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RESEARCH ARTICLE

AN INVITRO STUDY TO COMPARE THE PULL OUT BOND STRENGTH OF A FIBER POST SYSTEM WITH TWO DIFFERENT POST SPACE DIAMETERS LUTED WITH TWO COMMERCIALY AVAILABLE RESIN CEMENTS

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Abstract

Objective: To compare and evaluate the bond strength of a fiber post cemented to different post space diameters using two commercially available resin cement.

Methodology: 60 freshly extracted maxillary central incisor teeth with similar dimensions were selected and sectioned horizontally from CEJ. Endodontic treatment was done on all specimens and divided into two groups Group 1 and 2 (n=30) based on the post space diameter (0.9mm and 1.1mm). Each group was subdivided into two 1A, 1B, 2A, 2B (n=15) according to the cement used. Following the post space preparations, the canals were rinsed and dried. The adhesive resin cement was applied and posts were seated to full depth and excess cement was removed. After 24 hours specimens underwent 10,000 thermal cycles and preserved in saline solution. Specimens were mounted into universal testing machine and tensile force at a crosshead speed of 1 mm/ min was applied to the posts until they debond from the root canals. Data was analyzed using ANOVA test, Independent t test and Tukey HSD test.

Result: The result shows increased bond strength in snug fit than passive fit. ie; more bond strength was observed in Group 1A (mean =26.75 KgF) and Group 1B (mean =15.72 KgF) where post size and peeso reamer drill size were same. When comparing two cements RELYX shows more bond strength (1A=26.75, 2A=14.82) than PANAVIA cement (1B=15.72, 2B=10.51).

Conclusion: A post with snug fit post space preparation shows better resistance to pull out test than over prepared post space preparation. Cement RELYX U-200 shows higher tensile bond strength than PANAVIA-F cement.

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Introduction:-

A post restoration plays a vital role in increasing the strength of an endodontically treated tooth that is severely destructed by increasing the strength of crown and prevents fracture during functional loading¹. It also provides retention and stability for a core. The retention of a post is influenced by various factors like the post type and design, type of luting cement, cementation procedure and post space preparation.

Dentist should select a post with minimum diameter in order to maximize preservation of remaining dentin.² Selection of the post type depends on the condition of the tooth and operators choice. Since 1990's fiber-reinforced posts have been used more often for severely destructed endodontically treated teeth.¹ The modulus of elasticity of fiber reinforced post(18-22 Gpa) is similar to that of tooth dentine(18 GPa)². Therefore, the stress produced by the fiber post and natural teeth is similar, thereby reducing the risk of root fractures by 95% -99 %³. Compared to cast posts, the incidence of repairable fracture for fiber post is high.³

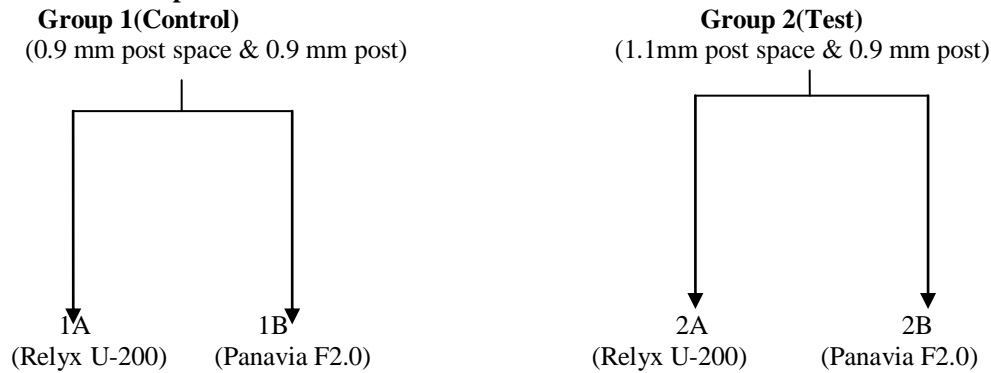
Several studies states that resin cement have a superior strength when compared with other cements for luting endodontic post. One of the reason for the superior strength of resin cements over other cement is the ability of resin cements to supplement micromechanical retention by adhesive bonding.⁴ The main adhesive mechanism of self-adhesive cements is attributed by a chemical reaction between phosphate methacrylates and hydroxyapatite. One of the major advantages of Self-adhesive resin cement is the simplified procedure that overcomes the technique sensitivity of multistep systems. Self adhesive cements do not require any pretreatment of the dental surfaces, as their application is accomplished via single clinical step.⁵

