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Original Research Article

Comparative Evaluation of the Fracture Resistance of Endodontically Treated Maxillary Central Incisors Restored with Pre-Fabricated Glass Fiber Posts and Experimental Dentin Posts an in Vitro Study

Dr. Hetal Chapla[1], Dr. Nimisha Shah[2], Dr. Rajkumar Chapla[3], Dr. Ruchi Rani Shah[4], Dr. Monali Mataliya[5]

[1]MDS, Conservative Dentistry and Endodontics,
[2]Professor & Head, [4]Assistant Professor,
Department of Conservative Dentistry and Endodontics, K. M. Shah Dental College,
Sumandeep Vidyapeeth, Piparia, Vadodara.
[3]Resident, Department of Prosthodontics Crown and Bridge, K. M. Shah Dental College,
Sumandeep Vidyapeeth, Piparia, Vadodara.
[5]BDS, Consultant

Corresponding Author: Dr. Hetal Chapla

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ABSTRACT

Aim: Comparative evaluation of the fracture resistance of endodontically treated maxillary central incisors restored with prefabricated glass fiber posts and experimental dentin posts prepared human root dentin.
Materials & method: Thirty six extracted human Maxillary central incisors were divided in to three groups. In Group-I (Control group) 12 samples, Group-II (Glass fiber posts)12 samples, Group-III (Dentin posts) 12 samples. Twenty four teeth were restored with Glass fiber posts and Solid dentin posts and numbered as Group-II and Group- III respectively while Group-I acted as a control, without any posts only core build up. Teeth were loaded at 130° angle to their long axes after core build up and the failure load were recorded.
Result: Statistical analysis showed that Group III (Dentin posts) (120.9 ± 1.447) and Group II (Glass Fibre posts) (118.6±1.437) the mean failure load value was significantly higher than Group I (Control group) (59.71±2.684). There had no statistically significant difference between group II (Glass fiber posts) and group III (Dentin posts) (Table-1) (Graph-1).
Conclusion: Teeth restored with the dentin posts exhibited marginally better fracture resistance than those restored with glass fiber posts.
Keywords: Glass fiber posts, Dentin posts, fracture resistance.

INTRODUCTION

The restoration of endodontically treated teeth has been studied extensively. Posts are widely used for the restoration of the teeth when there is insufficient coronal tooth structure to retain a core for the definitive restoration. Cast posts and cores are commonly advocated for teeth with little remaining coronal structure or for uniradicular teeth with small coronal volume.

Endodontically treated anterior teeth have traditionally been restored with cast or wrought metal posts and cores. These metallic posts have a much higher modulus of elasticity than the supporting dentine; this mismatch in modulus could lead to stress concentration and leads to failure. This has lead to search for a plastic based material that has modulus closer to that of dentine. Besides this, cast post and core requires; removes additional tooth structure; involves additional laboratory time and cost and is technique sensitive. So, Prefabricated post systems or Tooth-colour posts have increased in popularity since they were introduced in 1997. [1]

Polyethelene fiber- reinforced posts, carbonposts, glass fiber-reinforced posts, are few examples of most commonly used pre-fabricated post in today's dental practice.

These posts have the advantages of being highly esthetic, low modulus of elasticity which results in less incidence of post or root fracture, and have better retention, as post is actually bonded to tooth structure rather than cemented and thus creates a monoblock. These posts are also biocompatible, saves clinician's time, and easy to place. [2]

Glass fiber -posts contain a high percentage of continuous reinforcing fibers embedded in a polymer matrix. Matrix polymers are commonly epoxy resins or other polymers with a high degree of conversion and a highly cross-linked structure. [3,4] The elastic moduli of Glass fiber posts are closer to dentin than that of any metal post .This post is largely replaced metal post and decreases chances of root fracture. But limitations of glass fiber posts are

(1) limited radiopacity

(2) Due to difference in mechanical properties of post and biomechanical property of root dentin, it causes stress at the interface and spontaneous/ debonding of post.

