ORIGINAL RESEARCH PAPER
Volume-8 | Issue-11 | November - 2019 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

FRACTURE RESISTANCE OF WIDE ROOT CANALS RESTORED WITH AND WITHOUT ACCESSORY FRC POSTS-AN IN VITRO STUDY.

Dentistry

Harish Haridas*
Department of Dentistry, P K Das Institute of medical Sciences, Vaniyamkulam, Ottappalam, Palakkad, Kerala 679522 *Corresponding Author

ABSTRACT

Background: Traditionally in earlier times a cast metal post and core restorations were the gold standard for restoring endodontically treated teeth. With recent improvements in bonding of composite resin to dentin and with prefabricated FRC post system, true internal retention was achievable with more predictable success from failure to fracture.
Objective: A study to compare the FRC post with and without accessory post on the resistance of structurally compromised central incisor.
Methodology: Forty freshly extracted upper central incisors were divided into four Groups. The samples of the four groups were de coronated at standardized length of 15mm from root apex. All the samples were then fractured at a crosshead speed of 0.5mm/min until fracture. The loads were recorded.
Results: The group one offered least resistance to fracture as compared to other three groups which is statistically significant($p<.05$).Incorporation of two accessory posts made a remarkable increase in load to fracture as evident from values obtained from group 4 which was statistically significant($p<.05$) as compared to other groups.
Conclusions: It may be concluded that FRC post with two accessory posts offered better absorption and distribution of load leading to maximum resistance to fracture as compared to the other groups.

KEYWORDS

Accessory posts, modulus of elasticity, fracture resistance

INTRODUCTION:

Post endodontic restoration can be the finest service rendered by the dental practioner if one takes into account knowledge of sound biological and mechanical principles involving the tooth structure and the restoration. In restoring endodontically treated teeth, core stability and post retention play a primary role in the ultimate longevity and success of the treatment.

The factors to be considered in the treatment plan are
1. Amount of remaining tooth structure.
2. Location of area of destruction and isolating the areas for reinforcement.
3. Mechanical retention and resistance of post.
4. Bonding of canal wall to post and core.
5. Modulus of elasticity similar to dentin.

Traditionally in earlier times a cast metal post and core was extensively used for structurally compromised teeth. In times to come, it has been proven to increase the risk of catastrophic root fracture which cannot be re-treated. The fracture occurrence is due to its high modulus of elasticity and other unfavorable mechanical properties of the metal post and the core. In the last few decades various commercially available prefabricated post systems have been developed making post selection an important and difficult task.

Prefabricated posts may be broadly classified as
- Active or passive
- Parallel or tapered
- Based on material composition (metallic or non metallic)

The non metallic post system have gained popularity owing to its improved fracture resistance of the teeth, better bonding behavior and closely matched modulus of elasticity to dentin. Currently FRC post systems have gained priority owing to its acceptable esthetics, and fulfillment of the clinical criteria and needs.

With the advent of resin cement and dual cure bonding system the hypothesis of the monoblock concept is extensively utilized in endodontic rehabilitation of structurally compromised teeth. The extremely high polymerization shrinkage stresses in the root canal has been considered as one of the failure possibilities of the monoblock concept. Hence in our study a comparative analysis of the monoblock effect of FRC post with and without accessory post on fracture resistance of structurally compromised central incisor has been evaluated

PROCEDURE

Forty freshly extracted upper central incisors with fully formed apices were selected and stored in saline for the study. They were then decoronated with a safe sided diamond disc at a length of 15 mm from root apex. Estimation of provisional working length was made by placing a size 10 K file into the root canal until it was observed at the apex. The final working length was calculated after subtracting 1mm from the length.

The coronal 3rd was flared with no 2 &3 Gates Glidden drills in decreasing order. The root canal were cleaned and shaped using Protaper according to manufacturer's instructions up to F3. 17% EDTA and sodium hypochlorite were used as irrigants. The roots were irrigated with saline after every instrumentation. Later canals were dried with paper points..It was followed by obturation with F_3 guttapercha with resin sealer. Forty central incisors were divided in to four groups of 10 samples each.

GROUP I:- (Figure:2)
Single post and dowel diameter prepared to the corresponding drill size.

