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Original Research Article

A comparative evaluation of fracture resistance of three recent composite systems in Class II mesio occluso distal cavities - An in vitro study

Bindu Madhavi Gosala[1]*, Sandya Rani Kollabathula[1], Mounika Anukolu[1], Ramakrishna Raju Kanumuri[1]

[1] *GSL Dental College and Hospital, Rajahmahendravaram, Andhra Pradesh, India*

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ABSTRACT

Background: Though composite resins have received popularity as restorative materials because of their physical properties, there was a dearth in the research about fracture resistance among recently emerged composite systems including Tokuyama Estelite Sigma Quick, Admira Fusion, and Beautifil II LS nanohybrid composite systems.
Aim: To compare and evaluate the fracture resistance of maxillary premolars with class II mesio occluso distal cavities restored with Tokuyama Estelite Sigma Quick, Admira Fusion, and Beautifil II LS nanohybrid composite systems.
Materials and Methods: Current invitro research was conducted on 44 intact human premolar teeth-Eleven specimens were kept completely intact for control group (Group G1). Class II MOD cavities were done with high-speed handpiece and under constant irrigation in remaining 33 teeth, Group G2, Group G3, Group G4 were restored with Tokuyama Estelite Sigma Quick (Tokuyama Dental, Tokyo, Japan.), Beautifil II LS (Shofu, Germany.), Admira Fusion (Shofu, Germany.) respectively. SPSS version 20 software to analyse the data; and ANOVA followed by Tukey's post-hoc analysis to compare the fracture resistance were used.
Results: With a fracture resistance of 1297.27±10.27 N, Group 1 (Control) had highest fracture resistance. Group 4 has the least fracture resistance (Admira Fusion). Every pairwise comparison was significant too.
Conclusion: Among the three materials studied, Beautifil II LS had higher fracture resistance and Admira Fusion had the least fracture resistance.

1. Introduction

Composite resins have received popularity as restorative materials because of their aesthetic and superior bonding properties- attributed to acid etch technique in their placement.[1] But, shortcomings like polymerization shrinkage, water sorption and technique sensitivity led to newer formulations. Nanohybrid composites with high filler volume and better mechanical properties are being increasingly used.[2]

Tokuyama Estelite Sigma Quick, with radical amplified photo- polymerisation initiator (RAP technology) that balances the high polymerisation activity, has excellent strength and durability due to its high filler loading.[3] Another latest trend in composites is Admira Fusion- a universal nanohybrid ORMOCER restorative material, which is a three-dimensional cross-linked polymer and it polymerizes without leaving a residual monomer.[4] Beautifil II LS is a novel nano-hybrid composite system having SRS (steric repulsion structured) molecule that is designed to minimize polymerization shrinkage, thus resulting in a sturdy and stable restoration.[5]

* *Corresponding author*.
E-mail address: doc.madhavigosala@gmail.com (B. M. Gosala).

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These recent composites are distinct in composition and filler content. The scientific literature on their material properties is sparse. Therefore, we aimed to compare the fracture resistance of Tokuyama Estelite Sigma Quick, Admira Fusion and Beautifil II LS nanohybrid composite systems with that of the tooth. Maxillary teeth were selected for restoration as their steep cuspal inclines lead to cuspal separation during mastication and greater incidence of fracture than mandibular premolars. In addition, MOD cavities considered to be the poorest in handling the fracture resistance were designed.[6,7]

2. Materials and Methods

We conducted an invitro study on 44 sound extracted human permanent premolar teeth. Our objectives were to compare the fracture resistance of class II MOD cavities, restored using Tokuyama Estelite Sigma Quick, Beautifil II LS, and Admira Fusion with that of natural tooth.

The sample size was derived using G*Power 3.1.9.2 software by considering 5% alpha error, 80% power, and 0.53 effect size. Fully erupted teeth with mature apices, intact enamel and dentine without any carious lesion, restorations, and developmental defects were included. Teeth with open apices or resorption, previous restorations, or with any anatomical variation were examined under dental operating microscope and excluded. Ethical clearance was obtained from the Institutional Ethical Committee and the study was conducted according the rules of Declaration of Helsinki.

