post space preparation should be devoid of any undercut. The acrylic patterns of the root canal were sprued, invested***, casted in A Ni–Cr alloy****, and polished.

Post cementation:

Post space was etched with 37% phosphoric acid for 10 seconds followed by rinsing with water and drying with absorbent paper points. It was not recommended to use sodium hypochlorite due to the release of oxygen, which can interfere in the polymerization of resin cements.

Post cementation for all groups was made by CEMENT–POST (Chemically cured resin cement). The procedures were done according to manufacture instruction. A radiograph was taking after setting the post cement.

Constructions of composite core:

The length of the remaining part of the posts heads in all groups were 4mm. The total height of the core was 5 mm for all groups[20]. Light-cured composite Filtek Z-250 (Shade A1) was used for core construction in all groups according to manufactures instruction.

The composite was placed using the incremental technique and light cure 20s for each increment. Transparent Polyester cones for root core reconstruction were used to standardize the thickness and the height (5 mm) of the composite core in all groups.

Constructions of metal crown:

Specimens used were prepared to receive complete crowns by using cellulose acetate crown formers• for the standardization of wax patterns. Margins of the acetate crowns were trimmed with scissors to adapt the preparation. After isolating cores with a thin coat of separating medium to permit easier separation of wax pattern from the core, the acetate crown was filled with casting wax•• and placed on the cores. Excess wax was removed and trimmed with a spatula [20]. The wax patterns of the crowns were sprued, invested, and casted in A Ni–Cr alloy. Crowns were cemented to the teeth with glass-ionomer cement•••. The specimens' measurement was 21mm after crown cementation.

Evaluation methods;

Fracture resistance, of the three post systems were evaluated immediately after post preparation and immediately after cementation, 1 Month, and 3 Months after obturation.

Fracture resistance test:-

All specimens were fixed to an acrylic base at 45^{o} angle .They were fixed to universal testing machine and subjected to static load••••[21]. Failure loads were measured under a static loading test using the machine with a loadcell of 5kN and data were recorded using Nexygen computer software••••• at a crosshead speed of 1 mm/min and

* *Nucleojet Angelus, Londrina-PR- Brazil.*

** *Acrosone cold cure denture base material 10, Fathy Tolbah St., Industrial Zone, El-Salam City, Cairo,Egypt.*

*** *Gilvest MG Speed Dental, BK GiulinI Gmbh 67065 Ludwigshafen / Germany.*

**** *PROTECHNO-N; Polígono Empordà Internacional C/ Garrotxa, 617469 – Vilamalla, Girona – SPAIN.*

• *Strip Crown System C, No. 58; Swedish Dental Supplies, Akarp, Sweden.*

•• *Thowax; YETI Dentalprodukte GmbH, Engen, Germany.*

••• *Promedica, Germany.*

•••• *Model LRX-Plus; Lloyd Instruments Ltd., Fareham, UK.*

••••• *Nexygen-MT; Lloyd Instruments.*

at angle of 45° against the tooth axis. Load was applied with a custom made load applicator [chisel steel rod placed at the middle third of the palatal surface / 3mm below the incisal edge of the teeth] attached to the upper movable compartment of the machine. Failure manifested by audible crack sound and confirmed by sudden drop along load-deflection curve recorded by Nexygen computer software.

Statistical Analyses

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. Three-factorial analysis of variance ANOVA tests of significance comparing variables affecting mean values were carried out§.

RESULTS

Fracture resistance results

Fracture resistance results (Mean ±SD) measured in Newton (N) for all groups as function of post type, obturation technique and investigation times are summarized in table (1) and graphically drawn in figure (1).

Table (1) *the interaction between factors affecting fracture resistance results*.

		Obturation technique		Statistics
	Time	Thermoplasticized	Lateral	ANOVA
Group A1 Titanium post	Immediate	326^BC ±47.6	315 ^BC ±72.6	0.0467*
	1 month	330^BC ±87.5	327 ^BC ±103.1	
	3 months	327 ^BC ±51.2	337 ^BC ±87.7	
Group A2 Glass fiber post	Immediate	400 ^AB ±60.3	386^AB ±58.1	
	1 month	397 ^AB ±94.6	370 ^AB ±77.7	
	3 months	450 ^AB ±52.3	412 ^AB ±79.7	
Group A3 Custom made post	Immediate	268 ^DE ±44	255 ^DE ±32.2	
	1 month	250 ^DE ±38.9	260 ^DE ±63.3	
	3 months	215 ^DE±56.6	204 ^D ±40.8	

