Comparison of regional bond strength among different types of posts luted with different types of cement

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ABSTRACT

Background: This in vitro study was carried out to investigate the effect of post space regions (coronal, middle and apical), the effect of post types (Manually Milled Zirconia post, Prefabricated Fiber post, prefabricated Zirconia post) and the type of cement used (GIC, self-adhesive resin cement) on the bond strength between the posts and root dentin by using push-out test.

Material and methods: Forty eight mandibular premolars extracted for orthodontic reasons (single rooted) were instrumented with ProTaper system (hand use) and obturated with gutta percha for ProTaper using AH26® root canal sealer following the manufacturer instructions. After 24 hours, post space was prepared using Zirix and Glassix drills no.3 creating 8 mm depth post space. The prepared samples were randomly divided into three main groups (16 samples each) according to the type of post used (Group **A**. Manually Milled Zirconia post, Group **B**. Prefabricated Fiber post and Group **C**. Prefabricated Zirconia post) .each group was subdivided into two subgroups (each subgroup contains 8 samples) according to the type of cement used (subgroup **A1**.Manually Milled Zirconia post cemented with GIC, subgroup **A2**.Manually Milled Zirconia post cemented with Speed cem),(subgroup **B1**.Prefabricated Fiber post cemented with GIC, Group **B2**. Prefabricated Fiber post cemented with Speed cem) and (subgroup **C1**.Prefabricated Zirconia post cemented with GIC, subgroup **C2**. Prefabricated Zirconia post cemented with Speed cem), after cementation and incubation for 24hrs, at 37°c and 100% humidity. Each root was sectioned horizontally into 3 slices (2 mm in thickness) representing the coronal, middle and apical regions of the post space. Push out bond strength test was performed and measured using a universal testing machine (Tinius-Olsen) at across head speed of 0.5 mm/min.

Results: The results showed that regarding the root region, the bond strength values increased significantly from apical to coronal region for all types of posts in both tested cements. For the effect of post type, the manually Milled Zirconia post cemented with the self-cured resin cement (Speed cem) showed higher bond strength values. For type of cement, the self-adhesive resin cement (Speed cem) showed higher bond strength values.

Conclusions: the retention of post restoration was affected by root region, type of post and type of cement used.

Keywords: Zirconia post, fiber post, Glass ionomer cement, Speed cem, root region. **(J Bagh Coll Dentistry 2014; 26(1):1-6).**

INTRODUCTION

Endodontically treated teeth with excessive wear result in a lack of coronal tooth structure and frequently need post to retain the coronal restorative portion. Although posts are recommended to strengthen the teeth, several investigators have cautioned that posts with inadequate resistance to rotational forces on the posts can weaken the teeth; consequently root fractures constitute the most serious type of failure in post-restored teeth [(1)]**.** Metal posts may negatively affect the esthetic results. Besides corrosion reactions can cause metallic taste, oral burning, oral pain, sensitization, and other allergic reactions**.** A wide range of esthetic posts have become commercially available, such as fiber reinforced composite resin posts (FRC) and yttrium stabilized zirconia-based ceramic posts [(2)]. Zirconia has been widely promoted by various **CAD\ CAM** systems as a superior material for restorations, so there is a possibility to fabricate the entire post-and-core complex from presintered, zirconia-reinforced alumina ceramic blanks using copy milling or computer-aided design/manufacturing **(CAD/CAM)** techniques [(3)].

Water-based cements, such as glass ionomer cement (GICs) have been suggested as alternatives for the luting of posts .The visco elastic properties of GICs was rendered more favorable to the preservation of bond integrity than the stiffer resin based-cements during the polymerization shrinkage [(4)].

Recently developed self-adhesive resin cements do not require pretreatment of the dentin. Because these cements do not use an adhesive system, they drastically reduce the number of application steps, shortening clinical treatment time and decreasing technique sensitivity since it minimizes procedural errors throughout the treatment phases [(5)].