(3) Difference between resin chemistry of the epoxy resin of post and methacrylate base composite resin which can lead to formation of interfacial gaps and adhesive failure. [4]

These limitations can be eliminated with biologic post/ dentin post. The dentin posts closely resembles root dentin in all the physical properties like modulus of elasticity, viscoelastic behaviour, compressive strength, thermal expansion etc. Furthermore the dentine post forms a micromechanical homogenous unit with the root dentin that result in uniform stress distribution. Similarity in elasticity of a dentin posts to root dentin may allow post flexion is some as tooth flexion which act as a shock absorbent. [5]

The dentin posts are biocompatible, having excellent adhesion to the dental structure and composite resin, and having a low cost. Furthermore, the formation of a sole biomechanical system (monoblock) by means of an adhesion joining the dental structure, the cement agent, and the dentin post allows for a better distribution of stress along the root, minimizing the rate of adhesive and cohesive failure. There are very few studies have been conducted on the effectiveness of dentin posts. [6,7]

Hence, the purpose of the study was to compare the fracture resistance of endodontically treated maxillary central incisors restored with prefabricated glass fiber posts and experimental dentin posts prepared from human root dentin.

MATERIALS & METHODS

Freshly extracted 36 maxillary central incisor with completely formed apices were selected on basis of similar root sizes and absence of caries, visible fracture line or cracks. Root length (15±1.0mm) and width at cervical area (8±2.0mm) were standardized with digital caliper. Teeth were stored at 37º c in 0.2% Chloramine-T for 24 hours.

Specimen preparation

- All samples were decoronated 2mm incisal to the labial CEJ with the use of a water-cooled diamond disc (40,000 cycles/min). Access openings were done, Working length was established 0.5mm short of apical foramina and canals were prepared with K-files (Mani) using step-back technique to the master apical file size of 70(figure:-1). 5.25% sodium hypochlorite and

17%EDTA gel used during biomechanical preparation after each instrumentation for 1min each. This was followed by final rinse with distilled water before obturation with gutta-percha and AH plus sealer (Densply) using cold lateral condensation method which was later verified by IOPA.

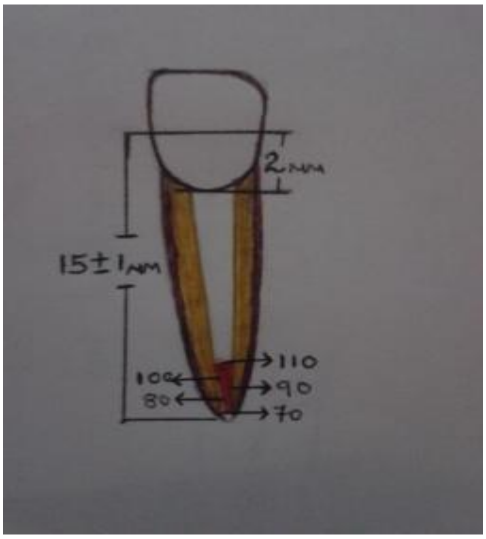


Figure -1

- Study groups hence comprised
  Group I- 12 teeth without any post space preparation and only core build up
  Group II- 12 teeth restored with prefabricated glass fiber posts
  Group III- 12 teeth restored with solid dentin posts
  Post spaces were prepared in 24 samples with special calibrated drills supplied by manufacturer of glass fiber post(size-1, 1.1mm dia.) leaving 5mm of root filling intact to preserve the apical seal.

Preparation of experimental dentin posts

For preparing a dentin posts, caries free, maxillary freshly extracted canines for periodontal reasons were selected and scaling of the teeth were done and teeth were decoronated. Canines were autoclaved according to CDC and OSHA guide lines. (121ºC for 15 min). Each tooth was sectioned longitudinally (bucco-lingually) into two halves along the root canal. Cylindrical dentine blocks were prepared out of each section using diamond drills under water cooling. Dentine post try in was done in clear acrylic block, post space was made from FRC post drill (size-1, 1.1mm dia.), to match it with the size of FRC posts.

Posts cementation

Dentin and FRC Posts were cemented using dual-cure resin cement (Para Core Coltene) according to the manufacturer's instruction. Cement was spread to the post and placed in the canal. Post was held under moderate finger pressure. After 2sec of light curing, excess cement was removed using cotton pellet and further curing done for 20sec.

Core fabrication

Pre formed standardized transparent polytetrafluoroethylene matrices (Coltene core former no.2) were used for core buildup using dual cure composite resin. Height of core was adjusted to 5.0±0.2mm.

