COMPARISON OF THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH THREE FIBER REINFORCED MATERIALS AT DIFFERENT LEVELS: AN IN VITRO STUDY

By

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Master of Dental Surgery

In

Branch IV - Conservative Dentistry & Endodontics

Under the guidance of

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Dept. of Conservative Dentistry & Endodontics

St. Gregorios Dental College

Chelad, Kothamangalam
2020-2023

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled "Comparison of the Fracture Resistance of Endodontically Treated Teeth Restored with three Fiber Reinforced Materials at Different Levels: An In Vitro Study" is a bonafide and genuine research work carried out by me under the guidance of Prof. Dr Robin Theruvil, Department of Conservative Dentistry & Endodontics, St. Gregorios Dental College, Chelad, Kothamangalam.

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CERTIFICATE BY THE GUIDE

This is to certify that the dissertation “Comparison of the Fracture Resistance of Endodontically Treated Teeth Restored with three Fiber Reinforced Materials at Different Levels: An In Vitro Study” is a bonafide research work done by Dr Ann Mariya Sunny, in partial fulfilment of the requirement for the degree of Master of Dental Surgery.

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Date:

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ABSTRACT

AIM

To evaluate the fracture resistance of endodontically treated teeth, when restored with three different fiber reinforced materials placed at three different levels.

MATERIALS AND METHODS:

70 intact maxillary first premolars were selected for the study and standardized based on anatomical measurements. It was then randomly divided into 10 Groups which consisted of one Control Group of intact premolars and 9 test Groups. The first 3 Groups were restored with Interlig FRC at the coronal 1/3rd, middle 1/3rd and cervical 1/3rd respectively. Groups 4 to 6, were restored using Ribbond FRC at the coronal 1/3rd, middle 1/3rd and cervical 1/3rd respectively. Groups 7 to 9 were restored using EverStick FRC at the coronal 1/3rd, middle 1/3rd and cervical 1/3rd respectively. Group 10 was kept as the Control Group. The teeth were endodontically treated and MOD cavities were prepared on the teeth with standardised dimensions. In Groups 1, 4 and 7, the fiber was placed at the cervical 1/3rd and rest of the cavity was restored using composite. In Groups 2, 5 and 8, the cavity was filled to the middle 1/3rd using composite resin. The fiber was placed in the middle 1/3rd and the rest of the cavity was built up using Composite. In Groups 3, 6 and 9 the cavity was filled to the occlusal 1/3rd with composite resin. A groove of 2 × 1 mm was made buccolingually on the cusp tips. The fiber was placed in this groove and restored with composite resin. All teeth were mounted on acrylic blocks and subjected to fracture on the Universal Testing Machine.

RESULTS: Fracture resistance was most for Interlig fiber followed by EverStick Fiber and the least was for Ribbond Ribbon Fiber. Fracture resistance was observed most when the fibers were placed at the cervical 1/3rd followed by occlusal 1/3rd and the least was for middle 1/3rd.

CONCLUSION: According to this study, Interlig fibers showed the greatest fracture resistance when compared with the other fibers. Although all fibers showed greater fracture resistance at the cervical 1/3rd when compared to the middle and occlusal 1/3rd, Interlig Fiber showed the most fracture resistance at the cervical 1/3rd when compared with the other fibers at the same position.

KEYWORDS: Fiber reinforced composites, Fracture resistance, Interlig fiber, EverStick fiber, Ribbond Ribbon fiber.

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INTRODUCTION

INTRODUCTION

Endodontically treated teeth have low fracture resistance when compared with sound teeth due to several reasons such as decrease in dentin elasticity, decrease in water content, and more importantly due to the extensive loss of tooth structure like the cusps, marginal ridges and the pulp chamber roof due to caries, previous restorations and endodontic access cavity preparation.[1]

Excessive loss of coronal tooth structure warrants the use of extensive restorative modalities such as cusp capping, post placement and/or crown. The success of endodontic treatment depends on the quality of the final restoration and endodontic treatment is considered incomplete without restoration of the crown. However, the selection of the best final restoration for endodontically treated teeth is still a matter of controversy and so far, a wide range of amalgam, direct and indirect composite resin and full-coverage restorations have been suggested.[2]

The risk of cusp fracture under occlusal forces is high in maxillary premolars due to their special anatomic configuration and their unique position in the dental arch. Furthermore, because of their location in the appearance zone during smiling, the esthetic factor should be taken into account in these teeth in addition to fracture resistance.[3]

Fracture resistance further decreases when such endodontic treatment is associated with mesio-occlusal-distal (MOD) cavities since the loss of marginal ridge integrity on both sides decreases the tooth's stiffness. Based on in vitro studies, maxillary premolars with deep MOD cavities are susceptible to fracture if extrinsic forces are applied.[4]

In particular, fracture of the palatal cusps occurs more frequently due to their anatomic form, an unfavourable crown: root ratio, dental arch position and exposure to shear and compressive forces. Thus, the remaining tooth structure and the efficacy of the restorative procedure to replace the lost structural integrity are crucial for the longevity of endodontically treated teeth.

Dental composite is one of those materials which is undergoing revolutionising changes in recent years. One of the most effective changes was the incorporation of fibers with particulate filler composite resin. Generally, mechanical properties of fiber reinforced composites (FRCs) structures have been found to be superior to that of non-reinforced composites.[4] Introduction of fiber reinforced composite resins (FRC) have led to an increase in the restoration of extensive cavities with composite resins. FRCs technology may solve many of the problems associated with a metal alloy substructure. When compared with metal alloys, FRCs offer many other advantages including non-corrosiveness, translucency, lower cost, higher aesthetic, good bonding properties and repair facility.[5] Furthermore, their strength to weight ratios are superior to those of most alloys. In addition to mentioned merits, FRCs give alternatives for both indirect and laboratory fabrication.[5]

A finite element analysis has shown that FRC post-and-core systems are more appropriate than inflexible metallic post-and-core systems due to a coefficient of elasticity similar to that of dentin and better protection of remaining tooth structure.[6]

The typical FRC materials are made of polymer matrix that is reinforced by fine fibers, which was introduced to overcome the shortcomings of conventional composite resin like brittleness, ease of crack propagation and polymerization shrinkage.

Different fiber types such as Carbon fibers, Kevlar fibers, Vectran fibers, Glass fibers, Polyethylene fibers have been added to composite materials.[7] Carbon fibers prevent fatigue fracture and strengthen composite materials, but they have a dark color, which is undesirable esthetically.[8] Kevlar fibers made of an aromatic polyamide, are the evolution of nylon polyamide.[8] They increase the impact strength of composite materials. However, they are also unesthetic, and hence, their use is limited.[9] Vectran fibers are synthetic fibers of new generation, made of aromatic polyesters. They show a good resistance to abrasion and impact strength, but they are expensive and not easily wielded.[7] Glass fibers consisting of glass interlaced filaments, improve the impact strength of composite materials. They have excellent esthetic properties, but do not easily stick to resinous matrix.[10] Polyethylene fibers improve the impact strength, modulus elasticity, and flexural strength of composite materials.[11]

Among them, glass fibers and polyethylene fibers and have a wide application in dentistry. So, in my study I have compared the fracture resistance of two types of glass fibers, which are Interlig and EverStick and a polyethylene fiber called Ribbond at different levels.

The FRC structure consists of light cure monomers, having the function of holding the fibers together in the composite structure, whereas fiber is the reinforcing part providing stability and stiffness.[12] FRCs are currently commonly used in several fields of dentistry such as fixed prosthodontics, restorative dentistry, periodontology, and in repairs of removable prosthodontic devices. The common types of fibers used in dentistry are glass and polyethylene fibers. Glass fibers have high tensile strength combined with low extensibility. Their transparent appearance makes them well suited for dental applications with high cosmetic demands. The components of glass fibers can be classified into six categories depending on their composition and application (A, C, D, E, R and S glass) with difference in mechanical and chemical properties.[13] Polyethylene fibers are one of the most durable reinforcing fibers available. They are made of aligned polymer chains, having low modulus and density, and presents good impact resistance. They are white in colour and thus it is possible to use them in aesthetic dental applications.[14]

Composites reinforced with fibers such as polyethylene and glass fibers have shown significant improvement in the marginal integrity and fracture strength of composite resins by the application of a fiber layer beneath the restoration.[15]

Several studies have confirmed the efficacy of high molecular-weight polyethylene fibers for the reinforcement of composite resins as stress breakers in extensive composite resin restorations, indicating that placement of these fibers increases the fracture resistance of endodontically treated teeth.[16]

The effectiveness of fiber reinforcement technology is dependent on many variables including the type of resin used, the quantity of fibers in the resin matrix, fiber type, length, form, orientation, adhesion to the polymer matrix and impregnation of fibers with the resin.[13] The use of each type of fiber within FRC structure has its own properties and advantages over the other type, therefore awareness of the advantages and limitations of each type of fiber will enable the clinician to select the best FRC for a particular clinical situation. There is limited number of literatures that compare between the two FRCs (glass and polyethylene fibers), and to make it easy for the dental practitioners to find out the appropriate material to use in dental clinics.

