A COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND RETENTION OF THREE DIFFERENT FIBER REINFORCED POSTS IN ENDODONTICALLY TREATED TEETH WITH OVAL-SHAPED CANALS – AN INVITRO STUDY

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in partial fulfilment of the requirements
for the degree of

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ADHIPARASAKTHI DENTAL COLLEGE AND HOSPITAL

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CERTIFICATE

This is to certify that **DR.KAUSHALYA.P**, Post Graduate student (2014-2017) in the Department of Conservative Dentistry and Endodontics, Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319, has done this dissertation titled **"A comparative evaluation of fracture resistance and retention of three different fiber reinforced posts in endodontically treated teeth with oval-shaped canals" – An invitro study**. Under our direct guidance and supervision in partial fulfilment of the regulations laid down by the Tamilnadu DR.M.G.R Medical University, Chennai – 600032 for MDS., (Branch-IV) **CONSERVATIVE DENTISTRY AND ENDODONTICS** degree examination.

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I dedicate this dissertation to my family members who always wanted to see me where I am today.

Dr.Kaushalya.P

Post Graduate Student

DECLARATION

TITLE OF THE DISSERTATION	**“A comparative evaluation of fracture resistance and retention of three different fiber reinforced posts in endodontically treated teeth with oval-shaped canals" – An invitro study.**
PLACE OF THE STUDY	Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319
DURATION OF THE COURSE	3 years
NAME OF THE GUIDE	Dr.S.Thillainayagam MDS.,
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I hereby declare that no part of the dissertation will be utilized for gaining financial assistance or any promotion without obtaining prior permission of the Principal, Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319. In addition, I declare that no part of this work will be published either in print or in electronic media without the guides who has been actively involved in dissertation. The author has the right to reserve for publish work solely with the permission of the Principal, Adhiparasakthi Dental College and Hospital, Melmaruvathur – 603319.

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ABSTRACT

BACKGROUND

Restoration of endodontically treated teeth remains a major challenge in dentistry, especially in cases of severe coronal destruction. Such cases require post retained restorations. The main reasons hampering the long term success of post retained restorations are loss of retention and root fracture. Retention can be improved by using resin based luting cements. Root fractures can be minimized by using fiber posts. Kersten *et al.*, 1986 reported that shape of the root canal plays an important role in successful treatment, apart from the efficiency of different root canal filling techniques especially in oval shaped canals. Only few studies have demonstrated the fracture resistance and retention of different prefabricated post systems in oval shaped root canals and determined the respective failure modes.

AIM

To compare and evaluate the fracture resistance and retention of three different fiber reinforced posts in endodontically treated teeth with oval-shaped canals.

MATERIALS AND METHODS

Sixty human mandibular premolars with oval canals were selected for the study. The samples were decoronated at the level of CEJ to obtain a root length of 13 ± 1mm. Cleaning and shaping of the

samples were performed using Rotary Protaper files till F3 size, followed by obturation of the root canals. The samples were then divided in to 3 groups (n=20) according to the fiber posts used. Group1 (Everstick Post), Group 2 (RelyX Post), Group 3 (Macrolock Oval Post). Post space preparation was done and posts were luted with the respective dual cure resin cement. Each group was then divided into 2 subgroups (a&b) n=10 for fracture resistance and retention tests respectively. For fracture resistance test core build up was done with direct composite and light cured. The retention test did not require any core build up. Fracture resistance and retention tests were performed on each group using universal testing machine at a cross head speed of 1mm/min. Failure modes were also evaluated.

RESULTS

The results showed that the fracture resistance of group 3a (Macrolock Oval Post) was significantly higher than the other two groups. Group 1a had least fracture resistance. More number of unfavourable fractures were seen in Group 1a. The retention of group 3b (Macrolock Oval Post) was significantly higher than the other two groups. Group 1b had least retention.

CONCLUSION

Fracture Resistance and retention of all the three groups were statistically significant i.e, Macrolock Oval Post> RelyX Post> Everstick Post.

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LIST OF ABBREVIATIONS

ANOVA	: Analysis of Variance
CFRC	: Carbon Fiber Reinforced Composite
C-factor	: Configuration factor
DC	: Dual Cure
Fig	: Figure
FRC	: Fiber Reinforced Composite
GFR posts	: Glass Fiber Reinforced posts
MOD	: Mesio-Occluso-Distal
Ni-Cr	: Nickel-Chromium
RDIZ	: Resin Dentin Inter-diffusion Zone
SC	: Self Cure
TC	: Thermocycling
UDMA	: Urethane Dimethacrylate
ZDC posts	: Zirconia Dioxide Ceramic posts

INTRODUCTION

The restoration of endodontically treated teeth is a critical step in successful root canal treatment.[1] Reconstruction of endodontically treated teeth is often necessary before the final restoration is placed, especially when the remaining coronal tooth structure is not adequate enough to provide retention and resistance for the final restoration.[2] When there is a loss of large amount of clinical crown due to damage, it is often impossible to achieve sufficient anchorage of a restoration in the remaining dentin. In such situations, a root-canal-retained restoration is required.[3] Hence, posts are indicated for endodontically treated teeth that are highly susceptible to fracture because of their insufficient coronal tooth structure.[4]

Restorations of the root filled tooth by a post to retain a crown dates back more than 200 years, when Fauchard used posts constructed from gold or silver.[5] Over the next century, the post crowns became the most popular method of restoration of traumatized tooth.

For many years the standard “Artificial Tooth Structure” in dentistry was the post and core fabricated in cast gold. Tomes proposed the principles of post dimensions as early as 1848 and these procedures still closely conform to those used today.[6]

There has been a significant development in post systems in recent years with respect to post and core materials, shape, design, bonding system and techniques for removal. Following trauma if less than one half of the coronal structure is remaining on a pulpless tooth, it is advisable to place a post and core, thereby providing adequate connection of the root structure to the coronal core.[7] The restoration of the endodontically treated tooth is an important aspect of dental practice involving a range of treatment options of varying complexity.[8]

Modern dentistry aims at preserving pulpal vitality and avoiding the use of posts considering post application as the last treatment option. If, however, endodontic therapy is cannot be avoided then the conservation of the remaining tooth structures is most important. Generally, endodontically treated teeth have already undergone remarkable coronal destruction, loss of radicular dentin, reduced level of proprioception and an overall reduction in the capability of the tooth to resist a large amount of intra-oral forces. In the present era of Aesthetic, Conservative and Adhesive dentistry, aesthetic and functional restoration of a pulpless tooth is a demanding challenge.

The post endodontic treatment of teeth presents the dental practitioner with the difficulties in selecting from a large array of materials, technique and designs.[7] The main reasons hindering the long term success of post retained restorations are loss of retention and root fracture. Post retention can be improved by an adhesive luting technique involving resin based luting agents. Root fracture can be minimized by using fiber post which have modulus of elasticity similar to dentin that allow for a more uniform distribution of loads along root dentin compared to metal posts.

However, the restoration of endodontically treated teeth with fiber–reinforced post system has been drawing the attention of a constantly growing number of clinicians.

The addition of fibers to a polymer matrix can result in a significant improvement in the mechanical properties such as strength, fracture toughness, stiffness and fatigue resistance.[5] Adhesive composites are used to build up the core and form a mechanical unit with the tooth. Also, the mechanical behaviour and related mechanism of failure of fiber posts have been compared to those of metallic posts. While metallic posts tend to produce an irreversible root fracture on failure, the root fracture in case of a fiber posts is usually located more coronally and is more easily re-treatable. In addition, the fiber posts are more easily retrievable than metallic or ceramic posts.

D.Cecchin et al., reported that the eugenol-based sealer negatively interfered with the bond to root dentin; however, the resin- and calcium hydroxide-based sealers did not interfere with the bond strength of the fiberglass post cemented with self-adhesive resin cements.[9]

Apart from the above mentioned factors it has been reported that shape of the root canal plays an important role in successful treatment. It is a proven concept that close canal adaptation with minimal tooth structure removal provides a conservative and long lasting treatment for the restoration of endodontically treated teeth.[10]

Cross-sectional root canal configurations are classified as round, oval, long oval, flattened or irregular. Oval is defined as having a maximum diameter of upto two times greater than the minimum diameter. Post placement in oval shaped canals leads to removal of sound tooth structure to adapt the post to the canal. This in turn can affect the strength of the tooth structure.[11]

There are only few studies which demonstrate the efficacy of the fracture strength and retention of different prefabricated post systems in oval shaped root canals and determined the respective failure modes. In this study the fracture resistance of endodontically treated teeth with oval canals restored with three different fiber post systems will be evaluated.

INSTITUTIONAL ETHICS COMMITTEE AND REVIEW BOARD

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An ISO 9001:2008 certified institution. Accredited by NAAC with "B" grade.

Recognised by DCI, New Delhi. Affiliated to: The Tamil Nadu Dr. M.G.R. Medical University, Chennai.

This ethical committee has undergone the research protocol submitted by **DR.KAUSHALYA.P**, Post Graduate Student, Department of Conservative Dentistry and Endodontics under the title **"A COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND RETENTION OF THREE DIFFERENT FIBER REINFORCED POSTS IN ENDODONTICALLY TREATED TEETH WITH OVAL-SHAPED CANALS" – AN INVITRO STUDY"** Reference No: 2014-MD-BrIV-SAT-09 under the guidance of **DR.S.THILLAINAYAGAM, MDS.,** for consideration of approval to proceed with the study.

This committee has discussed about the material being involved with the study, the qualification of the investigator, the present norms and recommendation from the Clinical Research scientific body and comes to a conclusion that this research protocol fulfils the specific requirements and the committee authorizes the proposal.

Date: **Member secretary**

AIM AND OBJECTIVES

AIM

To compare and evaluate the fracture resistance and retention of three different fiber reinforced posts in endodontically treated teeth with oval-shaped canals.

OBJECTIVES

- To evaluate the fracture resistance of three different fiber reinforced post in endodontically treated teeth with oval canals.
- To evaluate the retention of three different fiber reinforced post in endodontically treated teeth with oval canals.
- To correlate the relation of post geometry and fracture resistance of endodontically treated teeth with oval canals.
- To evaluate the failure modes for each post system.

REVIEW OF LITERATURE

Standlee JP et al (1972)[12] compared the stress distribution of smooth sided parallel posts; smooth sided tapered posts and threaded parallel posts by photoelastic analysis. They concluded tapered posts exhibit a wedging effect and produce the highest stresses at the shoulder. Smooth-sided parallel posts generate the highest apical stresses.

Lovdahl PE et al (1977)[13] compared the fracture resistance of endodontically treated teeth restored with cast gold post and pin amalgam restoration. They concluded that endodontically treated teeth with natural crowns demonstrated greater strength than either of the two restorative types. Pin-retained amalgam cores were significantly stronger than cast-gold dowel-cores.

Guzy GE et al (1979)[14] compared the fracture loads of endodontically treated teeth, with and without endodontic posts to determine if the post reinforces the root against fracture. They concluded that there was no statistical significant reinforcement with cementation of posts.

Davy DT et al (1981)[15] utilized the finite element technique to analyze mechanical stress patterns in a reconstructed maxillary central incisor. A series of designs for endodontic dowel posts incorporated into the prostheses had been comparatively evaluated in this study. They concluded the effect of taper was found to be slight if the local tapered-post diameter was comparable to the cylindrical post diameter in the high-stress region. The tapered-post design experienced slightly higher tensile and slightly lower shear stresses than the cylindrical post. Using the peak stresses in the dentin and at the dentin-post interface as a criterion, the cylindrical post with the largest diameter was the best design.

Standlee JP et al (1982)[16] determined the stress distribution properties of the Dentatus screw and compared it to tapered smooth-sided, parallel-sided serrated, parallel-sided tapped threaded using photoelastic stress analysis. They concluded that the tapered, self-threading; Dentatus endodontic screw causes severe wedging forces.

Eshelman EG et al (1983)[17] compared three dowel materials and fracture resistance of teeth. They concluded a progressive load to a dowel-containing tooth will cause fracture of the root.

Reinhardt RA et al (1983)[18] Reported that a parallel-sided post disperses the stresses uniformly along its length except at the apex, where there is concentration of the stresses.

Sorensen JA et al (1984)[19] evaluated 1273 endodontically treated teeth and compared the clinical success rate of six coronal-radicular stabilization methods, recorded the failure of dowel systems and the effect on endodontically treated teeth, and determined the effect of dowel length on the clinical success rate. They concluded the cast parallel-sided serrated dowel and core and the parallel-sided serrated dowel with an amalgam or composite resin core recorded the highest success rate. The tapered cast dowel and core displayed a higher failure rate than teeth treated without intracoronal reinforcement.

Yazdanie N et al (1985)[20] concluded from their study that carbon fiber acrylic resin composites were stronger and stiffer than unfilled acrylic resin. The strands were more efficient strengtheners than are woven mats. Therefore, it may be possible to reduce the amount of fiber included.

Cooney JP et al (1986)[21] investigated the retention and stress distribution of two tapered-end posts with different embedment depths and post diameters. Under simulated functional loads, the tapered-end posts produced wedging stresses near the apex. More uniform stress distributions were –observed with the parallel-sided posts.

Kersten et al (1986)[10] reported that shape of the root canal plays an important role in successful treatment, apart from the efficiency of different root canal filling techniques especially in oval shaped canals. It is a proven concept that close canal adaptation with minimal tooth structure removal provides a conservative and long lasting treatment for the restoration of endodontically treated teeth.

Leary JM et al (1987)[22] concluded internal tooth structure is removed from the tooth makes it weaker and teeth with posts do show more reinforcement than non-posted teeth with the same manipulation characteristics. Some load transfer appears to exist with cemented posts.

Greenfeld RS et al (1989)[23] compared a parallel-tapering, threaded, split-shank post with a parallel serrated post under applied compressive-shear loads. They conclude that parallel threaded post was superior to parallel serrated posts in resisting loads.

Hunter AJ et al (1989)[24] examined the effect of root canal preparation, post preparation, and posts on the relative stresses in the cervical and apical regions of tooth models representing an intact maxillary central incisor by two-dimensional photoelectricity. They concluded that if considerable enlargement of the root canal has occurred, a post with a moderate diameter and length substantially reinforces the tooth. Removal of internal tooth structure during root canal therapy is accompanied by a proportional increase in stresses at the cervical area, particularly on the tension side.

