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RESEARCH ARTICLE
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AN IN-VITRO EVALUATION OF FRACTURE RESISTANCE OF MAXILLARY PREMOLAR WITH LARGE MOD CAVITY RESTORED WITH PREHEATED AND DIRECT COMPOSITE SYSTEM.

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Abstract:
Objective: The present study compared the fracture resistance of teeth with large MOD cavity restored with direct and preheated composite system.

Method: 45 extracted maxillary premolar with similar dimensions were collected. Fifteen intact teeth served as control (Group I) (n= 15).Standardized large MOD cavities were prepared on remaining 30 teeth and were randomly divided into two experimental groups (Group II and III) (n = 15). Teeth in Group II were restored with direct Composite and Group III with preheated composite (50^{0}C).Universal Testing Machine was used to measure the fracture resistance. Fracture resistance was measured in Newton (N).

Results: By using multiple comparison: Tukey Test no significant difference was found between group I and group II (p=0.072), group I and group III (p=0.990), group II and group III (p=0.140)

Conclusion: Based on the results of the present study, it can be concluded that maximum fracture resistance is shown by intact teeth followed by preheated composites and then conventional composites.

Keywords: Preheated composite, Direct composite, fracture resistance, Large MOD cavities , Estilite Sigma Quick.

Introduction

Fractured tooth is one the most common dental problem. Trauma, caries, extensive cavity preparation and endodontic treatment are contributing factors for tooth fragility. However, cavity preparation procedures seems to be the major cause of most cuspal fracture.[1, 2] A significant reduction in tooth strength is brought by mesio-occluso-distal (MOD) cavity preparation which is due to the loss of both the marginal ridges and microfractures caused by applied occlusal forces.[3]

It has been suggested that the adhesive nature of composite has the capability to decrease flexion and bind the cusps, which is the main cause of fractures in amalgam restored teeth.[1] Dental resin–based composites are complex materials that set through a free radical polymerization mechanism that involves cross-linking of monomer chains, resulting in a high polymerization shrinkage ranging between 2% and 6% by volume.[4]

Resin-based composites with a higher filler content show reduced polymerization shrinkage as the volume of resin is minimized. Recent nanofiller technology with nanometric fillers impregnated in nanoclusters leads to high filler loading resulting in an increase in high compressive strength and flexure strength.[5]

Group of new composites Estelite sigma quick with spherical supranano zirconia and silica fillers and higher filler loading not just impart improved physical properties but also made it esthetically demanding, quick curing time and enhance handling characteristics.[4]

Freedman & Friedman (2003) claimed that warming resin based restorative materials prior to placement and contouring enhances composite adaptability to preparation walls.[6,7] An additional advantage of heating composites prior to placement is increase in monomer conversion as well as an improvement of the polymerization rate. [8]This approach helped to increase the mechanical properties, the degree of conversion and the flow of the material and is subsequently reflected on materials adaptation and retention into tooth cavities and can also provide the possibility to fill deep cavities using single increment of the preheated resin composite[9]

This, in vitro study assessed the influence of 2 different composite systems on fracture resistance of premolar with large MOD cavity. Estilite sigma quick (Tokuyama Dental, Japan) with spherical supranano zirconia and silica fillers was used in direct composite system. The increase in temperature of composite enhances both radical and monomer mobility, more highly crosslinked polymer networking and improved mechanical and physical properties may be anticipated .For preheated composite same Estilite Sigma Quick (Tokuyama Dental, Japan) was preheated at 50°C.

Literature search reveals that there is no study which compares the fracture resistance of conventional composite and preheated composites taking large MOD cavity into consideration.

So in this study, comparison of fracture resistance of teeth with large MOD cavity restored with direct composite system with Estilite Sigma Quick, preheated composite system by preheating Estilite sigma quick composite at 50 ^{0}C using AR composite heater were done.

Null hypothesis was that there is no difference in fracture resistance of intact teeth and teeth with large MOD cavity restored with direct and preheated composite.
Materials and Methodology

45 extracted maxillary premolar with similar dimensions. (9.0- to 9.6-mm bucco-lingual distance; 7.0- to 7.4-mm mesio-distal distance and 7.7- to 8.8-mm cervico-occlusal distance) were collected. All specimens were evaluated and examined for cracks or other structural deficiencies under a stereomicroscope microscope (20X magnification).

Root surfaces were dipped into melted wax to a depth of 2 mm below the cementoenamel junction then vertically embedded in stainless steel mould with self-cure acrylic.

After setting the acrylic resin, the teeth were extruded from the moulds and the wax was removed from the resin blocks.