The present study, aims to preserve and reinforce the remaining tooth structure without cusp capping or post placement but only by using the reinforcement effect of composite fibers in different positions in extensive composite restorations of endodontically treated maxillary premolars. This study was designed to compare the fracture resistance of these teeth when restored with three fiber reinforced materials at different levels.

These fibers are placed at different levels, occlusal 1/3rd, middle 1/3rd and cervical 1/3rd of the coronal restoration and tested for its fracture resistance. This study was done to obtain the best position for fiber insertion which would offer the maximum fracture resistance to the tooth as well as the restoration.

AIM & OBJECTIVES

AIM

To evaluate the fracture resistance of endodontically treated teeth, when restored with three different fiber reinforced materials placed at three different levels.

OBJECTIVES

To compare the fracture resistance of endodontically treated teeth when restored using:

1. Three different fiber reinforced materials.
2. Fiber reinforced material placed at three different levels.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Eskitascioglu et al. (2002)[6] used polyethylene fibre ribbon in combination with bonding agent and flowable composite under composite restoration to act as a stress absorber because of its lower elastic modulus. This elastic layer between the composite and dentine was believed to have increased the fracture strength. Another explanation for this phenomenon was believed to be that due to the bonding ability of the material, the cusps may have bonded together.

Potter et al. (2004)[17] in his study addressed the critical aspects, such as effects of fabric layer thickness, ratio and configurations, fiber position and orientation as well as the test specimen size. However, the selection and use of continuous reinforcement was largely on an ad hoc basis, with diverse claims being made by manufacturers, without a thorough understanding of the material-based performance, demands for the material based on its specifics for application or details of response characteristic at levels beyond those of mere "strength" and "modulus". Further, each fabric was known to respond in different manner with respect to manipulation and drape to changes in substrate configuration.

Schwartz et al. (2004)[18] said that premolars are more likely than molars to be subjected to lateral forces with more detrimental nature. Bearing in mind their position in the esthetic zone, esthetic requirements should be fully achieved when restoring upper premolars.

Belli et al. (2005)[19] said that use of flowable resin in root-filled molar teeth with MOD cavities did not increase the fracture strength while on the other hand when a leno weave ultra-high modulus polyethylene fibre was inserted into the bed of flowable resin, the fracture strength of teeth was notably increased.

Gordan et al. (2006)[20] in his study said that common complication potentially contributing to the loss of integrity and influencing the resistance of a restored tooth was interfacial microleakage. This was caused by polymerization of composite resin and accompanied with contraction stress. The concomitant volume reduction generated a tensile force at the weakest area of the tooth-restoration interface, and stress-relieving gaps formed promoted microleakage. If these gaps exceeded 60 pm in width, postoperative sensitivity and secondary caries were observed at the outer margin of the restoration.

Karbhari et al. (2007)[21] showed that clinically, when each of the different fabric configurations was used to reinforce dental composites, there were manipulation changes that occurred to some of the fabric materials. For the biaxially braided material, the fiber orientation changed after cutting and embedment in the composite when adapted to the tooth contours. The fibers in the ribbon spread out and separated from each other and became more oriented in a direction transverse to the longitudinal axis of the ribbon. When the leno-weave is cut and embedded in dental composites, the fiber yarns maintained their orientation and did not separate from each other when closely adapted to the contours of teeth. However, due to the orthogonal structure, gaps appeared within the architecture. So, the unreinforced local areas were reinforced with fiber reinforcement. The unidirectional glass fiber material did not closely adapt to the contours of teeth due to the rigidity of the fibers. It was difficult to manipulate the fibrous material which left a thicker final composite material. Further manipulation caused the glass fiber to separate with some visible fractures of the fibers themselves.

Strassler et al. (2007)[22] in his study told that, when the glass fibers broke, it pulled out the composite resin such that a crack developed that propagated through the glass fibers. In the case of a lock stitch weave with a polyethylene fiber, the crack stopped at the node of the leno-lock-stitch weave of the fiber ribbon, thus maintaining the integrity of the fiber reinforcement. The study tested a variety of fiber reinforcement materials. Their conclusion was that it was crucial that an appropriate fiber architecture be selected, not just from a perspective of higher strength, but one which has an overall damage tolerance and energy absorption. Differences in weaves and architectures resulted in substantially different performance and appropriate selection mitigated premature and catastrophic failure.

Tushima et al. (2008)[23] found that using a bonding agent without filler produced less flexural strength than the bonding agent with filler. Resin which contained filler allowed suitable fiber wetting which produced maximum reinforcement. The compatibility of the bonding agent with the composites was definitely a very important factor in affecting flexural strength.

Tuloglua et al. (2009)[24] in his study said that, development of fiber reinforced composite (FRC) technology brought a new material into the realm of metal-free, adhesive esthetic dentistry. Not only was the combination of composite resin and FRC shown to have significant benefits in terms of mechanical properties but the possibility of direct chair side application and the ability to bond to tooth structure made fiber-reinforced composite (FRC an attractive choice) available for a variety of dental applications.

Eronate et al. (2009)[25] reported that the degree of impregnation of the fiber used for reinforcement affected its characteristics. When the degree of impregnation was not enough, voids were created in the polymer matrix. This decreased the mechanical characteristics such as flexural strength in FRC. This caused water absorption in FRC and in long terms affects the consistency of FRC in the moist oral cavity.

Tang et al. (2010)[26] reported that post endodontic tooth fractures occurred due to the loss of tooth structure and induced stresses caused by endodontic and restorative procedures such as access cavity preparation, instrumentation and irrigation of the root canal, obturation of the instrumented root canal, post space preparation, post selected, coronal restoration and from inappropriate selection of tooth abutments for prostheses.

A. Lucchese et al (2011)[27] conducted a study to compare the morphological characteristics and to evaluate the capacity of impregnation through a SEM analysis of two types of fiber-reinforced composites (FRC's): Everstick and Ribbond. The SEM observations indicated that the two types of fiber-reinforced composites showed structural characteristics differing in number, diameter, length and orientation and showed that the usage of fiber-reinforced composites, without a preliminary treatment through impregnation of the fibers with fluid resin, determined imperfections at a level that could compromise clinical applications.

When using fiber-reinforced composites as a product in a fixed retention system, it is recommended that the fibers are subjected to a preliminary treatment in order to enhance their morphology and maximize their clinical efficiency.

Khan et al. (2013)[28] compared the in vitro fracture resistance of endodontically treated molars with mesio-occluso-distal (MOD) cavities restored with two different types of fibers. Both polyethylene ribbon and glass fiber under MOD composite restorations significantly increased the fracture strength with no statistical difference between the two groups. Therefore, both polyethylene and glass fiber reinforced composites can be used for access cavity restorations in teeth with weakened cusps.

Bassir et al. (2013)[29] conducted a study to evaluate the fracture resistance and mode of fracture of endodontically treated human premolars with different amounts of remaining tooth structure. 70 premolars were assigned into 7 groups. The fracture resistance was assessed under compressive load in a universal testing machine. Mode of fracture was assessed under stereomicroscope. It was concluded that the teeth with adhesive restorations showed significantly higher fracture resistance values as compared to non-restored ones.

Ilday et al (2014)[30] said that fiber-reinforcement is currently a popular approach in aesthetic dentistry to improve the mechanical properties of dental materials. The type of fiber that is used to restoration depends on the purpose of its usage and characteristics. In fiber-reinforced composite resin (FRC) restorations, the main function of fibers is usually to increase the stiffness and strength. FRC should be strong enough to support a significant load with minimal elastic distortion. In addition, the FRC infrastructure is semi-transparent and does not require opaque masking, which allows relatively thin layer composite resin application and excellent aesthetic appearance. Thus, they are used in adhesive bridges in anterior with their optical properties as well as their mechanical properties.