Reeh et al (1989)[25] compared the effect of endodontic and restorative procedures to the strength of pulpless teeth. They found that endodontic procedures reduced the relative stiffness by 5% to 20%

from occlusal cavity preparation and 63% from MOD cavity preparation.

Burns DA et al (1990)[26] compared the stress distribution during insertion and function of three prefabricated endodontic posts with different designs using the criteria of post length and diameter. They reported larger diameter posts at increased depths distributed stress more efficiently than the smaller, shorter posts when obliquely loaded.

King PA et al (1990)[27] compared four different types of post core system. They concluded post-retained crowns using a prefabricated CFRC post exhibited properties comparable with, and in some cases better than, those of existing prefabricated metal posts. The mode of failure of specimens restored with a CFRC post was more favourable to the remaining tooth tissue than was that of specimens restored with a metallic post

McDonald AV et al (1990)[28] determined the effect on impact fracture resistance of three methods for restoration of root-treated lower incisor teeth with otherwise intact natural crowns. The results suggested that there is no advantage from the point of view of fracture mechanics in 'restoring' intact root-treated teeth with either stainless steel or carbon fiber reinforced carbon rods.

Sorensen JA et al (1990)[29] determined the effect of different post designs and varying amounts of post-to-canal adaptation on the fracture resistance of endodontically treated teeth. Their results suggested tapered posts resulted in fractures that were directed more apically and lingually. Parallel-sided posts had a lower frequency of fracture upon failure, involving less tooth structure.

Weine FS et al (1991)[30] conducted a retrospective study on 51 patients with 138 endodontically treated teeth restored with tapered smooth posts. They concluded when tapered smooth posts are used properly, retentive problems do not occur.

Hatzikyriakos AH et al (1992)[31] compared the retention of tapered threaded posts, tapered cast posts and parallel serrated cemented posts. The posts that had least retention in their study were parallel cemented posts.

Sedgley et al (1992)[32] compared the biomechanical properties (hardness, toughness, punch shear strength and load to fracture) of 23 endodontically treated teeth with their contralateral vital pairs. They found no significant difference between them. However, the changes in pulpless teeth may be caused by the restorative procedure itself.

Mentink AG et al (1993)[33] did a retrospective study on 516 teeth restored with a cast post and core build-up and followed from 1970 till

1990. They analysed failure characteristics. They reported that recementation after loss of retention occurred most frequently

Viguie G et al (1994)[34] reported that for fabrication of posts and cores, short carbon fibers randomly distributed within the composite resin are recommended. This is commonly implemented by use of a preimpregnated form injected under pressure and vacuum.

Torbjorner A et al (1995)[35] compared custom cast and parallel-sided serrated posts with respect to type of failure and failure rate and evaluated possible background factors. Their resulted a significantly higher success rate was recorded for parallel-sided serrated posts, compared with custom-cast posts, regarding the total failure rate and the severity of the failure.

Purton D G et al (1996)[36] compared rigidity and retention in two different 1-mm diameter root canal posts—smooth carbon fiber posts and serrated stainless steel posts. They reported that the stainless steel posts were more rigid than carbon fiber posts.

Mendoza DB et al (1997)[37] evaluated the ability of resin-bonded posts to reinforce teeth that are structurally weak in the cervical area against fracture. The forces needed to fracture the roots in the zinc-phosphate cement group were lower than in the composite cement groups

Nergiz I et al (1997)[38] determined the retentive strength of tapered titanium posts with different surface textures and examined the effect of roughening dentinal walls of the prepared post space. The smooth post showed the lowest retentive strength. Sandblasting the smooth post more than doubled its retentive strength. The retentive strength of both smooth and sandblasted posts could be further increased by the addition of circumferential grooves, roughening the dentinal walls of the prepared post space increased the retentive strength of sandblasted posts with and without grooves even more.

Dean JP et al (1998)[39] evaluated the influence of endodontic and restorative procedures on fracture resistance of teeth, and compared the incidence of root fracture in teeth with clinical crowns removed that were restored with three different types of post and a composite core build-up. The results of the study revealed the group restored with the carbon post had no root fractures, whereas there were five fractures in each of the parallel and tapered post groups.

Asmussen E et al (1999)[40] determined the stiffness, elastic limit, and strength of a selection of endodontic posts. They reported that the ceramic posts were very stiff and strong, with no plastic behavior. The titanium post was as strong as, but less stiff than, the ceramic posts. Carbon fiber posts had the lowest values for stiffness, elastic limit, and strength of the posts investigated.

Bae JM et al (2001)[41] measured the flexural strength and the elastic modulus of composite resin with and without reinforcing fibers (a polyethylene fiber (Ribbond), a polyaramid fiber (Fibreflex), and three glass fibers (FibreKor, GlasSpan, Vectris) and to evaluate the reinforcing effect. They concluded fibers used in the study increased both yield and ultimate flexural strengths of composite resins. Unidirectional glass fibers and polyaramid fiber were effective in reinforcing both flexural strength and elastic modulus of composite resin.

Cormier C J et al (2001)[42] evaluated 6 post systems over 4 simulated clinical stages of tooth restoration to (1) determine quantitatively the fracture resistance strength at each stage when a static loading force is applied to cause failure; (2) determine the failure mode for each post system at each simulated clinical stage; and (3) determine the feasibility of removing failed post systems. They concluded the fiber posts evaluated provided an advantage over a conventional post that showed a higher number of irretrievable post and unrestorable root fractures. At the stage of final restoration insertion, there was no difference in force to failure for all but the FibreKor material, which continued to be weaker than all other tested materials. The fiber posts were readily retrievable after failure, whereas the remaining post systems tested were non-retrievable.

Ferrari M et al (2001)[43] evaluated the influence of four adhesive procedures in resin tag, adhesive lateral branch and resin dentin inter-diffusion zone (RDIZ) formation when used to bond fiber posts. They suggested a microbrush might clinically be used for bonding fiber posts into the root canal. When a microbrush was used, the bonding mechanism created between root canal dentin and bonding system was uniform along canal walls and more predictable.

Raygot C G et al (2001)[44] evaluated the fracture resistance and mode of fracture of endodontically treated incisors restored with cast post-and-core, prefabricated stainless steel post, or carbon fiber–reinforced composite post systems. Their results suggested the use of carbon fiber–reinforced composite posts did not change the fracture resistance or the failure mode of endodontically treated central incisors compared to the use of metallic posts.

Quintas AF et al (2001)[45] evaluated the role of surface treatments performed on plain carbon fiber posts, in relation to serrated carbon fiber posts, in the retention of the composite core. Their study concluded the surface treatments applied to plain carbon posts sandblasting, diamond burs for laminated veneers and alteration of the form of the head improved the retention to the core, producing values comparable to those of serrated posts, with no statistically significant difference.

Akkayan B et al (2002)[46] compared the effect of one titanium and 3 esthetic post systems on the fracture resistance and fracture patterns of crowned, endodontically treated teeth. They concluded significantly higher failure loads were recorded for root canal treated teeth restored with quartz fiber posts. Fractures that would allow repeated repair were observed in teeth restored with quartz fiber and glass fiber posts.

Nergiz I et al (2002)[47] investigated the effect of length and diameter on the retentive strength of sandblasted tapered prefabricated titanium posts. The results of the study were retention was affected strongly with the increase in the length (approximately 100%) than with the increase in the diameter (approximately 60%).

Pontius O et al (2002)[48] evaluated the survival rate and fracture resistance of maxillary central incisors restored with different post and core systems. Samples restored with a cast post and core demonstrated more vertical root fractures.

Newman MP et al (2003)[49] compared the effect of 3 fiber-reinforced composite post systems on the fracture resistance and mode of failure of endodontically treated teeth. Their results suggested the load to failure of the stainless steel posts were significantly stronger than all the composite posts studied. However, the mode of failure or deflection of the fiber-reinforced composite posts is protective to the remaining tooth structure.

Al-harbi F et al (2003)[50] evaluated the retentive strength of composite and ceramic endodontic dowel systems to the tooth and to the core foundation. They concluded resin dowel systems were more retentive in the root than the ceramic dowels but were similar to the titanium control.

Malferrari S et al (2003)[51] did a prospective clinical follow-up evaluated the acceptability of quartz fiber–reinforced epoxy posts used in endodontically treated teeth over a 30-month period. They concluded that over a 30-month period, the rehabilitation of endodontically treated teeth using quartz-fiber posts showed good clinical results. No crown or prosthesis decementation was observed, and no post, core, or root fractures were recorded.

Maccari PCA et al (2003)[52] evaluated the role of composition of prefabricated esthetic posts in fracture resistance of endodontically treated teeth in vitro. They compared the carbon fiber, glass fiber and ceramic post. They standardized the core by fabricating polyester matrices. They delivered the force at 45° during fracture resistance test at the middle third of the crown. The ceramic posts had least fracture resistance and associated with root fractures. Both the carbon fiber and glass fiber posts did not have any root fractures.

Kishen A et al (2004)[53] investigated the biomechanical perspective of fracture predilection in post-core restored teeth using computational, experimental, and fractographic analysis. These experiments aided in correlating the stress–strain response in structural dentine with cracks and catastrophic fractures in post-core restored teeth. It was observed from these experiments that the inner dentine displayed distinctly high strains (deformations), while the outer dentine demonstrated high stresses during tensile loading. This implies that the energy fed into the material as it is extended will be spread throughout the inner dentine, and there is less possibility of local increase in stress at the outer dentine, which can lead to the failure of dentine structure. During post-endodontic restoration with increase in loss of inner dentine, the fracture resistance factor contributed by the inner dentine is compromised, and this in turn predisposes the tooth to catastrophic fracture.

Lassila LV et al (2004)[54] investigated the flexural properties of different types of FRC posts and compare those values with a novel FRC material for dental applications. Their results suggested both carbon and graphite and glass fiber reinforced posts have similar flexural strength.

Sahafi A et al (2004)[55] evaluated the effect of cement, post material, surface treatment, and shape (1) on the retention of posts luted in the root canals of extracted human teeth and (2) on the failure morphology. They have concluded Parallel posts showed superior retention to tapered posts.

Galhano GA et al (2005)[56] evaluated the flexural strength of eight types of fiber posts (one carbon fiber, one carbon/quartz fiber, one opaque quartz fiber, two translucent quartz fiber, and three glass fiber posts)., by means of the three-point bending test. They found that the posts behaved similarly because of the same concentration and type of the epoxy resin used to join the fibers together. The results achieved allow for the suggestion that these materials would present a better response to the masticator forces if the superiority displayed on the direct load application on the post was considered.

Nagasiri et al (2005)[57] demonstrated that the survival rates of endodontically treated molars without crowns at 1, 2, and 5 years were 96%, 88%, and 36%, respectively. They also found that molar teeth with greater amount of remaining tooth structure after endodontic treatment had a survival rate of 78% at 5 years, and direct composite restorations had a better survival rate than conventional amalgam and reinforced zinc oxide and eugenol with polymethacrylate restorations.

Naumann M et al (2005)[58] evaluated the survival of glass fibre posts with two different shapes, parallel-sided and tapered in teeth with varying degrees of hard tissue loss. They concluded that parallel-sided and tapered glass fibre reinforced composite posts resulted in a similar rate of failure after 2 years of service. Post fractures and loss of post retention were the most frequent failure types. The majority of failures were restorable.

Balbosh A et al (2006)[59] evaluated the effect of surface treatment on the retention of glass fiber endodontic posts luted with resin cement and subjected to artificial aging. Their conclusion was treating the surface of the posts with ED-Primer material before cementation with Panavia F cement produced no significant improvement in the retention of the posts. Airborne-particle abrasion of the surface of the post significantly improved the retention

Dietschi D et al (2006)[60] evaluated the influence of the post material's physical properties on the adaptation of adhesive post and core restorations after cyclic mechanical loading. They compared 3 anisotropic posts (made of carbon, quartz, or quartz-and-carbon fibers) and 3 isotropic posts (zirconium, stainless steel, titanium). Their conclusion was Regardless of their rigidity, metal and ceramic isotropic posts proved less effective than fiber posts at stabilizing the post and core structure in the absence of the ferrule effect, due to the development of more interfacial defects with either composite or dentin.

Fokkinga WA et al (2006)[61] investigated in vitro fracture behavior of severely damaged premolars, restored with metal crowns with limited ferrule and several post-and-core systems, was investigated. They used static loads for the testing. They concluded that the fracture resistance and failure mode of severely damaged premolars restored with (adhesively cemented) crowns, with a limited ferrule, is independent from the (adhesively cemented) post-and-core systems applied.

Monticelli F et al (2006)[62] investigated the influence of different etching procedures of the post-surface on microtensile bond strength values between fiber posts and composite core materials. They concluded surface chemical treatments of the resin phase of fiber posts enhance the silanization efficiency of the quartz fiber phase, so that the adhesion in the post/core unit may be considered a net sum of chemical and micromechanical retention.

Perez BEM et al (2006)[63] evaluated the influence of thickness of luting cement on the bond strength of FRC posts to root dentin. They reported from their study that increase in cement thickness did not have significant effect on bond strength.

Pfeiffer P et al (2006)[64] evaluated the yield strengths of glass fibre-reinforced composite (FRC) posts and zirconia dioxide ceramic (ZDC) posts. They found that the yield strength was significantly higher for the zirconia and titanium posts when compared with GFR posts.

Stricker EJ et al (2006)[65] evaluated marginal adaptation, fracture modes, and loads to failure of composite crowns with different substructures on root-canal-treated premolars. In their results the teeth restored with glass fiber posts showed less root fractures.

Teixeira ECN et al (2006)[66] conducted a study to compare the in vitro retention, fracture and light transmission behavior of four different fiber-reinforced resin-based composite root canal posts. They used a vee block to simulate 45° angulated force on the posts. They concluded that parallel fiber-reinforced composite posts showed better retention than did tapered posts when dual-cured resin-based cement was used.

Vano M et al (2006)[67] evaluated the influence of various surface treatments to fibre posts on the microtensile bond strength with different composite resins. They concluded hydrogen peroxide and hydrofluoric acid both modified the surface morphology of fiber posts and with silane, significantly enhanced the interfacial strength between them and core materials.