Bond strength can be determined by several techniques, but the push out bond strength test is believed to provide a better estimation of the actual bonding effectiveness than conventional shear bond strength test, using a push out protocol, failure occurs parallel to the post-

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cement-dentin interface, which is similar to clinical condition. Although the micro tensile method has been also applied to root dentin, push out tests seem to be more reliable because of the absence of premature failures and variability of data distribution [6].

MATERIALS AND METHODS

Sample Selection

Forty eight extracted single rooted teeth (mandibular premolars), was extracted for orthodontic reasons were used in this study. The age, gender, pulpal status and reason for extraction were not considered, and the criteria for teeth selection including the followings: Single straight root, No visible root caries, No fractures, cracks or external resorption on examination with x10 magnifying eye lens and light cure device, Diagnostic X-ray was taken to confirm the existence of a single straight canal, fully formed apex and no signs of internal resorption, calcification or previous endodontic therapy, Patent apical foramen.

Samples preparation

Length of the root was determined by a digital vernier and marker. The tooth hold with moist gauze to avoid dehydration and the crown of the tooth was sectioned with a diamond discs mounted on straight hand piece, under water coolant. The length of the root was adjusted to 14 mm from a flat reference point to the root apex. The mold was obtained by using a plastic test tube (2.5ml).

The condensation silicon impression material base and catalyst were mixed according to manufacturer's instructions; the putty was folded and kneaded gently for about 30 sec. until the color was even, without any stripes. The putty material was placed inside the plastic tubes and the coronal end was adjusted with the coronal end of the tube. After that the teeth were placed in the center of the putty material with the aid of dental surveyor to position the long axis of the roots parallel to that of the plastic tubes.

Endodontic treatment

Root canal instrumentation was performed using ProTaper hand files (Dentsply Switzerland) in crown down technique. Irrigation performed using of 2.5% NaOCl after every change of file size throughout the cleaning and shaping of the root canals, dried with paper points and filled with gutta-percha for ProTaper F4 (Dentsply Switzerland)and AH26 root canal sealar (Dentsply, Germany).The excess gutta-percha at the canal orifice was removed. The access opening were sealed with temporary filling material, and stored at 37ºC, 100% humidity in an incubator for 24h

Sample grouping

The heavy body mounted roots were randomly assigned into three main groups (16 samples each) according to the type of post used (Group **A**. Manually Milled Zirconia post, Group **B**. Prefabricated Fiber post and Group **C**. Prefabricated Zirconia post) .each group was subdivided into two subgroups (each subgroup contains 8 samples) according to the type of cement used (subgroup **A1**. Manually Milled Zirconia post cemented with GIC, subgroup **A2**.Manually Milled Zirconia post cemented with Speed cem), (subgroup **B1**.Prefabricated Fiber post cemented with GIC, subgroup **B2**.Prefabricated Fiber post cemented with Speed cem) and (subgroup **C1**.Prefabricated Zirconia post cemented with GIC, subgroup **C2**.Prefabricated Zirconia post cemented with Speed cem)

Post space preparation.

After 24 hours, the temporary filling was removed, and the gutta percha of the cervical and middle thirds was removed with Pesso drills No.1, and the canal walls of each specimen were enlarged with tapered Glassix drills for fiber post groups and tapered Zirix drills for zirconia and copy milling posts groups under copious water cooling, creating (8mm) deep post space measured from the coronal end of the root, keeping at least 5mm of gutta- Percha apically. Post space preparation was done with a low speed straight hand piece attached to a dental surveyor to obtain vertical preparation with standard diameter and dentinal walls parallel to the long axis of the roots [7].

