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To Compare and Evaluate the Fracture Resistance of Three Post Endodontic Restorations Including Silver Amalgam, Dual Cure Composite Resin and Fibre Reinforced Composite Resin

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Abstract:-

- ***Background:***

Endodontically treated teeth are thought to be more prone to fracture. The last stage in a successful root canal treatment is to restore root canal-treated teeth with a permanent, definitive postendodontic restoration. Dehydration, dentin loss during endodontic procedures, and the elimination of significant anatomic elements like cusps, ridges, and the pulp chamber's arched roof—all of which contribute significantly to the normal tooth's support—are the causes of the fracture of endodontically treated teeth.

Consequently, intracoronal strengthening is necessary to prevent tooth fracture, especially in the posterior teeth where compressive stresses brought on by occlusal forces can cause tooth fractures.[1]

Since core materials typically replace a significant portion of the tooth structure and must withstand multidirectional masticatory forces,their compressive strength is crucial.[2]

- ***Aim:***

The purpose of this study was to compare the compressive strengths of three direct post enododontic restorations.

- ***Material and Methods:***

There are thirty extracted maxillary premolars chosen. After receiving root canal therapy, the teeth were divided randomly into three groups for immediate post-endodontic restorations: (i) silver amalgam (ii)Fiber-reinforced composite resin (iii) dual cure glass-reinforced composite resin . After that, a Universal Testing Machine was used to apply compressive stress on the teeth.

- ***Statistical Analysis:***

Fracture loads will be compared statistically, and the data will be analysed using version 21.0 of SPSS software, analysis of variance and the Post-hoc test for multiple comparisons.

- ***Result and Conclusion:***

Within the limits of the study, it showed that the post hoc tests reveal that the mean difference of compressive load strength is significant between all the groups, Amalgam has highest load strength followed by Fiber reinforced composite. Dual cure composite has lowest compressive load strength.

I. INTRODUCTION

One of the most difficult aspects of operative dentistry is the restoration of teeth that have had root canal therapy with a permanent post endodontic restoration. This is because the root canal treated teeth are thought to be more prone to fracture than healthy teeth as:

- Tooth structure loss due to caries, trauma, erosion, abrasion, and attrition is the cause of this.
- Removing previous restorations and recurrent caries under restorations.
- As a result of endodontic procedures producing microcracks in the remaining tooth structure.
- Due to removal of coronal and intraradicular dentine during access and root canal preparation. compromised dentine's collagen intermolecular cross-links.
- Dehydration: teeth that are non-vital are less moist than teeth that are. These alterations add up to a greater susceptibility to fractures.[3]

Maintaining the strength of endodontically treated teeth depends heavily on their post endodontic restoration.The traditional restorative approach, as stated in the classic literature and backed by numerous clinical investigations, entails a core build-up—either with or without a root canal post followed by placing a complete crown.

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In certain circumstances, such as the following, we cannot proceed with placement of full coverage restoration right away if:

- A tooth undergoing root canal therapy has to be monitored for aextented period of time for reviewing the periapical lesion's healing.
- The tooth has not fully erupted

In above mentioned cases, to prevent the failure of the root canal, a quick, high-strength, direct restorative material is necessary.[4]

As the direct restorative material resist multidirectional masticatory forces and replace a significant portion of the tooth structure, compressive strength is thought to be a crucial success indicator, particularly in posterior teeth where compressive stresses generated by occlusal forces can lead to fracture of teeth. The compressive strength of enamel (384 MPa) and dentin (297 MPa) and the fracture strength of a natural tooth (molar = 305 MPa; premolar = 248 MPa).[1]

The choice of suitable restorative materials to make up for the loss of coronal tooth structure is the most crucial element in the success of post-endodontic restorations.

The following core build-up materials are available: ➢Amalgam ➢Different types of composite resin (packable composite, fiber reinforced, flowable composite, light cure, dual cure, modified composite resins - polyethelenefiber reinforced, polyacid modified composites) ➢Resin modified glass ionomer cement.[5]

The first of which is a direct core build-up that includes dental amalgam because of its benefits, which include a low cost, good marginal seal, wear resistance, and compressive strength. Due to a number of factors, including environmental and aesthetic concerns and its lack of adherence to tooth structure, this material is gradually being removed from dental offices.