Maccari PC et al (2007)[68] evaluated the fracture strength of teeth with flared canals and restored with two fiber-reinforced resin systems and one custom cast base metal (Ni-Cr) post and core system. Their results suggested that teeth restored with cast posts had fracture strength twice that of teeth restored with resin posts. Fiber-reinforced resin posts failed at a compressive force comparable to clinical conditions, but all failures were repairable. While with the cast posts involved with root fractures.

Plotino G et al (2007)[69] evaluated the flexural modulus and flexural strength of different types of endodontic post in comparison with human root dentin. Their conclusion was FRC posts have an elastic modulus that more closely approaches that of dentin while that for metal posts was much higher. The flexural strength of fiber and metal posts was respectively four and seven times higher than root dentin.

Seefeld F et al (2007)[70] investigated the ultrastructure and resistance to fracture of eight different types of fiber post, and to verify the existence of a correlation between structural characteristics and flexural strength. In their study a strong correlation was found between fiber/matrix ratio and flexural strength of FRC-post systems.

Souza RAO et al (2007)[71] evaluated the influence of the brush type as a carrier of priming adhesive solutions and the use of paper points as a remover of the excess of these solutions on the push-out bond strength of resin cement to bovine root dentin. They concluded the application of paper points to remove excess adhesive improved the bond strength for all groups.

Bitter K et al (2008)[72] evaluated the effects of pretreatment (silanization) and thermocycling on bond strengths of 2 core materials to 3 different types of fiber posts. Their results suggested that silanization pretreatment significantly increased bond strengths and TC significantly decreased bond strength between all material combinations.

D'Arcangelo C et al (2008)[73] evaluated the influence of endodontic therapy, veneer preparation, and their association on fracture resistance and deflection of pulpless anterior teeth and assess whether restoration with quartz fiber-reinforced post can influence these properties. Their results were suggestive of fiber post restorations seemed to significantly increase mean maximum load values for specimens prepared for veneers. A fiber-reinforced post restoration can be suggested when endodontic treatment is associated with veneer preparation.

El-Ela OAA et al (2008)[74] determined the fracture resistance of endodontically treated anterior teeth restored with a novel nonmetallic post in combination with self-etching adhesives. They concluded that use of a novel glass fiber post was associated with the highest mean fracture force for maxillary anterior teeth, regardless of the bonding agent used, whereas the stainless steel post was associated with the lowest mean fracture force.

Kivanç BH et al (2008)[75] investigated the fracture strength of three post systems cemented with dual cure composite resin luting cement by using different adhesive systems. They concluded endodontically treated anterior teeth restored with glass fiber posts exhibited higher failure loads than teeth restored with zirconia and titanium posts. Self-etching adhesives are better alternatives to etch-and rinse adhesive systems for luting post systems.

Mehta SB et al (2008)[76] evaluated the outcomes of a fiber post cemented with two different luting agents. They concluded that the most common cause of failure was mechanical fracture at the post-core interface. The mechanical failures due to fractures occurring along the length of the post-core complex were a major cause of concern, the majority of mechanical failures associated with the use of fibre posts were non-catastrophic, amenable to repair and protective of the remaining tooth structure.

Soares CJ et al (2008)[77] evaluated the effect of cavity design and glass fiber posts on stress distributions and fracture resistance of endodontically treated premolars. Stress distributions were evaluated for each group in a two dimensional finite element analysis. They concluded that the loss of dental structure and the presence of fiber post restoration reduced fracture resistance and created higher stress concentrations in the tooth-restoration complex. However, when there was a large loss of dental structure, the post reduced the incidence of catastrophic fracture types.

Sahafi A et al (2008)[78] characterized and analyzed reported failures of post-retained restorations to identify factors critical to failure and to type of failure. They concluded that tapered posts were associated with a higher risk of tooth fracture than were parallel-sided posts.

Wang Y et al (2008)[79] evaluated influence of C-factor on the microtensile bond strength between fiber posts and resin luting agents. The summarized that the influence of a clinically relevant cavity configuration on the adhesion established by two resin cements on glass fiber posts was not statistically significant.

Zhang L et al (2008)[80] evaluated the effect of different curing modes (“Self-cure and Self-cure (SC&SC)”, “Self-cure and Dual-cure (SC&DC)”, and “Dual-cure and Dual-cure (DC&DC)”) of dual-curing luting systems and root regions on the pushout strength of fiber posts to intraradicular dentin. The results concluded that the photoirradiation of dual-curing resin cement after post cementation improved the push-out strength of translucent fiber posts to intraradicular dentin, which was dependent upon the type of resin cement.

Buttel L et al (2009)[81] investigated (i) the impact of FRC post fit (formcongruence) and (ii) the influence of FRC post length on the fracture resistance of severely damaged root filled extracted teeth. They concluded the fracture resistance of teeth restored with FRC posts and direct resin composite crowns without ferrules was not influenced by post fit within the root canal. These results imply that excessive post space preparation aimed at producing an optimal circumferential post fit is not required to improve fracture resistance of roots.

Dorriz H et al (2009)[82] compared the fracture resistance of endodontically treated teeth restored with different post and core systems in combination with complete metal crowns in teeth with no coronal structure. In their study the prefabricated glass fiber post with composite core group showed the most favorable fracture pattern in all test groups.

Schmage P et al (2009)[83] compared the bond strengths of fiber reinforced composite posts luted into over sized dowel spaces with FRC posts luted into precisely fitting dowel spaces using five different resin cements or build-up composites. Based on their results they concluded retentive bond strengths of FRC posts showed significant reduction if they were inserted into over sized dowel spaces compared with precise fitting dowel spaces.

Signore et al (2009)[84] stated that the choice of appropriate definitive restoration of endodontically treated maxillary anterior teeth should be guided by the amount of remaining hard tissues as well as functional and aesthetic considerations. However, in cases of inadequate remaining coronal tooth structure, post-retained cores are often required to support complete crown restorations.

The preparation of a post space significantly weakened endodontically treated teeth. A post did not significantly strengthen endodontically treated teeth.

Fernando Massa et al (2010)[85] assessed the influence of post-and-core systems on the resistance to fracture of mandibular premolars restored with metal crowns and a 2.0-mm cervical ferrule. They concluded that the restoration of mandibular premolars with composite resin core (without post) showed an increased resistance to fracture when compared with other post-and-core systems whenever a minimum of 2.0 mm of remaining tooth structure was covered with a full metal crown (ferrule effect). Preservation of tooth structure was the most important factor in tooth resistance.

Poskus LT et al (2010)[86] assessed the influence of post pattern and resin cement curing mode on the retention of glass fibre posts. They concluded that the retention of glass fibre posts was not affected by post design or surface roughness nor by resin cement-curing mode. The choice of serrated posts and self-cured cements is not related to an improvement in retention.

Prabeesh Padmanabhan (2010)[87] compared the fracture resistance and primary mode of failure of three different pre- fabricated posts like stainless steel, carbon fiber and ceramic posts in endodontically treated crowned permanent maxillary central incisors. He concluded that the pre-fabricated stainless steel post exhibited a significantly higher fracture resistance at failure when compared with the carbon fiber post and the ceramic post. The mode of failure of the carbon fiber post was more favorable to the remaining tooth structure when compared with the pre-fabricated stainless steel post and the ceramic post.

Bitter K et al (2012)[88] evaluated the effect of cleaning method, luting agent and preparation procedure on the retention of fibre posts. They concluded that different cleaning methods did not lead to significant differences in root canal cleanliness and did not enhance fibre post retention inside the root canal. However, post space preparation using a Round Bur might be beneficial for improving retention, especially when self-adhesive cements are used.

Vassiliki Nova et al (2013)[89] evaluated the pull-out bond strength of a fibre-reinforced composite post system luted with self-adhesive resin cements. They concluded that different resin cements influenced the pull-out bond strengths, whereas the cement thickness itself was not responsible for any differences. They also reported that Self-adhesive resin cements can provide an acceptable retention of FRC posts even in case of use with wider post space conditions.

Andreas Thomas et al (2014)[90] evaluated the influence of post surface design on pull-out bond strength of fiber-reinforced composite posts. They concluded that The post surface design and luting system selection influenced the bond strength of conventionally and adhesively luted quartz fiber reinforced composite posts to bovine root canal dentin.

Xiao-jing Li et al (2014)[91] evaluated the Effect of luting cement and thermomechanical loading on retention of glass fibre posts in root canals. They concluded that Resin-modified glass ionomer cements have the potential benefit of achieving long-term retention when used for luting glass fibre post to root canal dentine. So it may be recommended for the cementation of glass fibre post in clinics.

Sebnem Begum Turker et al (2016)[92] determined the fracture resistance and the mode of fracture of endodontically treated teeth restored with different fiber posts and all-ceramic crowns. They concluded that in terms of optimizing fracture resistance, the fiber post size selection should be done according to the forces applied to the restored teeth.

MATERIALS AND METHODS

Materials used:

Tooth preparation:

- Diamond disc
- Straight hand piece (NSK EX - 6) S.No: F6X44766; Japan
- Micro-motor NSK EBB75900
- Ruler

Cleaning and shaping:

- K-files (Mani Inc, Japan)
  - Size 10 – Lot No: R16H067100
  - Size 15 – Lot No: R161023500
  - Size 20 – Lot No: R15I008300
- Protaper rotary files – Lot No:1289192
- EndoMate DT NSK model MPFI6R C871001
- Mini Endo Block (Dentsply Maillefer, Ballaigues)
- Sodium HypoChlorite 5.25% (Comdent corporation, Mumbai)
- PulpDent 17% EDTA (Pulpdent Corporation USA)
- Saline (Baxter, Tamilnadu, India)

Obturation:

- ProTaper Gutta – Percha points (Dentsply Maillefer, Ballaigues) F3 size- Lot No:1771371
- EndoRez Sealer (Ultradent) Lot No: BC3T2

- Pluggers (Dentsply Maillefer, Ballaigues) Lot No: 1160346
- GP holding tweezers (Sun, germany)

Post endodontic restoration:

Fiber Posts Tested

- EverStick Glass Fiber Post(GC) Lot No : 1411181
- Macrolock oval Fiber Posts (RTD) Lot No: 323541609
- RelyX Fiber post (3M ESPE, France) Lot No: 70201138800

Luting Cements

- G-CEM (GC) lot No: 1504221
- Rely X U 200 (3M ESPE, Germany) Lot No: 625134
- Sealbond Dual Cement (RTD, France) Lot No. 328481610

Materials for core buildup

- Scotchbond Multi- Purpose Etchant Lot No: N714933
- Spectrum Bond Nano technology Dental Adhesive Lot No: 1503000
- Composite resin : Lot No: N642334
- Light cure unit
- Composite instrument (Dispodent)
- Vacuum adaptus system and matrix
- DPI – RR Cold Cure (DPI, Mumbai) B.No: L-61515
- Aquasil LV (dentsply) Lot No. 150409
- Glass slab
- Spatula

- Gloves & masks

Fracture resistance test:

- Metal moulds to fabricate resin blocks
- Metal block to hold the specimens
- Universal testing machine (Lloyd LR100K, Lloyd instruments Ltd, Segensworth, Fareham, England) Serial No: 011265