Construction of zirconia post and core:

To fabricate a zirconia post, a cast metal post must be fabricated firstly by waxing, Green wax (Yeti, Germany) fabricated in the root samples, phosphate bonded investment(Yeti dental, Germany) was mixed, then the wax patterns were coated with the investment material using the and allowing the investment to set for 1 hour. After that the ring was placed in a cold furnace (Combilabor, Germany) and the temperature was set for 480 °C soaked for 15 minutes. The temperature was then raised to 650 °C and held for another 15 minutes before raising it to 950 °C and holding for another 15 minutes. The ring was removed from furnace at the time of nickel based alloy melted in centrifugal casting machine. Then the cast post was tried to fit by using a disclosing agent, if a pressure spot was detected it was adjusted with carbide bur to obtain a passive fit. Then cast metal posts were fixed in the holding plate of copy milling machine for milling.

After milling, the milled structure is 30% larger than the cast metal post, this enlargement was necessary to compensate for shrinkage that would be occur during sintering process in zirkon zahn furnace at1500c for 8hours

Post cementation

Prior to post cementation, the post space was irrigated with 2.25% Naocl and then final irrigation was accomplished with (2ml) of distilled water and the post space was dried with paper point size F4. Before cementation procedures, prefabricated posts were marked at a distance of (8mm) from the apical end corresponding to the post space preparation. In this way complete seating of the post could be verified [8].

The coronal part of the prefabricated post (above the marked area) was attached to the dental surveyor (mandrel clamp was fitted to the upper arm to hold the post to which the prepared specimens was then fitted) .while for the fabricated post, the core was attached to the mandrel clamp of the dental surveyor.

Monobond-S was applied to the post surface of subgroups A2, B2 and C2 that were cemented with Speed cem with a brush. After being allowed for a 60 seconds contact at room temperature, the post surface was dried with air.

After that the cement was mixed according to the manufacturer's instructions. The cement was then applied to the tip of the #40 lentulo spiral and passed down to the post space .that the heavy body mounted plastic tube placed on the base of the dental surveyor and the upper arm holding the post was lowered down until the post was fully seated inside the post space. Excess of luting agent was immediately removed with a small brush. A constant load of (2Kg) was applied for 60 sec to stabilize the post in position. The specimens were sealed with temporary restoration and stored in distilled water for 24 hrs, at 37°C.

Preparation of the specimens for push-out test

Mold construction

After the storage period, the roots were removed from the putty material, washed thoroughly and then embedded in clear orthodontic resin. Three ml disposable plastic syringes were used as molds into which the freshly prepared acrylic mixture was loaded. Before loading the syringes with acrylic, the apical end of the roots were fixed on the face of the plastic piston of the syringes with a resin adhesive so that the roots would be almost centrally located within the acrylic blocks and To ensure that the sectioning would be almost perpendicular to the long axis of the roots .The acrylic was prepared by mixing powder and liquid as recommended by the manufacturer in a porcelain jar. After loading the syringe with the freshly prepared workable acrylic mixture, the piston of the syringe with the root fixed on its apex was pushed into the acrylic mixture with gentle pressure to allow the complete embedding of the root into the acrylic, and to allow the escape of the excess material through the opened syringe tip. The material was allowed to cure under cooled water to compensate for the anticipated rise in the temperature of the samples subsequent to the exothermic curing reaction of the cold cure resin. The acrylic molds were allowed to cure completely for at least 30min as recommended by the manufacturers [9]. After complete curing of the acrylic, the plastic syringes were cut off and the mold was obtained.

Root sectioning

The sectioning of the root was made by using diamond disc mounted on straight handpiece and engine with a rotation speed regulator. The hand piece was assembled in a cutting device. The cuts were made under heavy flow of cold water (19-25°C) to minimize the smearing .the extruded part of the post that is not luted to the inside of the canal was sectioned to standardize the diameter of the post at the coronal section, as a result, all the remaining sections (within each sample) had a constant diameter at both the coronal and the apical sides From each specimen, 3 post/dentin sections (cervical, middle, and apical) were obtained, each 2 mm in thickness. Thus, each study group of 8 roots provided a total of 24 test specimens. The exact length of post segments in each section was measured using a vernier [10].Then each slice was marked on its apical side with indelible marker, one spot for the apical segment, two for the middle and three spots for the coronal segment, to make sure that the load will be applied in apico-coronal direction due to the conical shape of Posts.