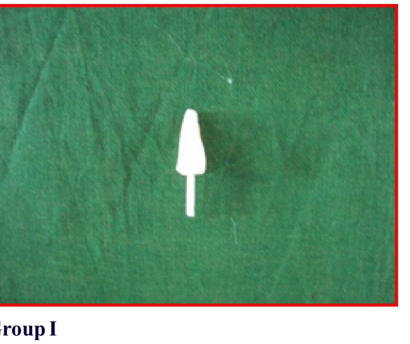


Figure 2: Group I

GROUP II:- (Figure:3)
Single post and dowel diameter of 3.5 mm

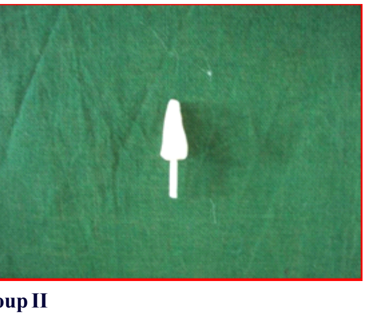


Figure 3: Group II

GROUP III:- (Figure:4)
Primary post and one accessory post with dowel diameter of 3.5 mm.

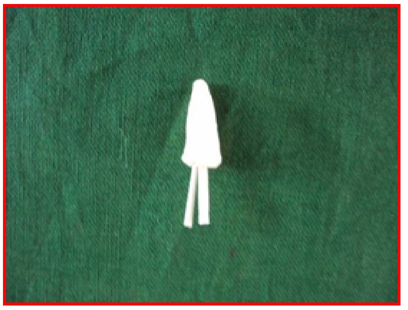


Figure 4:Group III

GROUP IV:- (Figure:5)
Primary post and two accessory post with dowel diameter of 3.5 mm.

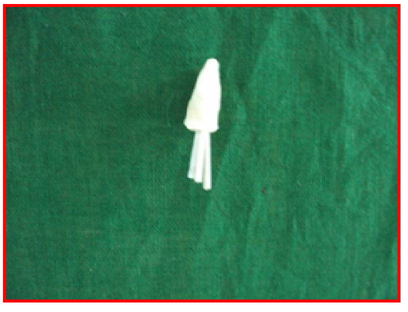
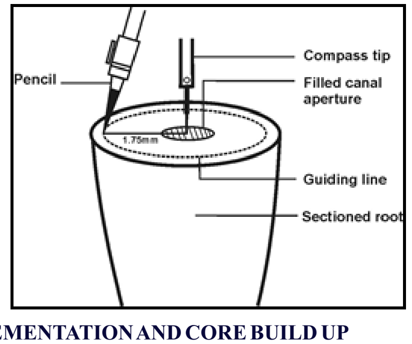


Figure 5: Group IV

After forty eight hours of obturation dowel space was prepared to a length of 10mm for Group I with manufacture's corresponding drill. Group 2,3 and 4 dowel space was prepared for the primary post with a dowel length of 10mm using corresponding drill and the dowel diameter was further increased to 3.5 mm width and length 8 mm to simulate weakened root.

METHODOLOGY FOR INCREASING DOWEL DIAMETER OF 3.5MM

The point of compass was positioned on the center of the filled canal aperture and circular guidelines of 3.5mm in diameter where inscribed on the sectioned tooth surface. The post space was prepared using 702 surgical bur in a circumferential motion on all sides .



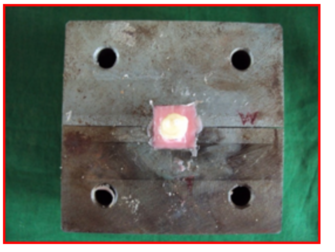
POST CEMENTATION AND CORE BUILD UP

The post was cleaned by wiping with alcohol and allowed to evaporate for one minute. The silane coupling agent was applied on to post surface and kept for one minute for drying. The dowel space prepared was etched with 37% et chant for 15 seconds, flushed thoroughly with distilled water and blot dried with paper points.