Teeth were kept in 100% humidity throughout procedure. A thin coat of polyvinylsiloxane was painted on the root surface of all samples within 1mm of CEJ, to simulate the effect of periodontal ligament.

Sample teeth were then mounted in acrylic block, shaped as equilateral triangles of 60°, such that the long axis to a level 2mm apical to the CEJ was on a universal testing machine , which was set at a cross head speed of 2.5mm/min(figure:-2).

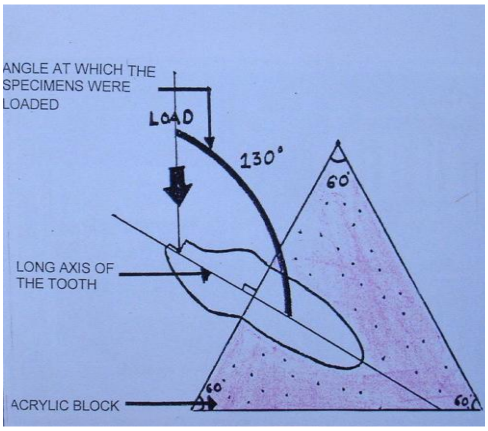


Figure-2

Mechanical loading

Samples were stored in distilled water for 24 hours at 37ºc in a humidor to simulate conditions in the oral cavity prior to fracture test. Chisel shape blade was used. A compressive load was applied 2mm cervical to the incisal edge on the palatal aspect at angle 130º to the long axis of the tooth at crosshead speed of 2.5 mm/min. Failure threshold was defined as the point at which the loading force reached the maximum value for fracturing the root or post. The results were recorded, tabulated, sent for statistical evaluation.

RESULTS AND DISCUSSION

The restoration of endodontically treated teeth, although practiced for many years, remains a major concern in dentistry. The tooth structure that remains after endodontic treatment is undermined and weakened because of decreased moisture content, coronal destruction from dental caries, fracture, previous restoration, and endodontic therapy. In such cases, use of Post and Core is commonly advocated to provide stability and retention to the crown. [8]

Glass fiber posts have an elastic module similar to dentin and can therefore transmit occlusal forces in a uniform way. They also feature good aesthetic value, absence of corrosion, adhesive cementation and easy removal if needed. [9] Glass-fibre resin post systems that are composed of unidirectional glass fibres embedded in a resin matrix are reported to reduce the risk of fractures of filled roots. [10]

Modulus of elasticity of glass fiber post is close to the dentine (13-18Psi). which result in improved stress distribution between the post and dentin thus resulting in improved flexibility of teeth under applied loads. Fiber posts contribute to minimizes the risks of unrestorable root fractures. By adhering it creates monoblock. In present study Para Post taper lux glass fibre posts (colyene / whaledent) were used. Para Post Taper Lux are alternatives to metal posts when metal-free restorations are desired. They are made of translucent fiber resin material that reflects the natural hues of the tooth and eliminates shadows through composite restorations at the gingival/crown interface. Composition of this post is Glass Fiber 60% and Resin 40%. With good mechanical properties. [1]

Marcé M. et al. conducted an in vitro study of the fracture resistance of endodontic teeth restored with four intraradicular post systems. Results showed that, there were only significant differences relating to fracture resistance glass fiber post, which had high fracture resistant than other posts systems. [11]

Dentin posts or biological posts made from roots of extracted and donated canines were used, as they allow for a juxtaposed adaptation to the root canals and do not cause stress to the dentin, since they contain the same biomechanical behavior as the restored teeth. The adhesion provided among the “Dentin posts or Biological Post” the cementing agent, and the dental structure allows one to attain a sole biomechanical system (monoblock) with materials that are compatible among themselves. The use of posts in teeth with great compromise of the dental structure allows the occlusal forces that will place pressure on the tooth to be better distributed throughout the root. [12]

These facts call for a careful assessment of the patient’s occlusion in the investigation of interference in protrusion movements and the presence of premature contacts, factors that can lead to the failure of the technique, minimizing the rate of adhesive and cohesive failure. These “Biological Restorations” take on special importance in restorative dentistry, especially since they are less expensive, which makes this practice a feasible option within schools of Dentistry that attend mostly to people of a lower economic level. [12,13]

Many others have been performed a clinical cases by mean of dentin posts or biological post, aimed at the esthetic and functional reconstruction of fractured maxillary central incisors.