One of the major problems facing by clinician is the mismatch between the diameter of the post space and that of the post while restoring endodontically treated teeth. Even though manufacturer provide size-matched drills to permit good fitting of posts to the root canal, due to variation in the anatomy of root canals resin cement thickness around the post can vary . In addition, flared canals from carious extension, trauma, pulpal pathosis and iatrogenic problems can compromise the adaptation of the posts to canal walls.⁶ The effects of luting cement and root canal sealer on the retention of endodontic post have been extensively examined, but only a few studies have focused on the influence of post space diameters and the cement thickness and its role in retention of post.

The purpose of this in-vitro study was to evaluate the bond strength of two commercially available resin cement bonded to fiber post in the root canal with two post space diameters, i.e one with snug fit and the other with a passive fit.

Materials & Methods:-

Sixty freshly extracted human maxillary central incisors with single canal and similar dimension were selected for the study. The external debris was removed from the teeth by an ultrasonic scaler. Teeth with roots shorter than 10 mm or with defects or cracks were excluded and the roots similar in dimension of around 12 mm were taken to avoid any error during the study and for standardization. After scaling the selected specimens were stored in 0.5% Chloramine T disinfectant solution to prevent cross contamination (figure 1). The crown surface of each tooth was sectioned horizontally from cemento-enamel junction (CEJ) (figure 2), using a diamond disc rotary cutting instrument mounted on a high-speed hand piece with water-spray cooling. Pulpal tissue was removed using a barbed broach. Canal patency was determined by passing a file after the pulp is removed. Working length was established 1.0 mm short of the apical foramen. The root canals were mechanically enlarged using endodontic files operated at 300 rpm. 3% NaOCl and 15% EDTA was used as an intracanal irrigants when the canals are instrumented. The final preparations had a 6-degree taper and a 0.25-mm diameter at the apex. The enlarged canals were then rinsed with distilled water and then dried with paper points .Then the canals were obturated with 0.06 taper gutta percha using resin based endodontic sealer(figure 3). The post spaces were prepared 24 hours after completing endodontic procedures to ensure complete setting of the sealer (figure 4). The specimens were divided into two main groups: Group 1(control) and Group 2(test) (n=30) based on the peeso reamer drill size. The post space preparation is done with peeso reamer drills(mani), of size 2 (0.9mm) and size 3 (1.1 mm) After the preparation each main group were then subdivided into two subgroup each Group 1A(n=15) ,Group 1B(n=15) and Group 2A(n=15),Group 2B(n=15) according to the cement used.

Schematic Representation:

In Group 1, a size 2 peeso reamer drill with a diameter of 0.9mm was used such that minimum of 3-5mm gutta percha was left apically with a length of 7mm maintained for post cementation. In group 2, a size 3 peeso reamer drill with a diameter of 1.1 mm was used. Here also a minimum of 3-5mm gutta percha was left apically with a length of 7mm maintained for post cementation. After the post space preparation, the root canals were rinsed with 3% NaOCl for 1 minute. Final irrigation was accomplished with distilled water using an endodontic syringe and then the post spaces were dried with paper points. For cementation of PANAVIA Cement, each canal was conditioned with auto polymerising primer. The primer was applied using a micro brush and excess primer was removed using paper points. Allow the primer to dry for 30 seconds. Then the panavia cement paste A and B is dispensed on a mixing pad and mixed using a spatula (figure 5). For the cementation of RELYX cement, the cement was dispensed to mixing pad by a clicker system and mixed using a spatula (figure 6). The mixed cement was then applied to the canal wall using a lentulospiral instrument. All posts with a diameter of 0.9 mm were seated to its full depth in the prepared spaces using finger pressure, ensuring that all posts had extended to the desired length from the sectioned root surface. After the seating of the post each specimens were light cured for 30 seconds (figure 7). Excess cement was removed with a small brush. Thirty minutes after the cementation procedures, all root specimens were stored in distilled water for 24 hours. Then the specimens underwent thermocycling for 10,000 thermal cycles between 5°C and 55°C, with a 30-second dwell time and a 5-second transfer between temperature baths. After thermocycling, the specimens were preserved in a saline solution at room temperature for 1 week. Roots were then mounted on a custom made holder with auto polymerizing acrylic resin extending to a level 1 mm below the CEJ (figure 8). Specimens were then mounted onto the universal testing machine and subjected to tensile force at a crosshead speed of 1 mm/ min to the posts until they were debonded from the root canals (figure 9). The amount of Force required to debond the post from the root canal was recorded in kilogram force (Kg F).