Then, light body silicone was injected into the resin blocks and the teeth were placed in their previous sockets to mimic periodontal ligament.

Teeth were then randomly divided into 3 groups of 15 premolar each .Group I –Intact teeth. Group II – Direct Composite , Group III – Preheated composite.

Standardized large MOD cavities were prepared except intact teeth (Group I) using a 271 carbide taper fissure bur of dimension 0.8mm in high-speed water-cooled hand piece on rest of the experimental group specimens (group II and group III), bur was changed after every 5 cavity preparations.

The dimensions were
- Pulpal depth – 2mm ± 0.2mm
- Occlusal width – 2/3rd of the intercuspal distance
- Height of the axial wall – 1.5 mm
- Width of the gingival wall – 2mm

After completion of preparation, all surfaces were washed and air dried using water and air spray. Each group was then treated as follows

Group II: Direct Composites
Bonding agent (Plafique bond, Tokuyama, Japan) was applied using an applicator tip on the cavity surface. Mild air was applied followed by curing for 10 seconds using LED light-curing unit (1200mW/cm^2) kept at a distance of 2mm, according to manufacturer's instructions.Initially, the missing mesial and distal walls were restored with 1-mm-thick composite [Estelite sigma quick composite (Tokuyama Dental, Japan)] using the Tofflemire matrix system.Composite was then placed in increment of 1 mm with a Teflon coated instrument by incremental layering technique and cured for 10s for each increment. Finishing and polishing was performed using composite finishing and polishing kit.

Group III: Preheated Composite (Estilite Sigma, Tokuyama Dental, Japan.) Bonding agent was applied same as in group II. Composites were pre-heated at 50^{0}C using composite heating conditioner (A R Heater, US).The missing mesial and distal walls were restored with 1-mm-thick pre heated composite [Estelite sigma quick composite (Tokuyama Dental, Japan)] using the Tofflemire matrix system (0.001") (GDC INDIA). Preheated composite was then placed in increments of 1 mm with a Teflon coated instrument, cured for 10s was done same as in Group II. Finishing and polishing was performed using composite finishing and polishing kit (Shofu dental,India)All the specimens were then submitted to thermal stress in a thermal cycling machine (500 cycles at 5°± 2°C–55°C ± 2°C) with a dwell time of 30 seconds and a transport time of 5 seconds.

Following thermocycling, all specimens were stored in distilled water at 37°C for 24 hours before fracture testing.

The fracture resistance of the teeth was measured using an Instron India universal testing machine. Each specimen was subjected to compressive loading using a 5 mm round diameter stainless steel ball at a strain rate of 2 mm/min.

The force necessary to fracture the specimen was recorded in Newton (N) and data obtained was tabulated and subjected to the statistical analysis using IBM SPSS Statistics professional software.

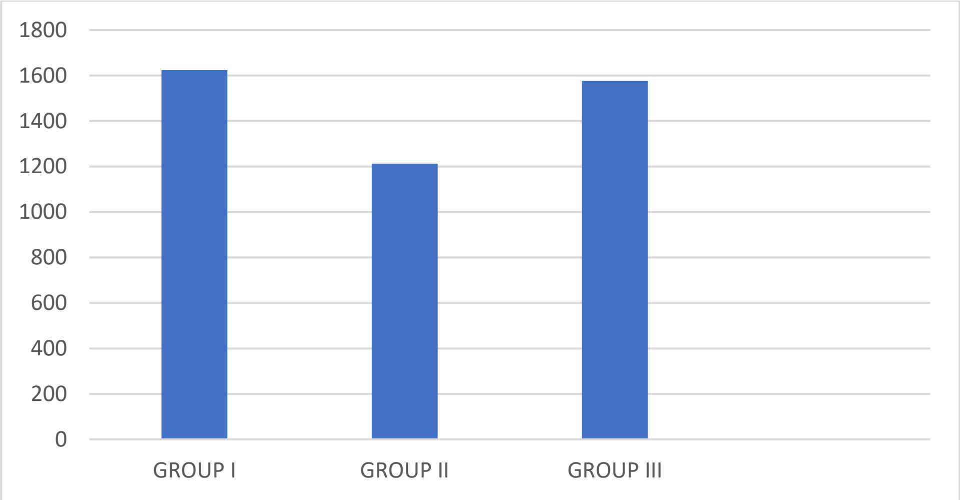
Results

Statistical analysis of this study was carried out to find whether there is any significant difference betweenthe fracture resistance values obtained in the study. Analysis of the data was done by using descriptive and inferential statistics both.The software used in the analysis were SPSS 24.0 and Graph Pad Prism 7.0 version and $p<0.05$ was considered as level of significance.

