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RESEARCH ARTICLE

EVALUATION OF THE FRACTURE RESISTANCE AND MODULUS OF ELASTICITY OF COMMERCIALLY AVAILABLE CORE MATERIALS IN MOLAR TEETH– AN IN VITRO STUDY

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ABSTRACT

Background: Most of the endodontically treated teeth often show considerable anatomic defect of the tooth structure, frequently requires good core build up material having a fracture resistance and good modulus of elasticity for longevity of restoration. In developing material market and propaganda about the same has led to selection bias because of less evidence based literature; so the study was aimed to evaluate three commercially available core materials in permanent posterior teeth through the evaluation of parameters like fracture resistance and modulus of elasticity.

Aims and objectives: To evaluate the in vitro effect of core materials on the fracture resistance of endodontically treated teeth.

Materials and Method: The in vitro study was planned to assess the fracture resistance and modulus of elasticity of three commercially available core materials. Each group was restored with 1) Metal modified Glass Ionomer cement (miracle mix, GC), 2) Bulk fill posterior composite(ivoclar) and 3) Ever X posterior core composite (GC) respectively. All the samples were subjected to fracture test using UTM (universal testing machine) INSTRON. The observer and testing person were blinded for the procedures. The results were tabulated and SPSS -20.0 was used for statistical analysis. The statistical test used were Mean, Standard deviation (SD), p-value, and One way Annova, Posthoc Tukey Test.

Results: The fracture resistance and modulus of elasticity of three different materials were 1834.79 N& 270.08Mpa for Ever X posterior core material, 1352.49 N &207.84Mpa for bulk fill composite and 769.7N & 178.8 Mpa (very less) for miracle mix.

Conclusion: The study results showed Ever X posterior core composite is the best core material followed by bulk fill composites and miracle mix. Within the limitation of this study Ever X posterior core composite is better than the other two.

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INTRODUCTION

Loss of tooth structure may occur due to caries, trauma and endodontic procedures combined with loss of structural integrity, which can contribute to the tooth fracture. (Kishen, 2006) Endodontically treated teeth are susceptible to fracture than vital teeth, because of the lost tooth structure, moisture, during cleaning and shaping of root canal & excessive compaction forces during Obturation (Johnson *et al*., 2000). The prognosis of tooth depends not only on the success of root canal treatment but also depends on the type of reconstruction and the amount of remaining tooth structure. Failure to protect such teeth may lead to fracture and ultimate loss of the tooth. Therefore, intracoronal strengthening of teeth is important to protect them against fracture; particularly in posterior teeth where occlusal forces can lead to fracture of unprotected cusps. An optimal final restoration for endodontically treated teeth should maintain function,prevent tooth fracture under masticatory load and esthetics. It preserves the remaining tooth structure, give bulk to the tooth structure which should reinforce it and prevents micro leakage. (Danoshkazomi, 2004) Fabrication of crowns and bridges, require core materials to when extensive tooth lost because of caries or previous dental restoration or treatment. A core build-up is a restoration placed in a severely damaged tooth in order to restore the bulk of the coronal portion of the tooth. (Combe *et al*., 1999) Various materials are being used for building up the tooth core.

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Amalgam, glass ionomer cements and composites are used as core materials. Composite adhesive cores are becoming increasingly popularnow a days, because of good bonding and adhesive system. Studies were undertaken to measure the mechanical properties of direct core build-up materials such as: compressive strength, diametrical tensile strength, elastic modulus, flexural strength, shear bond strength in anteriors. (Combe *et al*., 1999; Cho *et al*., 1999) Compressive strength is considered to be a critical indicator of success. High compressive strength is necessary to resist masticatory and para functional forces. (Cho *et al*., 1999) The studies in posterior teeth comparing these three commercially available materials are scarce in the published literature. So, the study was planned to examine the ultimate fracture resistance of badly damaged molars which were endodontically treated and restored with three different core materials. The study also gives recommendation for the selection of material to clinician so that, successful restoration of the tooth can be performed.

MATERIALS AND METHODS

The in vitro blind study was performed in the Department of prosthodontics and Endodontics during the year 2014-15 involving twenty one extracted mandibular first molar teeth. The was approved by Institutional ethics committee. The collected teeth were cleaned of all debris, blood and stored in 0.1% thymol during the entire course of the study to prevent the antibacterial growth and dehydration which make them brittle. The inclusion criteria were Teeth extracted for periodontal reasons, Teeth which are free of caries .were taken for the study. The exclusion criteria was teeth with congenital or developmental anomalies and Teeth which are restored are not included in the study After selection of teeth according to inclusion and exclusion criteria; the teeth are randomly categorized into 3 groups with seven teeth in each group based on the method of core build up done. The sample size was selected based on the statistical significance. The formula for the significance is

$$n \geq (1 + \overline{g-1})\ \frac{(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2}{d^2} + \frac{{Z^2}_{1-\frac{\alpha}{2}}\ \overline{g-1}}{2(1 + \overline{g-1})}$$