Fig-1 Armamentarium for preparation of samples and Cleaning and shaping

Fig-2 Armamentarium for Obturation

Fig -3 Armamentarium for Post endodontic restoration

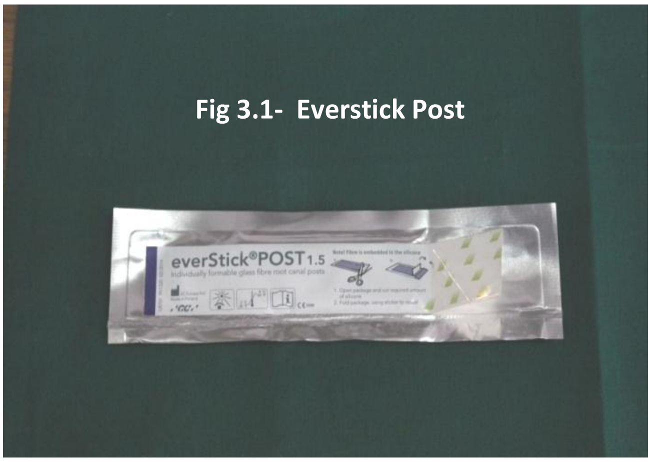


Fig 3.1- Everstick Post

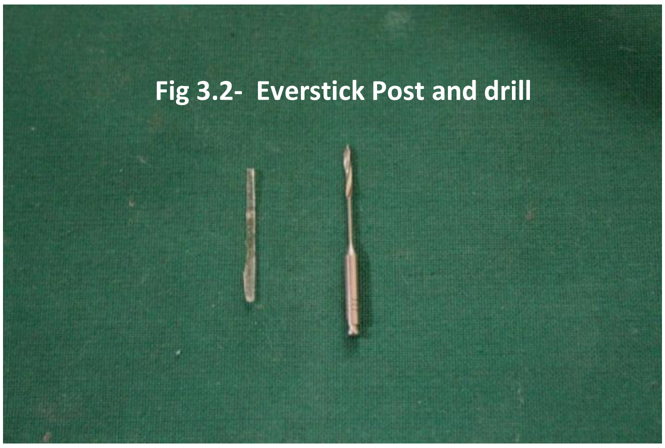


Fig 3.2- Everstick Post and drill

Fig 3.3- G-CEM Resin Cement

Fig 3.4- RelyX Post

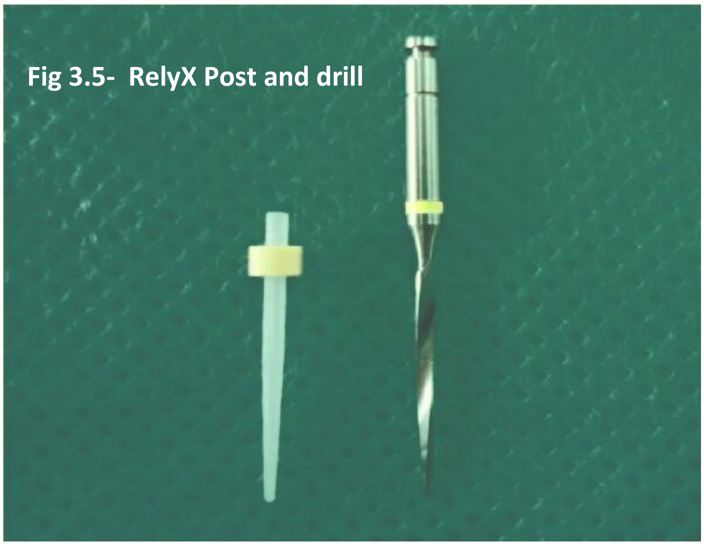


Fig 3.5- RelyX Post and drill

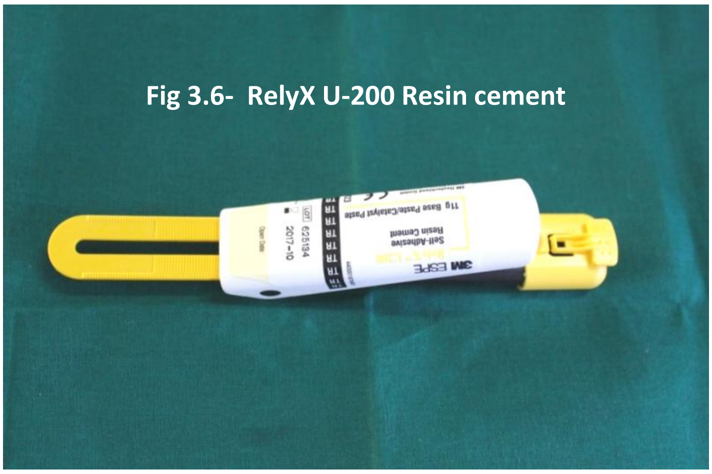


Fig 3.6- RelyX U-200 Resin cement

Fig 3.7- Macro-Lock Oval Post

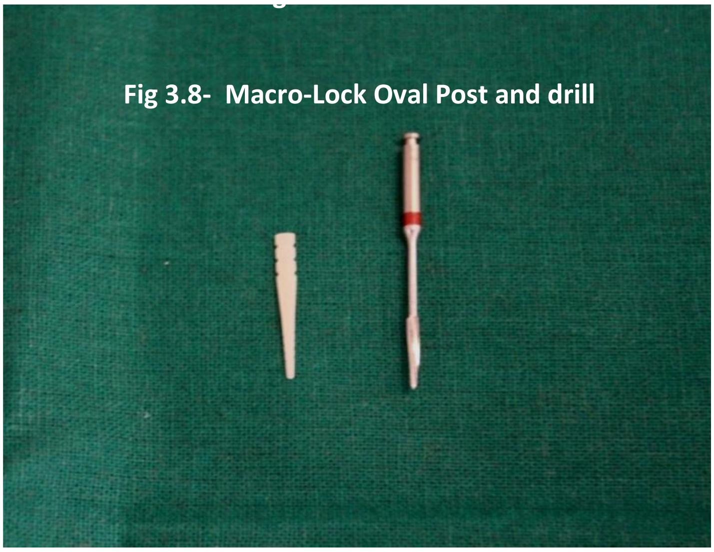


Fig 3.8- Macro-Lock Oval Post and drill

Fig 3.9- Sealbond Dual Resin cement

Fig -4 Armamentarium for core buildup

Fig -5 Armamentarium for Model Preparation

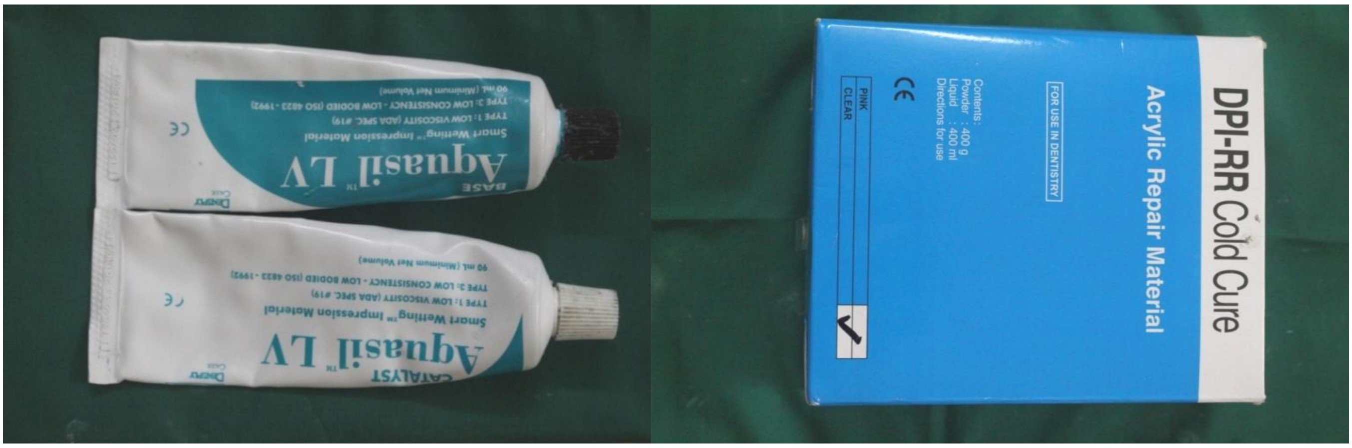
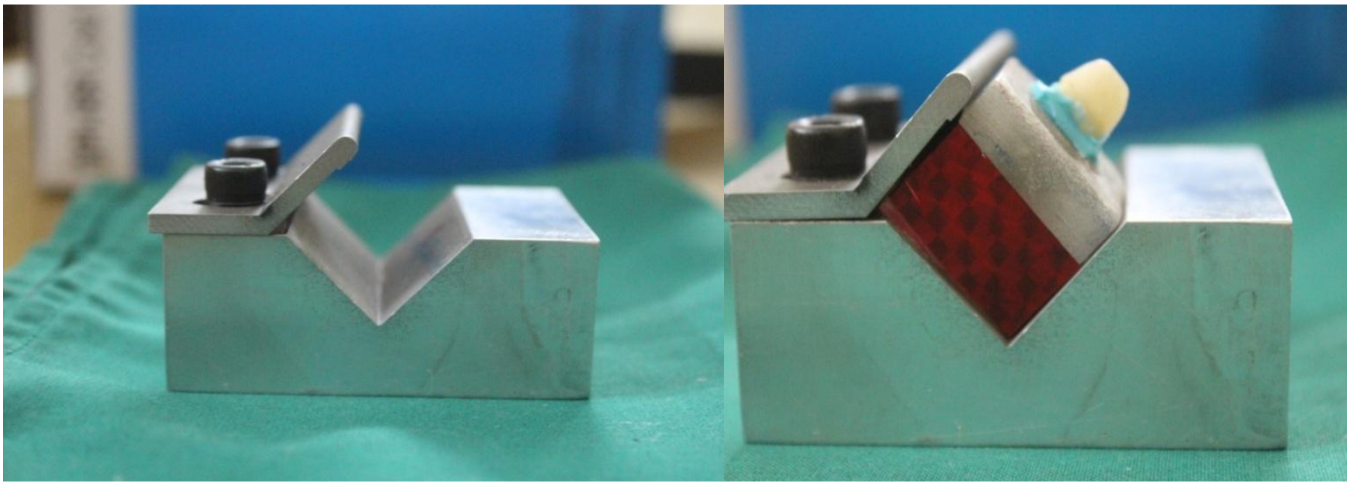


Fig - 6 Metal slot for holding the model at 45˚ angulation



Preparation of Specimens:

60 extracted single rooted human mandibular premolars with oval canals similar root dimensions were included in this study. The teeth with extremely curved roots, fracture lines, severely calcified roots and root caries were excluded from the study. The teeth samples were stored in saline until all the required specimens were collected. The evaluation of the oval canals was done by taking radiograph in the laboilingual aspect and mesiodistal aspect of each tooth. The ratio between the long and the short canal diameter at 5mm from the apex was calculated. A ratio $\geq$2 indicated the presence of oval canal.[104]

The samples were sectioned just below the cemento–enamel junction with diamond disc under coolant, such that the remaining root length will be 13 ± 1 mm.[81]

Endodontic Treatment:

The canal patency was checked and working length was determined with 10 K- file. The working length was determined with a 10 K–file. The file was introduced into the canal until it was seen at the apex. From that length 1mm was reduced and taken as working length.[93]

The cleaning and shaping of the canals were done by crown down technique using rotary ProTaper files till F3 size. The canal was irrigated frequently with 5.25% sodium hypochlorite and 17% EDTA and finally rinsed with saline.

The canal was dried and the obturation was done with Protaper Gutta-Percha (Dentsply) and EndoRez (Ultradent) sealer.

The teeth were stored in saline at room temperature for the sealers to set. The obturating material was removed to 8 mm with the heated pluggers in order to prepare post spaces.

The teeth samples were divided into 3 groups (n=20).

Group 1 : Everstick Fiber Post (GC)

Everstick post (Fig-3.1) is a soft and flexible, thus adaptable, polymer and resin impregnated unpolymerized glass fiber post. The post adapts to the morphology of the canal. The root canal area are completely filled with everstick posts. For this reason the adhesive surface and the strength in the most critical part of the tooth is maximized.[107]

Group 2: RelyX Fiber Post (3M ESPE)

RelyX Fiber Post (Fig-3.4) is a radio-opaque, translucent, glass-fiber reinforced composite root post. These are made from glass fibers embedded into a composite resin matrix, for superior mechanical properties the glass fibers have parallel orientation and are distributed equally over the surface area.[108]

Group 3: Macrolock Oval Fiber Post (RTD)

Macrolock Oval Post (Fig-3.7) is a “hybrid” post design for the restoration of wide, flared canals. The unique OVAL shape provides anti-rotation benefit, while replacing weaker cement with high strength fiber composite. Passive grooves lock into the cement in the ROUND apical portion of the post. Oval fiber posts are preferable to circular fiber posts in oval-shaped canals, given the stress distribution at the post - dentin interface.[109]

Post Endodontic Restoration:

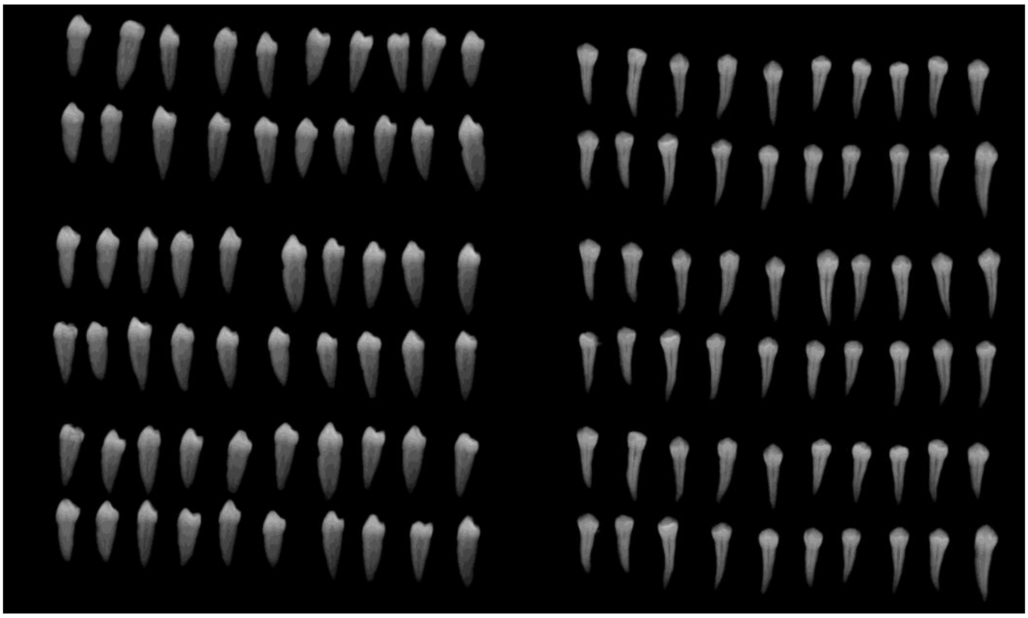
The apical diameters of the posts were kept constant as 0.9mm. The post spaces were prepared using respective drills supplied by the manufacturer.

