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# Evaluation of the push out bond strength of fiber reinforced post using three different dentin bonding adhesives and microscopic evaluation of its fracture modes

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**ABSTRACT:**

**Background:** A successful endodontic treatment has to be complemented with an adequate post-endodontic restoration, to make the endodontically treated tooth to function indefinitely as an integral part of the masticatory apparatus. It is impossible to achieve sufficient anchorage of a restoration in the remaining dentin when a large portion of the crown has been lost to damage. In such situations, post and core restorations are required for additional retention.

**Aim:** The aim of the present study was to compare the push-out bond strength of a fiber-reinforced post luted with dual cure resin cement using three different bonding adhesives at three different levels of roots.

**Materials and methods:** A total of sixty maxillary central incisors teeth were decoronated, endodontically treated and post space was prepared. The teeth were randomly divided into four groups, depending upon adhesive protocol used: Adper single bond 2, One coat bond, Futurabond DC and control group (without any bonding adhesive). After luting of a fiber post, samples were cut into 3 mm sections, to determine its push-out bond strength with universal testing machine. Also, fracture modes were analyzed using stereomicroscope.

**Statistical analysis used**: The push-out bond strength values were expressed in MPa and analyzed with ANOVA and Tukey's test.

**Results:** The push-out bond strength at coronal level (11.5405 MPa) was statistically significant higher (p value .000) as compared to that of middle (7.3550 MPa) and apical (5.2120 MPa) third levels. Total-etch bonding adhesive (Adper Single Bond 2) showed statistically significant more values than that of other bonding adhesives. Majority of fractures (>60%) were adhesive type-I i.e. at the interface between the luting agent and root canal.

**Conclusion:** Application of bonding adhesive prior to luting agent, significantly increased the push-out bond strength value and the mean push-out bond strength value of total-etch bonding adhesive was more than that of self-etch bonding adhesives. Analysis from failure modes revealed that interfacial adhesion was weakest between luting agent and root canal.

**Key words:** Fiber post, total-etch bonding adhesive, self-etch bonding adhesive, push-out bond strength.

## I. INTRODUCTION:

The restoration of the endodontically treated tooth represents a key factor during treatment planning because of its impact on the long-term prognosis of the tooth.[1] It is generally assumed that the loss of hard tissue leads to decrease in load carrying capacity of endodontically treated tooth. Therefore, posts are essentially indicated for the endodontically treated tooth, to increase its longevity.[2] Traditionally prefabricated posts made of cast metal were used but due to their high rigidity, metal posts seem to vibrate at high frequencies when loaded with lateral forces. It had been suggested that due to mismatch in the modulus of elasticity; as metallic materials have much higher modulus than that of the supporting dentin, leading to stress concentrating at the luting cement, resulting in its failure.[3] This has led to a hunt for a plastic-based material that has a modulus closer to that of dentin. The use of fiber posts is a priority in the restoration of endodontically treated teeth because they elastic modulus of these posts is closer to dentin than metallic posts, thereby mitigating the risk of vertical fractures of root canal treated teeth.[4]

The adhesion between the resin cement and the dentine, as well as between the resin

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cement and posts, is responsible for retention of fiber posts in root canals. The term bonding agent no longer covered the multi-step application procedure and therefore, replaced by adhesive system.[5] Bonding of fiber posts to intracanal dentin is difficult, which could be because of the factors affecting the retention of fiber posts in root canals as the type of the tooth, endodontic treatment, intracanal post surface preparation, bonding adhesives and cement and method of application of the luting cement. It has been reported that cementation of posts using adhesive systems will lead to increase in the retention of the post and decreases the chances of debonding & microleakage at the dentin-fiber post interface.[6]