*Different letters indicating significant (Duncan; P≤0.05) *; significant (P≤ 0.05)*

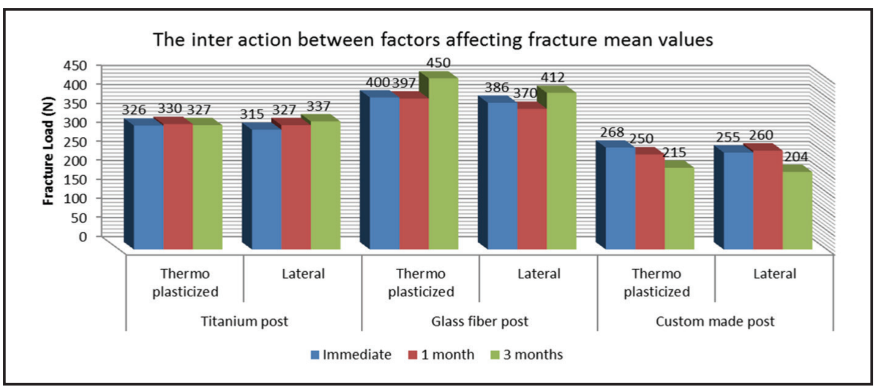

Fig. (1): Histogram showing interaction between factors affecting fracture mean values.

§ *Assistat 7.6 statistics software*

Relation of Post type, Time, and Obturation technique resistance;

At Immediate;

Thermoplasticized injectable technique;

It was found that Glass fiber post group recorded statistically significant ($p<0.05$) highest fracture resistance mean value (400±60.3) followed by Titanium post (326±47.6) while Custom made post recorded lowest (268 ±44) significant fracture resistance mean value ($p\leq0.05$).

Lateral obturation;

It was found that Glass fiber post group recorded statistically significant ($p\leq0.05$) highest fracture resistance mean value (386 ±58.1) followed by Titanium post group (315±72.6) while Custom made post recorded lowest (255±32.2) significant fracture resistance mean value ($p\leq0.05$).

At one month;

Thermoplasticized injectable technique;

It was found that Glass fiber post group recorded statistically significant ($p\leq0.05$) highest fracture resistance mean value (397±94.6) followed by Titanium post (330±87.5) while Custom made post recorded lowest (250±38.9) significant fracture resistance mean value ($p\leq0.05$).

Lateral obturation;

It was found that Glass fiber post group recorded statistically significant ($p\leq0.05$) highest fracture resistance mean value (370±77.7) followed by Titanium post (327±103.1) while Custom made post recorded lowest (260±63.3) significant fracture resistance mean value ($p\leq0.05$).

At three months;

Thermoplasticized injectable technique;

It was found that Glass fiber post group recorded statistically significant ($p\leq0.05$) highest fracture resistance mean value (450±52.3) followed by Titanium post (327±51.2) while Custom made post recorded lowest (215±56.6) significant fracture resistance mean value ($p\leq0.05$).

Lateral obturation;

It was found that Glass fiber post group recorded statistically significant ($p\leq0.05$) highest fracture resistance mean value (412±79.7) followed by Titanium post group (337±87.7) while Custom made post recorded lowest (204±40.8) significant fracture resistance mean value ($p\leq0.05$).

DISCUSSION

Restoration of root filled teeth prior to prosthodontics rehabilitation with fixed crowns or bridges often requires core build-ups. The build-up involves at least replacing of lost tooth structure using an alloplastic material to provide an adequate core for the preparation. If the remaining tooth structure is inadequate for the stable retention of a direct core build-up material, a post must be placed into the canal to retain the core [22].

To simulate clinical conditions, natural teeth were used in this study, since artificial teeth do not simulate natural dentin, and they unrealistically adhere to the post, which does not resemble the clinical situation [23].

However natural teeth differ in length, width, and size.Thus, in this study, the mesiodistal and buccolingual dimensions of each tooth were recorded at the level of the cervical margin to ensure that each experimental group contained teeth of similar dimensions, and teeth were sectioned 15 mm from the apex to the amelocemental junction, at a level corresponding to the clinical gingival margin to standardized the root length [10, 13].

All root canals used in this study were prepared by using the crown-down technique using ProTaper™ rotary system up to size F5 (finishing 5) for all specimens [24].

NaOCl of 2.6% concentration was the irrigant solution used after each file. The specimens received a final rinse with 17% EDTA solution in order to remove the smear layer then were rinsed with sterile water [10,14, 24].