For analyzing the data, statistical test used was Anova followed by Tukey HSD test. For comparison between two cements Independent t-test was used. All analysis were done under 95% confidence intervals with $p < 0.05$ considered as statistically significant

Result:-

Table1 represents the mean values obtained for RelyX U200 cement and Panavia F2.0 cement with two different post space diameters and was expressed in kilogram force. Group 1A represents Rely X U200 cement with 0.9 mm post space diameter, Group 2A represents RelyX U200 cement with 1.1 mm post space diameter, Group 1B represents Panavia F2.0 cement with 0.9 mm post space diameter and Group 2B represents Panavia F2.0 cement with 1.1 mm post space diameter. The mean values of Group 1A was 26.75, for Group 2A 14.82, for Group 1B it was 15.72 and for Group 2B the mean value was 10.51 The values obtained were compared using one way ANOVA test and there were significant differences among all the four groups. The highest value was observed for Group 1A and lowest for 2B. The inference from the result was that Relyx cement had better bond strength than Panavia-F2.0. Also a snug fit post space preparation gives more pullout resistance than a passive fit preparation

Table 2 shows multiple comparison between two different cements and two different post space diameters which was done by Tukey HSD test. Group 1A,1B,2A,2B were compared with each other and it showed highly significant values(0.000), there was no significant difference when comparing group 2A and 2B (0.765). The significance level was set at < 0.05 level.

Table 3 shows the mean tensile bond strength of Rely x cement with two different post space diameters. The two groups were compared by Independent t test. The mean value shows statistically significant difference ($p < 0.001$) among the groups. RelyX U200 cement with a snug fit post space preparation or a smaller film thickness showed better bond strength than the enlarged post space preparation

Table 4 shows the mean tensile bond strength of Panavia F2.0 cement with two different post space diameters. The two groups were compared by Independent t test. The mean value showed statistically significant difference ($p < 0.001$) among the groups. Panavia cement with a snug fit post space preparation or a smaller film thickness showed better bond strength than the enlarged post space preparation

Graphical representation of mean tensile bond strength of RelyX U200 and Panavia F2.0 cement with different post space diameters are shown in graph 1, 2 & 3

Discussion:-

Posts are generally used to rehabilitate the teeth when the remaining tooth structure cannot provide adequate support and retention for holding the restoration.⁵ Hence, a post restoration plays a vital role in increasing the strength of an endodontically treated tooth.¹ Historically, intra radicular posts were made from metals or alloys, where there was a mismatch of the modulus of elasticity between metal post and dentin, which led to irreversible root fractures. The reason for increased root fractures were due to the high stress concentration seen along the bonded interface between post and dentin.⁷ Whereas, fiber reinforced post have a modulus of elasticity similar to that of dentin, thus reducing the possibility of root fracture by 95 %-99%.²

Prefabricated post systems have recently become increasingly popular since they can provide satisfactory results by saving chair side time and reducing cost to the patient.⁴ The deeper the post is placed, the more retentive it becomes. Post diameter is also an important factor when we plan for restoring the teeth. Radicular dentine has to be preserved to reduce the potential for perforations and to resist tooth fracture. Goodacre suggested that post diameters should not exceed one third of the root diameter at any location.⁴ In order to limit the reduction of radicular dentine a post with a diameter of 0.9 mm was used in this study.