The canal walls of post spaces were acid etched with 37% ortho phosphoric acid. The bonding agent was applied and cured. The posts were sectioned to 12mm with diamond bur under coolant.[62,67]

Table 1: Fiber posts with their respective shape and luting cements

S.NO	POST	SHAPE OF THE POST	LUTING CEMENT
1	Everstick fiber post (GC)	Flexible	G-CEM (GC)
2	RelyX fiber post (3M EPSE)	Round	RelyX U 200 (3M ESPE)
3	Macrolock Oval fiber post (RTD)	Oval	Sealbond Dual Cement (RTD)

Fig 7- labiolingual and mesiodistal view of the samples for evaluation of oval canals



Labiolingual view Mesiodistal view

Fig 8- Tooth samples before and after decoronation

Fig 9 – Obturated samples

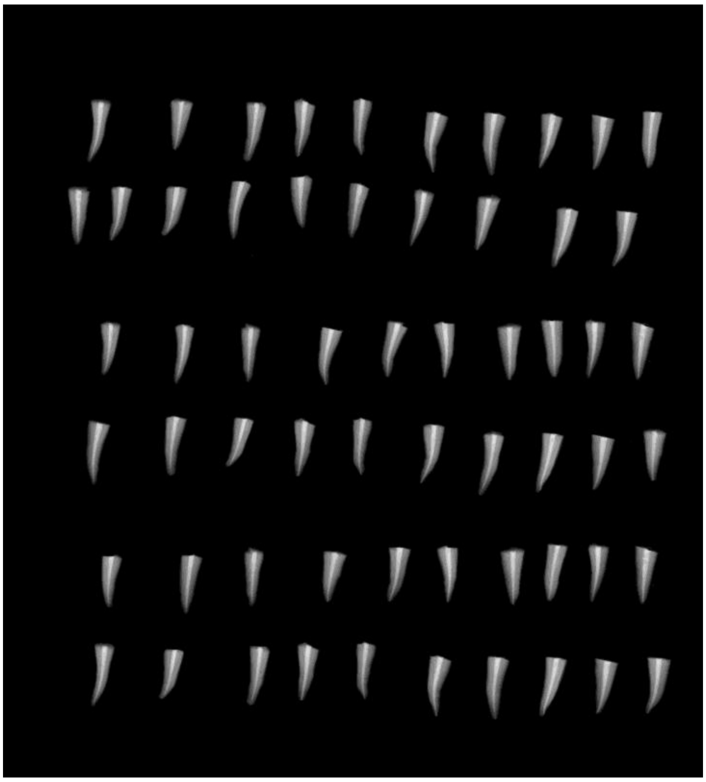
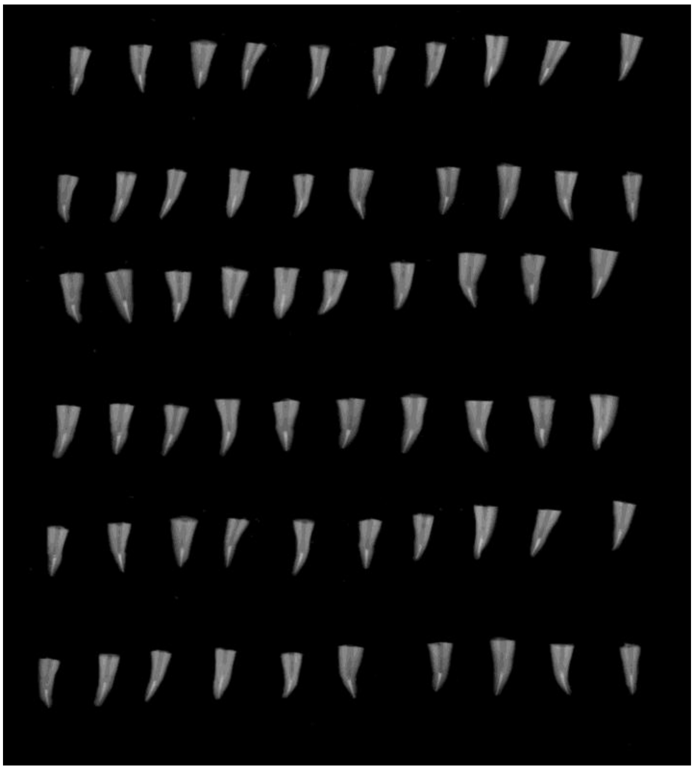


Fig 10- Specimens after Post Space Preparation

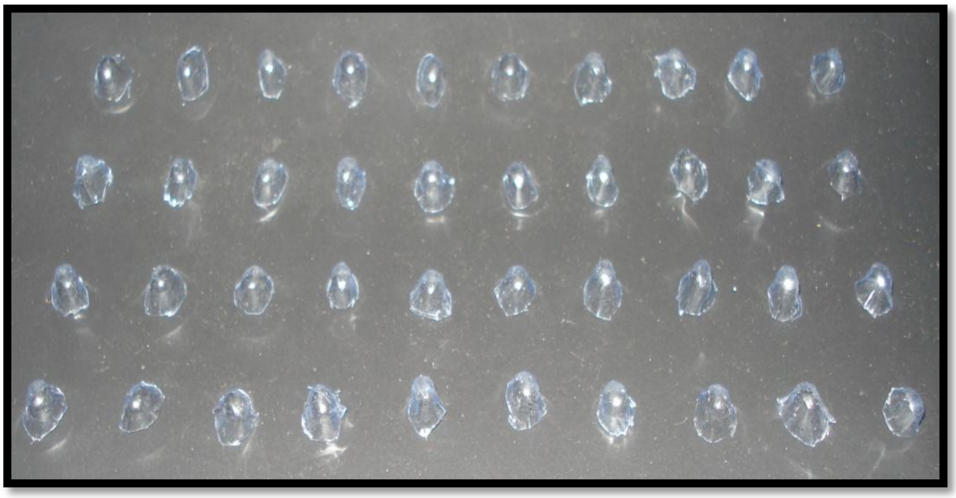


The posts were luted with the respective dual cure resin cement (Everstick post-GCEM, RelyX post – RelyX U-200, Macrolock oval post- SealBond). The posts were seated with finger pressure for 10 seconds and then excess was wiped off and light cured for 40 seconds using light cure unit.

Each group was then divided into 2 subgroups (a&b) n=10 for fracture resistance and retention tests respectively.

For fracture resistance test core build up was done with direct composite and light cured. The matrix was adapted over the core using vacuum adaptus system. Using these matrices core build up was done for the rest of the samples. The retention test did not require any core build up. [46,52]

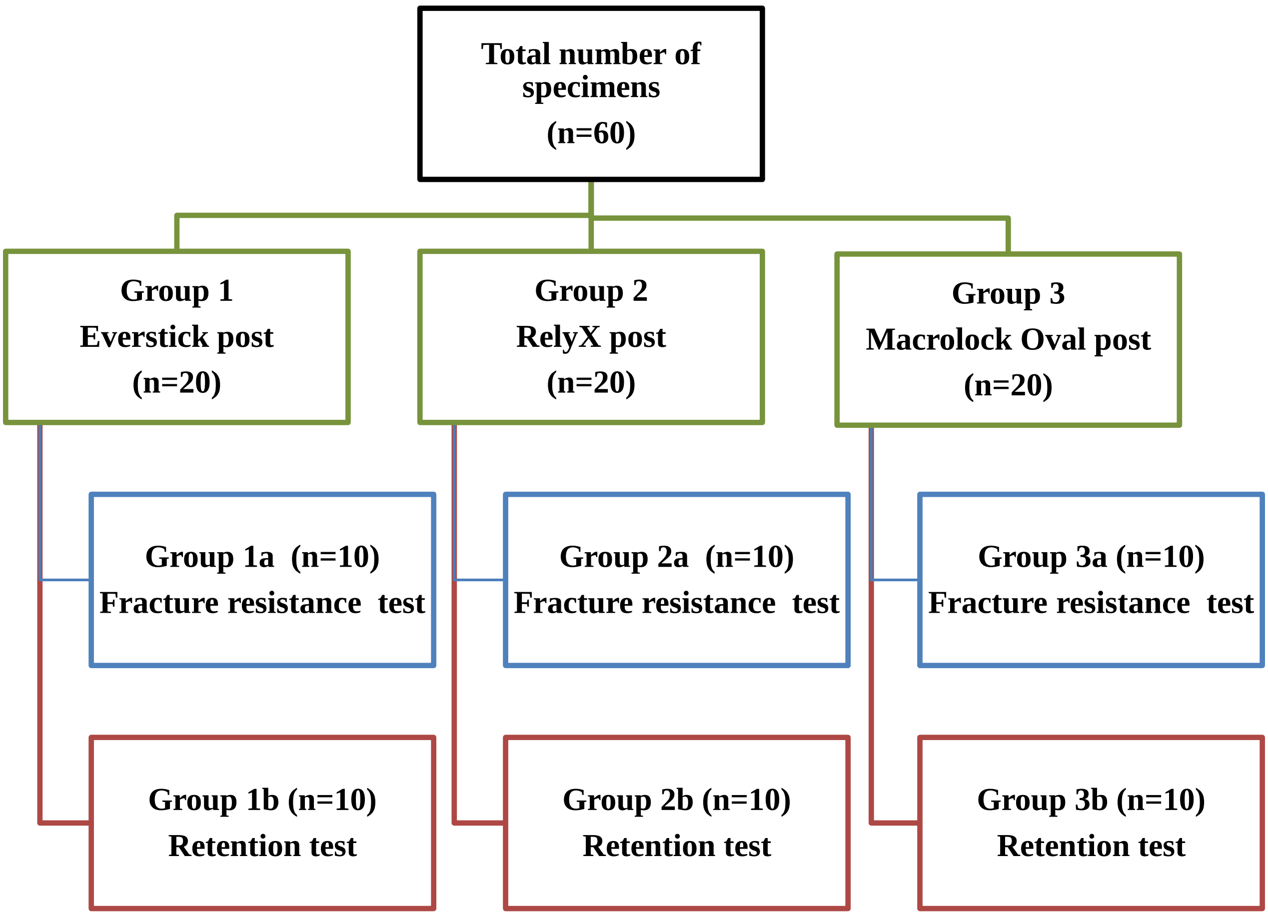
Fig 11- Matrices for core build up



Artificial Periodontal Ligament:

To simulate periodontal ligament first the roots were covered with uniform layer of wax 2mm below cervical margin and immersed in the self cure acrylic resin in the custom fabricated metal mould of size 2.5×2.5×2.5cm.

The resin blocks were de-waxed by immersing them in hot water. The light body impression material (aquasil LV, Dentsply) was mixed and coated over the roots and the teeth were repositioned in the resin blocks such that 2mm of the root protruding out of the block, the excess material was removed. [68]



Fracture Resistance Test:

To hold the resin at 45˚ angulations a metal block was fabricated (fig-6). The resin blocks with the teeth were mounted on the metal blocks and subjected to static compressive load at 45° angulations at a crosshead speed of 1mm/minute using universal testing machine (LR100K, Lloyd) (Fig-15), until there was a sudden drop of the stress-strain curve. The load to fracture was measured.[82]

The location of failure in all samples was recorded. When the teeth exhibited vertical or oblique fractures extending into or below the surrounding acrylic resin block, the fracture was considered to be unfavourable and no restorable. Fractures of the tooth above the acrylic resin block were considered restorable and more favourable.[68]

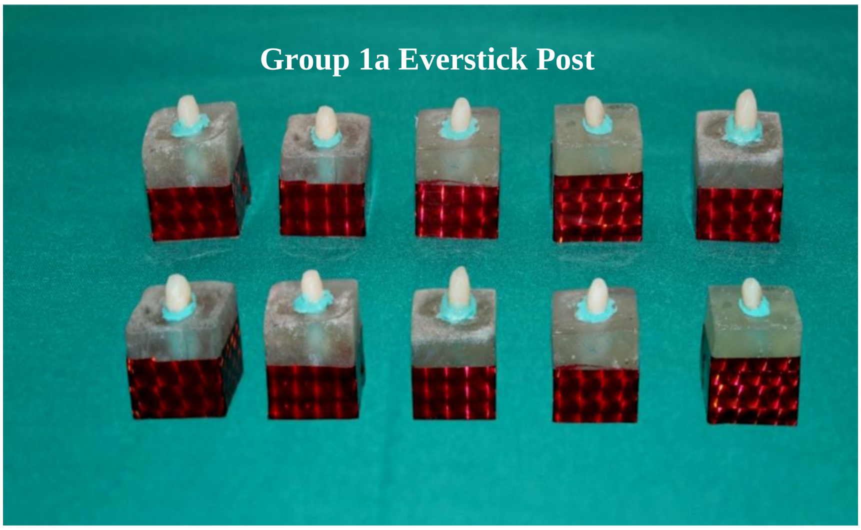
Retention Test

The resin models were held in the testing machine and the posts were extracted using vice clamps mounted in the universal testing machine operated in tensile mode at 1mm/min (Fig-16). The direction of tensile loading was parallel to the long axis of the tooth. The data were recorded in Newtons. Modes of failure were also noted.[89,90]

Statistical Analysis:

The statistical analysis was done using one way ANOVA and Tamhane's Post Hoc test was done for intergroup comparison at p value < 0.05.

Fig 12- samples for fracture resistance test



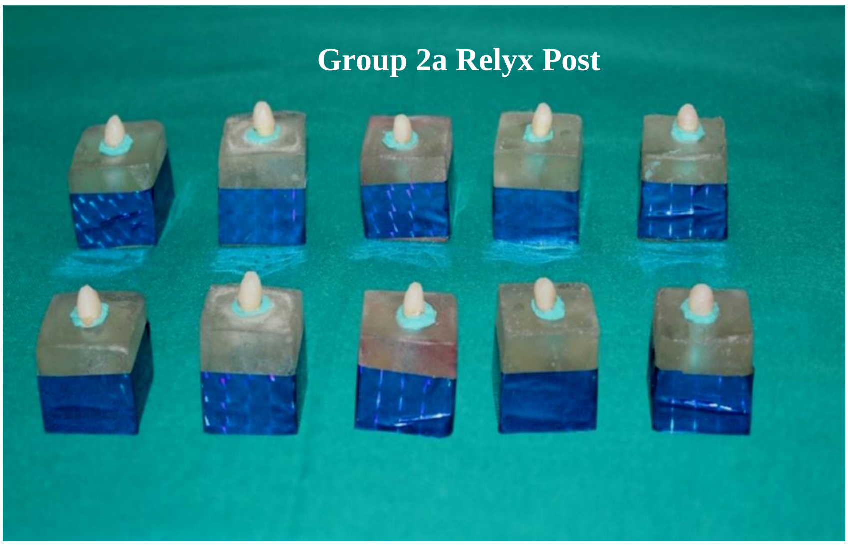
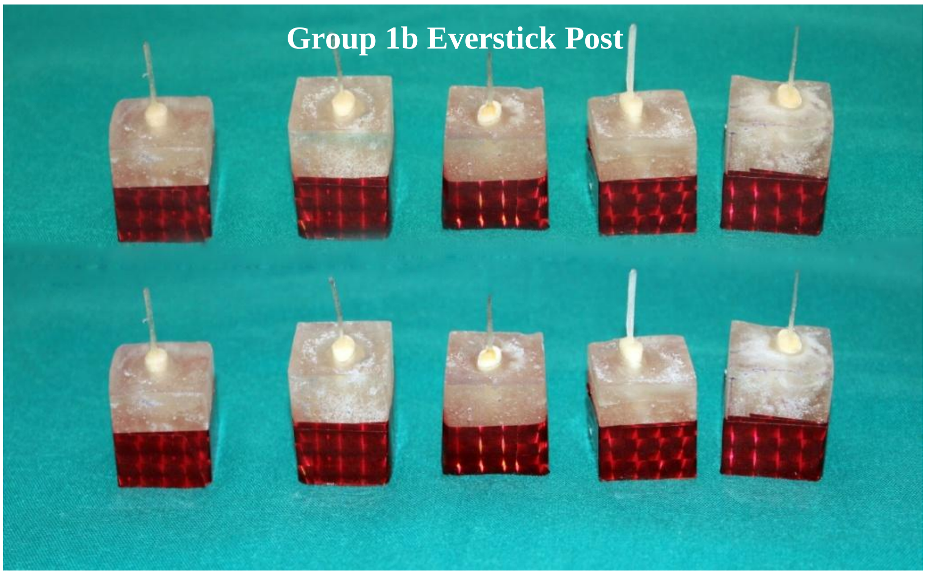