Push-out bond strength test

Push-out test was performed by applying a compressive load to the apical aspect of each slice via a cylindrical plunger mounted on Tinius-Olsen Universal Testing Machine managed by computer software. The test was carried out in the laboratory of the Ministry of Science and Technology of Iraq. Because of the tapered design of the posts, different sizes of punch pins were used: 1.0 mm diameter for the coronal and middle slices, and 0.6mm for the apical slices .except for manually milled zirconia post which has agreater diameter, so 1.2mm diameter for the coronal and middle slices, and 0.8mm for the apical slices were used. The punch pin was positioned to contact only the post, without stressing the surrounding root canal walls.

Each specimen was placed in a mold with its apical direction upward and the coronal direction downwards because the load should be applied to the apical aspect of the root slice and in an apical–coronal direction, so as to push the post towards the larger part of the root slice, thus avoiding any limitation to the post movement. The mold was fixed to the lower jaw of the universal testing machine so that the specimen post surface was perpendicular to the compressive force applied. The contact between the punch tip and the post section occurred over the most extended area, to avoid notching of the punch tip into the post surface. Loading was performed at a crosshead speed of 0.5 mm/ min until the post segment was dislodged from the root slice [11].

A maximum failure load value was recorded in Newton (N) and converted into MPa, considering the bonding area (mm²) of the post segments by using the formula of a conical frustum.

$\Pi\ (R1+R2)\sqrt{(R1-R2)^2+h^2}$

Where R1 represents the coronal post radius, R2 represents the apical post radius and h is the thickness of the slice

RESULTS

The results of the descriptive statistics which include the minimum, maximum, mean, and standard deviation values of the push-out test for both types of cements in different root regions are shown in **(Fig .1), (Fig .2), (Fig .3), (Fig .4), (Fig. 5) and (Fig .6).**

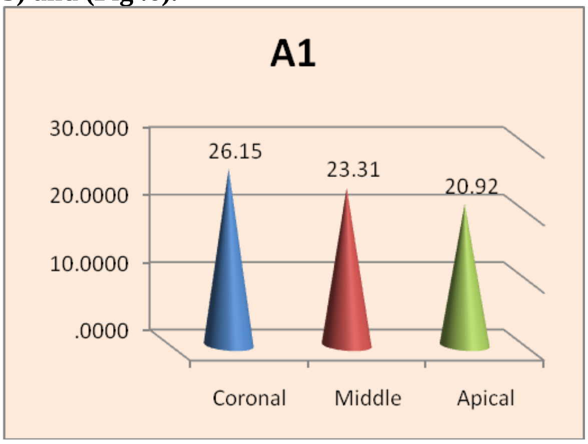

Fig. 1: Mean push-out bond strength of manually milled Zirconia post cemented with GIC.

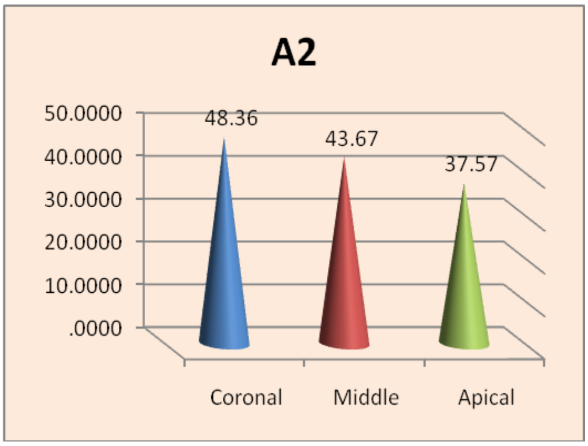

Fig. 2: Mean push-out bond strength of manually milled Zirconia post cemented with Speed cem.

