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RESEARCH ARTICLE

A COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF FIBRE REINFORCED COMPOSITE, FLOWABLE COMPOSITE AND A CORE BUILD UP MATERIAL: AN *IN-VITRO* STUDY

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ABSTRACT

Background: An ideal restoration in a tooth should be able to maintain the esthetics and proper form and function. Cavity preparation on a tooth reduces its fracture resistance. Composite resins as restorations have shown to increase the fracture resistance of the teeth . The drawback with these were stress development and low fracture resistance. These disadvantages forced the researchers to search for a newer generation of composite that has better fracture strength with less polymerization shrinkage.

Aim: This study aimed to evaluate and compare the fracture resistance of fibre reinforced composite, flowable composite and a core build up material on class II cavity.

Method and Materials: 90 human maxillary premolars were selected and divided in to 5 Groups. Group 1 served as control group. In Group 2,3,4 & 5 class II cavities were prepared. Group 3,4 & 5 were restored with EverX posterior, SDR and Paracore respectively. All the samples were subjected to Universal testing machine.

Results: Statistical tools used were one way analysis of variance, Dunnett's test and Tukey's post hoc test. p value <0.05 was considered statistically significant. Group 3 showed highest mean fracture resistance.

Conclusion: Fibre reinforced composite (Group 3) showed maximum mean fracture resistance which was statistically significant when compared to all the tested restorative materials.

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INTRODUCTION

Dental caries is one of the most prevalent disease in modern civilization due to the change in our lifestyle. It's successful long term treatment has been the area of concern for dentists across the world. Various restorative materials like silver amalgam, gold alloys, gallium alloys and various restorative cements have been developed for the restoration of carious tooth, with silver amalgam being used for more than a century. The drawbacks of silver amalgam and various other restorative materials compelled the researchers to develop a material with better esthetics and physical properties (Sekar *et al*., 2002). This led to the introduction of dental composite which is a combination of two or more chemically different materials with a distinct interface between them and having properties better than those of the components acting alone (Sekar *et al*., 2001). Adhesive dentistry revolutionized the scope of esthetic dentistry. In recent years composite resin has become the material of choice for the restoration and is very popular among the dentists.

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An ideal restoration in a tooth should be able to maintain the esthetics, function, preserve the remaining tooth structure and prevent microleakage (Sekar, 2002). Any cavity preparation in a tooth reduces its fracture resistance. One of the important intent of the tooth restoration is to re-establish its fracture resistance when subjected to occlusal load. Composite resins have shown to increase the fracture resistance of the teeth when used as a final restoration (Landy *et al*., 1984; Gelb *et al*., 1986; Morin *et al*., 1984 and Share *et al*., 1982). The inherent drawback encountered using conventional composites were stress development due to polymerization shrinkage and insufficient fracture resistance (Manley *et al*., 1979). These disadvantages obligated the researchers to search for a new generation of composite that has better fracture strength with less polymerization shrinkage. The recently introduced composites like ever X Posterior (a fiber reinforced composite), Smart dentin replacement-SDR (a bulk fill composite) and Paracore (a dual cure composite) promised to have a better fracture resistance as compared to the conventional composites (Sekar *et al*., 2002). Ever X Posterior is a fiber-reinforced composite designed to be used as dentine replacement. The short fibers of ever X Posterior material makes it a perfect material of choice to reinforce any composite restoration in large size cavities. Smart dentin replacement, SDR is a new posterior composite bulk fill material for dentin replacement combining the handling properties of a flowable composite with minimal shrinkage stress. Para Core is a composite based, dual-cured, radiopaque core build up material which can be used to build up the lost tooth structure. It is pragmatic that the strength of a restoration is of paramount importance for success of a posterior tooth restoration. Keeping this requirement in mind these newer composite materials have been introduced in the market with superior physical properties. Due to lack of substantial conclusive literature on the strength and success of these materials as a class II cavity restoration , this *in-vitro* study was designed to compare the fracture resistance of three recently introduced restorative material i.e. fiber reinforced composite (everX posterior), flowable composite (SDR) and core build up resin composites material (Paracore) using Universal testing machine.

MATERIAL AND METHODS

This study was done in Department of Conservative Dentistry, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow in collaboration with Centre of Plastic Engineering and Technology, Lucknow. Freshly extracted human maxillary premolars were obtained. These premolars were extracted during routine orthodontic treatment. Gross cleaning of all the teeth were done under running tap water and then with ultrasonic scaler unit (Biosonic, Coltene Whaledent, Switzerland). Sample inclusion criteria was mature tooth free from any crack, caries or restoration. 90 tooth samples were selected for this study. The selected samples were randomly divided into five groups. Group 1 consisted of 10 teeth serving as control group. Group 2 consisted of 20 teeth in which cavity was prepared but not restored. Group 3 consisted of 20 teeth in which cavity was prepared and restored with ever X posterior restorative material. Group 4 consisted of 20 teeth in which cavity was prepared and restored with SDR restorative material. Group 5 consisted of 20 teeth in which cavity was prepared and restored with Paracore restorative material. Group 2 to Group 5 were further subdivided into sub group A and subgroup B comprising of 10 samples in each subgroup. Sub group A comprising the mesio-occlusal (MO) cavities and Subgroup B comprising the mesio-occluso-distal (MOD) cavities.