Mean fracture resistance in samples of group I was 1624.13±546.56, in group II it was 1231.09±371.41, in group III it was 1575.98±484.06(**Table 1 and Graph 1**)

TABLE 1 : DESCRIPTIVE STATISTICS OF FRACTURE RESISTANCE OF THREE GROUPS

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Group I	15	1624.13	546.56	141.12	1321.45	1926.80	1039.04	2899.20
Group II	15	1231.09	371.41	95.89	1025.41	1436.77	704.62	1789.34
Group III	15	1575.98	484.06	124.98	1307.92	1844.05	962.36	2682.20

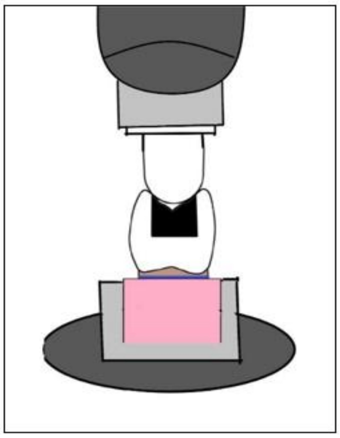


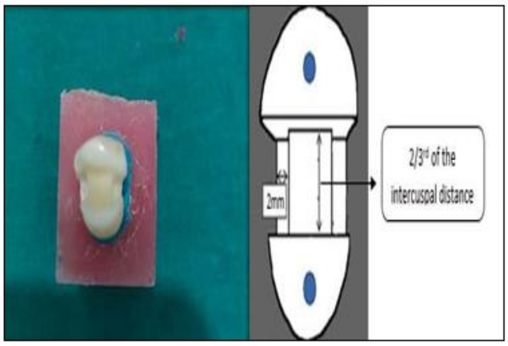
GRAPH 1: COMPARISON OF FRACTURE RESISTANCE

By using multiple comparison: Tukey Test no significant difference was found between group I and group II (p=0.072), group I and group III (p=0.990), group II and group III (p=0.140)(**Table 2**)

TABLE 2: MULTIPLE COMPARASION BY TUKEY TEST

Group		Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II	393.03	157.75	0.072,NS	-24.67	810.74
	Group III	48.14	157.75	0.990,NS	-369.56	465.85
Group II	Group III	-344.89	157.75	0.140,NS	-762.60	72.81





Discussion

According to a study conducted by **Joynt et al. in 1987**[10], preparation of an occlusal cavity reduces the tooth stiffness by 20%. If a marginal ridge is also involved and it is removed during the preparation the occlusal cavity gets converted into a proximal cavity and the tooth stiffness further reduces by 2.5 folds resulting in an overall 46% reduction in tooth stiffness. If both marginal ridges are included in the cavity preparation design, the stiffness decreases by 63%

In present study maxillary premolars were chosen as they are more prone to fracture due to the anatomical shape with steep cuspal inclines which leads to cuspal separation during mastication.[4]

In this study the apical root end of each tooth was aligned vertically along their long axis in self-curing acrylic, 1mm apical to cementoenamel junction. In almost all the reviewed in vitro studies, specimens have been embedded in acrylic resin blocks and a space should be left around the roots and light body silicon index was made for the duplication of periodontal ligament and distribute the load of the occlusal forces to the alveolar bone evenly.[11,12,13]

Relatively wide MOD cavities restored with amalgam frequently develop cusp fractures due to continuous functional occusal forces. This is mainly due to inability of amalgam to strengthen the weakened cusps.[10] So, in this study large MOD cavities were considered in order to evaluate the ability of adhesive restorative materials to reinforce the remaining tooth after restoring a wide MOD cavity.

In this study, intact teeth (control group) group showed highest fracture resistance among all the experimental groups. It is due to the presence of the palatal and buccal cusps with intact mesial and distal marginal ridges which form a constant circle of dental structure, strengthening the tooth.[14]However no statistical difference was found between the restored groups and intact teeth. Therefore, the null hypothesis for this study that was ‘there is no statistical difference in fracture

resistance of intact teeth and teeth with large MOD cavity restored with conventional and preheated composite' was accepted.
In the present study, Group II (Conventional Composite) exhibited lesser fracture resistance than group III (Preheated Composities). However, statistically significant difference was not found .These results are similar to the study conducted by Othman H. Abdulhameed and Zainab M. Abdul-Ameer [15], in which they have concluded that the preheated composite exhibited high fracture resistance when compared with conventional composites, but it was statistically non-significant. This slight increased fracture resistance may be due to preheating the composites before photopolymerisation, as it reduces viscosity and increases the flowability by increasing the degree of conversion. When temperature increases, both the radical and monomer mobility increases resulting in a more highly cross-linked polymer network.[16] This process may promote the improvement of mechanical and physical properties, such as enhanced flexural and diametral tensile strength and higher surface hardness, of pre-heated composite materials.[16,17]

This is an *in vitro* study therefore it is possible that the interferences from the study might not correlate completely with similar situations completely. Further *in vitro* and *in vivo* studies with a greater number of samples are required to access the fracture resistance of conventional and preheated composites.