The following material were used for the core build up in three groups were as follows Group 1: samples restored with miracle mix, Group 2: samples restored with bulk fill composite and Group 3: samples restored with Ever X posterior. The experimental teeth were mounted in auto polymerizing acrylic resin blocks (4 x 2.5 x 2.5 mm). Care was taken that the acrylic resin extends only up to the cemento-enamel junction. All the samples were subjected to access cavity preparation of 6mm from the central fossa creating two wall defect involving the distal and buccal wall and pulp extirpation was done. Obturation was done followed by biomechanical preparation, care was taken to ensure that same amount of restorative material is used because a standardized preparation was done. The access cavity was restored with different materials. All the materials were used precisely according to the manufacturer's instructions as described for core materials. All the samples were stored in distilled water at 37o C for one day before testing. Testing for fracture resistance was done using Instron 8801- universal testing machine (Figure/ Table -1). For the purpose of testing each specimen was first placed and secured in a specially adapted jig (Figure/ Table -2). Sample was placed on the loading platform, compressive pressure was applied at a cross head speed of 0.5mm/min using a ball ended plunger touching the central area of restoration uniformly. Failure was detected by fracture of the sample. Readings were obtained graphically which were interpretated numerically. Two experienced observers were recruited for recording the reading. The observers were blinded for the procedures performed for testing. The observers for testing involved were faculty of engineering who were not having the knowledge of material science involved in the study and nor they explained about the material used in the study. The study samples were given with sample names A, B, C while testing. The computerised observations tabulated by technician of Universal testing machine and saved the same directly in the system. Which were taken for statistical analysis by statistician who was also blinded. Because statistician was not aware of the materials used in different samples used. The observations were tabulated using Microsoft Excel data sheet. The statistical analysis done using SPSS 20.0. Mean, Standard deviation (SD), p-value, and One way Annova, Posthoc Tukey Test statistical tests were performed.

RESULTS

Among three materials used Ever X posterior had high mean of 1834.79 N and standard deviation of 324.52 for maximum load, 25.96Mpa & 5.03 for compressive strength and 270.08 & 52.02 for modulus of elasticity respectively followed by nano hybrid composites and miracle mix (Figure / Table-3). The mean difference between Ever X posterior and Nano hybrid composite for maximum load is 482.30, for compressive strength and for modulus of elasticity is 62.24. (Figure / Table-4) The mean difference between Ever X posterior and miracle mix for maximum load is 1065.09, for compressive strength 13.972 and for modulus of elasticity is 91.306. Whereas the mean difference between Nano hybrid composites and miracle mix for maximum load is 582.79, for compressive strength is 7.33 and for modulus of elasticity 29.07. From the results it was shown that Ever X posterior is having maximum compressive strength with a mean of 25.95 MPa and maximum modulus of elasticity with a mean of 270.08 MPa.

DISCUSSION

Many methods have been adopted to restore endodontically treated teeth; which have decreased fracture resistance due to the loss of tooth structure during endodontic access cavity preparation procedures. Several attempts have been made to restore endodontically treated teeth with different post systems to increase the fracture resistance. However some studies have contradicting results because endodontic posts do not reinforce the crown, as enlargement of the root canal space after completion of root canal treatment can weaken the tooth structure. Pins are used to reinforce the cusp of the tooth, these pins create stresses and suffer with corrosion in the dental tissue. Many other restorative materials have been tried with varying success. Amalgam is traditionally regarded as the best build-up material under conventionally cemented crowns as it has good bulk strength and is sealed by its own corrosion products. Amalgam's main disadvantage lies in its mercury content. (Shah *et al*., 2012; Wassell *et al*., 2002) Also, the potential electrolytic action between the metal sub structure of the future crown; however the intervening cement will act as an insulator and limit ion liberation. The amalgamretention is due to mechanicalbut there is no adhesion to the tooth structure.