Chandra et al. (2014)[31] reported that, Interlig (by Angelus dental) is a braided glass fiber impregnated with light-cured composite resin. It is biocompatible, esthetic, translucent, practically colourless and disappears within the composite or acrylic without show-through. It is manufactured by a process called resination where the fibers are pulled along a convoluted path through the resin bath. Pressures at the rollers, force the resin into the fabric or fiber bundles.

Robert A. Lowe (2015)[32] in his work explains about EverStick, which raises the bar in fiber reinforcement of dental restorations. The unique composition of EverStick also expands the clinical application for the uses of fiber reinforcement in the general dental practice. The product itself has different designs (eg, diameter, number of fibers) for different dental applications. Each consists of fiber reinforcement imbedded in a matrix of polymethyl methacrylate (PMMA) and bis-GMA (interpenetrating polymer network), making the fibers bondable not only to direct but also to indirect dental materials. EverStick® C & B is commonly used for direct resin bridges and provisional dental restorations. EverStick® Post is used for endodontic posts in combination with direct resin crown build-ups. Finally, everStick®Perio is typically used for periodontal splints and orthodontic retention. This article describes and demonstrates some of the clinical uses of this very useful and unique dental material.

Deliperi et al. (2017)[33] in his work presented a restoration technique based on an understanding of the biomechanical properties of the dentinoenamel complex and the physico-mechanical properties of the resin-based composite and included the stress generated from both polymerization shrinkage and occlusal forces. The dentinoenamel complex is a functional interphase that provided crack tip shielding and should be preserved during restorative procedures. The term ‘‘wallpapering’’ described a concept of covering the cavity walls with overlapping closely adapted pieces of Leno weaved ultra-high-molecular-weight polyethylene ribbons. The ribbons are adapted and polymerized as closely as possible against the contours of the residual tooth substrate. The resulting thin bond line between the fibers and the tooth structure created a ‘‘bond zone’’ that was more resistant to failing due to the intrinsic stress and energy absorbing mechanism of the ribbons. The formation of defects and voids, from which crack propagation started was also reduced. The fiber's tight adaptation to tooth structure allowed a dramatic decrease of the composite volume between the tooth structure and the fiber, thus protecting the residual weakened walls from both the stress from polymerization shrinkage and the occlusal load. Thus, fiber reinforced stress was less in direct composite restorations, making it possible to be a part of the restoration of structurally compromised vital and nonvital teeth.

Shah et al. (2019)[34] in his in-vitro study evaluates and compare the flexibility and bond strength of stainless-steel wire, glass fiber reinforced composite and polyethylene fiber reinforced composite used in splinting of traumatized permanent teeth. The highest flexibility was observed with polyethylene fiber reinforced composite, followed by stainless steel wire while glass fiber reinforced composite demonstrated the lowest flexibility. Polyethylene fiber reinforced composite showed the highest bond strength, followed by glass fiber reinforced composite, while stainless steel wire exhibited the least bond strength.

Doshi et al. (2019)[35] explained in his study that E-glass fiber post showed a significantly higher fracture resistance than the glass fiber or carbon fiber posts, which may be attributed to its minimal preparation of post space, lower modulus of elasticity, and the unique technique of placement and bonding. There was no catastrophic failure in this group. The mode of failure of the samples was due to debonding of composite cores, which is considered favourable as it can be repaired.

Scotti et al. (2020)[36] mentions in his study that, direct resin composite restorations are the most widespread, useful, and least invasive approach to restore endodontically posterior teeth. To increase fracture resistance, glass fibers and fiber posts have been inserted into direct composite restorations. Particularly, ultrahigh-molecular-weight polyethylene fiber with an ultrahigh elastic modulus were tested to reinforce the polymer-based materials.

Shafiei et al. (2021)[37] evaluated the effect of fiber reinforcement on the fracture resistance of endodontically treated teeth restored with flowable or paste bulk fill composite resin compared to conventional composite resin. The conventional nanohybrid composite resin with flowable and bulk fill composite resins without fiber had comparable fracture resistance. Fiber significantly increased the fracture strength of endodontically treated premolars restored with conventional composite resin. Although this reinforcing effect was not statistically significant for flowable and bulk fill composite resins, the strength of bulk fill composite resin with fiber was comparable with conventional composite resin with fiber. Therefore, it was suggested that bulk fill composite resin with fiber simplified the composite placement along with added advantage of better adaptability.

Vatsal et.al. (2021)[38] in his study compared the fracture strength of a natural tooth pontic reinforced with polyethylene-fiber post vs glass-fiber post. The mean fracture strength of polyethylene (Ribbond) fiber post was 56.7±13.0 MPa and glass (Interlig) reinforcement fiber post was 38.56±8.68 MPa. A significant difference was observed between the mean fracture strength of polyethylene (Ribbond) fiber post and glass (Interlig) reinforcement fiber post. Both the fiber reinforced splint materials were effective in stabilizing the natural tooth pontic. Ribbond fiber, a polyethylene fiber post, had better fracture strength than Interlig glass fiber post and was used effectively for the stabilization of the natural tooth pontic.

Agrawal et al. (2022)[39] analysed the outcome of fiber placement and orientation over fracture resistance in wide Class II (MOD) cavities prepared on maxillary premolars. Fiber placement significantly increased the fracture resistance. The highest fracture resistance was shown by the horizontal orientation of polyethylene fiber on both pulpal and gingival floor of MOD cavities and gave the highest fracture resistance in maxillary premolars and repairable mode of fracture.

Jakab et al. (2022)[40] reviewed the available literature evaluated and compared the mechanical performance of the different materials and methods utilized for horizontal splinting in large MOD cavities. Seven out of eleven studies showed that horizontal splinting with long fibers improved the fracture resistance of the restored teeth. Three articles showed no significant difference between the fracture resistance of the restored groups. Only one article reported a lower fracture resistance to the horizontally splinted group when compared with conventional direct composite restoration. Within the limitations of this review, evidence suggested that long fiber reinforcement could be used to improve the fracture resistance of heavily restored teeth.

Sfeikos et al. (2022)[41] reviewed the literature and evaluated and compared the influence of different fiber reinforcement types on the performance of posterior large composite restorations. The study comparisons between glass (continuous or short) and polyethylene (woven) fiber-reinforced composites (FRCs) in posterior cavities of human teeth, and reported the effect of fiber inclusion on fracture resistance, microleakage, and marginal adaptation of restorations. Four out of nine studies, which tested the fracture resistance of FRC restorations, revealed similar performance of the glass and polyethylene fibers and the rest majority showed superior reinforcement of glass fiber. Moreover, the reviewed studies revealed that, using fibers within the composite restorations reduced the microleakage and improved the marginal adaptation of the restoration, regardless of the fiber type. FRCs strengthened the restorations of structurally compromised teeth and improved their performance when compared with plain composite restorations.

RELEVANCE

This study focuses on how to increase the fracture strength of an endodontically treated teeth without sacrificing existing tooth structure or by over-preparation. This study helps to preserve the natural esthetics, shade and the contour of teeth. Following caries removal and endodontic treatment, the residual tooth structure needs to be preserved and used as a substrate for adhesion. The stress and shrinkage due to polymerization of an extensive post endodontic composite restoration is one of the factors that affects the outcome of the final restoration. The reinforcement of the restoration using fiber reinforced materials can help overcome these deficiencies.

There are different fibers available in the market. However, not many studies are reported where they are compared. In addition, the level at which these fibers are placed to provide maximum strength for the restoration is taken into consideration.

This study was conducted on tooth samples with a Class II MOD preparation to simulate the tooth structure lost due to caries process. The fibers were placed buccolingually to splint both the cusps together.

The 3 fibers used in this study for comparison for maximum fracture resistance were Interlig fiber splint, Ribbond Ribbon Splint and GC Everstick fibers. They were further compared by placing them in the occlusal 1/3rd, middle 1/3rd and cervical 1/3rd of the coronal restoration to see which position showed the maximum fracture resistance.

MATERIALS AND METHODS

MATERIALS AND METHODS

RESEARCH APPROACH

Qualitative and Quantitative analysis

RESEARCH HYPOTHESIS

Placement of fiber reinforced materials as part of the coronal restoration of endodontically treated teeth increases its fracture resistance. Fracture resistance differs when the same fiber is placed at different positions.