One of the relevant problems clinicians face when restoring endodontically treated teeth is the mismatch between the diameter of the post space and that of the post which vary due to flared canals from carious extension, trauma, pulpal pathosis and iatrogenic misadventure, that can compromise the adaptation of the posts to canal walls.^{2, 6}

Contemporary resin cements have typically been used for the cementation of fiber posts. Traditional etch-and-rinse multistep resin cements are described as technique sensitive because they are affected by moisture and extended chair side time. In addition, disadvantages of shorter working time and high viscosity, may result in incomplete seating of the post.⁸ Self-adhesive resin cements have been marketed to simplify clinical procedures and overcome the technique sensitivity of multistep systems. Self-etching and self-adhesive systems have less chair side time and more ease of use.⁸ Hence, a self etch cement (Panavia F2) and a self adhesive cement (RelyX U-200) were used in this study for comparing which type of adhesive system provide a better tensile bond strength.

A resin based sealer was used in this study for obturating the canal in order to avoid any negative effect of eugenol based sealant on the cement. Since this is an invitro study, thermocycling was done in order to simulate aging and temperature variations experienced by the tooth in the oral cavity.⁹ The specimens were subjected to 10,000 cycles, which corresponded to 12 months aging.

Boschian Pest et al compared bond strengths between post space dentin and a resin luting agent, and between a resin luting agent and fiber posts, and reported significantly lower bond strength values between root canal dentin and resin luting agent.¹⁰ Moreover, it was observed that all adhesive systems significantly reduced the bond strength when the cementation was in a closed cavity as compared to that in an open cavity. The high C-factor (ratio between bonded and non bonded surfaces) of the closed cavity in root canals led to higher polymerization stress, reducing the bond strength.²

Some retrospective clinical studies showed that debonding occurs when the film thickness is too great,^{11, 12} and they have proposed that the thinner the cement layer, the higher the retentive strength would be,^{13, 14} whereas Othman et

al states that the over-preparation of dowel spaces helps to improve the retention of post.¹⁵ Archangelo et al says resin cement thickness significantly influenced the pullout strengths of fiber-reinforced posts.²

On the basis of these theoretical considerations and clinical evidence, this study was designed to test the effect of resin cement film thickness and its influence on the pullout strength of an endodontic glass fiber posts. Pullout tests are an efficient method to assess tensile bond strengths. Moreover, in a clinical situation, cohesive failure of fiber posts often occurs as whole fiber post shedding. The situation that a fiber post fractured within the root canal was rarely encountered in this study also. Therefore, pullout tests more effectively mimic the clinical situation.¹⁶

The null hypothesis of this study was that, increased post space diameter will increase the bond strength of fiber reinforced post luted with resin cement. Here, in this study a glass fiber post of 0.9 mm and two peeso reamers with diameters of 0.9 and 1.1 mm were selected. One is a snug fit with drill size matched with the post for RelyX (Group 1A) and for Panavia F2 cement (Group 1B) and the other is over prepared canal, with a drill one size bigger than the post diameter for RelyX (Group 2A) and Panavia F2 cement (Group 2B). After the pull out test, higher tensile bond strength values were observed in Group 1A and Group 1B where the drill size matched with post was used. Group 2A and Group 2B showed significantly lower tensile bond strength values than Group 1A and 1B. Group 2A and 2B have greater film thickness when compared with Group 1A and 1B. The possible reason for decreased bond strength for the increased film thickness can be due to the formation of voids or bubbles, which could be the area of weakness within the material. Whereas, the formation of voids or bubbles is comparatively less in a thin and uniform layer of cement. Moreover, the polymerization stress, developing within a relatively thin film of cement, would be minimal.⁶ Even though the post space preparation and cementation was done by single operator to avoid possible errors there were chances that during the setting process, the post had cemented closer to one wall than the other wall in oversized post spaces, which might have lead to uneven thickness of cement around the post eventually decreased the pullout strength. In a snug fit preparation fit of the post was accurate, so the post will not get displaced to one wall and an even layer of cement film thickness was present around the walls. Therefore, this study showed that a precise fit of anatomic posts can improve post retention. Hence, the null hypothesis was rejected.