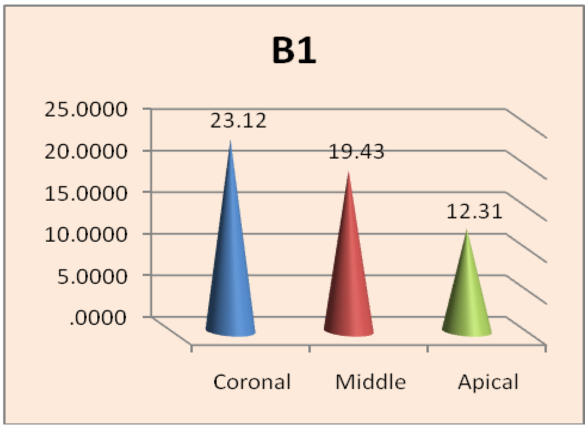

Fig. 3: Mean push-out bond strength of Prefabricated Fiber post cemented with GIC.

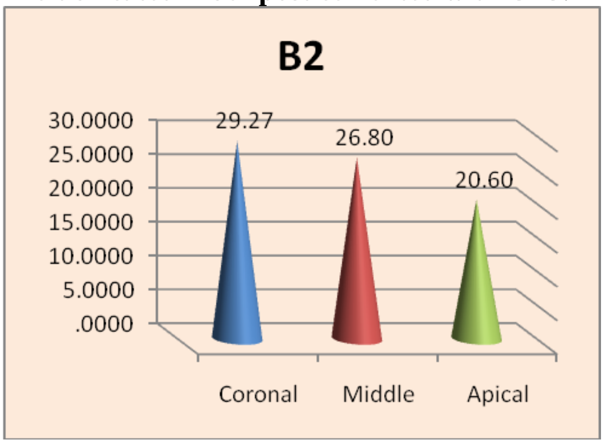

Fig.4: Mean push-out bond strength of Prefabricated Fiber post cemented with Speed cem.

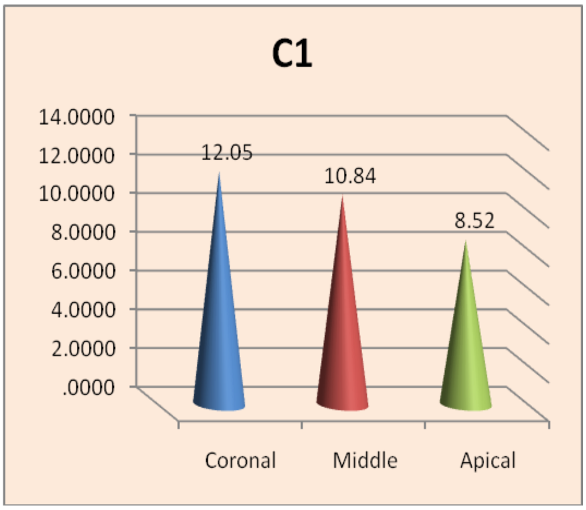

Fig. 5: Mean push-out bond strength of Prefabricated Zirconia post cemented with GIC.

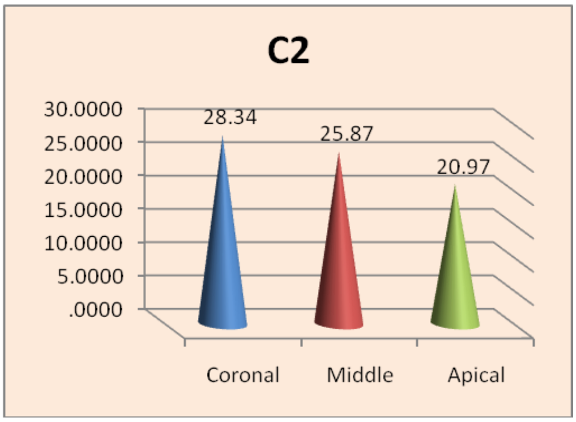

Fig.6: Mean push-out bond strength of Prefabricated Zirconia post cemented with Speed cem.