In present study conventional method of clear acrylic block was used to standardise the dentin posts with glass fiber posts. Post space was prepared in clear acrylic block with help of pre fabricated drill (tapered) Size-1 1.1mm diameter (Coltene) which was used for glass fiber post.

A complete filling of the root canal is expected to form a monoblock, a solid mass without gaps that seals the root perfectly and remains stable in the oral environment. According to this concept, the monoblock is strong enough to support mastication and dissipates resistance capacity throughout the remaining tooth structure. This is theoretical, however, and currently available adhesives do not provide a hermetic, leak proof seal. Conventional dual-cure resin cements are indicated for luting procedures because they have low solubility, high mechanical quality and adhesive properties. [14]

The characteristics of the dual-cure cements are independent and complementary to those of light-activated chemical cements, which makes them ideal for deep cavities such as the root canal.

In present study para core adhesive system (coltene / whaledent) were used Para Core is a composite-based, dual-cured, radiopaque core build up material in syringes. Para Core is also suitable for use in cementing root posts and indirect restorations. Para Core contains: methacrylates, fluoride, barium glass, amorphous silica. Para Bond Non-Rinse Conditioner (NRC) contains: water, acrylamidosulfonic acid, methacrylate. ParaBond Adhesive A contains: methacrylates, maleic acid, benzoyl peroxide. Para Bond Adhesive B contains: ethanol, water, initiators. Indications of Para Core are permanent cementation for all types of root canal posts, core build-ups, crowns, bridges, inlays, onlays (ceramic, metal, and composite). Advantages are -It available in two shades:1) Bright white to differentiate from tooth structure 2) Dentin shade for esthetic restorations under ceramic crowns ,Non-slumping consistency, stackable, bonds to all fiber resin post materials, especially Para Post Fiber Lux/Taper Lux, chemically cures in 4 minutes, fluoride release, radiopaque. Physical properties are Compressive Strength 284 MPa, Flexural Strength 122 MPa, Average Particle Size 2 µm, Range of Particle Size 0.4-5.0 µm. [15]

In 2012 Yu Tian et al. conducted a study on Failure of Fiber Posts after Cementation with Different Adhesives with or without Silanization Investigated by Pullout Tests and Scanning Electron Microscopy. Result showed there was a statistically significant difference between the 3 experimental adhesive systems ($P < .001$) and between each experimental group and NEG-CON and POS-CON ($P < .05$). PAR(Para Core) was significantly different from RXU (RelyX Unicem)and RXA (RelyX ARC) ($P <0.05$). No statistically significant differences existed between RXU and RXA and between the use of silanization or not. Representative samples for SEM showed cohesive failure as the principal fracture mode for PAR and mainly adhesive failure for RXU and RXA. [16]

For Core fabrication para form (coltene / whaledent) custom made standardized transparent polytetrafluoro-ethylene matrices were used for core buildup using dual cure composite resin. “The use of a coreformer provides a predictable, economical and efficient method for producing a strong, well-adapted and durable foundation core retained by a prefabricated post (dowel) and/or retention pins.” The advantages of this matrices are -The ideal complement for direct core build-ups, transparent for light-curing, plastic, disposable for single use, easy to place, cut, trim and remove, numeric coding in 10 sizes etc. [17]

In this experiment, a scenario was selected which is frequently encountered in everyday practice. Each tooth in the arch performs different function and are subjected to various forces. Milot et al. and Mentink et al. reported that the rate of fracture of post is higher in maxillary anterior region, as the direction of force is mostly not along the long axis of the tooth. [7]

Creating an artificial periodontal ligament using polyvinylsiloxane impression material coating on a root, which has modulus of elasticity very similar to that of natural periodontal ligament. [5]

Static compressive load was applied at speed of 2.5 mm/min at an angle of 130. Guzy and Nicolls reported that for incisors, a loading angle 130-135 chosen to simulate a contact angle found in class I occlusion between mandibular and maxillary anterior teeth. A high speed of load application was used because at lower speed more fracture deformation take place so, that higher value of fracture resistance may be obtained. [5]