This study also compared the tensile bond strength of two dual cure resin cements with different film thickness. Self adhesive RelyX cement shows higher bond strength than self etch Panavia cement. The possible reason is, Self-adhesive resin cements contain multifunctional phosphoric acid methacrylates which demineralize the tooth surface and react with the hydroxyapatite of the hard tissue. In addition, self-adhesive systems have better moisture tolerance, which explain the superior bonding performance of the self-adhesive system than the self-etch system. Insufficient moisture control while using self etch system after rinsing the root canal can be one of the reason for decreased bond strength of Panavia cement.¹ Study done by Toman et al also showed that displacement resistance values for the self-adhesive system were significantly higher than for the self-etch system.¹⁷

The limitations that have encountered during the study are; correct dimension of the post space diameters cannot be standardized due to the variation in the root canal anatomy of tooth, Also, there can be operator error during post space preparation even though it was done by single operator. In addition, since this was an in vitro study; it cannot exactly mimic the clinical situation in the oral cavity. Hence, further in vivo studies are required with proper standardization, to evaluate the clinical performance of the materials

Conclusion:-

Within the limitations of this study, the following conclusions were drawn:

1. A post with snug fit post space preparation with the size matched drill shows better resistance to pull out test than over prepared post space preparation.
2. Cement RelyX U-200 shows higher tensile bond strength than Panavai F2.0 cement.
3. Increased film thickness shows decreased bond strength.

Table 1:- Depicts mean tensile bond strength (Kg F) of different materials by one way ANOVA test.

Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value and significance
					Lower Bound	Upper Bound		
Group 1A	15	26.75	3.98	1.02	24.55	28.96	112.32	<0.001 HS

Group 2A	15	14.82	2.60	0.67	13.38	16.26		
Group 1B	15	15.72	0.67	0.17	15.34	16.09		
Group 2B	15	10.51	1.57	0.40	9.64	11.38		

Table 2:- Depicts mean tensile bond strength between two different cements (Relyx U200 & Panavia F) and two different post space diameters (0.9 & 1.1 mm) which was done by Tukey HSD test.

Groups	Compared with	Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1A	Group 2A	11.93*	0.000 HS	9.48	14.37
	Group 1B	11.03*	0.000 HS	8.58	13.47
	Group 2B	16.24*	0.000 HS	13.79	18.68
Group 2A	Group 1B	-11.93*	0.000 HS	-14.37	-9.48
	Group 2B	-0.89	0.765 NS	-3.34	1.54
Group 1B	Group 2B	5.20*	0.000 HS	2.76	7.65

* The mean difference is significant at the 0.05 level. HS – Highly Significant

Table 3:- Depicts mean tensile bond strength (Kg F) between Group 1A and Group 2A by Independent t test.

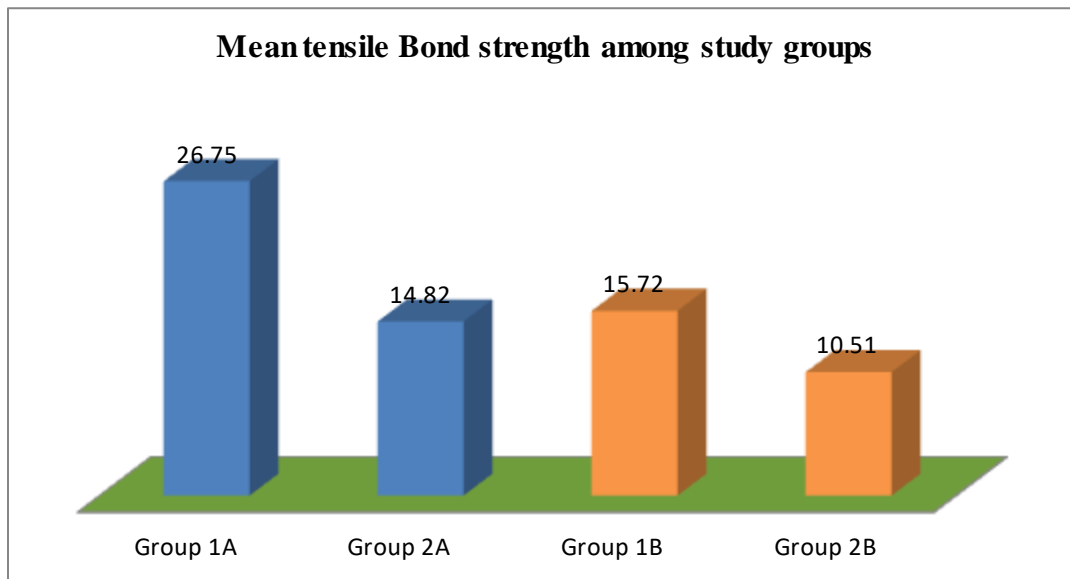
Groups	N	Mean	Std. Deviation	t value	p value and Significance
Group 1A	15	26.75	3.98	9.712	<0.001 HS
Group 2A	15	14.82	2.60		