NULL HYPOTHESIS

There is no significant difference between fracture resistance of endodontically treated teeth restored with different fiber reinforced materials, when the fiber reinforced materials are placed at different positions.

STUDY DESIGN

In vitro study

STUDY SETTING

Study was conducted at:

St. Gregorios Dental College, Chelad, Kothamangalam.

J.J. Murphy Research Centre, Rubber Park India (P) Ltd.

SAMPLE AND SAMPLE SIZE

Sample size was calculated using statistical package G*power (3.1.5)

The minimum sample size was obtained as n= 7 samples per Sub Group. The total sample size required for this study was 70(10*7).

Figure 1: Tooth Samples

The materials and methodology used for this study are described under the following headings:

1. Selection of specimens

2. Armamentarium

3. Specimen preparation

- Class II MOD preparation
- Endodontic preparation & obturation
- Restoration using fiber reinforced composite at different levels

4. Fracture testing

5. Statistical analysis

SELECTION OF SPECIMENS

70 Human permanent multi rooted maxillary first premolars, freshly extracted for orthodontic purposes were collected from the Department of Oral and Maxillofacial Surgery, St. Gregorios Dental College.

INCLUSION CRITERIA

- Multi rooted premolars
- Non carious teeth
- Teeth with complete root formation

EXCLUSION CRITERIA

- Immature teeth with open apex or other structural anomalies.
- Canal with moderate or accentuated curvature.
- Calcifications in the pulp chamber.
- Internal resorptions.
- Previous endodontic treatment and metallic dental restorations in the crown or root.
- Previous fracture or evident fracture lines on crown or root or both.

70 permanent maxillary multi-rooted freshly extracted premolars were selected. Disinfection was done by keeping the teeth in 10% formalin for 7 days.

After debridement and cleansing, the teeth were stored in 0.1% Thymol solution at 4^0C until use and during the time in between the different phases of the experiment in order to prevent their dehydration. The anatomic crown height was measured from the occlusal surface to the cementoenamel junction on all 4 sides of the teeth; the buccolingual and mesiodistal dimensions were measured. Specimens were mounted on acrylic blocks and were subsequently assigned to 9 test and 1 Control Group (n = 10). Teeth were stratified in order to have similar averages of tooth dimensions in each Group so that the influence of size and shape variations on the results were minimized.

STUDY GROUPS

1. Group 1(G 1): Coronal restoration using Interlig FRC at occlusal 1/3.

2. Group 2(G 2): Coronal restoration using Interlig FRC at middle 1/3.
3. Group 3(G 3): Coronal restoration using Interlig FRC at cervical 1/3.
4. Group 4(G 4): Coronal restoration using Ribbond FRC at occlusal 1/3.
5. Group 5(G 5): Coronal restoration using Ribbond FRC at middle 1/3.
6. Group 6(G 6): Coronal restoration using Ribbond FRC at cervical 1/3.
7. Group 7(G 7): Coronal restoration using Everstick FRC at occlusal 1/3.
8. Group 8(G 8): Coronal restoration using Everstick FRC at middle 1/3.
9. Group 9(G 9): Coronal restoration using Everstick FRC at cervical 1/3.
10. Group 10(G 10): Coronal restoration without any FRC (Negative Control).

ARMAMENTARIUM

Figure 2: Instruments for Coronal Class II preparation

CORONAL CLASS II MOD PREPARATION:

Preparation: 245 Tungsten Carbide Bur - 0.8mm tip, 2.7mm length (Prima Dental).

Core restoration material: 3M ESPE Z350 XT Filtek.

Flowable composite: 3M ESPE Z350 XT Filtek.

FIBER REINFORCED MATERIALS USED:

1. Interlig fiber splint
2. Ribbond Ribbon Splint
3. GC EverStick fibers

Figure 3: Interlig fiber splint

Figure 4: GC EverStick fibers

Figure 5: Ribbond Ribbon Splint

ENDODONTIC PREPARATION:

Endodontic access: FG 1 Coarse 21 mm diamond Endo access bur (Dentsply)

Canal negotiation: #10 K-file 25 mm (Dentsply)

Canal instrumentation: ProTaper Gold – SX, S1, S2, F1, F2

Irrigants: 5.25% sodium hypochlorite, 17% EDTA solution and saline

Obturation: Gutta percha - Single-cone size 25, 0.06 taper

Sealer: Resin based sealer- AH Plus (Dentsply)

Measuring fracture resistance: Universal Testing Machine

Figure 6: Endodontic Instruments

METHODS

CORONAL CLASS II MOD PREPARATION:

MOD cavities were prepared such that the remaining lingual and buccal wall thicknesses measured 2.5± 0.2 mm from the height of contour of each respective surface and the gingival cavosurface margin was at 1.5 mm coronal to the CEJ.

Figure 7: Coronal Class II MOD preparation.

ENDODONTIC PREPARATION & OBTURATION:

Access cavity was prepared by an FG 1 Coarse diamond Endo access bur.

Root canals were negotiated with size 10 K-type files to the major apical foramen and canals were instrumented to length with nickel titanium rotary instruments, ProTaper Universal up to F2 file size.

Canals were irrigated using 5.25% sodium hypochlorite followed by 17% EDTA and saline.

The canals were dried and filled with gutta-percha using lateral condensation technique (single-cone size 25, 0.04 taper) and a resin-based endodontic sealer.
After obturation, the pulp chamber spaces were cleaned with 91% Isopropyl alcohol to receive coronal restoration.
Flowable composite was used to seal the orifice.
Subsequently, the teeth were randomly divided into 10 groups.

FIBER INSERTION

Control Group: (G10)

No-fibers placed
The tooth is etched, bonded and cured. It was restored with bulk fill composite resin.

Fibers at cervical 1/3rd

The tooth was etched and bonded. A layer of flowable composite was added to the gingival 1/3rd. Composite resin impregnated fiber [2 mm width and 0.2 mm thickness] was inserted into the cavity and cured. Rest of the cavity was restored with bulk fill composite.

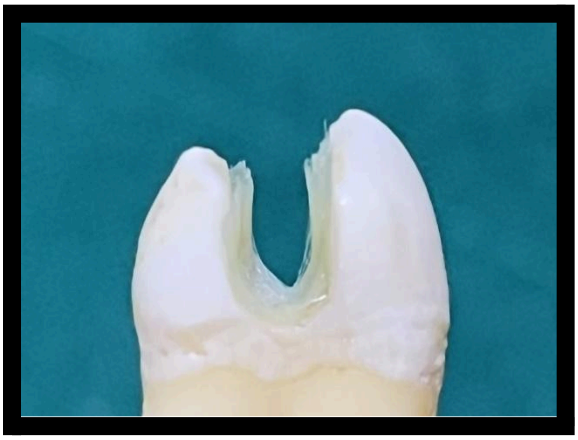


Figure 8: Fibers at cervical 1/3rd

Fibers at middle 1/3rd

The tooth was etched and bonded. The cavity was filled and cured with composite resin up to the middle third. A layer of flowable composite was added and the fiber of similar dimension was placed into it. Rest of the cavity was restored with bulk fill composite.

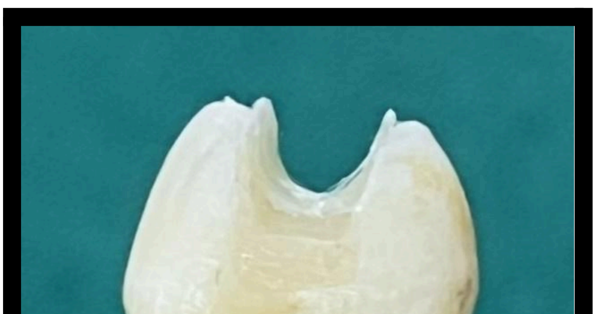


Figure 9: Fibers at middle 1/3rd

Fibers at occlusal 1/3rd

Restore the cavity similar to no fiber group. A groove of 2× 1mm was made buccolingually on the cusp tips. The tooth was etched and bonded. A layer of flowable composite was added. A fiber of similar dimension was placed onto the floor of the groove and cured. Remaining part of the groove was restored with bulk fill composite.

Figure 10: Fibers at occlusal 1/3rd

TESTING

All teeth were mounted on a self-curing acrylic resin at the angle of 30◦ from the tooth long axis and up to 2 mm apical to cemento-enamel junction.