The retention of fiber posts in the roots depends on the bond strength between the post material and a resin luting agent, as well as the bond strength between the resin luting agent and post space dentin.[7] Bond strength between tooth and post can be measured through conventional tensile testing, either on external root dentin or on the post space surface using push-out and pullout methods. The push-out bond test was firstly used for evaluating the bond strength with root canal dentin in 1996, as it provides a better estimation of the bonding than that of conventional shear test. The push-out test is a true shear test, as a fracture occurs almost parallel to the dentin-bonding interface. Also, it has been considered to be more dependable than the microtensile test for bonded posts; because high number of premature failures occurred during specimen preparation with microtensile testing. In addition to that push-out bond test simulates the clinical conditions more closely.[8]

The aim of the present study was to compare the push-out bond strength of a fiber-reinforced post luted with dual cure resin cement using three different bonding adhesives - Adper single bond - light-cured, total-etch; One coat bond - light cured, self-etch and Futurabond DC - dual cured, self-etch at three different levels (coronal, middle and apical) of root. Also, Stereomicroscopic evaluation was performed to evaluate their fracture modes.

## II. MATERIALS AND METHODS:

Sixty freshly extracted maxillary central incisor teeth were selected and immersed in 5 % concentration of sodium hypochlorite (Dentpro Limited, Mohali, India) to remove debris and adherent soft tissue. Hard deposits were removed using an ultrasonic scaler and teeth were stored in formalin (Avarice Laboratories Private Limited, Uttar Pardesh, India). The crown of each tooth was cut transversely at the level of cemento-enamel junction using a double side coated diamond disc mounted in a straight handpiece with micromotor. The armamentarium and materials used in study were shown in figure 1 and 2 respectively.

A size #10 K-file (MANI Tochigi, Japan) was inserted into the canal until the tip of instrument was just visible at apical foramen, working length was established 1 mm shorter of that and confirmed radiographically. The root canals were prepared upto working length with K-files (MANI Tochigi, Japan) using step-back technique. The apical portion was enlarged to a 45 No. master apical file and middle & coronal portion of canal was shaped upto three times larger instruments. After each instrument, canals was copiously irrigated with one ml of 5.25% sodium hypochlorite solution (NaOCl) (DentPro, Amrit Chemicals and mineral agency, Mohali, India) and recapitulated. After completion of instrumentation, final irrigation was performed with two ml of 5.25% NaOCl (DentPro, Amrit Chemicals and mineral agency, Mohali, India), two ml of 17 %EDTA (Shivam dental EDTA, Shivam industries, Jammu, India) and five ml of normal saline.

After cleaning and shaping, canals were dried using paper point and obturated with Cold Lateral Condensation Technique. The primary or master gutta-percha cone was selected and its apical portion adjusted till its tug-back is achieved and confirmed radiographically. The apical half of primary gutta-percha cone was coated with AH-plus sealer. Spreader was inserted alongside the primary cone one mm short of working length to compact the apical part of canal. This process was repeated with secondary gutta-percha cones until the entire canal was filled with well condensed gutta-percha.

After twenty-four hours of endodontic treatment, a post space was prepared upto a depth of ten mm using peeso-reamers No.1 (0.7 mm diameter), No. 2 (0.9 mm diameter) and No. 3 (1.1 mm in diameter). The final drill used was Size 3 Tenax fiber trans drill of 1.3 mm diameter (Coltene-Whaledent; Altstatten, Switzerland) corresponding to that of fiber post (Tenax trans fiber post, Coltene-Whaledent; Altstatten, Switzerland).

Following the post space preparations, the canals were irrigated with 2 ml of 17 % EDTA and dried with paper points. Presence of any residual gutta-percha in the walls of post space was checked by radiographic evaluation. The composition and manufacturer's instructions of bonding adhesives and composite resin used in study was depicted in Table-I.

Post (Tenax trans fiber post, Coltene-Whaledent; Altstatten, Switzerland) was luted with dual-cured composite resin cement (Paracore dual cure cement, Coltene-Whaledent; Altstatten, Switzerland) with or without dentin bonding adhesive as:

**Group - I: Without Bonding Adhesive (Control) :** After post space preparation, no dentin bonding adhesive was used and post was luted with dual cure composite resin cement Paracore (Coltene Whaledent; Altstatten, Switzerland) and light cured using LED curing light (1200 mW/cm$^2$ Woodpecker, China) for twenty seconds.