Fig13- Samples for Retention Test



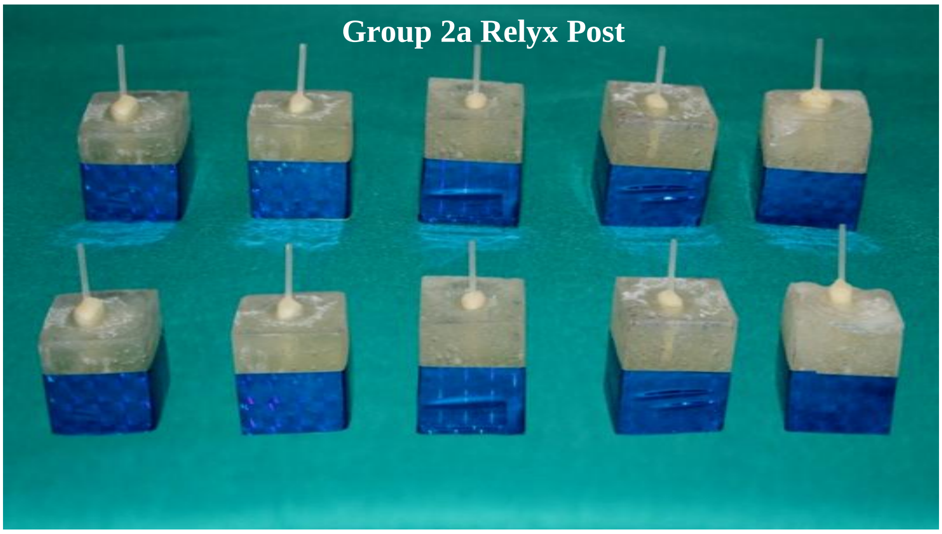


Fig 14-Universal Testing Machine

Fig- 15 Fracture resistance test

Fig- 16 Retention test

FLOW CHART FOR FRACTURE RESISTANCE TEST

60 single rooted premolar with oval canals decoronated

↓

Cleaning and shaping done using Rotary ProTaper

↓

Obturation done using ProTaper GP F3 size and EndoRez resin sealer

↓

Post space preparation done with drills provided by the manufacturer.

↓

Posts luted with dual cure resin cement

↓

Core build up done with direct composite

↓

Specimens mounted on resin blocks with simulated periodontal ligament

↓

fracture resistance of each group was evaluated using universal testing machine

FLOW CHART FOR RETENTION TEST

60 single rooted premolar with oval canals decoronated

↓

Cleaning and shaping done using Rotary ProTaper

↓

Obturation done using ProTaper GP F3 size and EndoRez resin sealer

↓

Post space preparation done with drills provided by the manufacturer.

↓

Posts luted with dual cure resin cement

↓

Specimens mounted on resin blocks

↓

Retention of each group was evaluated using universal testing machine

RESULTS

RESULTS OF FRACTURE RESISTANCE TEST

Individual fracture resistance values are displayed in table 2 and statistics of the fracture strength values of the experiment groups are displayed in table 3. The results showed that the fracture resistance of group 3a (Macrolock Oval Post) was significantly higher than the other two groups. Group 1a (Everstick Post) had the least fracture resistance. Group 2a (RelyX Post) was also statistically significant than group 1a and 3a.

Failure Modes

Table 4 shows the distribution of mode of failure (favourable and unfavourable) of the three experimental groups after mechanical testing. Group1a had higher amount of unfavourable fractures i.e., 5 out of 10 followed by Group 2a which had 4 out of 10 and group 3a had least amount of unfavourable fractures 2 out of 10.

Table 2: Fracture Resistance of three Groups in Newton(N)

Group 1a (Everstick)	**Group 2a (RelyX)**	**Group 3a (Macrolock)**
488.59	540.68	592.13
501.60	548.28	590.52
482.61	538.05	589.49
483.77	537.12	596.93
490.78	550.89	598.62
479.34	539.72	609.38
475.47	530.15	588.77
505.51	534.20	594.98
489.18	532.17	586.07
481.98	542.06	592.19

Table 3: Statistics for Fracture Resistance values

(one-way ANOVA Test)

Groups	**n**	**Mean**	**SD**	**F-value**	**p-value**
Group 1a	**10**	487.88	9.522	473.071	**0.000**
Group 2a	**10**	539.33	6.595		
Group 3a	**10**	593.90	6.640		

As per the obtained statistical results, the p value is significant, $p<0.05$.

Table - 4 Failure Modes of each Group

	Group 1a	Group 2a	Group 3a
Favourable	5	6	8
Unfavourable	5	4	2

Intergroup Comparison (Tamhane's Post Hoc Test)

Table – 5 Fracture Resistance of Group 1a Vs Group 2a

	Mean	SD	Mean difference	Standard error	P value
Group 1a	487.88	9.522	106.025	3.67	**0.000**
Group 2a	539.33	6.595	54.576	2.95	**0.000**

$p < 0.05$ Group 1a is statistically significant than Group 2a

Table – 6 Fracture Resistance of Group 1a Vs Group 3a

	Mean	SD	Mean difference	Standard error	P value
Group 1a	487.88	9.522	51.449	3.66	**0.000**
Group 3a	593.90	6.640	54.576	2.95	**0.000**

$p < 0.05$ Group 1a is statistically significant than Group 3a

Table – 7 Group 2a Vs Group 3a

	Mean	SD	Mean difference	Standard error	P value
Group 2a	539.33	6.595	51.449	3.66	**0.000**
Group 3a	593.90	6.640	106.025	3.67	**0.000**

$p < 0.05$ Group 3a is statistically significant than Group 2a

RESULTS OF RETENTION TEST

Individual retention values are displayed in table 8 and statistics of the fracture strength values of the experiment groups are displayed in table 9. The results showed that the retention of group 3b (Macrolock Oval Post) was significantly higher than the other two groups. Group 1b (Everstick Post) had the least retention. Group 2b (RelyX Post) was also statistically significant than group 1b and 3b.

Table 8: Retention of three Groups in Newton (N)

Group 1b (Everstick)	Group 2b (RelyX)	Group 3b (Macrolock)
84.12	142.15	164.38
83.22	138.20	160.48
79.17	139.22	168.17
84.78	140.43	165.12
88.18	144.52	163.30
86.88	143.78	162.89
80.43	145.49	167.71
84.19	142.09	159.14
87.09	138.94	170.22
83.48	144.28	158.31

Table 9: Statistics for Retention values (one-way ANOVA Test)

Groups	n	Mean	SD	F-value	p-value
Group 1b	**10**	84.15	2.841	1668.77	**0.000**
Group 2b	**10**	141.91	2.600		
Group 3b	**10**	163.97	3.962		

As per the obtained statistical results, the p value is significant, $p<0.05$.

Intergroup Comparison (Tamhane's Post Hoc Test)

Table –10 Retention of Group 1b Vs Group 2b

	Mean	SD	Mean difference	Standard error	p-value
Group 1b	84.15	2.841	79.818	1.54	**0.000**
Group 2b	141.91	2.600	22.062	1.49	**0.000**

$p < 0.05$ Group 1b is statistically significant than Group 2b

Table –11 Retention of Group 1b Vs Group 3b

	Mean	SD	Mean difference	Standard error	p-value
Group 1b	84.15	2.841	57.756	1.21	**0.000**
Group 3b	163.97	3.962	22.062	1.54	**0.000**

$p < 0.05$ Group 1b is statistically significant than Group 3b

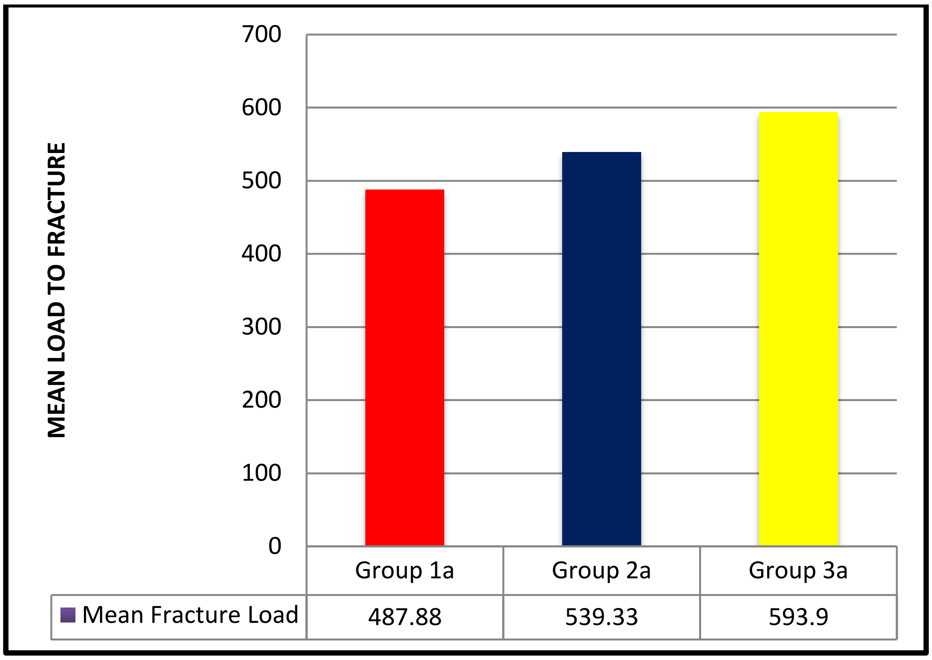
Table – 12 Retention of Group 2b Vs Group 3b

	Mean	SD	Mean difference	Standard error	p-value
Group 2b	141.91	2.600	57.756	1.21	**0.000**
Group 3b	163.97	3.962	79.818	1.54	**0.000**

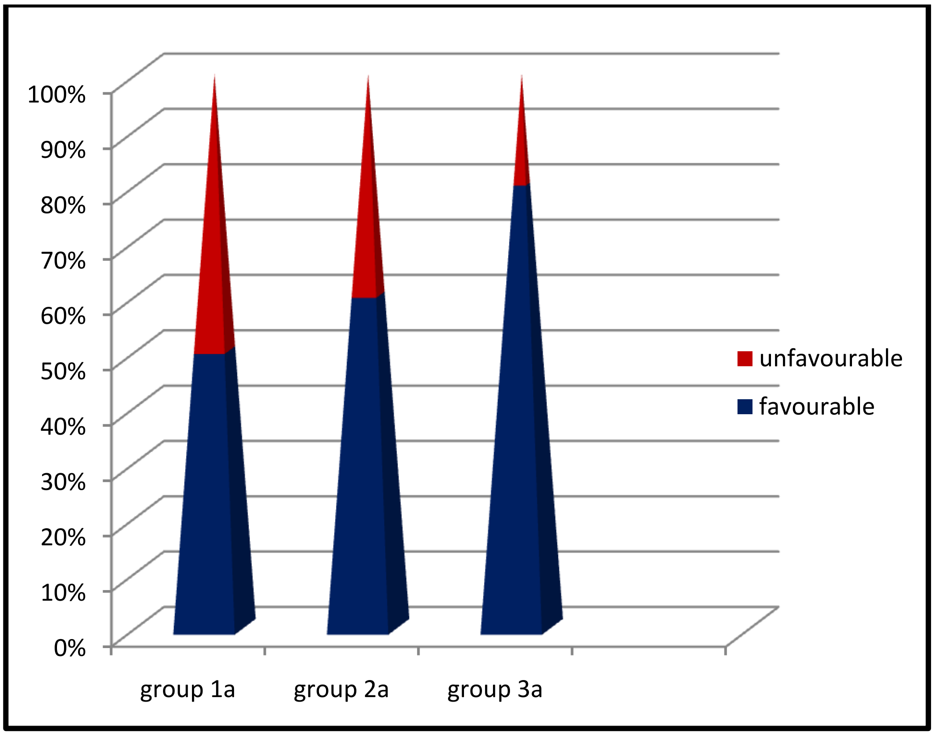
$p < 0.05$ Group 3b is statistically significant than Group 2b