The obturation of the root canals were done using lateral condensation technique (B1) using F5 points (size 50) 0.04 ProTaper gutta-percha cones[14], and the other half of specimens were obturated by vertical condensation technique (B2) using obtura II with gutta-percha pieces [15].

The sealer used in obturation was AH plus that was used in several studies [24,25]. AH plus was used to avoid the effect of eugenol sealers on the retention of resin cemented posts due to the presence of eugenol on the canal walls appeared to have an adverse effect on post retention [25].

A 9 mm post space was created in each tooth. The smear layer was removed with EDTA 17% for 1 min. After a final rinse with sterile water the canal was dried with paper points. The posts were premeasured and marked at 9 mm with a marking pen to standardize the post length in the post space [17]. The apical 5mm of the root canal filling was left to preserve the apical seal [18,26].

Adhesive resin cement (cement post) was used to cement the three types of post used in this study because adhesive resin cement have the ability to bond to both the radicular dentin and post allowing the use of conservative post insertion techniques as well as reducing potential stress [10] .

Light-cured composite was the material of choice for core builds up because of its good bond strength, controlled and quick setting, good aesthetics, and adequate compressive strength. Moreover, composite core materials have a higher fracture resistance [27,28].

Transparent Polyester cones for root core reconstruction were used to standardize the thickness and the height (5 mm) of the composite core in all groups [20].

In the current study the failure loads were measured under a static loading test using the machine with a load cell of 5kN at a crosshead speed of 1 mm/min and at angle of 45° against the tooth axis this angle resemble clinically comparable angle of loading in anterior teeth [21].

The statistical analysis of fracture resistance results of this study showed at Immediate, 1 month, and 3 months showed that; no statistical significant difference between Thermo plasticized injectable and lateral obturation technique ($p \geq 0.05$). While in relation to the post types the Glass fiber post group recorded statistically significant ($p \leq 0.05$) highest fracture resistance mean value followed by Titanium post while Custom made post recorded lowest significant fracture resistance ($p \leq 0.05$) in both obturation techniques.

These results are in agreement with other studies[16,29] which refer these results to the difference of the modulus of elasticity of the posts. Cast posts have a high modulus of elasticity, and when they are subjected to occlusal forces, they produce forces against the root dentin walls, which have a lower modulus of elasticity, thus increasing the possibility of coronal-radicular fracture. Whereas fiber-glass posts have a modulus of elasticity similar to that of dentin, thus diminishing the stress transmitted to the dental structure and reducing the possibility of fracture. This may explain the lower clinical incidence of root fractures in teeth restored with glass fiber posts, when compared with teeth restored with metal posts.

These results are in disagreement with other studies which reported that the cast post-core restorations luted with adhesive resin cement exhibited the highest fracture resistance [27,30], and also disagreement with Michael et al [31] who stated that there were no significant differences of mean maximum load to fracture of intact endodontically treated anterior teeth restored with prefabricated titanium post and composite resin with sound teeth, and Al-Wahadni et al. [10], who reported that teeth restored with Radix-titanium posts were more resistant to fracture than those restored with either carbon or glass fiber posts. **The high values of fracture that was reported with the custom made post could be expliained by the funnel preparation that weaken the root structure.**

CONCLUSIONS

Within the criteria of this study.

1- Both the thermos plasticizing and compaction techniques showed the maximum fracture resistance for endodontically treated teeth with fiber post followed by titanium post.

2- Cast post with both condensation techniques showed the least fracture resistance.