**Group-II: Fifth Generation, Two-step, Total-Etch bonding adhesive: Adper Single Bond 2 (3M ESPE; Seefeld, Germany):** After post space preparation, root dentine was treated with 37% phosphoric acid for fifteen seconds, washed with water for 10 seconds and was gently dry with air for 5 seconds. Agitate the bonding adhesives (Adper single bond (3M ESPE; Seefeld, Germany) on to the root dentin as well as post for 15 seconds and light cured for ten seconds. After that, dual cure composite resin cement Paracore (Coltene Whaledent; Altstatten, Switzerland) was used to lute the post using LED light (1200 mW/cm$^2$, Woodpecker, China) for twenty seconds.

**Group-III: Seventh Generation, One-step, Self-Etch bonding adhesive: One Coat bond (Coltene Whaledent; Altstatten, Switzerland):** After post space preparation, bonding agent – one coat bond (Coltene-Whaledent; Altstatten, Switzerland) was applied to root dentin as well as on post. Agitate the surface with adhesive for twenty seconds, gently dry with oil free air for five seconds and cured for ten seconds with LED light. After that, dual cure composite resin cement Paracore (Coltene Whaledent; Altstatten, Switzerland) was used to lute the post using LED light (1200 mW/cm$^2$, Woodpecker, China) for twenty seconds.

**Group-IV: Eight generation, One-step, Self-Etch bonding adhesive: Futurabond DC (Voco, Germany):** After post space preparation, one drop each from liquid 1 and liquid 2 of futurabond DC (Voco, Germany) was mixed in the mixing well with an applicator tip for an approximately 2 seconds, so as to create a homogeneous mixture and then applied on to root dentin as well as on post, air dried for 5 seconds and cured for ten seconds. After that, dual cure composite resin cement Paracore (Coltene-Whaledent; Altstatten, Switzerland) was used to lute the post using LED light (1200 mW/cm$^2$ Woodpecker, China) for twenty seconds.

The prepared roots of the tested teeth were sectioned horizontally to the long axis of the root into 3 mm sections using a diamond saw under water irrigation for the push-out test. The apical 3-4 mm of the samples containing gutta-percha was cut-down using a double side coated diamond disc mounted in a straight handpiece with micromotor. From the remaining coronal segment of the samples, three cross-sections of 3 mm thickness from cervical area were obtained and the thickness was checked with a digital vernier calipers. The specimens were then placed in an acrylic mold.

To determine the push-out bond strength, sections were mounted in universal testing machine (Tinius Olsen, United Kingdom). A fitting device was fabricated to fit the upper and lower arm of universal testing machine. The upper fitting device had a tip diameter of 0.8 mm. The lower fitting device had a hole in its center to allow for the dislocation of posts from the specimens (sections). A cylindrical piston of 0.8 mm in diameter was placed in the middle of post as shown in figure 3. The load was applied in apico-cervical direction at a cross head speed of one mm / min until post was dislodged. The peak value of the load required for dislocating the post from the specimen was recorded in Newtons. The push out strength (in Megapascals) was calculated by dividing the recorded peak load by the calculated bonding surface area, i.e. push-out bond strength (MPa) = Maximum load (N) / bonding surface area.

All the sections were examined under stereomicroscope of magnification 40 X (Motic, Hong-Kong), to determine their fracture mode at the interface, which were classified as follows: (shown in figure 4)

TYPE I: Adhesive fracture between the resin cement and the root canal.
TYPE II: Adhesive fracture between the resin cement and the fiber post
TYPE III: Cohesive fracture of post system
TYPE IV: Mixed fracture

## III. STATISTICAL ANALYSIS:

Data obtained in the present study was subjected to statistical analysis using one-way analysis of variance (ANOVA) and Tukey's post hoc tests. The mean push-out bond strength and fracture modes were calculated for each group.