GRAPHS

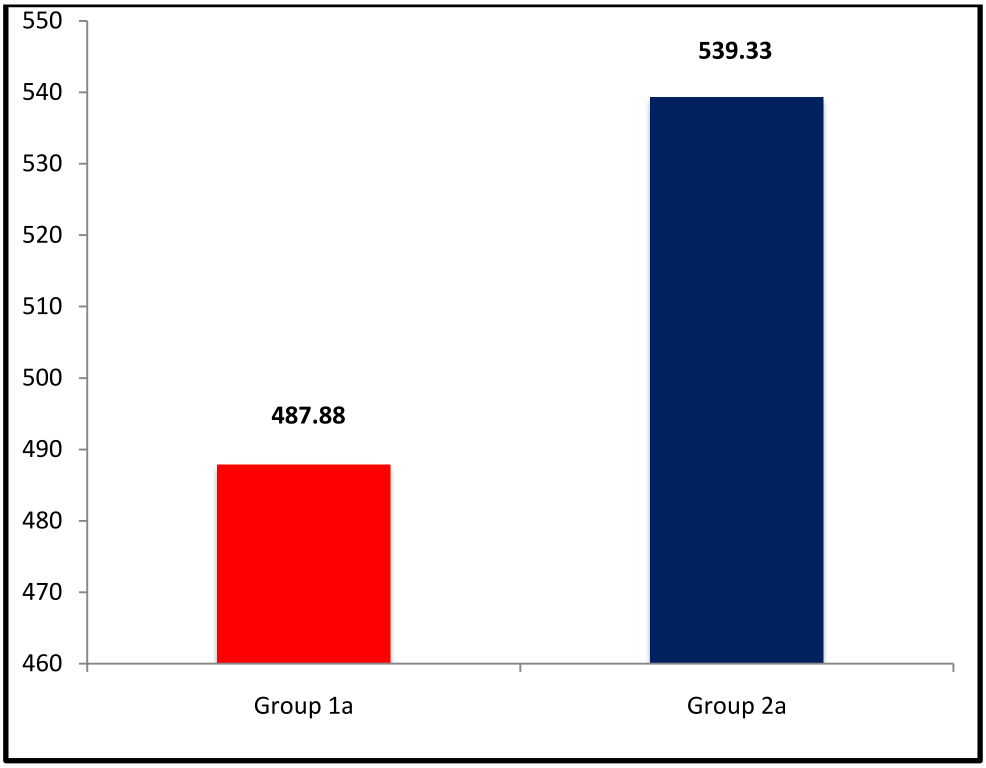
Graph 1- Mean Fracture Resistance



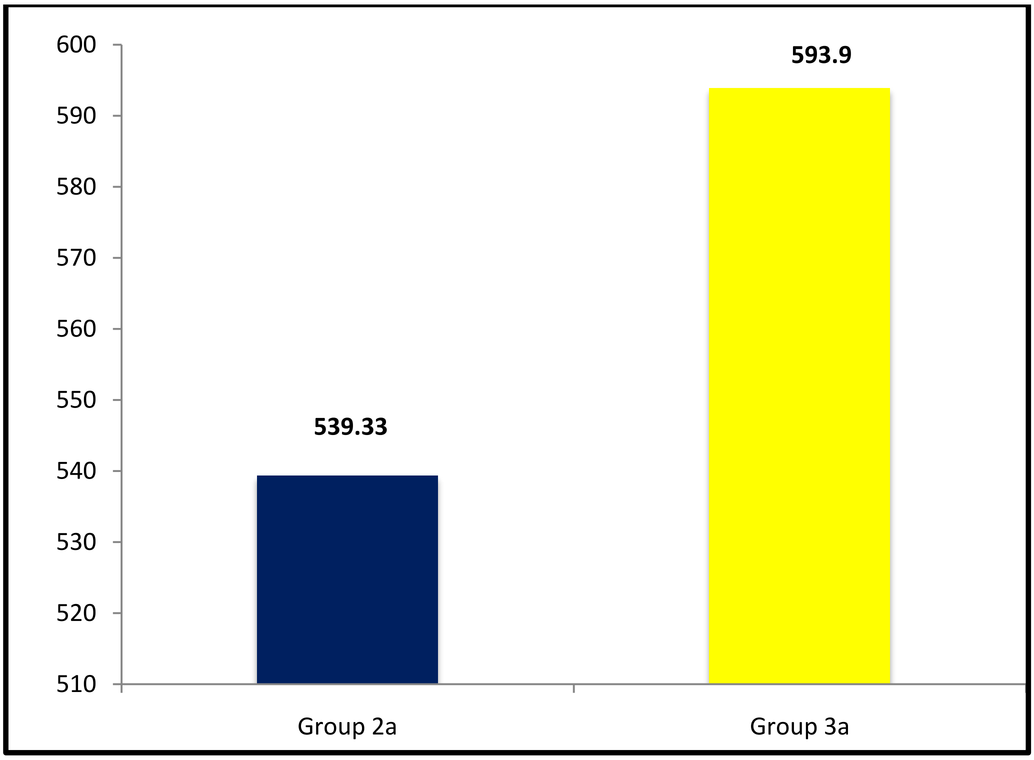
Graph 2- Failure modes of each group



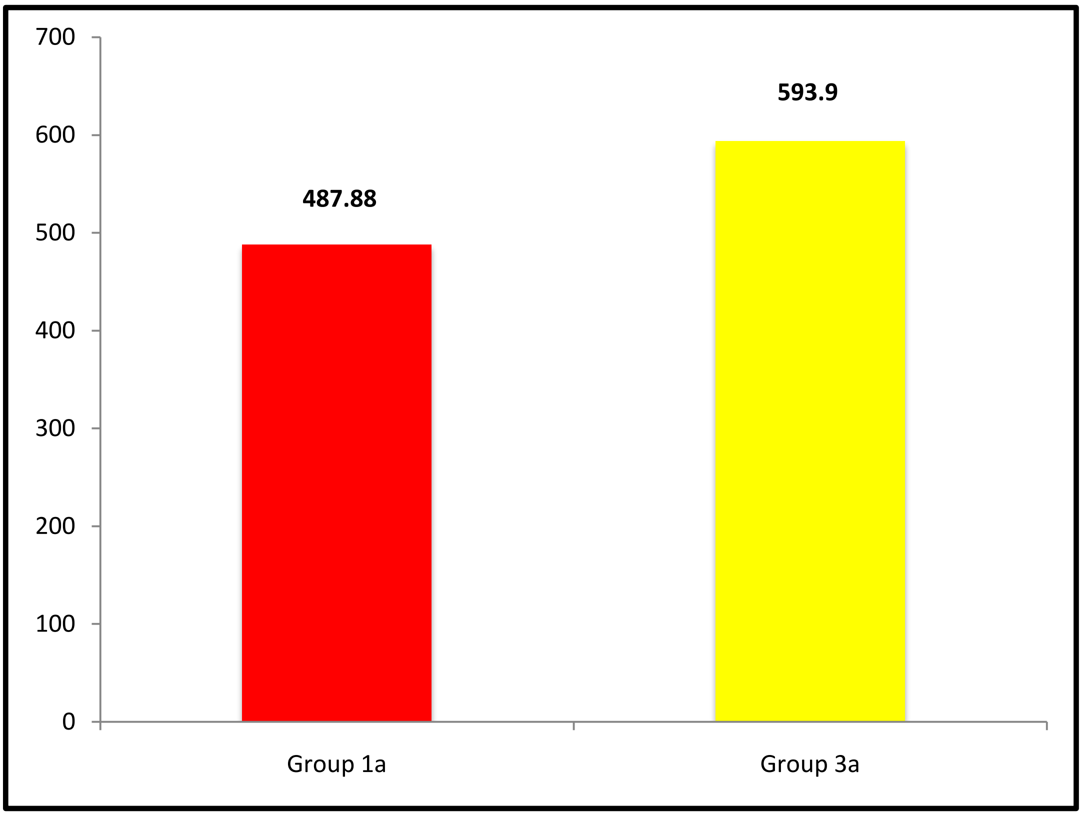
Graph 3 - Fracture Resistance of group 1a Vs group 2a



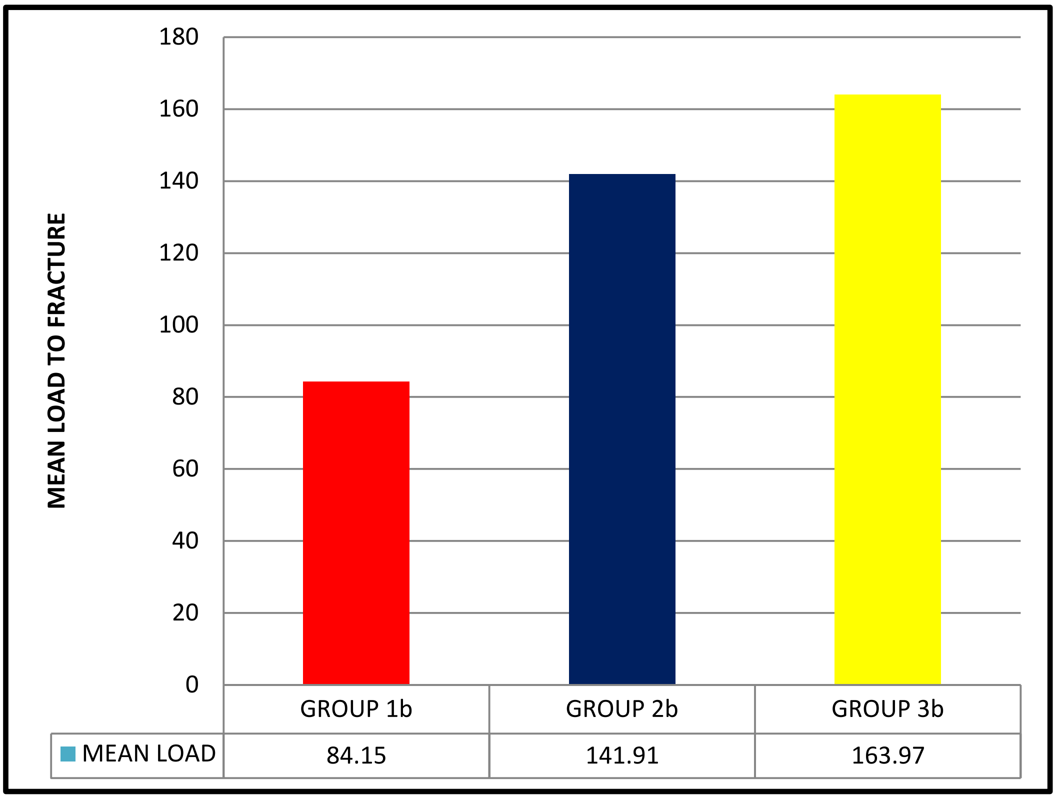
Graph 4 - Fracture resistance of group 2a Vs group 3a



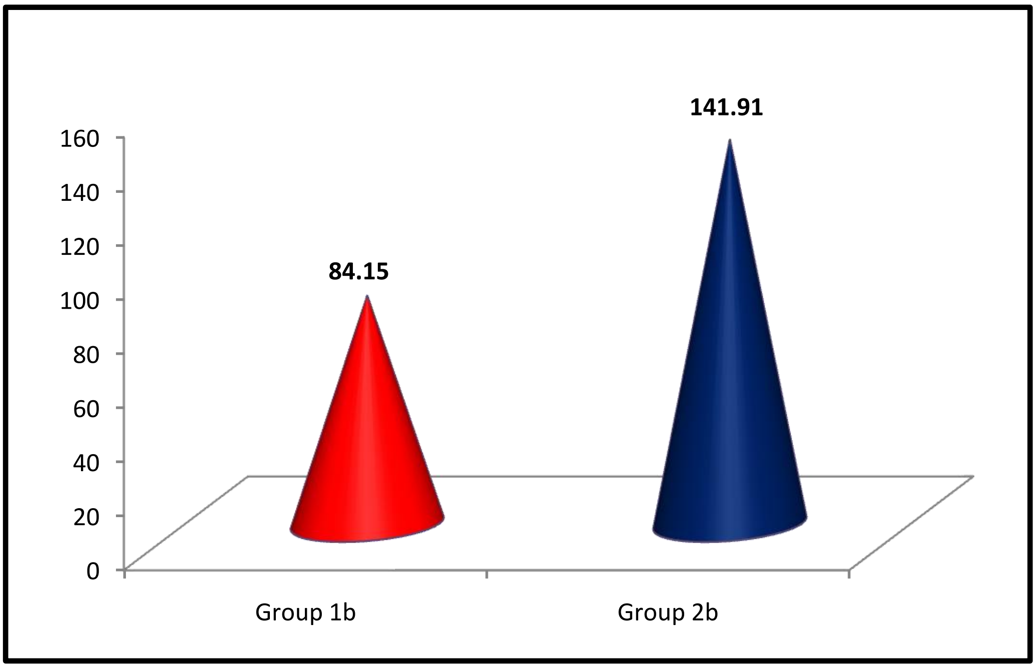
Graph 5 -Fracture resistance of group 1a Vs group 3a