Dual cure bonding agent was adequately coated on to the walls of dowel space and post surface with the applicator tip provided with the kit. Post cementation was done using dual cure resin cement. The resin cement was coated in to walls of the dowel space with lentuilo spirals. The post was also uniformly coated with dual cure resin cement and slowly inserted to preset depth (10mm) to allow the excess cement to flow out. It was light cured from the butt end of the post for 40 seconds and later then cured from all the sides for the same duration respectively after ascertaining the intensity with the radiometer before each curing cycle. Core build up was done at a 6mm height with luxacore composite resin.

PREPERATION FOR FRACTURE TESTING

An acrylic mould (Figure:6)was prepared using a cast metal template measuring 25mm height. A pencil mark was done around the teeth to denote the depth to be inserted (14mm) and projection of 7m out of the resin block. The tooth sample coated with separating medium of petroleum jelly was embedded in acrylic mould before the initial cure to the desired length of 14mm . Care was taken to ensure 7mm (including the core and the tooth substance) were projecting out of resin block. This standardized procedure was followed for all the groups. The root specimen was removed after the initial cure of acrylic block and stored in saline. The acrylic block is allowed to set for 24 hours.



Acrylic mould prepared

Before subjecting to testing the teeth is inserted 1mm short of previous pencil mark (13mm) to simulate PDL space with a projection of 8mm out of the resin block. Elastomeric light body material was injected in to prepared space of the acrylic block in to which the root fits to simulate PDL.

FRACTURE TESTING

The prepared acrylic block along with the tooth sample was mounted onto the fabricated jig and held in position by interlocking pins which served as vice. The prefabricated jig creates an angulation of 1350 (Figure:7)of the tooth specimen to the stylus labio-palatally (clinical simulation)

The specimen is subjected to loading at the core in a universal testing machine at a cross head speed of 0.5 mm/min until fracture. The load to fracture is measured in KgF which was recorded from the monitor attached to the universal testing machine(Figure:8).

Figure 7: Mounting of tooth at 135°

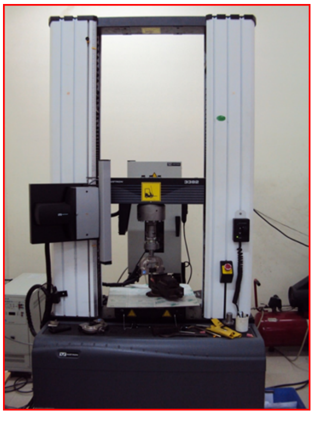


Figure 8: Universal testing machine

RESULTS:

Mean value for load to fracture for all the groups **(Figures:9 to 12)** is as follows, Group I -31.625, Group II -40.743, Group III-44.697, Group

IV-56.840. It is evident from the table 1,2,3 presented shows that group one offered least resistance to fracture as compared to other three groups which is statistically significant(p<.05). It is interesting to note from the values that there is an appreciable increase in resistance to fracture when one accessory post in Group III as compared to Group II but was not statistically significantly (p>.05) between the groups. Incorporation of two accessory posts made a remarkable increase in load to fracture as evident from values obtained from group4 which was statistically significant (p<.05) as compared to other groups.

Since the significance value of the ANOVA test is less than 0.05 (P = 0.000), the null hypothesis will have to be rejected and it is inferred that the mean values of the groups are not the same. To test which pair of groups have dissimilar mean values, independent samples student's t-tests are applied. Comparisons of all possible groups are given in the tables 4 to 10.

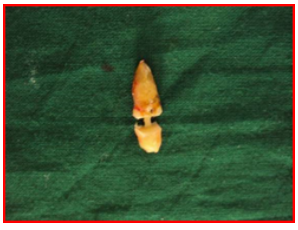
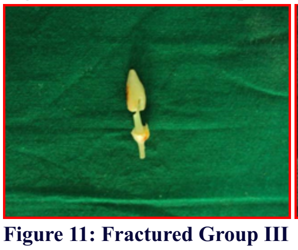