Advances in composite materials and the development of enamel-dentine bonding systems have sparked a movement toward more conservative methods.[6]

Composite resin is usually utilized for the direct core build up restorative material. Its application allows dentine conservation, promotes intra-coronal reinforcement, and makes adhesive bonding to the radicular dentine easier. Three distinct curing modes—self, light, and dual cure—are accessible for the wide range of resin composite core materials that are commercially available.[7]

II. DUAL CURE COMPOSITE RESIN

was developed to make up for the lack of photon accessibility in deep cavities, particularly in the pulp chamber, by combining on-demand setup of light-curing materials with self-cure properties. The benefit of light exposure in dual-cure composite resin to reach maximal polymerization.[8]

Despite numerous advances in material science, composite resins used for extensive restorations or in high stress-bearing areas have some deficiencies due to their low fracture resistance and polymerization shrinkage, which can cause microcracks to form in the tooth structure. Therefore, in endodontically treated teeth undergoing direct restoration with resin composite, efforts to minimize stress in the residual tooth structure and at the interfaces are essential.[9]

In order to improve the behavior and reaction of the traditional materials already in use, fiber reinforced composites (FRC) were introduced.Fiber-reinforced composite resin has the potential to modify a tooth's fracture resistance and strengthen the weak cusp in teeth that have undergone root canal therapy. Because the fibers prevent cracks, they improve the material's structural qualities. The fibers are shielded and macroscopic unidirectional fibre bundle orientation is stabilized by the resin matrix, also offers optimal reinforcement.[10]

The aim of this study was to compare and evaluate the fracture resistance of the three direct post endodontic restorations.

III. MATERIAL AND METHOD

Thirty recently extracted, fully formed human maxillary premolars without caries, fractures, restorations, cracks, or fractures were gathered for this in-vitro study from the Department of Oral and Maxillofacial Surgery.Only the teeth extracted for periodontal and orthodontic purposes were gathered.

Calculus was mechanically removed from the root surfaces using curettes. To ensure operator safety, the teeth were soaked in 3% sodium hypochlorite for an hour. All teeth had a standard coronal access cavity prepared using a high-speed handpiece and an Endo-Access bur. The size 10 K-file verified the patency. The #15 size K-files were placed until the root apex could see the file tip, and the length determined. One millimeter less than this length was chosen as the working length. The canals were instrumented till #25 K files and were enlarged till #25 0.04 taper with Neoendoflex file. The canals were continuously irrigated using regular saline and 3% sodium hypochlorite. Paper points were used to dry the canals. With the use of resin-based sealer and #25 0.04 taper guttapercha cones, obturation was accomplished.

After that, the teeth (n=10) were divided into three groups randomly for direct post endodontic restoration:

- Group 1: Silver amalgam
- Group 2: Dual cure composite resin
- Group 3: Fiber reinforced composite resin.

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The components were combined in accordance with the manufacturer's recommendations, and plastic carrying tools were used to complete the core build up. The teeth were embedded in self-curing acrylic resin blocks up to the CEJ level using silicone molds.

Using a conical bar positioned centrally on the occlusal surface and applied parallel to the tooth's long axis until fracture, all specimens were subjected to compressive axial loading in a universal testing machine. Each tooth's fracture forces were expressed in Newtons (N). After being tallied, the collected data were statistically analyzed.

IV. RESULT

In order to assess the fracture resistance to compressive load of thirty freshly extracted human maxillary premolars that had undergone endodontic treatment and three distinct post-endodontic restorations, an experimental study was conducted on them.

The results of this study showed a statistically significant difference in the mean compressive load strengths between the groups. The highest and lowest compressive load strengths were obtained for Group 1 (Silver amalgam) and group 2(Dual cure composite resin).