All specimen teeth embedded in the resin were mounted on the Universal Testing Machine (Autograph AG-1). Loading was done by a stainless-steel sphere bar with a diameter of 6 mm, positioned in a manner, parallel to the long axis and centred over the teeth until the bar just contacted the occlusal surface of the restoration as well as the buccal and lingual cusps of the teeth at a speed of 1mm/min._The force necessary to fracture the specimen was recorded in Newton (N), and the data obtained was tabulated.

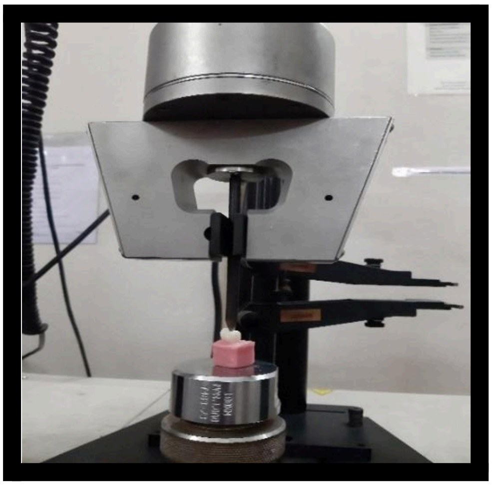


Figure 11: Testing of a tooth sample on Universal testing Machine (Autograph AG-1).

Figure 12: Sample tooth after fracture testing

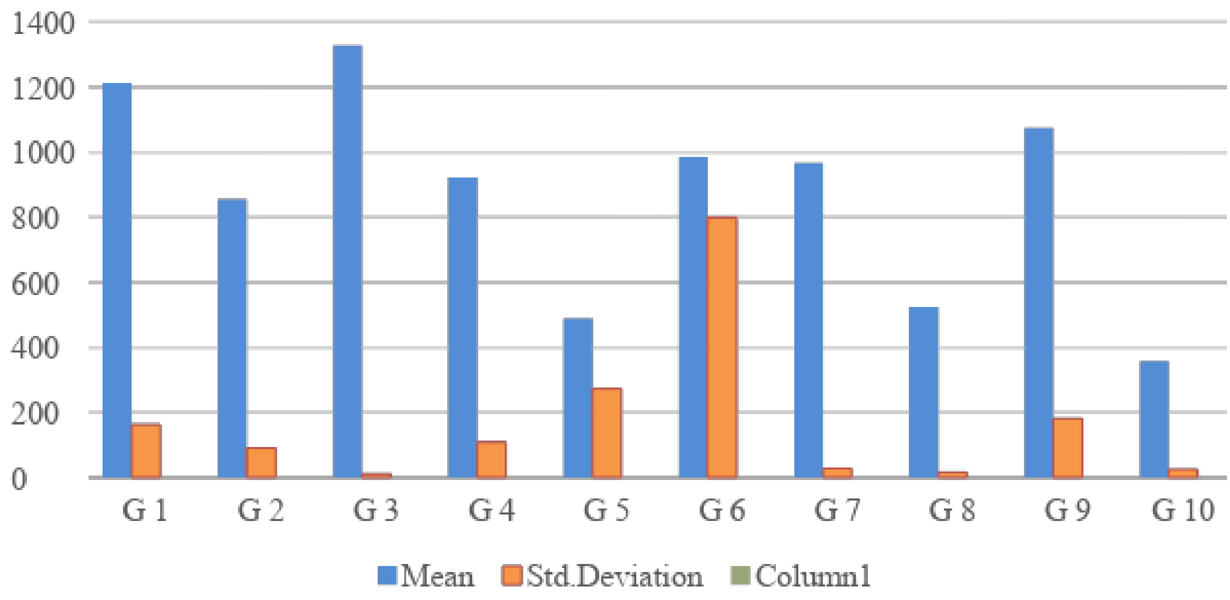
STATISTICAL ANALYSIS

The data recorded on the computer was collected, tabulated, and statistically analysed. One way ANOVA test was done for the analysis of differences between the groups and then the Post Hoc Analysis was done to find out the significant difference between any of the two given Groups. Statistical analyses were performed using SPSS software (IBM). In all the analysis significance level was taken to be 0.05 (i.e., if the p-value was less than 0.05, the null hypothesis was rejected or it was concluded that the null hypothesis was statistically significant)

Descriptives			
VALUES			
	N	Mean	Std. Deviation
Group 1	7	1328.00	10.801
Group 2	7	856.29	90.998
Group 3	7	1213.14	163.152

Group 4	7	1075.14	181.034
Group 5	7	524.00	16.031
Group 6	7	967.14	28.009
Group 7	7	587.00	79.286
Group 8	7	488.57	273.598
Group 9	7	985.57	98.882
Group 10	7	357.43	53.647
Total	70	838.23	338.567

Table 1: Mean and Standard deviation



Graph 1: Mean and Standard deviation

ONE WAY ANOVA

There was a statistically significant difference between the Groups determined by F (9,60) = 7.805 and p = 0.000 at 1 % level of significance by the analysis of One way Anova.

ANOVA					
VALUES					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6933529.200	9	770392.133	47.371	.000
Within Groups	975769.143	60	16262.819		
Total	7909298.343	69			

Table 2: One way ANOVA

POST HOC TESTS

The Tukey HSD post hoc analysis was done between different Groups to find out the significant difference between any two given Groups.

Multiple Comparisons				
Dependent Variable: VALUES				
Tukey HSD				
(I) TYPE OF MATERIAL	(J) TYPE OF MATERIAL	Mean Difference (I-J)	Std. Error	Sig.
Group 1	Group 2	471.714*	68.165	.000
	Group 3	114.857	68.165	.799
	Group 4	741.000*	68.165	.000
	Group 5	839.429*	68.165	.000
	Group 6	342.429*	68.165	.000
	Group 7	252.857*	68.165	.015
	Group 8	804.000*	68.165	.000
	Group 9	360.857*	68.165	.000

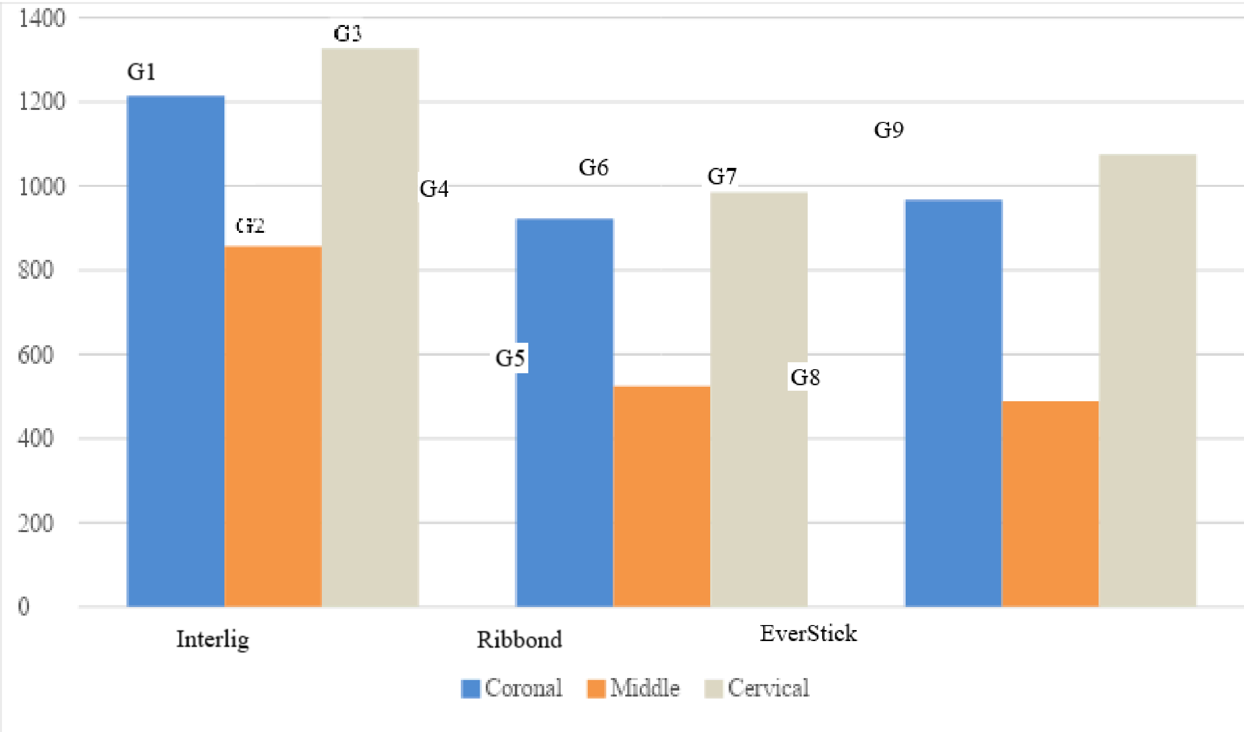
	Group 10	970.571*	68.165	.000
Group 2	Group 3	-356.857*	68.165	.000
	Group 4	269.286*	68.165	.007
	Group 5	367.714*	68.165	.000
	Group 6	-129.286	68.165	.671
	Group 7	-218.857	68.165	.061
	Group 8	332.286*	68.165	.000
	Group 9	-110.857	68.165	.830
	Group 10	498.857*	68.165	.000
Group 3	Group 4	626.143*	68.165	.000
	Group 5	724.571*	68.165	.000
	Group 6	227.571*	68.165	.043
	Group 7	138.000	68.165	.586
	Group 8	689.143*	68.165	.000
	Group 9	246.000*	68.165	.021
	Group 10	855.714*	68.165	.000
Group 7	Group 4	488.143*	68.165	.000
	Group 5	586.571*	68.165	.000
	Group 6	89.571	68.165	.946
	Group 8	551.143*	68.165	.000
	Group 9	108.000	68.165	.850
	Group 10	717.714*	68.165	.000
Group 8	Group 4	-63.000	68.165	.995
	Group 5	35.429	68.165	1.000
	Group 6	-461.571*	68.165	.000
	Group 9	-443.143*	68.165	.000
	Group 10	166.571	68.165	.320