From Figures **(1), (2), (3), (4), (5)** and **(6),** it is obvious that the mean push-out bond strength (MPBS) of the Speed Cem was higher than that of GIC in all three regions. It's also clear that the coronal region in both cements had higher MPBS values, followed by middle and apical regions. The highest MPBS was seen at the coronal region of Manually Milled Zirconia post cemented with Speed cem, while the lowest value was seen at the apical region of the Prefabricated Zirconia post cemented with GIC.

DISCUSSION

The bond strength of posts in coronal, middle and apical regions

This result could be attributed to different factors:

Concerning self adhesive resin cement

The gradual decease in the number of the dentinal tubules from the coronal to the apical part of the root thus the reduced infiltration of the adhesive into the tubules and less formation of the resin tags in the apical parts, and because the adhesion is enhanced by penetration of the resin into the tubules, its values are low at the apical third.

This coincides with other findings [12,13] who stated that the difference in the number of tubules may explain why the strongest adhesion occurred in the most coronal sections where there is a greater number of tubules per square mm, but this result conflicts with Gaston et al. and Foxton et al. [14,15] who stated that the apical bond strength was significantly higher in the apical region because the bond strength is related more to the area of solid dentin than to the tubule density. Gaston et al. and Foxton et al. [14,15] prepared that post space without previous endodontic treatment; also they didn't use any irrigation solution.

Concerning GIC cement

The residual water present inside the dentinal tubules is not completely eliminated by drying the root canal with paper points. Therefore, this residual water within the dentinal tubules could be advantageously employed to achieve hygroscopic expansion of GICs and increasing the frictional resistance to post dislodgment, as the number and size of dentinal tubules is higher in the coronal region so that the amount of residual water will be more which is necessary to achieve a sufficient hygroscopic expansion and increasing the bond strength more than in the coronal region than in the apical region. This coincides with Onay et al. [16]. Who reported a significant difference in bond strength among these three root regions, where the difference in number and size of dentinal tubule may have affected the amount of moisture available for the suggested advantage of hygroscopic expansion of the GIC cement.

Comparison of bond strength among prefabricated fiber post, prefabricated zirconia post and manually milled zirconia post.

The result of this study revealed that the highest bond strength for the custom made zirconia post (**manually milled zirconia post**) cemented with resin cement and the lowest bond strength for the prefabricated zirconia post cemented with Glass ionomer cement. The smooth surface and loss of fitness for the prefabricated posts reduce their bond strength.This coincides with Pahlevan et al. [17] who stated that the fitness is a critical factor in post retention and it should not rely only on the bonding ability of resin cement for post retention.

In this study, the prefabricated fiber post showed higher bond strength than the prefabricated zirconia post, due to presence of epoxy resin in the chemical structure of fiber post. This will give a capacity for this post to form a chemical bond with the cement.

Comparison of push out test values between the self -adhesive resin cement and Glass ionomer cement

This study revealed that the bonding strength values of the self-curing resin cement material is higher than the Glass ionomer cement material, This remarkably superior performance of the adhesion in the root canal when using resin cement may be explained by the unique characteristics of this material. The dentin conditioner that is part of the resin cement has the ability to remove the smear layer, etch and demineralized dentin. This allows monomers with small molecular size to penetrate the opened tubules and the space between the collagen fibrils in the demineralized dentin, creating resin tags and hybrid layer. These structures provide an effective micromechanical retention mechanism for this resin-based cement. While GICs bonding mechanism relies on the micromechanical retention of the polymer within the dentin substrate conditioned by the polycarboxylic acid, and also on the ionic interaction between the cement and dentin. This coincides with Gernhardt et al. [18] who stated that higher bond strength values were obtained from resin cements because of their retentive properties to tooth structures.

But the result findings conflict with Pereira et al. [19] who stated that Glass ionomer cement delivered better bond strength when compared to resin cement, as possible explanation for such out come was based on the fact that Glass ionomer cement gets benefit from post maturation hygroscopic expansion due to water storage, leading to an increased frictional strength.