Conclusion:

Based on the results of the present study, it can be concluded that maximum fracture resistance was shown by intact teeth followed by preheated composites and then conventional composites. So, preheating composites can be a considered as a beneficial option to increase the fracture resistance of teeth with large MOD cavity. However *in vivo* studies as well as studies comparing preheated and indirect composites should also be considered.

REFERENCES

1. Torabzadeh H, Ghasemi A, Dabestani A, Razmavar S. Fracture resistance of teeth restored with direct and indirect composite restorations. J Dent (Tehran). 2013 Sep;10 (5):417-25.
2. Atalay C, Yazici AR, Horuztepe A, Nagas E, Ertan A, Ozgunaltay G. Fracture Resistance of Endodontically Treated Teeth Restored With Bulk Fill, Bulk Fill Flowable, Fiber-reinforced, and Conventional Resin Composite. Oper Dent. 2016 Sep-Oct;41(5):E131-E140.
3. Hegde V, Sali AV. Fracture resistance of posterior teeth restored with high-viscosity bulk-fill resin composites in comparison to the incremental placement technique. J Conserv Dent 2017 SepOct;20(5):360-364
4. Hada YS, Panwar S. Comparison of the fracture resistance of three different recent composite systems in large Class II mesio-occlusal distal cavities: An in vitro study. J Conserv Dent 2019;22:287-91.
5. Nahedh HA, Sibai NS. Evaluation of Interfacial Gap Volume of Two Low-shrinkage Composites Using Micro-Computed Tomography. Oper Dent. 2017 Nov/Dec; 42(6):658-668.
6. Freedman PD. Clinical benefits of pre-warmed composites. Private Dent. 2003;8(5):111-4.
7. Friedman J. Thermally assisted polymerization of composite resins. Contemp Esthetics Rest Practice 2003;7: 46.
8. Elkaffas AA, Eltoukhy RI, Elnegoly SA, Mahmoud SH. The effect of preheating resin composites on surface hardness: a systematic review and meta-analysis. Restor Dent Endod. 2019 Nov; 44(4):e41
9. Uctasli MB, Arisu HD, Lasilla LV, Valittu PK. Effect of preheating on the mechanical properties of resin composites. Eur J Dent. 2008 Oct; 2(4):263-268.
10. Joynt RB, Wieczkowski G Jr, Klockowski R, Davis EL. Effects of composite restorations on resistance to cuspal fracture in posterior teeth. J Prosthet Dent. 1987 Apr;57(4):431-5

11. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. Braz Oral Res. 2005 Jan-Mar;19(1):11-6.
12. Hshad ME, Dalkılıç EE, Ozturk GC, Dogruer I, Koray F. Influence of different restoration techniques on fracture resistance of root-filled teeth: in vitro investigation. Oper dent. 2018 Mar;43(2):162-9
13. Luthria A, Srirekha A, Hegde J, Karale R, Tyagi S, Bhaskaran S. The reinforcement effect of polyethylene fibre and composite impregnated glass fibre on fracture resistance of endodontically treated teeth: An in vitro study. J of Conserv Dent 2012 Oct;15(4):372.
14. Asopa S, Mandava J, Chalasani U, Anwarullah A, Ravi R, Fracture resistance of endodontically treated molars restored with resin composites. IP Indian J Conserv Endod 2017;2(3):89-97.
15. Othman H. Abdulhameed, Zainab M. Abdul-Ameer. Fracture resistance of weakened premolars restored with different preheated bulk fill composites (A comparative in vitro study) J. Bio. Env. Sci. 2018 oct; 13(4): 237-247.
16. Dionysopoulos D, Papadopoulos C, Koliniotou-Koumpia E. Effect of temperature, curing time, and filler composition on surface microhardness of composite resins. J Conserv Dent 2015;18:114-8.
17. Yang JN, Raj JD, Sherlin H. Effects of Preheated Composite on Micro leakage-An in-vitro Study. J Clin Diagn Res. 2016 Jun; 10(6):ZC36-ZC38.