Group 9	Group 4	380.143*	68.165	.000
	Group 5	478.571*	68.165	.000
	Group 6	-18.429	68.165	1.000
	Group 10	609.714*	68.165	.000
Group 4	Group 5	98.429	68.165	.908
	Group 6	-398.571*	68.165	.000
	Group 10	229.571*	68.165	.040
Group 5	Group 1	-839.429*	68.165	.000
	Group 2	-367.714*	68.165	.000
	Group 3	-724.571*	68.165	.000
	Group 4	-98.429	68.165	.908
	Group 6	-497.000*	68.165	.000
	Group 7	-586.571*	68.165	.000
	Group 8	-35.429	68.165	1.000
	Group 9	-478.571*	68.165	.000
	Group 10	131.143	68.165	.653
Group 6	Group 1	-342.429*	68.165	.000
	Group 2	129.286	68.165	.671
	Group 3	-227.571*	68.165	.043
	Group 4	398.571*	68.165	.000
	Group 5	497.000*	68.165	.000
	Group 7	-89.571	68.165	.946
	Group 8	461.571*	68.165	.000
	Group 9	18.429	68.165	1.000
	Group 10	628.143*	68.165	.000

*. The mean difference is significant at the 0.05 level.

p value less than 0.01 indicated that the Groups were highly significant and greater than 0.05 was insignificant.

Table 3: Tukey HSD post hoc analysis



Graph 2: Fracture resistance of different fibers at different levels

HOMOGENEOUS SUBSETS

VALUES						
Tukey HSD[a]						
TYPE OF MATERIAL	N	Subset for alpha = 0.05				
		1	2	3	4	5
Group 1	7					1328.00
Group 2	7			856.29		
Group 3	7				1213.14	1213.14
Group 4	7			1075.14	1075.14	
Group 5	7	524.00	524.00			
Group 6	7			967.14		
Group 7	7		587.00			
Group 8	7	488.57	488.57			
Group 9	7			985.57		
Group 10	7	357.43				
Sig.		.320	.908	.061	.586	.799
Means for groups in homogeneous subsets are displayed.						
a. Uses Harmonic Mean Sample Size = 7.000						

Table 4: Homogeneous subsets

RESULTS

RESULTS

The mean, standard deviation and standard errors of fracture strength values and distribution of fracture patterns are presented in Table 1. One-way ANOVA showed significant differences in fracture strength between the groups ($p<0.001$), as presented in Table 2. Two-by-two comparisons of the Groups with the Tukey HSD post hoc analysis showed significant difference between the different Groups ($p<0.001$), as presented in Table 3. The mean and standard deviation of different Groups were displayed on Graph 1.

Highest fracture strength was obtained by Group 3 with a mean value of (1328.00±10.801), which was Interlig fibers placed at the cervical $1/3^{rd}$. Among the test Groups, Group 5 showed the least fracture resistance (488.57±273.598), which was Ribbond fibers placed at the middle $1/3^{rd}$. The least fracture strength values was obtained by Group 10 (Control Group) with a mean value of (357.43±24.9), where the teeth were without fibers, as shown in Graph 2. This showed that reinforcing the composite restoration with fibers increased the fracture strength of the coronal restoration.

Fracture resistance was significantly higher, when the fibers were placed at cervical $1/3^{rd}$ among all the fibers taken for this study. Fracture resistance, when fibers were placed in the occlusal $1/3^{rd}$ showed greater value compared to fibers placed in the middle $1/3^{rd}$, but was lesser compared to the fibers placed in the cervical $1/3^{rd}$. Fracture resistance was least when the fibers were placed at middle $1/3^{rd}$ among all the fibers taken for this study.

As per Table 5, the fibers placed in the occlusal $1/3^{rd}$, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC. As per Table 6, when the fibers were placed in the middle $1/3^{rd}$, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC. As per Table 7, when the fibers were placed in the cervical 1/3rd, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC.

Interlig fiber Group showed the best fracture resistance when the fibers were placed in the occlusal 1/3rd, middle 1/3rd and cervical 1/3rd, followed by Everstick fiber group. Least fracture resistance was observed in the Ribbond ribbon fiber group when placed in all the three levels.

Sample	**Interlig G1**	**Ribbond G4**	**Everstick G7**	**Control G10**
1	1463	950	987	302
2	1045	1089	963	410
3	1132	1000	952	390
4	1371	1021	969	430
5	1270	980	920	300
6	1180	790	1010	315
7	1031	1069	969	355

Table 5: Fracture resistance of endodontically treated teeth with fibers at Occlusal 1/3rd measured in Newton (N)

Sample	**Interlig G2**	**Ribbond G5**	**Everstick G8**	**Control G10**
1	759	110	506	302
2	964	784	539	410
3	847	572	537	390
4	742	120	498	430
5	950	750	540	300
6	923	571	530	315
7	809	513	528	355

Table 6: Fracture resistance of endodontically treated teeth with fibers at Middle 1/3rd measured in Newton (N)

Sample	**Interlig G3**	**Ribbond G6**	**Everstick G9**	**Control G10**

1	1324	692	814	302
2	1347	482	1341	410
3	1325	587	1071	390
4	1320	650	920	430
5	1337	580	1231	300
6	1328	630	1143	315
7	1315	488	1006	355

Table 7: Fracture resistance of endodontically treated teeth with fibers at Cervical 1/3rd measured in Newton (N)

DISCUSSION

DISCUSSION

Fracture resistance of endodontically treated teeth is an important factor in the longevity of teeth, which is under the influence of restorative procedures. Various techniques have been suggested in different studies for the restoration and strengthening of compromised endodontically treated teeth. Advances in adhesive dentistry and chemical composition of composite resins have resulted in the ability to render direct restorations with an acceptable strength and esthetic appearance for posterior teeth.[35]

This study evaluated the fracture resistance of endodontically treated maxillary first premolars with mesio-occluso-distal (MOD) cavities. Preparation of an MOD cavity decreases cusp stiffness up to 63%; however, preparation of an endodontic access cavity alone decreases cusp stiffness by approximately 5%.[36] The fracture resistance and the amount of remaining tooth structure after endodontic treatment were influenced by restorative procedures.[37] Cast restorations are known to reinforce root canal treated teeth but require extensive and precise preparation of the tooth. Restoration of a tooth with direct resin bonded composites eliminates the need for sacrificing any further tooth structure.[38] After root canal treatment all the residual tooth structure can be a substrate for adhesion. Root-filled mandibular premolars were used in the study as these teeth present specific challenges for the restorative dentist. Esthetic considerations and cusp fracture were found to be more concentrated in premolars.[39] Furthermore, longitudinal root fractures were found to be more common in premolars with narrow roots in the mesio-distal dimension and post space preparation may increase the risk of root perforation and root fracture. The width of tooth preparation also influences the cusp fracture of premolars and MOD cavity is known to further lower the fracture resistance.[40] Therefore, in the current study preparation of MOD cavity was considered for simulation of the worst clinical situation.