REFERENCES

1. Zhi-Yue L, Yu-Xing Z. Effect of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. J Prosthet Dent 2003; 89: 368-73.
2. Meyenberg KH, Luthy H, Schaerer P. Zirconia posts: a new all-ceramic concept for nonvital abutment teeth. J Esthet Dent 1995; 7: 73-80.
3. Pfeiffer P, Nergiz I, Schmage P. Yield strength of zirconia and glass fibre posts. J Oral Rehab 2006; 33:70–74
4. Dauvillier BS, Feilzer A, de Gee AJ, Davidson CL. Viscoelastic parameters of dental restorative materials during setting. J Dent Res 2000; 79(3): 818-23.
5. Monticelli F, Ferrari M, Toledano M. Cement system and surface treatment selection for fiber post luting. Med Oral Pathol Oral Cir Bucal 2008; 13: E214–21.
6. 6.Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004; 112: 353 -61.
7. Edson A, Melissa S, Emanuel S, Silvana P, Ricardo S, Manuel N. Effect of eugenol–based endodontic cement on the adhesion of intraradicular posts. Braz Dent J 2006; 17(2):130-3.
8. D'Arcangelo C, Zazzeroni S, D'Amario M, Vadin M, De Angelis F, Trubiani O, Caputi S. Bond strengths of three types of fibre-reinforced post systems in various regions of root canals. J Endod 2008b; 41(4): 322-8.
9. Gencoglu N, Garip Y, Bas M, Samani S. Comparison of different gutta-percha root filling techniques: Thermafil, Quick-Fill, System B, and lateral condensation. Oral Sur Oral Med Oral Pathol Oral Radiol Endod 2002; 92(3): 333-6
10. Akgungor G, Akkayan B. Influence of dentin bonding agents and polymerization modes on the bond strength between translucent fiber posts and three dentine regions within a post-space. J Prosthet Dent 2006; 95(5): 368–78.
11. Vano M, Cury AH, Goracci C Chieffi N,Gabriele M, Tay FR, Ferrari M. The effect of immediate versus delayed cementation on the retention of different types of fiber post in canals obturated using a eugenol sealer. J Endod 2006b; 32(9): 882–5.
12. Perdigão J, Gomes G, Augusto V. The effect of dowel space on the bond strength of fiber posts. J Prosthodont 2007; 16(3):154-64.
13. Zobra YO, Erdemi A, Turkyilma A, and Eldeniz AU. Effects of different curing units and luting agents on push-out bond strength of translucent posts. Am Associ Endod 2010; 36(9):1521-5
14. Gaston BA, West LA, Liewehr FR, Fernandes C, Pashley DH. Evaluation of regional bond strength of resin cement to endodontic surfaces. J Endod 2001; 27(5): 321-4.
15. Foxton RM, Nakajima M, Tagami J, Miura H. Adhesion to root canal dentin using one and two-step adhesives with dual-cure composite core materials. J Oral Rehabil 2005; 32(2): 97-104.
16. Onay EO, Korkmaz Y, Kiremitci A. Effect of adhesive system type and root region on the push-out bond strength of glass-fibre posts to radicular dentine. Int Endod J 2010; 43: 259-268.
17. Pahlevan A,Mirzaei M,Akbarian S: Shear bond strength of zirconia post to root dentine with two different cements and comparison with fiber post. JIDA 2011;23(1):17-23
18. Gernhardt CR, Bekes K, Schaller HG. Short-term retentive values of zirconium oxide posts cemented with glass ionomer and resin cement: an *in vitro* study and a case report. Quintessence Int 2005; 36: 593-601.
19. Pereira JR, Valle AL, Ghizoni JS, Ramos MB: Evaluation of push out bond strength of four luting agents and SEM observation of the dentine fiber glass bond interface. Int Endo J 2013; 18:10111-12089