## IV. RESULTS:

The mean values and standard deviation of push-out bond strength among different bonding

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adhesives at different regions of root were shown in Table-II and graph-I. Two way analysis of variance demonstrated that bond strength was significantly influenced by type of bonding adhesive protocol, the root space region and the interaction between these two factors (p <0.001).

The mean value of push-out bond strength of Adper single bond 2 adhesive at coronal (14.1120 MPa) and middle (8.9707 MPa) level of root was higher than that of group-III and group-IV and was statistically highly significant (p<0.001); whereas the difference among group-III and group-IV was not statistical significant. At apical level, maximum bond strength was found in group-IV (6.2767 MPa); the difference among group-II and group-IV was not statistical significant, however the difference among group-III and group-IV was significant as depicted from Table-III

On comparing the different levels of root canal, mean push-out bond strength at coronal level (11.5405 MPa) was higher than those at the middle (7.3550) and apical third levels (5.2120) and difference was stastically highly significant (p<0.001).

Stereomicroscopic images were examined to evaluate the fracture modes of all materials as described in Table-IV and it had been found that most of fractures occur at cement-dentin interface. Adper single bond 2 bonding adhesive provided adhesion than that of other adhesives as cohesive failures occurred mainly in that group.

## V. DISCUSSION:

A successful endodontic treatment has to be complemented with an adequate post-endodontic restoration to make the pulpless teeth to function indefinitely as an integral part of the masticatory apparatus. Endodontic restoration is a very important step after root canal treatment to preserve the remaining tooth structure and prevention of tooth fracture. Most of the endodontic teeth need full-coverage restoration after endodontic treatment, and others need first post placement for core

buildup, especially, if there are destructed walls in the endodontic tooth than full-coverage restoration[9]. Coronal reconstruction and root anchorage using fiber post associated with dentin bonding adhesive allows for the preservation of maximum amount of tooth structure.

Sadaf D et al, assessed the effect of timely placement of coronal restoration on endodontically treated teeth and found that extraction of endodontically treated teeth were more likely to be 73%, when final restoration were placed after 60 days than that of 25%, when restoration was placed 15-59 days after completion of an endodontic treatment.[10]

Considering the importance of interfacial bond between the luting agent and root canal dentin, the present study was undertaken to evaluate the effect of push-out bond strength of tenax trans fiber post luted with dual cure resin cement (Paracore) using different bonding adhesives as Adper single bond 2 - light cured, total-etch; One coat bond - light cured, self-etch and Futurabond DC - dual cured, self-etch and without using any dentin bonding adhesive at three different levels (coronal, middle and apical) of roots of sixty extracted maxillary central incisors. Push-out bond strength was determined using universal testing machine.

The mean push-out bond strength value for group-II bonding adhesive i.e. Adper single bond 2 was significantly higher than that of other bonding adhesives. It could be because of total-etch bonding system, where an etching and subsequent rinsing helps in removing the smear layer; there by opening the dentinal tubules, increasing the dentinal permeability and decalacifying the inter-tubular and peritubular dentin. When the peritubular dentin is completely removed, the circumferentially oriented collagen fibers that mark the extreme boundary of the tubules are exposed and available for resin infiltration. Thus around each resin tag, a “cylindrical hybrid layer” develops, which anchors the tag to adjacent intertubular dentin, leading to increase in bond strength value[11].

However, Self-etch bonding adhesives (as in one coat bond and futurabond DC bonding adhesive) uses non rinse acidic monomers that simultaneously dissolve / modify the smear layer, demineralize the dentin surface beyond the smear layer and infiltrate the exposed collagen with hydrophilic monomers, where they co-polymerize with the resin to the same depth into the dentin. The result is the formation of a hybridized complex; a hybridized smear layer and hybrid layer whose thickness is related to the aggressiveness of the self etching agent[12].