Figure 9: Fractured Group I **Figure 10: Fractured Group II**



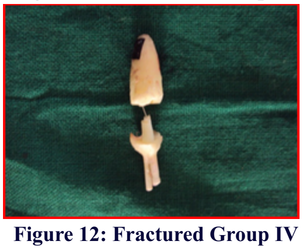


Figure 11: Fractured Group III **Figure 12: Fractured Group IV**

Graph: Mean Max. Load of the Four Groups

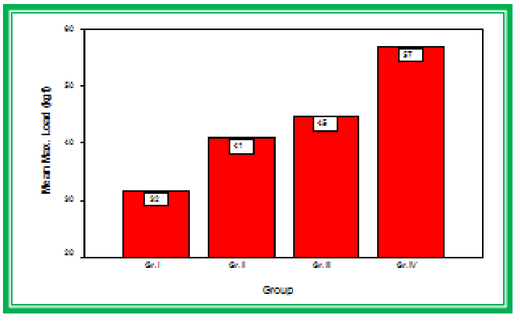


Table 1: Load to Fracture (KgF)

Sl. No	Group 1	Group 2	Group 3	Group 4
1	33.400	44.500	48.264	59.1 54
2	38.600	43.221	46.522	60.142
3	18.632	36.241	33.542	54.158
4	29.465	43.900	51.264	46.112
5	32.891	46.200	53.187	63.953
6	29.482	44.300	49.215	60.157
7	37.221	53.400	31.241	59.925
8	31.285	24.165	24.150	49.430
9	33.427	37.600	55.432	60.123
10	31.851	33.900	54.153	55.249
Mean	**31.625**	**40.743**	**44.697**	**56.840**

Table 2: Summary Information of Maximum Load (kgf) of the Four Groups

Group	Details	Mean	SD	SE
Gr. I	Single Post with dowel diameter corresponding to the drill size	31.625	5.439	1.720
Gr. II	Dowel diameter of 3.5mm and the length 8mm – to stimulate weakened roots – single post	40.743	8.060	2.549
Gr. III	Dowel diameter of 3.5mm and the length 8mm – to stimulate weakened roots – Single post + one accessory post	44.697	10.975	3.471
Gr. IV	Dowel diameter of 3.5mm and the length 8mm – to stimulate weakened roots – Single post + two accessory posts	56.840	5.557	1.757

Table 3: Oneway ANOVA

	Max. Load (kgf)				
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	3280.030	3	1093.343	17.788	.000
Within Groups	2212.744	36	61.465		
Total	5492.774	39			

DISCUSSION

Most dental trauma occurs primarily in the anterior region of the mouth affecting the maxillary jaw more than mandibular jaw. Mechanically the maxillary central incisor behaves like an elastic beam fixed at one end during function as a cantilever when not loaded along its longitudinal axis causing failure due to the flexural and torsional characteristics of post and core.

From a functional stand point an ideal post system should have an optimal combination of resilience, stiffness, flexibility and fracture resistance. At the same time it should be stiff enough not to distort permanently bend or structurally fail under masticatory forces and external trauma. Thin walled roots restored with cast metal post and cores are at an increased risk of failure from fracture. Increasing the thickness of the walls with a suitable dentin substitute may reduce this risk. The elastic moduli of many resin based cement along with FRC post approximate that of dentin, which may allow bonded resin based cement to strengthen the remaining root dentin. It also reduces the transfer of mechanical stresses unlike rigid metal post to remaining dentin. Resin based cements and glass fiber posts have a modulus of elasticity closely matching to that of dentin, the recent concept of secondary monoblocks probably suits restorative and endodontic procedures suitably. Secondary monoblocks are those that have two circumferential interfaces, that is one between the cement and dentin and the other between cement and core material[1]

The FRC post and the dual cure adhesive resin cement reinforcing the root canal dentin fulfill the above mentioned parameters of the concept of secondary mono block.

The FRC post used in our study had a composition of fiber glass 87% and epoxy resin 13%. The FRC post chosen for the experiment belongs to the opaque family which is known to exhibit higher bond strength as compared to translucent post system[2]

From an engineering point of view the relationship of the faciolingual diameter of the tooth to the failure load is significant for the loading direction used. This significance is related directly to the stress pattern induced due to applied loading.. The wider the faciolingual diameter of the tooth the greater was the resistance to failure[3]. Clinically the anterior teeth are placed at an angle to the occlusal plane; the forces are therefore not directed along the long axis. This makes the teeth susceptible to fracture when an unfavorable directional load is applied[4,3]. Hence the 135^{0} angulation of the impact force from the faciolingual direction was more significantly relating to the clinical situation and the monoblock effect.