Table 1. The mean and standard deviation of maximum load, compressive strength and modulus of elasticity of Ever X posterior, Nanohybrid composite and Miracle mix

ANOVA TEST										
Different Loads	Material type	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	P-value
						Lower Bound	Upper Bound			
maximum load(N)	Ever x posterior	7	1834.797143	324.5270399	122.6596916	1534.659690	2134.934596	1401.3800	2196.9200	0.001*
	Nano hybrid composite	7	1352.497143	277.9919125	105.0710667	1095.397505	1609.596781	973.0700	1796.2500	
	Miracle mix	7	769.707143	210.8443778	79.6916841	574.708616	964.705669	560.7000	1164.8700	
	Total	21	1319.000476	516.9407938	112.8057294	1083.691848	1554.309104	560.7000	2196.9200	
Compressive strength(Mpa)	Ever x posterior	7	25.955714	5.0311061	1.9015794	21.302717	30.608711	18.7600	31.3800	0.001*
	Nano hbrid composite	7	19.321429	3.9713869	1.5010432	15.648508	22.994349	13.9000	25.6600	
	Miracle mix	7	11.984286	3.4636294	1.3091289	8.780963	15.187609	8.2000	18.3600	
	Total	21	19.087143	7.0790650	1.5447786	15.864791	22.309495	8.2000	31.3800	
modulous of elasticity(Mpa)	Ever x posterior	7	270.085714	52.0002326	19.6542405	221.993520	318.177908	219.0900	370.9000	0.015*
	Nano hbrid composite	7	207.849286	34.5085850	13.0430191	175.934168	239.764404	162.7600	267.0000	
	Miracle mix	7	178.778857	67.6623388	25.5739602	116.201631	241.356084	97.4900	266.0100	
	Total	21	218.904619	63.7577305	13.9130774	189.882448	247.926790	97.4900	370.9000	

*Statistically significant P<0.05

Table 2. Compares mean difference of maximum load, compressive strength and modulous of elasticity of one type of restorative material with other two types

POSTHOC TUKEY TEST							
Dependent Variable	(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
maximum load(N)	Ever x posterior	Nano hbrid composite	482.3000000*	147.05	0.01*	107.00	857.60
		Miracle mix	1065.09	147.05	0.01*	689.79	1440.39
	Nano hbrid composite	Ever x posterior	-482.30	147.05	0.01*	-857.60	-107.00
		Miracle mix	582.7900000*	147.05	0.01*	207.49	958.09
	Miracle mix	Ever x posterior	-1065.09	147.05	0.01*	-1440.39	-689.79
		Nano hbrid composite	-582.79	147.05	0.01*	-958.09	-207.49
Compressive strength (Mpa)	Ever x posterior	Nano hbrid composite	6.6342857*	2.25	0.02*	0.90	12.37
		Miracle mix	13.9714286*	2.25	0.01*	8.23	19.71
	Nano hbrid composite	Ever x posterior	-6.6342857*	2.25	0.02*	-12.37	-0.90
		Miracle mix	7.3371429*	2.25	0.01*	1.60	13.08
	Miracle mix	Ever x posterior	-13.9714286*	2.25	0.01*	-19.71	-8.23
		Nano hbrid composite	-7.3371429*	2.25	0.01*	-13.08	-1.60
modulous of elasticity (Mpa)	Ever x posterior	Nano hbrid composite	62.24	28.41	0.10	-10.26	134.74
		Miracle mix	91.3068571*	28.41	0.01*	18.81	163.81
	Nano hbrid composite	Ever x posterior	-62.24	28.41	0.10	-134.74	10.26
		Miracle mix	29.07	28.41	0.57	-43.43	101.57
	Miracle mix	Ever x posterior	-91.3068571*	28.41	0.01*	-163.81	-18.81
		Nano hbrid composite	-29.07	28.41	0.57	-101.57	43.43

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

Figure / Table –3. The mean and standard deviation of maximum load, compressive strength and modulus of elasticity of Ever X posterior, Nanohybrid composite and Miracle mix

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	Miracle mix	7	11.984286	3.4636294	1.3091289	8.780963	15.187609	8.2000	18.3600	
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Figure / Table – 4: Compares mean difference of maximum load, compressive strength and modulous of elasticity of one type of restorative material with other two types

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		Miracle mix	582.7900000*	147.05	0.01*	207.49	958.09
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		Miracle mix	13.9714286*	2.25	0.01*	8.23	19.71
	Nanohbrid composite						
		Miracle mix	7.3371429*	2.25	0.01*	1.60	13.08
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		Miracle mix	29.07	28.41	0.57	-43.43	101.57