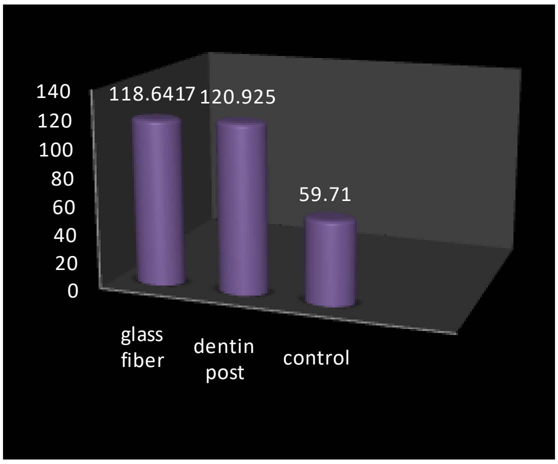
Result of present study showed that Group III (Dentin posts) (120.9 ± 1.447) and Group II (Glass Fibre posts) (118.6±1.437) the mean failure load value had significantly higher than Group I (Control group) (59.71Kg ±2.684). There was no statistically significant difference between group II (Glass fiber posts) and group III (Dentin posts)(Table-1,2) (Graph-1).

Table-1 (Mean failure load values for the three groups in Kg.)

	N	Std. Deviation		
	Statistic	Statistic(Kg)	Std. Error	Statistic
Control	12	59.7167	.7749	2.68424
Glass fiber post	12	118.6417	.4150	1.43746
Dentin post	12	120.9250	.4180	1.44796

Table-2 (Multiple comparison using students "t" test)

		Paired Differences					t	df	Sig. (2-Tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval Of The Difference				
					Lower	Upper			
Comparison 1	Control – dentin post	-61.208	3.3024	.95334	-63.3066	-59.1100	-64.204	11	.000
Comparison 2	Glass fiber post – dentin post	-2.2833	2.1493	.62046	-3.6490	-.9177	-3.680	11	.005
Comparison 3	Control – glass fiber post	-58.925	3.4330	.99103	-61.1062	-56.7438	-59.458	11	.000



Graph-1 (Mean failure load values for the three groups in Kg.)

In 2011 Kathuria A et al. conducted Ex- vivo study on fracture resistance of endodontically treated maxillary central incisors restored with fiber-reinforced composite posts and experimental dentin posts. Thirty maxillary central incisor were divided in to three groups of ten each twenty teeth were restored with FRC posts and solid dentin posts and ten teeth acts as a control, without any post .teeth were loaded by 135 angle to their long axis after core build-up and failure loads were recorded. Result of a study showed that teeth restored with dentin posts gave better fracture resistance than those restored with FRC posts. [7]

In 2012 Mahendran K A et al. conducted a study on Comparative Evaluation of Fracture Resistance under Static and Fatigue Loading of Endodontically Treated Teeth Restored with Carbon Fiber Posts, Glass Fiber Posts, and an Experimental Dentin Post System: An In Â Vitro Study. Seventy maxillary central incisors were obturated and divided into 4 groups: control group without any post (nÂ =Â 10), carbon fiber post group (nÂ =Â 20), glass fiber post group (nÂ =Â 20), and dentin post group (nÂ =Â 20). Control group teeth were prepared to a height of 5 mm. In all other teeth, post space was prepared; a post was cemented, and a core build-up was provided. Half the samples from each group were statistically loaded until failure, and the remaining half were subjected to cyclic loading, followed by monostatic load until fracture. Result showed One-way analysis of variance and Bonferroni multiple comparisons revealed a significant difference among test groups. The control group demonstrated highest fracture resistance (935.03Â Â±Â 33.53 N), followed by the dentin post group (793.12Â Â±Â 33.69 N), glass fiber post group (603.44Â Â±Â 46.67 N), and carbon fiber post group (497.19Â Â±Â 19.27 N) under static loading. These values reduced to 786.69Â Â±Â 29.64 N, 646.34Â Â±Â 26.56 N, 470Â Â±Â 36.34 N, and 379.71Â Â±Â 13.95 N, respectively, after cyclic loading. [18]

Hence future research is needed to highlight the outcome of the study. Moreover, further studies inclusive of cyclic loading of the dentin post are anticipated to provide a better insight into its properties.

CONCLUSION

Within the limitation of this study, it can be concluded that

- This study opens an introductory gate in support of the clinical implication of dentin posts.
- Dentin may emerge as a successful alternative to currently available posts materials. However, further in vivo or in vitro trials are required in this direction.

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