HS – Highly Significant

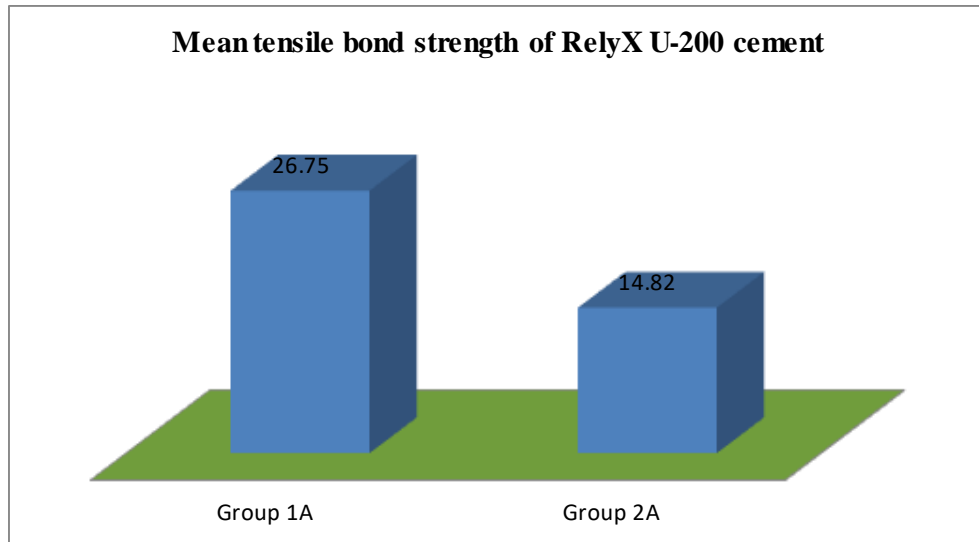
Table 4:- Depicts mean tensile bond strength between Group 1B and Group 2B using Independent t test.

Groups	N	Mean	Std. Deviation	t value	p value and Significance
Group 1B	15	15.72	0.67	11.786	<0.001 HS
Group 2B	15	10.51	1.57		