All the teeth were mounted on the acrylic block of standard dimension 7 mm mesiodistally and 10 mm faciolingually exposing only the crown portion of the teeth. Ideal mesioocclusal cavities (sub group A) were prepared with air rotor handpiece (NSK, Japan) using a round diamond point (SS white, USA) and a straight diamond point (SS white, USA). Cavity depth of 1.5 mm and facio-lingual width of occlusal portion of the cavity was kept 1.5 mm. The proximal step was prepared to a width of 2 mm faciolingually and 1.5mm mesiodistally. The gingival floor was kept 1.5mm coronally from the cementoenamel junction. Similar preparation was done for Sub group B, difference being that cavity was extended involving the mesial marginal ridge and distal marginal ridge for mesio-occluso-distal cavity. The cavities were finished using enamel hatchet (API, Germany) and Gingival margin trimmer (API, Germany). Teeth were then air dried and bonding agent G-Bond (GC, Japan) in Group 3, Xeno V+(Dentsply, Switzerland) in Group 4 and Para Bond (Coltene Whaldent, Switzerland) in Group 5 respectively was applied as per manufacturers instruction and light cured (D Lux, Diadent, Korea) for 20 seconds with intensity 700 mW/cm^2. All the teeth samples in Group 3 to Group 5 were restored with ever X posterior, SDR and paracore respectively and light cured for 20 seconds. All the samples were subjected to a compressive load in an Universal Instron Testing machine (Instron 3382, USA). A cross head speed of 1.2 mm/min with tip diameter 1 mm was used to apply a load in the centre of the tooth till fracture of each restoration. The load required to fracture the specimen was recorded and the data obtained was subjected to statistical analysis.

RESULTS

Data was summarized as Mean ± SD (standard deviation). Groups were compared by one way analysis of variance (ANOVA) and the significance of mean difference of control group with other groups is done by Dunnett's test. Groups were also compared by two way ANOVA and significance of mean difference within and between the groups was done by Tukey's post hoc test. A two-tailed p value less than 0.05 ($p<0.05$) was considered statistically significant. Analyses were performed on SPSS software (version 17.0). It was observed that the mean fracture resistance of Group 3(Ever X posterior) Subgroup A (MO) was the highest followed by Group 1(Control group), Group 3 Subgroup B, Group 5 Subgroup A, Group 4 Subgroup A, Group 4 Subgroup B, Group 5 Subgroup B, Group 2 Subgroup A and Group 2 Subgroup B being the least (Table 1).

Table 1. Fracture resistance of five different groups

Group	Subgroup	n	Min	Max	Mean	SD
Group 1	-	10	632.67	864.76	740.29	79.67
Group 2	Subgroup A	10	90.12	361.25	196.70	92.73
	Subgroup B	10	51.77	280.09	115.32	68.45
Group 3	Subgroup A	10	670.04	917.38	769.93	76.68
	Subgroup B	10	482.66	739.52	623.86	97.81
Group 4	Subgroup A	10	338.63	576.19	453.72	77.94
	Subgroup B	10	134.51	419.92	335.87	89.18
Group 5	Subgroup A	10	344.70	636.54	485.73	97.91
	Subgroup B	10	88.09	356.17	222.82	88.42

Table 2. Comparison (p value) of mean fracture resistance of control group with others groups by Dunnett test

Comparison	p value
Group 1 vs. Group 2 Subgroup A	<0.001
Group 1 vs. Group 2 Subgroup B	<0.001
Group 1 vs. Group 3 Subgroup A	0.968
Group 1 vs. Group 3 Subgroup B	0.021
Group 1 vs. Group 4 Subgroup A	<0.001
Group 1 vs. Group 4 Subgroup B	<0.001
Group 1 vs. Group 5 Subgroup A	<0.001
Group 1 vs. Group 5 Subgroup B	<0.001

Comparing the mean fracture resistance of control group with other groups, Dunnett test showed significantly ($p<0.05$ or $p<0.001$) different and lower fracture resistance in all groups as compared to control except Group 3 Subgroup A (Table 2).

Comparison of the mean fracture resistance between the subgroup A(MO) and subgroup B(MOD) in Group 2 to Group 5, Tukey test showed significant ($p<0.001$) difference in fracture resistance of MO and MOD restoration in Group 3 and Group 5 (Table 3). Mean fracture resistance of MO cavity restorations were higher when compared to MOD cavity in all the groups.