The results of the present study were in consistent with the results of Topcu FT et al[13], mean value at coronal level with XP bond (total-etch adhesive) was 13.685 MPa while that of Optibond (self-etch adhesive) was 9.778 MPa. Authors concluded that total-etch adhesives removes smear layer on the root canal dentin and smear plugs in dentinal tubules more effectively, enhancing the micromechanical retention of resin based cements and thus, increases the bond strength value.

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Also, Tavares AF et al[14] found that total-etch adhesives showed better performance, as etching procedure facilitates the removal of smear layer, increases the width of dentinal tubules and allows the formation of greater number of thicker and larger resinous tags as compared to self etch adhesives. Similarly, Albaladejo A et al[15] found that there were some morphological differences between the bonded structures when etch-and-rinse and self-etch adhesives were used. Hybrid layers created by the etch-and-rinse adhesives are thicker than those observed with the self-etching adhesive systems, which might lead to the difference in push out bond strength values.

However, on the other hand, yhe results were contraindicated by da Silva MB et al[16], where authors concluded that self-adhesive (16.89 MPa) showed better results than that of total-etch (11.56 MPa) adhesive system; as they are less technique sensitive and exhibit greater moisture tolerance. Also, Shafiei F et al[17] evaluated the bonding performance of universal adhesive (All bond universal) in etch & rinse mode and self-etch mode, concluded that adhesive performance of universal adhesives in etch and rinse was comparable to that of self-etch mode.

The mean push-out bond strength value in all the groups, was higher at coronal level than that of middle and apical third levels of root. The high number and density of dentinal tubules per square mm at coronal level, is responsible for high push-out bond strength value because of the formation of more resin tags. Also, at apical level; risk of presence of gutta-percha remnants, residual sealer, debris and thick smear layer is high; making this area difficult to clean and bond, leading to decrease in bond strength value.[18,19,20]

Specimens were analyzed under stereomicroscope at 40 X, to determine their fracture mode. Findings revealed that almost all the fractures in group-I were adhesive, usually at the dentin-cement interface; while the fractures in group-II, III and IV were both adhesive and cohesive; but there was no statistical significant difference among the groups at coronal (p-value .834), middle (p-value .994) and apical (p-value .560) third levels. The analysis of fracture modes in the study revealed that most of the fracture occurred at the interface between dentin and luting agent. The adhesion between resin cements and root dentin is difficult because of high polymerization stresses which occurs at the cement–dentin interface, competes with its bond strength.

These findings were in accordance with the study conducted by Mao H et al[21], found that adhesive fracture of the bonding interfaces accounted for the most common fracture (68.5%), while cohesive fracture either in dentin (18.5%) or fibre posts (13%) were lesser common findings. It had been concluded that interfacial adhesion was the weakest between the dentin and luting cement

Similar findings were also observed by Giachetii L et al[22], determined the fracture mode after push-out bond strength using scanning electron microscope and found that majority of fracture patterns (71.7%) were adhesive at the interface between resin composite and dentine. Also, Farid F et al[23] revealed that most of the fractures in fiber post system occurred at dentin–luting cement interface. The adhesion between resin cements and root dentin is difficult because of polymerization stress occurring at the cement–dentin interface, which might be affected by root canal geometry, responsible for its high configuration factor (C-factor).

Regardless of bonding adhesive protocol and the level of root, most of the fractures occurred at the interface between dentin and luting agent (more than 60%) which could be because of high polymerization stresses occuring at the cement–dentin interface, competing with its bond strength. The second most observed fracture modes were adhesive at the cement and post interface. This may have resulted from the absence of a chemical union between epoxy resin-based post and methacrylate-based resins. The cohesive fracture inside the post were observed in the present study mainly in group-II, it could also be evaluated that in these samples the frictional component was higher, enhanced by the good retentive strength between the post and the cement

## VI. CONCLUSIONS:

Under the limitations of this study, the following conclusions can be drawn:

a. Application of bonding adhesive prior to luting agent, significantly increased the push-out bond strength value.
b. The mean push-out bond strength value of total-etch bonding adhesive was more than that of self-etch bonding adhesives.
c. The coronal level showed statistical significant push-out bond strength value than that of middle and apical third level of root.
d. In all the groups, majority of fractures were adhesive type-I i.e. the interface between the luting agent and root canal indicating that interfacial adhesion was weakest between luting agent and root canal.