Generally the fracture on the specimen following the impact was noticed to be at the cemento enamel junction of the facial surface running obliquely to a higher level at the cervical 3rd of root palatally.

GROUP I:

In Group I the dowel diameter of the corresponding drill provided by the manufacturer had a tip diameter of 1mm to match the corresponding FRC post of 0.9mm tip diameter. The post was gently but firmly inserted to dowel space which was coated with dual cure resin cement. It was interesting to note that on subjecting it to load to fracture there was a push out of the FRC post other than the fracture occurred at the cemento enamel junction. This may be considered out as

1) When the curing material is bonded to all the sides of a rigid structure, bulk contraction cannot occur giving rise to internal stresses[5].
2) For thin bonded resin layers almost all curing contraction is guided only in one direction that is perpendicular to the walls[5].
3) Shrinkage stress occurs when the contraction is obstructed by the thin volume of space available for the dual cure resin cement which is known to increase the C-factor[5].
4) During cementation an increase in stress within the root canal for a preparation which closely matches the post size causes increased hydrostatic pressure which may lead to the incomplete seating of the post and may also lead to fracture of the root[6,7].
5) At a given shrinkage value the most rigid material will resist the highest stress. In this group it was the dentin which offered the maximum resistance to applied load[5]. When the force exceeded the elastic limit of dentin it ultimately fractured.

It is evident from the results (Table 1) to the applied load, that Group I offered the least resistance to fracture as compared to the other three groups which is statistically significant (p<.05) (Table No. 4,5,6).

Table 4: Gr. I and Gr. II

Independent Samples Test					
	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-tailed)
Max. Load (kgf)	1.907	.184	-2.965	18	.008

Table 5: Gr. I and Gr. III

Independent Samples Test					
	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-tailed)
Max. Load (kgf)	6.649	.019	-3.375	13.169	.005

Table 6: Gr. I and Gr. IV

Independent Samples Test					
	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	T	df	Sig. (2-tailed)
Max. Load (kgf)	.375	.548	-10.255	18	.000

GROUP II:

In Group II weakening of the root was done by widening the dowel space to a width of 3.5mm and dowel length of 8mm to accommodate accessory posts. It is interesting to note that in spite of weakening the root (3.5mm dowel space preparation) the resistance to fracture was at much higher load as compared to Group I. This may be attributed to the increased thickness of resin cement which provides the buffer zone that may contribute to uniform stress distribution between the post and the canal. A thicker layer of cement could transfer stresses to the tooth in a different manner as compared to uniform thin layer of cement as reported by earlier researchers[4,8]. It is evident from the fact that there was a statistical significance of higher load to fracture with p< .05 as compared to Group I as evident from (Table no:4). The push out fracture was also seen in this Group II. This may be attributed to the failure which contributed due to increased volume of cement as enumerated below.

1) The contractile forces come in to action when the reaction is initiated at very start of the polymerization reaction. Therefore all shrinkage must be regarded as a possible contribution to increased stress[5].
2) The bonded surface of a sample was large in relation to its unbonded surface, the linear curing contraction approach the volumetric curing contraction giving rise to inherent weakening of the resin cement[5].
3) During cementation micro movements are referred to alter the property of the cement causing inherent weakness[9,4,10].
4) The rigid set resin cements which act as a lever arm which may also contribute to the fracture of the root at the coronal 3rd[9,4,10].
5) Dual cure resin cement offers the advantage of establishing immediate coronal seal but has the disadvantage of blocking the avenue for stress relief by resin flow that may occur when the sub surface layer where light is unreachable, leaving behind chemically activated cement in its pre-gelation stage[11].

GROUP III:

In Group III with the similar preparations to Group II and additional accessory post was inserted for reinforcement. It is interesting to note that Group III exhibited a similar fracture at the cervical 3rd as seen in Group I. The FRC post had also fractured at the middle 3rd completely dislodging the fragment to a load marginally higher than Group II which was not statistically significant (Table No.7) between the two groups. The fracture of the post at the middle 3rd could be attributed to the fact that the variable thickness of the resin cement along the post at the middle 3rd could transfer stresses to the tooth and the post in a different manner thereby causing fracture of the FRC post also in that region[4]. The marginally higher load to fracture in Group III could have occurred due to the reduced flexibility because of one accessory post in the cervical 3rd contributing to the increased resistance.