REFERENCES

1. Villaca L, Ricardo J, Lins A, Alves J, and Fernando L. Fracture resistance of weakened roots restored with composite resin and glass fiber post. Braz Dent J 2008; 19:329-33.
2. Zadik Y, Sandler V, Bechor R, Salehrabi R. Analysis of factors related to extraction of endodontically treated teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 106:31-5.
3. Aykent F, Kalkan M, Yucel M, and Ozyesil A. Effect of dentin bonding and ferrule preparation on the fracture strength of crowned teeth restored with dowels and amalgam cores. J Prosthet Dent 2006; 95:297-301.
4. Pontius O, Hutter JW. Survival rate and fracture strength of incisors restored with different post and core systems and endodontically treated incisors without coronoradicular reinforcement. J Endodod 2002; 28:710-15.
5. Mitsui F, Marchi G, Pimento L, Ferraresi P. In vitro study of fracture resistance of bovine roots using different intra radicular post systems. Quintessence Int 2004; 35:612-6.
6. Pesce A, Lopez S, and Rodriguez M. Effect of post space preparation on apical seal: Influence of time interval and sealer. Med Oral Patol Oral Cir Bucal 2007; 12:464-8.
7. Abramovitz I, Lev R, Fuss Z, Metzger Z. The unpredictability of seal after post space preparation: a fluid transport study. J Endodod. 2001; 27:292-5.
8. Aksoy G, Cotert S, and Korkut L. Effect of an adhesive resin luting agent on the dowel-head retention of three different core materials. J Prosthet Dent 2005; 93:439-45.
9. Coelho G, El-Mowafy O, and Hernique J. Diametral tensile strength of a resin composite core with nonmetallic prefabricated posts: An in vitro study. J Prosthet Dent 2004; 91:335-41.
10. AL-Wahadni A, Hamdan S, Al-Omiri M, Hammad M, and Hatamleh M. Fracture resistance of teeth restored with different post systems: in vitro study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 106:77-83.
11. Torbjorner A, Karlsson S, Odman AP. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995; 73:439-44.
12. Sorensen J, Martinoff J. Intracoronal reinforcement and coronal coverage: a study of endontically treated teeth. J Prosthet Dent 1984; 51:780-4.
13. Santos-Filho P.C, Castro C.G, Silva G.R, Campos R.E, Soares C.J. Effects of post system and length on the strain and fracture resistance of root filled bovine teeth. Int Endod J 2008; 41: 493-501.
14. Bidar M, Sadeghi G, Gharechahi M, Mortazavi M, Forghani M. In vitro comparison of apical leakage in root canals obturated with 0.04 and 0.02 tapered gutta-percha. Iran Endod J 2010; 5:97-100.
15. Tani-Ishii N, Teranaka T, Clinical and Radiographic Evaluation of Root-canal Obturation with Obtura II. J Endodon 2003; 29:739- 42.
16. Akkayan B. 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. J Prosthet Dent 2004; 92:155-62.
17. Boone K.J, Murchison D.F, Schindler W.G, Walker W.A. Post Retention: The Effect of Sequence of Post- Space Preparation, Cementation Time, and Different Sealers. J Endodon 2001; 27:768-71.
18. Al-omari Q.D, Barrieshi K.M, Al-Awadhi S.A. Effect of post length and diameter on remaining dentine thickness in maxillary central and lateral incisors. Int Endod J 2011; 44; 956 - 66.
19. Patel A, Gutteridge D.L. Investigation of cast post and partial core design. J Dent 1996; 24:281-7l.
20. Aykent F, Kalkan M, Yucel M.T, Ozyesil A.G. Effect of dentin bonding and ferrule preparation on the fracture strength of crowned teeth restored with dowels and amalgam cores. J Prosthet Dent 2006; 95:297-301.

21. Pereira J.R, de Ornelas F, Conti P.C, do Valle A.L. Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts. J Prosthet Dent 2006; 95:50-4.

22. Balkenhol M, Rupf S, Laufersweiler I, Huber K, Hannig M. Failure analysis and survival rate of post and core restorations under cyclic loading. Int Endod J 2011; 44: 926- 37.

23. Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin-bonded preformed post. J Prosthet Dent 1997; 78: 10-4.

24. Farea M, Masudi S, Bakar Z. Apical microleakage evaluation of system B compared with cold lateral technique: In vitro study. Aust Endod J 2010; 36: 48-53.

25. Vano M, Cury A.H, Goracci C, et al. Retention of fiber posts cemented at different time intervals in canals obturated using an epoxy resin sealer. J dent 2008; 36:801-7.

26. Al-Omari W, Zagibeh A. The Retention of Cast Metal Dowels Fabricated by Direct and Indirect Techniques. J Prosthet Dent 2010; 19: 58- 63.

27. Civelek1 A, Kaptan F, Iseri U, Dulger O, Kazazoglu E. Fracture Resistance of Endodontically Treated Teeth Restored with Fibre or Cast Posts. Balk J Stom 2007; 11:196-200.

28. Abduljabbar T, Sherfudhin H, AlSaleh S.A, et al. Fracture resistance of three post and core systems in endodontically treated teeth restored with all-ceramic crowns. King Saud University J Den Scie 2012; 3: 33-8.

29. Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. Am J Dent 2000; 13:15-18.

30. Hu YH, Pang LC, Hsu CC, Lau YH. Fracture resistance of endodontically treated anterior teeth restored with four postand- core systems. Quintessence Int 2003; 34(5): 349-353.

31. Michael M.C. Husein A, Wan Bakar W.Z, Sulaiman E. Fracture resistance of endodontically treated teeth: an in vitro study. Arch of Orofacial Scien 2010; 5(2): 36-41.