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**Table-I: COMPOSITION AND MANUFACTURER'S INSTRUCTIONS OF ADHESIVES AND RESIN COMPOSITE USED IN THE PRESENT STUDY**

| BONDING ADHESIVES | pH | COMPOSITION AND TECHNIQUE |
|---|---|---|
| Paracore (Coltene-Whaledent; Altstatten, Switzerland) | | Methacrylates, fluorides, barium glass, amorphous silica. |
| Adper Single Bond 2 (3M ESPE, Seefeld, Germany) Etchant ph of 0.6 | 2.3 | ➢ Water, ethanol, *HEMA, *BisGMA, 35% phosphoric acid, dimethacrylates, initiators, nanofillers copolymers of polyacrylic acid and itaconic acid.<br>➢ Apply phosphoric acid etchant to prepared enamel and dentin surfaces for 15 seconds.<br>➢ Rinse with water for 10 seconds.<br>➢ Agitate bonding adhesives to etched surfaces for 15 seconds and air dried for 5 seconds.<br>➢ Light cured for 10 seconds using LED light. |
| One Coat Bond (Coltene-Whaledent; Altstatten, Switzerland) | 1.9 | ➢ UDMA, HEMA, glycerodimethacrylate, polyakenoate methacrylate and amorphous silica, ethanol.<br>➢ Apply bonding adhesive with applicator tip. Rub the surface for 20 seconds and gently dry with oil-free air for 5 seconds.<br>➢ Light cured for 10 seconds using LED light. |
| Futurabond DC (Voco, Germany) | 1.4 | ➢ HEMA, bis-GMA, HDDMA, UDMA, acidic adhesive monomer, catalyst, ethanol, Fluorides, water, initiators, nanofillers.<br>➢ Mix one drop from liquid 1 and liquid 2 of futurabond DC (Voco, Germany) on mixing palette with an applicator tip for approximately 2 seconds.<br>➢ Apply on root dentin as well as on post, air dried for 5 sec.<br>➢ Light cured for 10 seconds using LED light. |

(HEMA=2-hydroxyethyl methacrylate; UDMA= Urethanedimethacrylate; Bis-GMA= Bisphenol A-glycidylmethacrylate; Bis-HEMA Bisphenol2-hydroxyethyl methacrylate; TEGDMA= Triethylene glycol dimethacrylate; HDDMA =1, 6- Hexanediol Diacrylate)

**TABLE-II: COMPARATIVE ANALYSIS OF MEAN PUSH-OUT BOND STRENGTH (IN MPA) OF DIFFERENT GROUPS AT CORONAL, MIDDLE AND APICAL THIRD LEVELS BY TWO WAY ANOVA TEST**

| Group | Levels | Mean Value (in MPa) | Standard Deviation |
|---|---|---|---|
| I | Coronal | 9.9707 | 1.65325 |
| | Middle | 6.1107 | 0.76597 |
| | Apical | 3.647 | 1.14886 |
| II | Coronal | 14.1120 | 2.03687 |
| | Middle | 8.9707 | 1.90397 |
| | Apical | 6.1240 | 1.19050 |
| III | Coronal | 11.4847 | 1.09954 |
| | Middle | 7.2020 | 0.71007 |
| | Apical | 4.8253 | 1.07969 |
| IV | Coronal | 10.5947 | 1.28607 |
| | Middle | 7.1367 | 1.28915 |
| | Apical | 6.2767 | 1.21024 |