Table 1: Descriptive Statistics for Compressive Load Strength (N) between the Groups

	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Amalgam	521.200	14.4822	4.5797	500.0	542.0
Dual Cure Composite	339.200	15.1496	4.7907	320.0	365.0
Fibre Reinforced Composite	430.900	27.2497	8.6171	368.0	452.0

Table 2: Comparison of Compressive Load Strength between the Groups with ANOVA Test

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	165623.267	2	82811.633	210.219	.000
Within Groups	10636.100	27	393.930		
Total	176259.367	29			

P value is less than 0.05, the difference between the groups is statistically significant

Table 3: Multiple Comparison of Mean Differences between the Groups (Post Hoc Test)

Group I	Group J	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Amalgam	Dual Cure Composite	182.0*	8.88	0.00	163.79	200.21
	Fibre Reinforced Composite	90.3	8.88	0.00	72.09	108.51
Dual Cure Composite	Amalgam	-182.0	8.88	0.00	-200.21	-163.79
	Fibre Reinforced Composite	-91.7	8.88	0.00	-109.91	-73.49
Fibre Reinforced Composite	Amalgam	-90.3	8.88	0.00	-108.51	-72.09
	Dual Cure Composite	91.7	8.88	0.00	73.49	109.91

The Post Hoc tests reveal that the mean difference of compressive load strength is significant between all the groups. Amalgam has highest load strength followed by FRC. Dual Cure Composite has lowest compressive load strength.

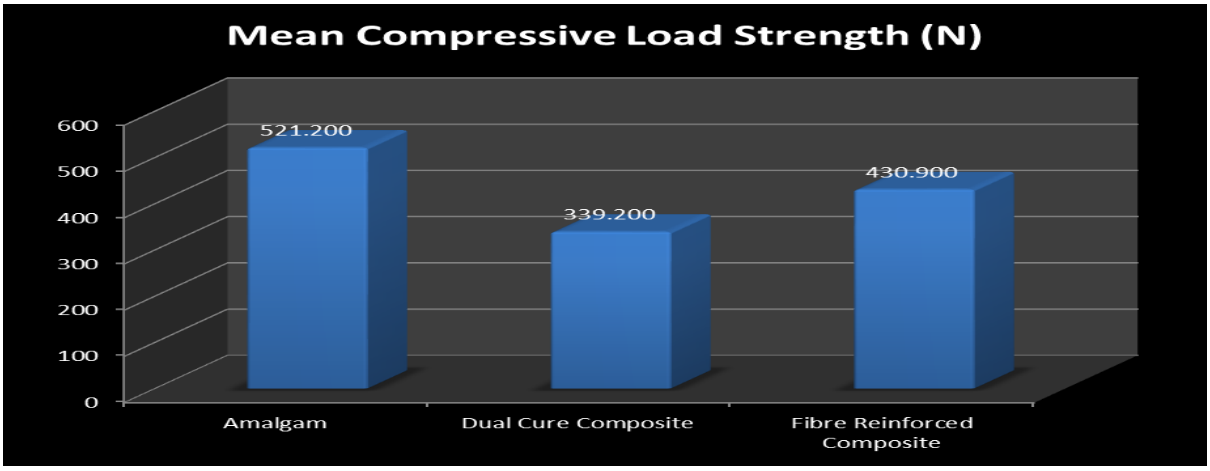

Fig 1: Graphical Representation of Mean Compressive Load Strength of the Three Post Endodontic Restoration Showing Silver Amalgam,Dual Cure Composite Resin and Fibre Reinforced Composite

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V. DISCUSSION

The present study was done to evaluate the fracture resistance of endodontically treated maxillary premolar restored with Amalgam, dual cure composite and fiber-reinforced composite .The study reveal that amalgam has highest load strength followed by fiber reinforced composite resin. Dual cure composite showed lowest compressive load strength. Because a high compressive strength is required to resist masticatory and parafunctional forces, compressive strength is regarded as a crucial success indicator.

Group 1 (Amalgam) showed the highest fracture resistance which could be attributed to high compressive strength of amalgam.Huysmans MCet al and Kovarik REet al had also demonstrated the improved performance of amalgam cores over resin composite cores by performing mechanical test. Among the three direct core buildup materials, amalgam had the greatest compressive strength which was in accordance to earlier studies. A study by Kovarik et al. compared amalgam, GIC and composite direct build up materials and they found that amalgam cores had the lowest failure rate, and that more than one million cycles were required to produce the median fatigue life of the amalgam cores.[11]Composite resin cores experienced 83.3 % failure and required only 385,212 cycles to achieve their median fatigue life. Hence due to its superior mechanical properties and longer function, amalgam is used for direct core build up procedures.[12]

It has long been believed that amalgam is the ideal material for cores build ups. Because of its many clinical, practical, and ergonomic advantages—such as its excellent compressive strength, resistance to wear, and ideal marginal seal—amalgam has been used as a direct restoration.While amalgam's dark color is not esthetic, it does aid in distinguishing the tooth structure when teeth are being prepared.