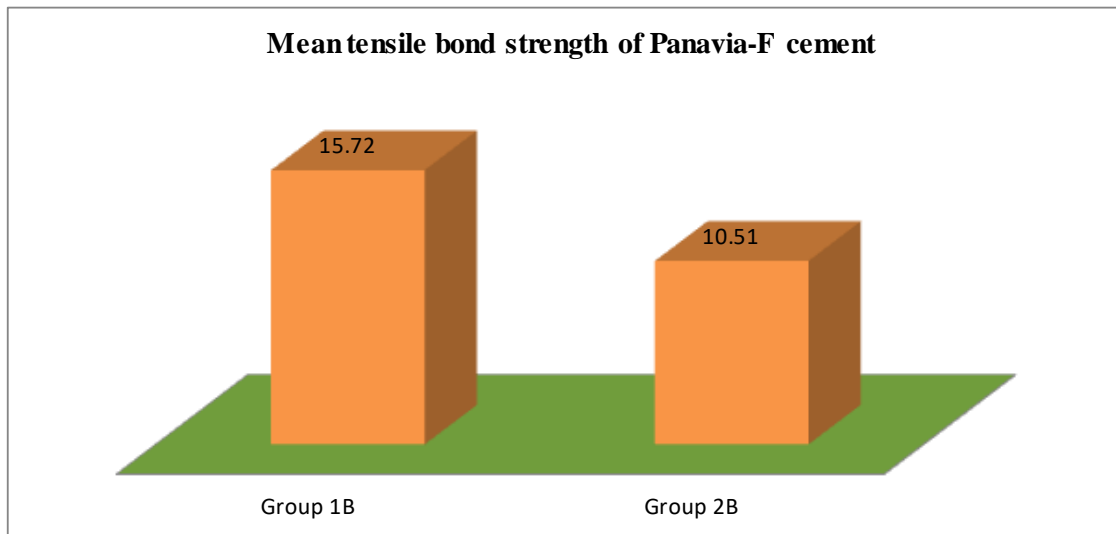
HS – Highly Significant



Graph 1:- Is a Bar diagram that shows the mean tensile bond strength among various groups.



Graph 2:- It is a Bar diagram that shows the mean tensile bond strength of Relyx cement with two different post space diameters. (Group 1A- 0.9mm, Group 2A- 1.1mm).



Graph 3:- Is a Bar diagram that shows the mean tensile bond strength of Panavia cement with two different post space diameters. (Group 1B- 0.9mm, Group 2B- 1.1mm).



Figure 1:- Specimens stored in disinfectant solution.



Figure 2:- specimens after decoronation.



Figure 3:- Specimens after obturation.



Figure 4:- Post space preparation in the specimens.

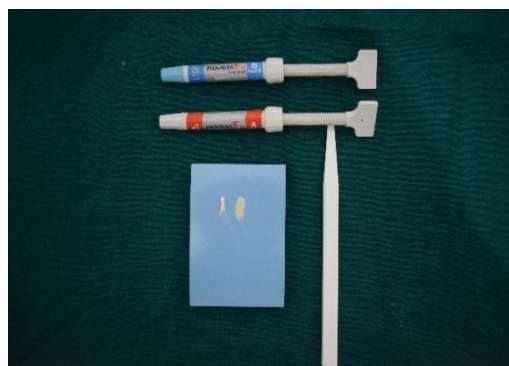


Figure 5:- Manipulation of panavia cement.

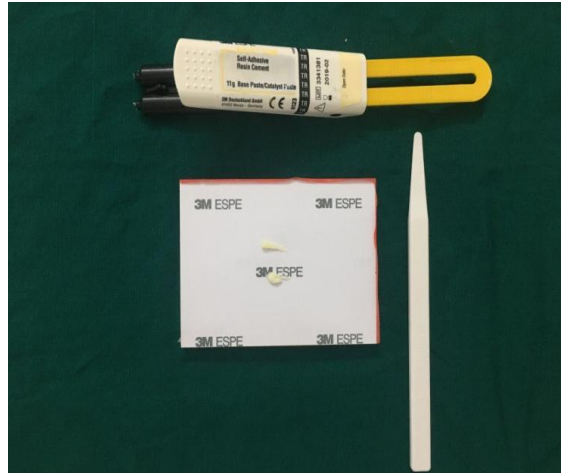


Figure 6:- Manipulation of relyx cement.

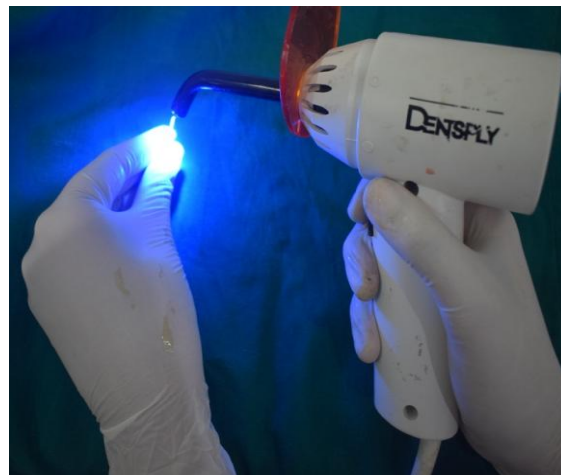


Figure 7:- Light curing the cement after the post placement.



Figure 8:- Specimen mounted on acrylic blocks and grouped as 1a, 1b, 2a, 2b based on the post space diameters and resin cements.



Figure 9:- Specimens mounted on universal testing machine for pullout test.

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