Considering the significant decrease in fracture resistance of endodontically treated teeth due to the loss of support by marginal ridges and the pulp chamber roof, it is necessary to apply proper restorative techniques to restore strength and reinforcement of the remaining tooth structure.[41] Some previous studies have shown that bonded composite resin restorations increase the strength of these teeth to a greater extent compared to unbounded amalgam restorations.[42,43] However, some other studies have reported no differences between these two restorative techniques.[44,45]

In addition to esthetics, modern composite materials have got high compressive strength for posterior restorations. It has been suggested that the use of resin composite in restorations reinforces dental stiffness as the adhesive nature of the composite binds the cusps and decreases their flexion. Flexion is considered to be the main cause of fracture in conventional, nonbonded amalgam restorations. Due to its low elastic modulus, composite resin can transmit the energy produced by the compressive forces to the adjacent dental structure, thus reinforcing the weakened tooth structure. Although, the tooth restoration interface suffers elastic stresses generated by the contraction of the material during polymerisation, these stresses can be dissipated by cuspal movement.

Several studies have shown that applying the force to the long axis of the tooth transmits the force uniformly.[46] In this study, force was also applied vertically at a constant speed using a universal testing machine. There are differences between natural occlusal and lateral forces in vivo and those induced by a universal testing machine. Forces generated intraorally during function vary in magnitude, speed of application and direction, whereas the forces applied to the teeth in vitro were at a constant direction and speed and they were increased continually until the fracture occurred. The results of the current study indicate that the use of a fibre under or over the final composite restoration significantly increase fracture strength. However, the clinical conditions and complexity of forces generated in intraoral restoration techniques described in this study must be evaluated further in vivo.

Lowest fracture strength is obtained by the control group with a value of (357.43±24.9), where the coronal restoration is done without reinforcing the composite with any fibers. This signifies that reinforcing the composite restoration with these fibers increased the fracture resistance of the coronal restoration drastically, as shown in Table 1.

In this study better fracture resistance is observed when the fibers are placed at cervical 1/3rd as shown in Graph 2. This might have been achieved through production of a restoration–dentin mono-block in the cervical region and favourable stress distribution pattern in the cervical third of the tooth.[47] This causes a much better distribution of stresses and through interconnection of the cavity walls creates a stronger and more resistant area in the cervical area of the tooth.[48] Fuji et al. placed fibers in three different positions (top, middle, and bottom) in their study and noticed that placing fibers at the bottom of restoration provides the best effects.[49] Amongst the fibers placed in the cervical1/3rd, maximum fracture resistance is obtained by Group 3, where the coronal restoration is done using Interlig; Angelus with a value of (1213.14±163.152), followed by Group 9, where the coronal restoration using Everstick Resin Bonded Fiber with a value of (1075.14±181.034) and least shown by Group 6, where the coronal restoration using Ribbond Ribbon splint with a value of (985.63±79.286) can be seen.

Less fracture resistance is observed when the fibers are placed at the middle 1/3rd. When the fibers are placed at this level, most of it is in contact with the composite resin than the tooth structure, as it is covered with a thicker amount of resin form above and below. The thickness of high-filled composite specimens may have reduced the effect of the fiber type.[50] Amongst the fibers placed in the middle 1/3rd, maximum fracture resistance is obtained by Group 2, where coronal restoration is done using Interlig; Angelus with a value of (856.29±90.998) followed by Group 8, where coronal restoration is done using Everstick Resin Bonded Fiber with a value of (524.00±16.031) and the least for Group 5 where coronal restoration is done using Ribbond Ribbon splint with a value of (488.57±273.598) can be seen.

Fibers when placed in the occlusal 1/3rd of the restoration also showed better fracture resistance but not as better when comparing to fibers place at the cervical 1/3rd. When comparing the fracture resistance among the fibers placed at the occlusal and cervical 1/3rd. The difference is less significant. This can be observed amongst all the three types of fibers taken for the study. This can be because the fibers along with the resin when bonded to enamel shows better fracture resistance than dentin. Placing fibres on the occlusal surface keeps buccal and lingual cusps together and protects the natural cusps resulting in higher fracture resistance. In addition, fracture resistance increases when fibres are placed close to the point where the force is exerted because it leads to a shorter working arm according to levers principle.[18] Amongst the fibers placed in the occlusal 1/3rd the maximum fracture resistance is obtained by Group 1 where coronal restoration is done using Interlig with a value of (1213.14±163.152) followed by Group 7, where coronal restoration is done using Everstick Resin Bonded Fiber with a value of (967.14±28.009) and the least for Group 4 where coronal restoration is done using Ribbond Ribbon splint with a value of (922.57±108.801) can be seen.

In this study Interlig fiber showed better fracture resistance. Interlig fibers showed maximum fracture resistance when place at the cervical 1/3rd with a mean value of (1328.00±10.801), followed by fibers at occlusal 1/3rd with a mean value of (1213.14±163.152) and the least for fibers placed at middle 1/3rd with a mean value of (856.29±90.998).

Interlig fiber is based on the E glass system, embedded in Bis GMA resin. It is a braided glass fiber impregnated with a light cured composite resin. It is composed of glass fibers (60%) and impregnated resin (40%). This Glass fiber has a perfect combination of esthetic and mechanical properties which is most desirable. It is easy to handle, easy to cut (special scissors are not required) and adapt, packed in sachets for protects fibers from light and heat.

With these properties, Interlig is the perfect material for immediate, highly conservative, durable, preventive and restorative dental procedure.

This study was based on the study done by Mangoush et al, were he concluded that most of studies found superior characteristics of glass FRCs over polyethylene FRCs.[51]

Everstick glass fibers followed Interlig fibers in terms fracture strength, showing glass fibers are having better fracture resistance than polyethylene fibers. Maximum fracture resistance was observed when the fibers were place at the cervical 1/3rd with a mean value of (1075.14$\pm$ 181.034), followed by fibers at occlusal 1/3rd with a mean value of (967.14$\pm$28.009) and the least for fibers placed at middle 1/3rd with a mean value of (524.00±16.031).

EverStick fibers are based on the E glass system embedded in PMMA, Bis GMA resin in a semi interpenetrating polymer network (IPN). It contains 4000 fibers in unidirectional mode and are coated with epoxy resin. Everstick fiber reinforcements are made of silanated glass fibers in thermoplastic polymer and light curing resin matrix. Everstick is a soft, pliable individually formable glass fiber post impregnated with resin.[52] Its unique, interpenetrating polymer network structure leads to superior bonding enabling reliable surface retained applications and perfect handling properties.[53]

With a unique design, EverStick fiber, comprises adhesive fiber bundles, which can be adapted into the prepared space to attain customized shape, which is then adhesively luted. This material utilizes a glass fiber network embedded in an interpenetrating polymer network matrix of polymethyl methacrylate. Due to the adaptive characteristic of EverStick fiber, a relatively uniform, void free, and thin cement layer between the composite and the dentin is created that potentially allows even distribution of occlusal forces.[54]

Everstick post has interpenetrating polymer network and elasticity modulus alike that of dentin (15–20 GPa), facilitating even distribution of occlusal stresses.[52] In a study, the composites filled with glass fibers showed high resistance against fracture or crack stopper and provided local support to eliminate the energy which was produced during the fracture. Reinforcing the composite by single, silicon-nitrate Whisker crystals was gained as well.[55]

This study shows that fracture resistance of glass fibers are more than polyethylene fibers. According to Karatas et al, the fibre type and thickness also affect the fracture strength value of restoration. The higher mean fracture strength value in glass fiber groups may be explained by the fact that the glass fiber is more compact and rigid than the polyethylene fiber.[56]

Silane impregnated glass fiber reinforcement produce significantly higher flexural strength for both PMMA and BAC resin compared to monomer impregnated polyethylene fiber reinforcement. This shows that silanized glass fibers seems to be the most appropriate method for reinforcing provisional restorative resins where esthetics and space are of concern.