Table 3. Fracture resistance (Mean ± SD) of subgroup A and Subgroup B of Group 2 to 5.

Group	Subgroup A (n=10)	Subgroup B (n=10)	p value
Group 2	196.70 ± 92.73	115.32 ± 68.45	0.426
Group 3	769.93 ± 76.68	623.86 ± 97.81	0.008
Group 4	453.72 ± 77.94	335.87 ± 89.18	0.062
Group 5	485.73 ± 97.91	222.82 ± 88.42	<0.001

DISCUSSION

Various studies have proved that composites restorative material reinforces the remaining tooth structure.[3,9] In order to achieve a good fracture resistance from composite restoration on a large carious lesion, search for a composite that can withstand the occlusal forces and also provide a long term treatment solution started. Today various newer generation composites have claimed to possess superior fracture resistance to their predecessors (Sekar, 2002). In this *in-vitro* study, ninety human maxillary premolars were chosen as they are easily available posterior teeth. All the teeth were randomly divided in to 5 Groups. Standardized MO & MOD cavities were prepared in Group 2 to Group 5. The standardized cavity design provided uniformity for the restorative materials to be tested and simulated the ideal intra oral cavity design. All the Experimental Group tooth samples were restored with their respective restorative materials. All the samples were then subjected to Universal testing machine for the evaluation of fracture resistance. The results obtained were statistically analyzed.

In the present study, the mean fracture resistance of Group 3 (everX posterior) was highest followed by Group 1 (Intact teeth) followed by Group 4 (SDR), Group 5 (Paracore) and Group 2 (cavity prepared & unrestored teeth) being the least. The increased fracture resistance of fibre reinforced composites restored in Class II cavity compared to intact teeth is due to restored marginal ridge and mechanical adhesion to the tooth structure and ability of the material to stop the crack propagation due to the presence of fibers in it (Mc Cullock, 1986 and Sufyan *et al*., 2015). In Group 3,Subgroup A cavity restored with ever X posterior showed highest fracture resistance among all the Groups (Group 1, 2, 4 & 5) but there was no significant statistical difference ($p>0.05$) in fracture resistance with intact tooth , SDR or Paracore composite resin. However, Subgroup B cavity restored with Fiber reinforced composite showed significant statistical difference (< 0.001) in fracture resistance when compared to Group 4 and Group 5 restorative materials. This difference in fracture resistance in case of fiber reinforced composite material is due to the presence of fibers which prevents and stop the crack propagation throughout the restoration. (Sufyan *et al*., 2015) Random fiber orientation and lowered cross-linking density of the polymer matrix by the semi- interpenetrating polymer network (IPN) structure has a significant role in enhancing mechanical properties (Garoushi *et al*., 2011). Reinforcing effect of the fibers fillers is based not only on stress transfer from polymer matrix to fibers, but also depends upon behavior of individual fiber which acts as a crack stopper. This can also be attributed due to large filler size present in ever X posterior and SDR composite.

The filler particle size of ever X posterior is 0.5-1.6 mm and SDR is 4.2 µm and average filler particle size of Paracore is 2 µm (Garoushi, 2013 and Mulder *et al*., 2013). Better fracture resistance of Group 3 and Group 4 can be attributed to large filler particle which strengthens physical properties (Magne *et al*., 2009). Other factor besides filler size which can be responsible for low fracture resistance is filler loading and stress transfer from resin matrices to filler particles (Magne, 2009; Magne *et al*., 2008; Zhao *et al*., 1997; Ferracane *et al*., 1998; Kim *et al*., 2000; Bonilla *et al*., 2001 and Kim, 2002). There may be difference in bond strength between filler particles and matrix among these resin composites (Magne *et al*., 2009). Group 4 had less mean fracture resistance than Group 3 and had more mean fracture than Group 5. The filler content in SDR composition (68 % by wt, 45% by vol.) and Paracore composition (74 % by wt, 52 % by vol.) is less when compared to ever X posterior (74 % by wt, 53.6 % by vol). This result obtained was in accordance with the results showed in the study conducted by Atabek Didem *et al.* (2014). It was concluded that low fracture strength of SDR was due to low amount of filler loading in the composition. Another study done by Sufyan K. Garoushi *et al.* showed fracture resistance of SDR to be less when compared to everX posterior (Garoushi *et al*., 2013). This suggested that flowable materials with less filler content are inferior when compared to more filled counterparts (Gu, 2007).

Conclusion

Within the parameters, This *in- vitro* study came to the following conclusions: ever X posterior showed maximum mean fracture resistance which was statistically significant when compared to all the composite resins. Hence, ever X posterior composite resin can be used as an ideal restorative material in Class II cavities. There was no statistically significant difference in mean fracture resistance of SDR and Paracore composite resin. Mesio-occlusal cavities showed greater mean fracture resistance than mesio-occluso-distal cavities.

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