**TABLE III: STATISTICAL ANALYSIS OF PUSH-OUT BOND STRENGTH AMONG DIFFERENT GROUPS AT CORONAL, MIDDLE AND APICAL THIRD LEVELS**

| Group | Comparative analysis between | Mean value | Standard deviation | Standard error | p-value* |
|---|---|---|---|---|---|
| Group-I | Coronal-Middle level | 3.86000 | 1.89824 | 0.49012 | .000 |
| | Coronal-Apical Level | 6.35600 | 2.17578 | 0.56178 | .000 |
| | | | | | |

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| | | | | | |
|---|---|---|---|---|---|
| | Middle-Apical Level | 2.49600 | 1.10643 | 0.28568 | .000 |
| Group-II | Coronal-Middle level | 4.28267 | 0.96603 | 0.24943 | .000 |
| | Coronal-Apical Level | 6.65933 | 1.66115 | 0.42891 | .000 |
| | Middle-Apical Level | 2.37667 | 1.17764 | 0.30407 | .000 |
| Group-III | Coronal-Middle Level | 5.14133 | 2.21874 | 0.57288 | .000 |
| | Coronal-Apical Level | 7.98800 | 1.58316 | 0.40877 | .000 |
| | Middle-Apical Level | 2.84667 | 1.21121 | 0.31273 | .000 |
| Group-IV | Coronal-Middle Level | 3.45800 | 1.44257 | 0.37247 | .000 |
| | Coronal-Apical Level | 4.31800 | 2.10094 | 0.54246 | .000 |
| | Middle-Apical Level | 0.86000 | 1.62783 | 0.42030 | .060 |

**TABLE-IV: EVALUATION OF FRACTURE MODES AMONG DIFFERENT GROUPS AT CORONAL, MIDDLE AND APICAL LEVELS**

| Region | Group | N | Type of failure pattern | | | |
|---|---|---|---|---|---|---|
| | | | Type-I | Type-II | Type-III | Type-IV |
| Coronal | I | 15 | 80% | 13.3% | 0% | 6.7% |
| | II | 15 | 46.7% | 33.3% | 13.3% | 6.7% |
| | III | 15 | 60% | 26.7% | 6.7% | 6.7% |
| | IV | 15 | 60% | 20% | 13.3% | 6.7% |
| Middle | I | 15 | 86.7% | 6.7% | 0% | 6.7% |
| | II | 15 | 66.7% | 20% | 6.7% | 6.7% |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | III | 15 | 66.7% | 13.3% | 6.7% | 13.3% |
| | IV | 15 | 60% | 20.0% | 6.7% | 13.3% |
| Apical | I | 15 | 93.3% | 0% | 0% | 6.7% |
| | II | 15 | 73.3% | 13.3% | 6.7% | 6.7% |
| | III | 15 | 80.0% | 6.7% | 6.7% | 6.7% |
| | IV | 15 | 66.7% | 26.7% | 0% | 6.7% |

**FIGURE 1: ARMAMENTARIUM USED IN THE STUDY**

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**FIGURE 2: MATERIALS USED IN THE STUDY**