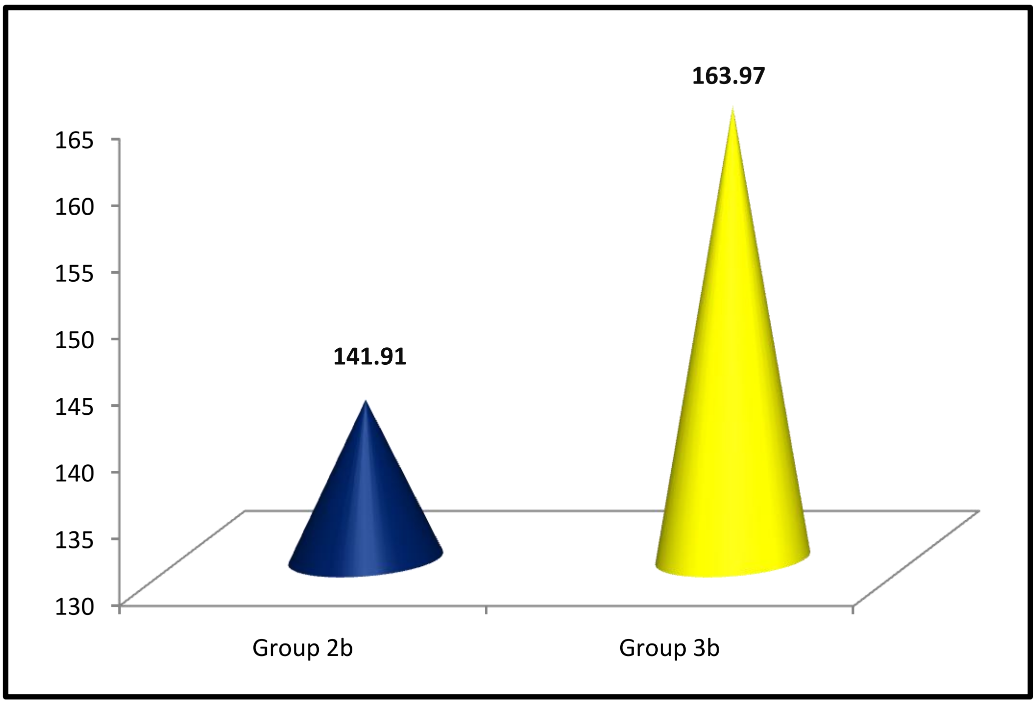
Graph 6 - Mean Retention



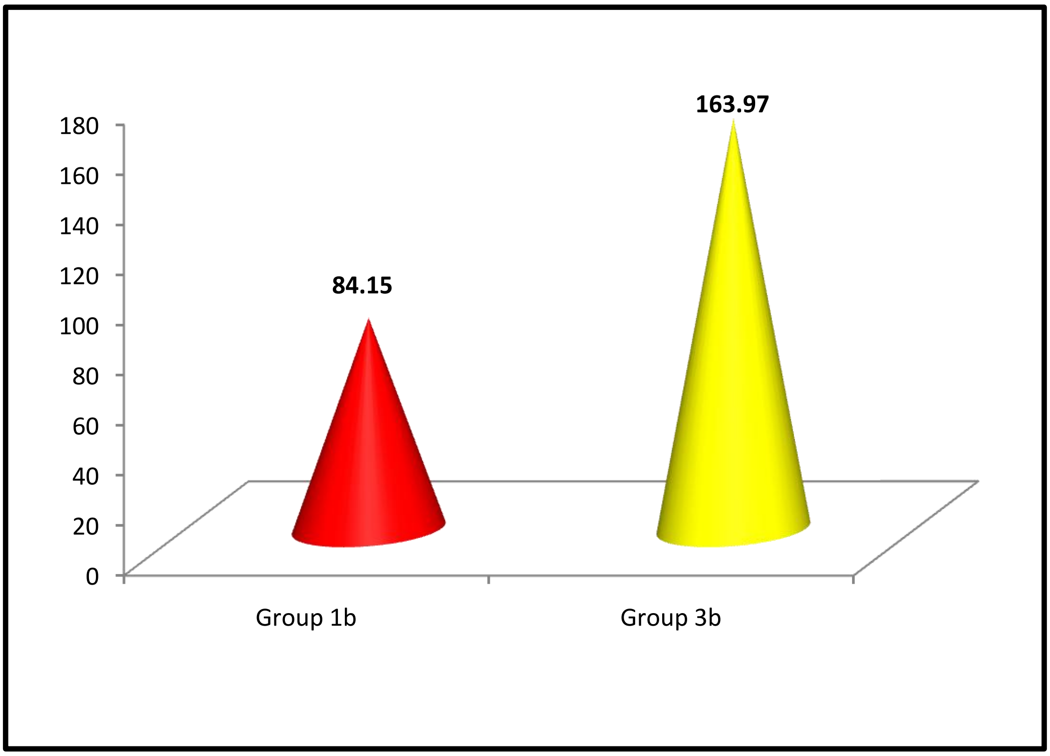
Graph 7 - Retention of group 1b Vs group 2b



Graph 8- Retention of group 2b Vs group 3b



Graph 9 - Retention of group 1b Vs group 3b



DISCUSSION

Teeth which are endodontically treated often have limited amount of remaining coronal structure and as such require a post retained restoration. [94] The idea of placing posts for strengthening the teeth was questionable since 1980’s. Later on it was proved that posts were used mainly for the retention of core and crown restorations. [95]

Almost all in-vitro studies showed that the post and cores fails to increase the fracture resistance of the endodontically treated teeth.[13,14,28] The endodontically treated teeth with natural crowns had greater strength than the teeth that were restored with custom fabricated post and core restorations.[28]

Traditionally custom fabricated post and core had been widely used to re-establish the dental structures lost during endodontic treatment. The custom fabricated post and core had some disadvantages such as poor retention, poor stress distribution, root fractures and difficulty to retrieve them from root canals.[13,94] The prefabricated metal posts also had the same problems.[17,26,48]

The rigid metal posts had a great disadvantage that they resisted lateral forces without distortion and this result in stress transfer to less rigid dentin causing potential root cracking or fracture.[95,96]

According to Duret and colleagues, an ideal post should have similar shape to the lost dentin volume and mechanical properties identical to dentin to provide long lasting bonding. The post should not induce tension while being set and minimal root canal preparation should be done to fit the post. This led to the development of non-metallic posts based on carbon-fiber reinforcement.[52,95] These posts had a tensile strength and modulus of elasticity similar to that of dentin.[27,40] The carbon fibre posts were black in colour hence, they were neither aesthetic nor did they conduct light. To compensate both of these factors, the silica fibre posts which are translucent and tooth coloured were introduced.

Literature review reveals increase in use of low modulus prefabricated posts. The prefabricated endodontic posts are classified according to shape and surface configuration. They are basically parallel, tapered or parallel tapered.[97] The tapered posts showed greater stress concentration at the coronal shoulder. These posts also exhibited a wedging effect on the teeth.[15,16] The reason for lower concentration of stress at the apex in these posts was due to absence of sharp angles and conservation of tooth structure during post space preparation.[29]

The posts placed in intact endodontically treated teeth did not increase the force required to fracture.[14] Moreover the post space preparation also significantly weakens the endodontically treated teeth. But Leary JM and Hunter A, proposed that cemented posts of moderate diameter showed some reinforcement than non-posted teeth.[22,24]

The posts with higher modulus of elasticity cause the root fractures when they fail. Comparatively the low modulus posts like fiber posts, even though have lower fracture resistance than metal posts, causes only little damage to the remaining tooth structure.[97]

The intrinsic anatomy of the root canal system creates many challenges giving importance to the necessity of proper disinfection, obturation and post space preparation. One such canal type which leaves lot of questions is the oval shaped canal.[98] The difficulties of completely eliminating gutta percha remnants, endodontic sealer and the smear layer from the post space walls are highly increased in oval canals. This led to the introduction of oval shaped posts which would not compromise or alter the shape of the root canal during post space preparation and post adaptation. There are only few studies which evaluate the fracture resistance and retention of fiber posts in endodontically treated teeth with oval canals.[99]

The results of this study stated that anatomically shaped posts increased the fracture resistance and retention of the tooth with oval canals. Several studies have explained the different mechanical testing methods evaluating the fracture resistance and retention of fiber post in terms of different canal anatomies. In this study the fracture resistance and retention of 3 fiber post systems differing in their geometries were tested under universal testing machine in endodontically treated teeth with oval root canal.

All the posts used in this study were fiber posts. These posts were selected because they possess flexural strength and modulus of elasticity similar to that of dentin.[40,44,56] Another advantage of fiber post is the capacity of glass particles to conduct light which may improve the polymerisation of resin luting cement.[49] Many studies indicate that these posts had a better adhesive bond with the resin luting cements.[50,59,100]

The standardization of the tooth samples was done by taking mesiodistal and buccolingual radiograph of each tooth. The ratio between the long and short canal diameter at 5mm from the apex was calculated. A ratio greater than 2 was assumed to be an oval canal.[104] The lengths of the teeth were standardized with the root section of all samples as 13$\pm$1mm. The apical diameters of all posts have been standardized to 0.9mm. Another variable which can affect the result is the post length which was standardized to 7mm inside the canal.

The post space was prepared with the respective drills provided by the manufacturer to enable the standardization.

Luting agent plays an important role in the success of post and core unit. The resinous material if used as luting system could significantly increase the fracture resistance of glass fiber posts.[101,102] The glass fiber post display a greater level of flexibility than metallic posts, this would cause flexion of the glass fiber post inside the canal. The resin luting system should have the elasticity to compensate this action. [76]

The curing mode affects the bond strength of resin cements. Usually maximum polymerization is required for achieving optimal bond strength. The photo radiation of dual curing resin cement after cementation improved push out bond strength.[80] In the present study also the dual cure resin cement was used with post cementation light curing to improve the degree of conversion.

Another factor that can affect the result is the interference of the sealer with the resin luting cement. There are studies which prove that eugenol based sealers interfere with the bonding of resin luting cements to the root canal dentin.[103]

In the present study Endorez resin sealer was used which is a UDMA based sealer so as to reduce the degree of interference of the sealer to the resin luting cement.

The core build up was standardized by using a custom made polyethylene matrix which had been used in previous studies.

Artificial periodontal ligament simulation was used. Sores CJ et al., proved that the root embedment method have a significant effect on fracture resistance of teeth.[105] The angle of impact of force during fracture resistance analysis had been standardized at 45°.[52,68,82] This angle was used to simulate the contact angle of class I occlusion between the maxillary and mandibular premolars. The load was given at a crosshead speed of 1mm/min.[75,82]

The results of the present study showed that fiber posts with oval shape exhibit maximum fracture resistance and retention followed by round post. The highest fracture resistance and retention of the group3 (Macrolock oval) could be mainly due to its shape and design. The unique oval shape provides anti-rotation benefit, while replacing weaker cement with high strength fiber composite. Oval fiber posts are preferable to circular fiber posts in oval-shaped canals, given the stress distribution at the post-dentin interface, close adaption into the canals and the thinner layer of resin cement between the post and the root dentin. Macro retentive serrations interlock with the cement & core material to increase retention. The additional bulk of fibres in the middle portion of the post offer maximum strength and fracture resistance which helps in protecting the tooth. Passive grooves lock into the cement in the round apical portion.[109] The better performance of Macrolock oval post maybe attributed to the above mentioned factors. Another factor to be considered here which could have been in favour of Group 3 is the composition of the resin luting cement (SealBond) which was used to affix the oval posts. Sealbond resin cement is UDMA based resin cement, which is in accordance with the composition of EndoRez resin sealer. Therefore there would have been minimum interference of the root canal sealer with the resin luting cement.

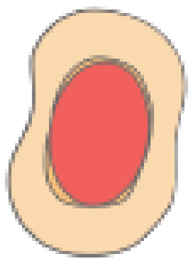


Fig-17 Cross sectional view of oval post adaptation

Group 2 performed significantly less than Group 3. In contrast with Macrolock Oval post which has round configuration in the apical part and oval configuration in the coronal part, RelyX has uniform cylindrical shape. One of the possible reasons for this could be the presence of large volume of cement around the cylindrical post to fill the empty root canal. This may cause reduced cohesive resistance of the cement and even reducing the bond strength to dentine. It has been reported in several studies that reduced cement layer thickness prevents cohesive failures and causes increase in retention of the post.[106]

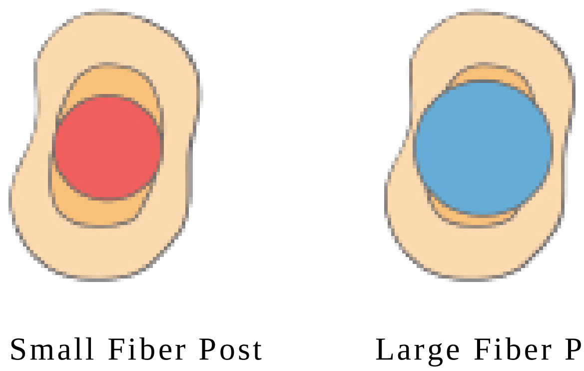


Fig-18 Cross sectional view of cylindrical post adaptation

The least fracture resistance and retention was found with the group1 i.e., flexible post. This could be due to less density of fibres than other groups and the cement layer around the post was thicker which caused lowest fracture strength and retention values among all the groups.[106]

On comparing the failure modes, the highest amount of unfavourable root fractures occurred in Group 1, this could have been due to the uneven distribution and less density of fibres which would have caused more stress on the tooth resulting in more amounts of unfavourable fractures.[106] Even though Group 2 had better fracture resistance they resulted in more unfavourable failures i.e., 4 samples out of 10. According to Kishen A et al during post endodontic preparation removal of more amount of inner dentin would result in more catastrophic fractures. Group 3 had least number of unfavourable failures. This could have been due to the uniform stress distribution and design of the post.

The present study was done to simulate the clinical situations by the formation of simulated periodontal ligament and core placement. However it is difficult to extrapolate the results directly into clinical practice as the oral conditions cannot be replicated perfectly. Another factor to be considered is the static load which was applied on samples. It does not truly represent the intraoral myriad of forces acting on the tooth. The study also evaluated the mandibular premolars with oval canals and therefore the results can be applied only to that group of teeth.

Further studies are required to check the fracture resistance and retention of these posts in clinical conditions. Studies can also be carried out to evaluate the push out bond strength of these posts at each level of root.

SUMMARY AND CONCLUSION

A wide variety and number of prefabricated posts are available in dentistry, in different geometries and sizes. Some aspects that can influence the post endodontic restoration include its length in the root canal, its size, its shape and the type of luting cement used to fix it. The aim of the current study was to evaluate the fracture resistance and retention of three glass fiber post systems in endodontically treated teeth with oval canals in relation to the post geometry.

Sixty single rooted mandibular premolars with oval canals were decoronated to length 13±1 mm. The working length was determined, cleaning and shaping was performed by crown down technique and obturation was completed.

Obturating material was removed upto 7mm with heated pluggers. The samples were divided into three groups (n=20). Group 1–Everstick Fiber Post ; Group 2–RelyX Fiber Post ; Group 3–Macrolock Oval Fiber post. The post spaces were prepared using respective size drills. Then the posts were luted using dual cure resin cement.

Each group was then divided into 2 subgroups ‘a’ and ‘b’ (n=10). Subgroup ‘a’ for fracture resistance test and subgroup ‘b’ for retention test.

The core build up was done for the samples in subgroup ‘a’ with direct composites using custom made polyester matrices of same size and shape for fracture resistance test. No core build-up was done for samples in subgroup ‘b’. All samples roots were mounted on resin blocks with simulated periodontal ligament. The models for fracture resistance test were then loaded in universal loading machine at 45º angulation with a cross head speed 1mm/min. The models for retention test were held in the testing machine and the posts were extracted using vice clamps mounted in the universal testing machine operated in tensile mode at 1mm/min.

The results of fracture resistance test showed that Group 3a (oval post) showed highest fracture resistance followed by Group 2a (cylindrical post) and the least was Group 1a (flexible post). The most number of unfavourable fractures were found with Group 1a followed by Group 2a; Group 3a had least number of unfavourable fractures.

The results of retention test showed that Group 3b (oval post) showed highest fracture resistance followed by Group 2b (cylindrical post) and the least was Group 1b (flexible post).

Considering the canal anatomy and the post geometry, the oval shaped posts had promising results in oval shaped canals when comparing with the cylindrical and the flexible posts.

From the present study it can be concluded that

- The teeth restored with oval fiber post resulted in higher fracture resistance in oval shaped canals.
- The teeth restored with cylindrical fiber post had better fracture resistance than the flexible fiber post but less than that of oval fiber posts.
- The teeth restored with oval fiber post resulted in higher retention in oval shaped canals.
- The teeth restored with cylindrical post had better retention than the flexible fiber post but less than that of oval fiber posts.
- The teeth restored with oval fiber post had less number of unfavourable failure followed by cylindrical post.

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