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

Figure 1. Instron Universal testing machine - 8801 used for testing

Figure 2. Specially adapted jig for testing of the core material

Because of this fracture resistance diminishes and micro-crack propagation of the remaining tooth occurs under fatigue loading. (Shah *et al*., 2012; Wassell *et al*., 2002) With recent advances in adhesive technology and stronger adhesive materials, glassionomers cements are being used for core build up, in view of the apparent ease of placement, adhesion, fluoride release, and matched coefficient of thermal expansion. Silver containing GICs (Eg: Cermet or the miracle mix) have been especially became popular. (Combe *et al*., 1999; Cho *et al*., 1999; Ziebert and Dhuru, 1995) The silver within the material may enhances its physical and mechanical properties. Many workers regard GIC as inadequately strong to support major core build-ups. (Combe *et al*., 1999; Cho *et al*., 1999; Ziebert and Dhuru, 1995) Hence they recommended that a tooth should have at least two structurally intact walls; if the GIC has to be considered for core build up. Because of the above mentionedreasons miracle mix is used as one of the restorative material in our study. (Combe *et al*., 1999; Cho *et al*., 1999) Composite resins are more commonly used now a days because they adhere to the tooth. Although composite is as strong as amalgam (Cho *et al*., 1999) it has only recently been accepted as a good core material. Without dentine bonding agents microleakage (Wassell *et al*., 2002; HazemAbouelleil *et al*., 2015) is a significant problem. In recent days Nano hybrid composites showed decrease in the micro leakage but the strength of the materials remained questioned. In recent times the filler component of the composite materials are modified and newer materials are introduced to increase the strength of the restorative materials, so these restorative materials were used in the study for comparisons. An increase in the filler amount in composite will increase strength of the core material. Effective bonds between composite and tooth are now possible, but moisture contamination is critical factor. Dentine is left damp following etching and rinsing which encourages better penetration of the primer which termed as 'wet bonding' (HazemAbouelleil *et al*., 2015). Much of the skill in placing a core involves the selection of the most appropriate material and technique. As wide array of core materials are available commercially, thus it is imperative to evaluate the properties of these before incorporating them into our clinical practice. So this study was performed to evaluate the fracture resistance and modulus of elasticity of commercially available core materials. The fracture resistance is the amount of force to which the restorative material can withstand. For these reason the amount of maximum load applied that is compressive strength where the material fractures and the modulus of elasticity were calculated. The results showed that Ever X posterior has maximum resistance to fracture and miracle mix shows least resistance and the Values significantly differ with $P<0.05$. On comparison maximum load, compressive strength and modulus of elasticity of each sample with remaining two were significant. The reason cited for enhanced properties of Ever x posterior are they have a filler volume percentage of 74.2 wt%, 53.6 vol%, Short E-glass fiber filler and barium glass; showing the role of the fibres in increasing the material stiffness and resistance to bending force during testing and probably during function. (HazemAbouelleil *et al*., 2015) Preetam shah *et al*. (Shah *et al*., 2012) conducted a study on fracture resistance of endodontically treated deciduous mandibular molars restored with three different core materials and they found that GIC core is having highest fracture resistance of 1745 N which is slightly higher than fracture resistance of sound tooth having 1646.66 N. On comparing the results obtained with our study Ever X posterior is having fracture resistance of 1834.79 N which is higher than GIC cores and sound tooth. Hazem Abouelleiletal (Ali *et al*., 2015) aimed to compare the mechanical properties of a new fibre reinforced composite and bulk fill composites and they conclude that fibre reinforced composite (Ever X posterior) have higher fracture resistance, flexural strength, modulus of elasticity and high microhardness values compared to other bulk fill composites which supports the results obtained from my study. Bonilla *et al*. (2000) conducted a study to compare the fracture toughness of five different core materials namely glass ionomer, resin modified glass ionomer, titanium reinforced composite, composite resin with fluoride and amalgam. The results concluded that titanium-reinforced composite resin, had greater resistance followed by amalgam and GIC, according to our study Ever X posterior showed higher fracture resistance followed by bulk fill composites and least with metal modified gic. Coltak *et al*. (2007), studied the fracture resistance of three core materials supported by post and concluded that composite resin supported by post had greater resistance followed by amalgam and GIC which is similar to results obtained from my study. The study was done in vitro conditions, where the in-vivo factors simulation is not possible. As the periodontal ligament is one of the factor where the tooth will have cushioning effect so that some part of force will be transferred to the ligament. This simulation was not possible in in-vitro study. The instructions of manufacturing company should be adhered for the success with good clinical practice. The material manipulation is sensitive for humidity and adhesion in case of adhesive bonding. The proportions are important to have proper strength after mixture.

Limitations of the study

The study even though followed randomisation to prevent selection bias, and observers were blinded to prevent the observer bias but less sample size is one of the limiting factor. In our study we considered only permanent molar tooth. The core build up has to be done uniformly with uniform defects to prevent the tooth factors associated for adhesion or tooth structure to enhance the strength of the core. Our study warrants further studies with a large sample size and in-vivo simulation to determine the validity.

Conclusion

Our study showed the use of Ever X Posterior is better core build up material with predictable prognosis for successful post endodontic restoration. The clinician should make the choice of the material depending on the type of tooth, loss of tooth material and type of occlusion, any para-functional habitsetc should be considered. The most common but important factors are good clinical practice with correct case selection for the success of prosthesis with material knowledge and handing.

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