Table 7: Gr. II and Gr. III

Independent Samples Test					
	Levene's Test for Equality of Variances		**t-test for Equality of Means**		
	F	Sig.	t	df	Sig. (2-tailed)
Max. Load (kgf)	1.531	.232	-.918	18	.371

GROUP IV:

In Group IV preparation is similar to Group II and Group III but two accessory posts were used as reinforcement. It is evident from the Figure 20 that the nature of the root fracture was at the higher level as compared to Group III. It was also interesting to note that the fracture of FRC post is more towards to the cervical 3rd as compared to Group III. This situation almost resembles fracture of a root canal filled tooth post-endodontically creating avenues for the mono block concept.

The Group IV exhibited the maximum load to fracture amongst all the groups tested (Table No.1). This can be attributed to the better reinforcement because of the two accessory posts which had occupied the entire dowel space making it more rigid and resistant[4]. It therefore nullifies the flexibility of a single post system. Statistically, Group IV was significant as compared to Group II, Group III and Group I (Table No.6,8,9). This may be explained by the fact that additional reinforcement was provided by the accessory posts leaving behind less volume for the resin cement. The reduced resin thickness caused reduction in volumetric shrinkage resulting in overall reduction in shrinkage stress (S-factor). The C-factor may be partially compensated by increasing the bonded surface and thereby decreasing the shrinkage volume[11].

The Group III and Group IV may be classified as secondary mono block according to this reference, since it has two interfaces and offered more resistance to fracture along with the fracture of the FRC post functioning as a single unit.

CONCLUSION:

Although the concept of creating a mechanically homogenous unit with root dentin is excellent in theory, accomplishing it within the root canal space is easier said than done. The modulus of elasticity of the post, root filling material, and the accompanying resin cement have to match the root dentin only when the loading stresses may be evenly distributed to form the mono block components. Within the scope of this study it may be concluded that Group IV (FRC post with two accessory posts) offered better fracture resistance as compared to the other groups.

REFERENCES:

1. Franklin R.Tay et al, Monoblocks in root canals: A hypothetical or a tangible goal, Journal of Endodontics, 2007. 33: 391-98
2. Mustafa Kalkan et al, Bond strength between root dentin and three glass-fiber post systems, The Journal of Prosthetic Dentistry, 2006; 96: 41-46.
3. Gary E. Guzy et al, In vitro comparison of intact endodontically treated teeth with and without endo – post reinforcement. The Journal of Prosthetic Dentistry,1979; 42: 1; 39-44.
4. Aquaviva S. Fernandes et al, Factors affecting the fracture resistance of Post – Core reconstructed Teeth: A Review. The International Journal of prosthodontics, 2001; 14: 4; 355-63.
5. Davidson C.L et al, Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives, Journal of Dentistry, 1997; 25, 435-440.

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

6. Aquaviva .S et al, Factors determining post selection: A literature review. The Journal of Prosthetic Dentistry, 2003; 90: 6; 556-62.
7. Peters M.C.R.B et al, Stress Analysis of a Tooth Restored with a Post and Core. J Dent Res. 1983; 62: 6, 760-63.
8. Loney R.W et al, Three - dimensional photoelastic stress analysis of the ferrule effect in cast post and cores. The journal of Prosthetic dentistry,1990; 63: 5; 506-12.
9. Allan .S Deutsch et al, Root fracture during insertion of prefabricated posts related to root size. The Journal of Prosthetic Dentistry, 1985; 53, 6: 786-89.
10. Brett I. Cohen et al, Four Different core materials measured for fracture strength in combination with five different designs of endodontic posts. The Journal of Prosthetic Dentistry, 1996; 76: 5; 487-95.
11. Franklin R. Tay et al, Geometric Factors Affecting Dentin Bonding in Root Canals: A Theoretical Modeling Approach. J Endod, 2005; 31: 8. 584-89.