The fact that amalgam does not adhere to tooth structures is one of its drawbacks due to which needs to be held in place during cavity preparations by retentive characteristics, which frequently involve removing a sound tooth structure.It has reduced flexural strength becauseof the fact that the modulus of elasticity of composites is approximately one-third the modulus of elasticity of amalgam, amalgams are three times more rigid.13

Therefore, in order to employ alternative materials as direct post endodontic restorations, we must search for ones with more advantageous qualities.

Group 2 (dual cure composite) showed the least compressive strength.Due to flowable resins decreased filler volume. It has been noticed that the results of fracture resistance load is directly proportional to the filler content in core materials, Group 2 (dual cure composite) had the lowest compressive strength. This might have been the reason for its subpar performance in contrast to fiber-reinforced composite. Filler content of FRC used is 76%wt ,57%vol and that dual cure is <70%.[14]

Conventional dual-cure composites cure the material by use of a chemical process in addition to visible light. Since core build-up restorations are thicker restorations, the ability to cure chemically is regarded as an extra benefit .The attainment of polymerization in deep areas due to chemical curing and the development of lower contraction stresses; this results in the possibility of bulk insertion, saving clinical time.

Dual cure core build up composite has its own drawbacks.It is clearly shown in literature that it was the brittleness of the conventional dual cure composite that generated the bulk of fractures that propagated easily through the whole thickness of the restoration and reached adjacent teeth, allowing further crack propagation and other drawbacks areshrinkage duringpolymerization , Low elasticity modulus, increased occlusal wear, and a higher coefficient of thermal expansion.[15]

Group 3 that is fiber reinforced composite had the higher fracture resistance value than dual cure composite resin values because of filler/fiber loading differences and support of the bulk substructure to the overlying conventional composite resin by transferring the stresses from the polymer matrix to the macroscopic unidirectional fibers, the individual fibers acting as crack stoppers and enhance the fracture toughness. The result were according to previous studies done by Säilynoja E etal.[10]

A combination of barium glass filler and e-glass fibers makes up fiber-reinforced EverX Posterior. These 1-2 mm long strands of E-glass are infused into composite materials, greatly improving their mechanical qualities. The composition of this reinforced composite, which is mostly made up of short e-glass fibers that control crack development by transmitting stress from matrix to fibers, is responsible for EverX Posterior's excellent performance. Because of their orientation, these fibers have the ability to regulate marginal microleakage and polymerization shrinkage.[16]

The macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins and improves their mechanical properties. The presence of fibers affects the fracture process that results in interrupting crack growth progression and thus enhances the fracture toughness of the fiber-reinforced composite material.

The presence of such energy-absorbing and stress-distributing fibers in FRC allows to stop crack propagation and deflect it away from the bulk of the material and toward the peripheries making it more fracture resistant than conventional composite.[17]

EverX Posterior has previously been shown to have better physical qualities than traditional composites, and Garoushi et al. advise using it in high stress-bearing application areas. Based on the current clinical study's results, it can be said that even though everX flow is a novel material, it performed admirably as a class I post-endodontic restoration and was not comparable to amalgam.

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Nevertheless, more clinical research could be done to confirm these findings.[18]

VI. CONCLUSION

Strength is not just an important factor to consider when choosing a core material. More robust core materials offer more equal stress distributions, improved resistance to deformation and fracture, a lower chance of compressive failure, increased stability, and a higher chance of clinical success.

The results of our study and other previous studies suggest that both amalgam and fiber reinforced composites may be indicated for use as core materials in particular clinical situations, despite the fact that the ideal core material is still undiscovered.

When compared to traditional dual-cure resin composites, the experimental fiber-reinforced resin composites showed improved fracture resistance. This may suggest that FRC performs better as a core build-up in applications with high levels of stress.

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