**FIGURE 3: INSTRON TESTING MACHINE USED FOR TESTING THE SAMPLES**

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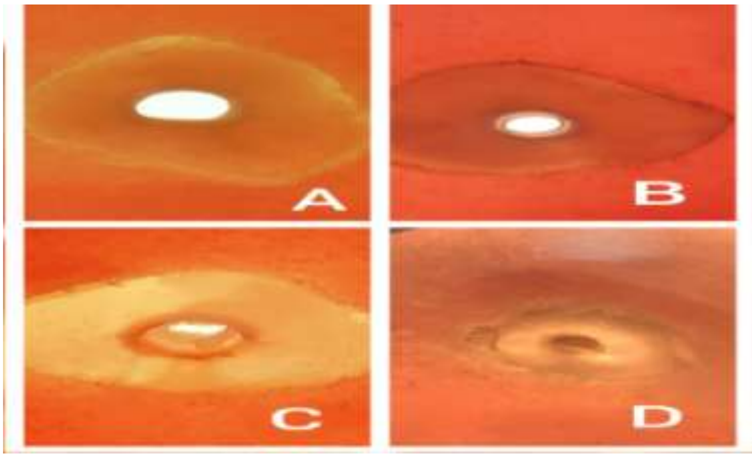
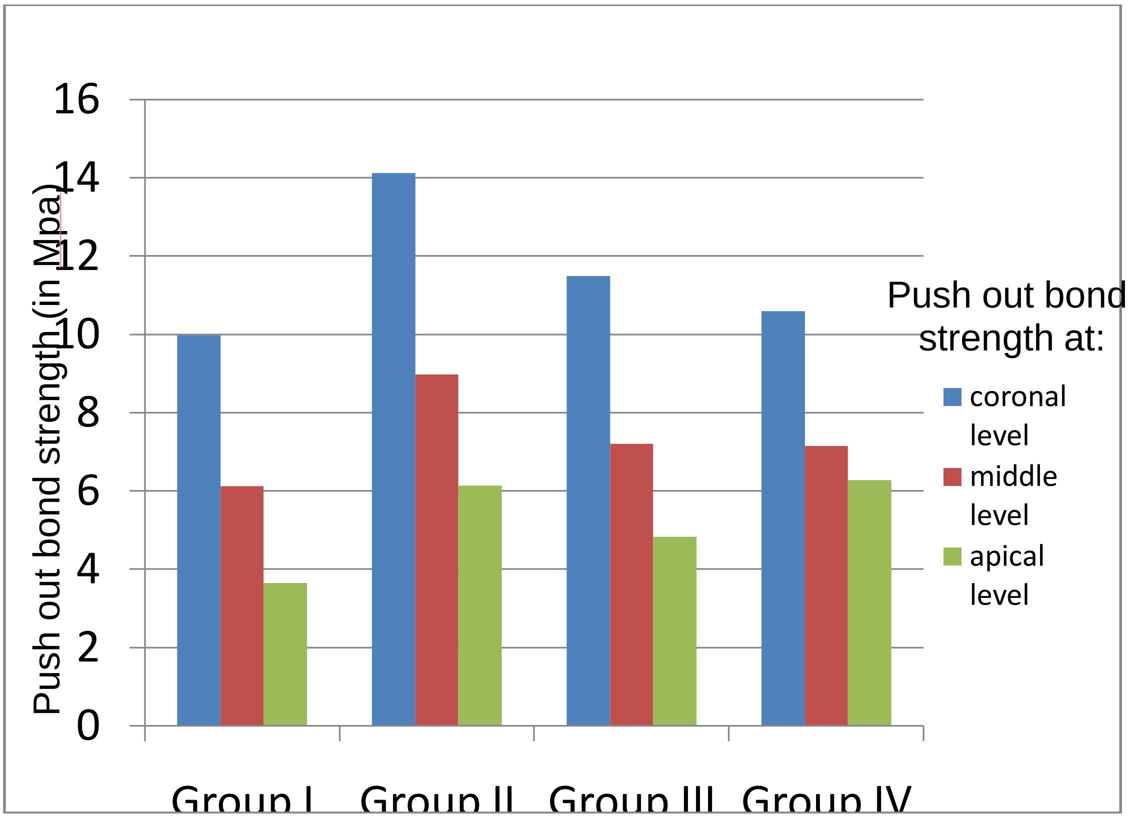



**FIGURE 4: EVALUATION OF FRACTURE MODES**

Fig. 4 (a): adhesive fracture between resin cement and root canal; 4(b): adhesive fracture between resin cement and fiber post; 4(c): cohesive fracture of post system; 4(d): mixed fracture

**GRAPH-I: COMPARATIVE ANALYSIS OF MEAN PUSH-OUT BOND STRENGTH (IN MPA) OF DIFFERENT GROUPS AT CORONAL, MIDDLE AND APICAL THIRD LEVELS BY TWO WAY ANOVA TEST**




X- Axis represents the samples at coronal, middle and apical third levels among different groups. Y-axis represents the push-out bond strength value in MPa