Mangoush et al. observed a similar finding that glass FRCs have superior characteristics and provide significantly better reinforcement than polyethylene FRCs. This is due to the difficulty in silanization and impregnation of polyethylene fibers leading to weak adhesion of the resin to polyethylene FRC whereas, in glass FRC materials, adhesion is promoted by silane coupling agents.[57]

Kamble et al. in his study said that, silane impregnated glass fiber reinforcement produce significantly higher flexural strength for both for polymethyl methacrylate and bis-acryl composite resin compared to monomer impregnated polyethylene fiber reinforcement. This shows that silanized glass fibers seems to be the most appropriate method for reinforcing provisional restorative resins where esthetics and space are of concern.[58]

The least fracture resistance among the fibers were for Ribbond Ribbon fibers. Ribbond fibers showed maximum fracture resistance when the fibers were place at the cervical 1/3rd with a mean value of (985.63±79.286), followed by fibers at occlusal 1/3rd with a mean value of (922.57±108.801) and the least for fibers placed at middle 1/3rd with a mean value of (488.57±273.598).

Ribbond ribbon fiber is a bondable reinforced polyethylene fiber, consisting of ultrahigh modulus, ultrahigh strength and molecular weight fibres. Is designed for use with applications in which thinness and higher modulus are the primary concerns. These thinner fibers with a higher thread count far exceed the breaking point of fiber-glass and are so tough that specially made scissors are required to cut them. These fibers have only 0.18 mm thick, and are treated with cold gas plasma to enhance its adhesion to synthetic restorative materials, including chemically cured or light-cured composite resins. Its composition utilizes pre-impregnated, silanized, plasma treated, ultra-high molecular weight (UHMW) polyethylene fibres. Ribbond fibers are not impregnated with resin, so they were saturated with an adhesive bonding agent before used.[59]

Ribbond has a three-dimensional leno-weaved triaxial braided structure, which renders mechanical interlocking of composite resin in various planes.[60] It has a high coefficient of elasticity (117 GPa) making it highly stretch, distortion, and traction (3 GPa) resistant.[61]

Resist, an unfilled resin based on Bis-GMA and UDMA, is the bonding agent recommended for impregnation of polyethylene fiber. It seems that the Resist provides the adhesion between the fibers and also diminishes the stress transferred from the matrix to the polyethylene fiber. When remarkable amount of the Resist remains around the fiber, the stability of FRC decreases.[62] If the bonding resin contains filler, the shrinkage will be reduced during the polymerization and therefore, produces less stress in the bonded increment.[63]

From Table 5 among the fibers placed in the occlusal 1/3rd, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC. From Table 6 among the fibers placed in the middle 1/3rd, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC. From Table 7, among the fibers placed in the cervical 1/3rd, Interlig FRC showed maximum fracture resistance followed by EverStick FRC and least by Ribbond FRC.

Interlig FRC clearly showed to be the fiber with the highest fracture resistance and had the maximum fracture resistance when placed at the cervical 1/3rd.

CONCLUSION

CONCLUSION

Within the limits of this in vitro study, it was seen that among the three fibers used, Interlig FRC showed the maximum fracture resistance followed by Everstick FRC and the least fracture resistance was observed for Ribbond FRC.

Among the different positions taken for the placement of the fiber, the maximum fracture resistance was observed in the cervical $1/3^{rd}$ of the coronal restoration followed by occlusal $1/3^{rd}$ and the least by middle $1/3^{rd}$.

SUMMARY

SUMMARY

SUMMARY

Endodontic treatment along with loss of coronal tooth structure may decrease the fracture resistance of a tooth to a drastic level. A good post endodontic coronal restoration is necessary for the longevity of the tooth. There are many ways of strengthening a restoration. Reinforcement of composite restoration with different types of fibers is a recent advancement among them.

Fiber reinforced composites offer many other advantages including non-corrosiveness, translucency, lower cost, higher aesthetic, good bonding properties and repair facility. Furthermore, their strength to weight ratios are superior to those of most alloys.

The Aim of my study was to evaluate the fracture resistance of endodontically treated teeth, when restored with three fiber reinforced materials placed at three different levels.

70 intact maxillary first premolars were selected for the study standardized based on anatomical measurements. It was then randomly divided in to 10 groups which consisted of one Control Group of premolars and 9 test Groups. The first 3 Groups were restored with Interlig FRC at coronal $1/3^{rd}$, middle $1/3^{rd}$ and cervical $1/3^{rd}$ respectively. Groups from 4 to 6 were restored using Ribbond FRC at coronal $1/3^{rd}$, middle $1/3^{rd}$ and cervical $1/3^{rd}$ respectively. And Groups 7 to 9 were restored using Everstick FRC at coronal $1/3^{rd}$, middle $1/3^{rd}$ and cervical $1/3^{rd}$ respectively. Group 10 was taken as the control group.

Access cavities were prepared and teeth were endodontically treated. MOD cavities were prepared on the teeth with standardised dimensions. In Groups 1, 4 and 7 the fiber was placed at the cervical $1/3^{rd}$ and rest of the cavity was restored using composite. In Groups 2, 5 and 8 the cavity was filled to the middle $1/3^{rd}$ using composite resin the fiber was placed in the middle $1/3^{rd}$ and the rest of the cavity was built up using composite. In Groups 3, 6 and 9 the cavity was filled to the occlusal $1/3^{rd}$ with composite resin. A groove of 2 × 1mm was made buccolingually on the cusp tips. The fiber was placed in this groove. And restored with composite resin. All teeth were mounted on acrylic blocks and subjected to fracture testing on Universal Testing Machine.

Based on the fracture test results and statistical analysis, it was concluded that the Interlig FRC offered maximum fracture resistance followed by Everstick FRC and the least fracture resistance was observed in Ribbond FRC. The fibers when placed at the cervical $1/3^{rd}$ offered maximum fracture resistance followed by coronal $1/3^{rd}$ and the least when placed at the middle $1/3^{rd}$ among all the fibers.

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ANNEXURE

ST. GREGORIOS DENTAL COLLEGE

UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ

CHELAD , KOTHAMANGALAM, ERNAKULAM DIST, KERALA - 686681

ETHICAL CLEARANCE CERTIFICATE

To,

Dr. Ann Mariya Sunny
St. Gregorios Dental College
Chelad, Kothamangalam

Dear Dr. Ann Mariya Sunny

Subject: Ethics Committee Clearance-reg

Protocol: Comparison of the Fracture Resistance of Endodontically Treated Teeth, Restored with three Fiber Reinforced Materials at Different Levels: An In Vitro Study.

At the Institutional Ethics Committee (IEC) held on 15th of January 2021, this study was examined and discussed. After consideration, the committee has decided to approve and grant clearance for the aforementioned study.

The members who attended the meeting at which the protocol was discussed were:

1) Dr .C.K.K Nair - Former BARC Scientist
2) Dr.Cinu Thomas A - Scientist, Vice Principal, Caritas College of Pharmacy
3) Dr.Lissy Jose – Former member of Women's welfare Association.
4) Adv. Jose Aranjani – Advocate.
5) Dr. Sauganth Paul – Reader, Department of Biochemistry, St. Gregorios Dental College.
6) Dr. EapenCherian – Secretary, Professor, St. Gregorios Dental College
7) Dr. Jain Mathew – Principal and Head of the Department, Department of Conservative Dentistry and Endodontics.
8) Dr. George Francis – Head of the Department, Department of Prosthodontics and Crown and Bridge.
9) Dr. BinoyKurian – Head of the Department, Department of Orthodontics and Dentofacial Orthopaedics.

Dr. C.K.K Nair
Chairman Institutional Ethics Committee
St Gregorios Dental College, Chelad

Dr. EapenCherian
Secretary.

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LIST OF ABBREVIATIONS USED

(In alphabetical order)

	ABBREVIATIONS	DESCRIPTIONS
1.	ANOVA	Analysis of Variance
2.	Bis GMA	Bisphenol A diglycidil dimethacrylate
3.	CEJ	Cementoenamel junction
4.	DEC	Dentinoenamel complex
5.	EDTA	Ethylenediaminetetraacetic acid
6.	FRC	Fiber reinforced composite
7.	MOD	Mesio-occluso-distal
8.	PMMA	Polymethyl methacrylate
9.	SEM	Scanning electron microscope
10.	UDMA	Urethane dimethacrylate