All the procedures were carried out by a single trained operator. The samples were stored in thymol solution at 37°C and 100% humidity until the beginning of the experiment. Teeth were cleaned by removing dental calculus. The root part of each sample was encircled with spacer wax, to simulate PDL (periodontal ligament). Metallic mould of 2 cm dimensions with cold cure acrylic resin (DPI, India) was used to mount the sample tooth. After the complete setting of the acrylic resin, tooth was taken out and spacer wax was removed. The space created in the acrylic resin block were filled with light body elastomeric impression material (Aquasil, Dentsply, Caulk Milford, DE) and tooth was placed back in the block.

The specimens were randomly assigned into four groups (n = 11). Eleven specimens were kept completely intact for the control group (Group G1), and Class II mesio-occluso-distal cavities were prepared in 33 specimens using highspeed hand piece with FG 330 bur (Brasseler USA). The dimensions of the cavities were standardized using Digital Callipers as: Occlusal box that was 2 mm deep in relation to bottom of the groove, a width of 1/3rd the inter-cuspal distance, an axial wall height of 1.5 mm and 2 mm width at the gingival wall.

The prepared samples were divided to receive three different restorative materials:

Group G2: restored using Tokuyama Estelite sigma quick (Tokuyama Dental, Tokyo, Japan)[8]

Group G3: restored using Beautiful II LS (Shofu, Germany)[5]

Group G4: restored using Admira Fusion (Shofu, Germany)[9]

Prepared MOD cavities were air-dried, and etchant used for 10s; then the cavities were rinsed for 30s and air-dried. 3M ESPE Single Bond Universal bonding agent was coated and cured for 20 s with Dentsply spectrum curing light. Tofflemire matrix band was applied for a further composite restoration. Estelite Sigma Quick was placed by incremental technique and cured for 10 s for each increment. Admira fusion and Beautifil II LS were placed in oblique increments in the tooth and each increment cured for 40s. Finishing and polishing was done using discs and burs. Thermocycling (SD Mechatronik, Germany thermocycler) was carried out-500 cycles at 5°C ± 2°C–55°C ± 2°C with 30 s dwell time and 5s transfer time.

Fracture resistance of the teeth was measured using Universal Testing Machine (FIE-UTES-40-HGFL). Each sample was subjected to compressive loading using a 5 mm round diameter stainless steel ball at a strain rate of 2 mm/min, such that the ball contacted the inclined planes of the facial and palatal cusps beyond the margins of the restoration. This simulated the tendency of the masticatory forces deflecting the cusps under stress. The force necessary to fracture the specimen was recorded in Newton (N), and data obtained were tabulated and subjected to the statistical analysis using IBM SPSS software version 20. ANOVA followed by a Tukey's post-hoc analysis was used for comparing the four groups.

3. Results

Both ANOVA and post-hoc analysis results revealed a significant difference in the fracture resistance of the four groups, with group 1 having highest fracture resistance, followed by groups 3, 2 and 4 (Tables 1 and 2).

4. Discussion

Dental composites have replaced amalgam as the restorative materials of choice due to their aesthetic properties.[10] In recent times, newer formulations like ORMOCER, and bioactive variants with varying filler content have been developed. We aimed at comparing three such novel composites for their fracture resistance against each other and also against that of natural tooth.

Of the three materials studied, though highest fracture resistance was demonstrated for Beautiful II LS, none of them were superior to natural tooth. Several previous studies that compared composites with natural teeth too found similar results,[11–13] citing that cavity preparation weakens the teeth structure.

Table 1: ANOVA for comparing the fracture resistance of the four groups.

Group	n	Mean±SD (N)	Min	Max	95% CI	F value	P value
Control	11	1297.27±10.27	1240	1360	1274.3 –1320.1	87.61	<0.001*
Tokuya ma Estelite Sigma Quick	11	1094.55±30.75	920	1260	1026.01 –1163.08		
Beautifu l II LS	11	1177.27±21.87	1080	1320	1128.5 – 1226		
Admira Fusion	11	824.55±17.54	720	920	785.4 – 863.6		

* Statistically significant at p<.05.

Table 2: Tukey's post hoc tests for multiple pair wise comparisons between the study groups for fracture resistance

Reference group	Comparison group	Mean diff	P value
Control	Tokuyama Estelite Sigma Quick)	202.72	<0.001*
	Beautiful II LS	120	0.002*
	Admira Fusion	472.72	<0.001*
Tokuyama Estelite Sigma Quick	Beautiful II LS	-82.72	0.045*
	Admira Fusion	270	<0.001*
Beautiful II LS	Admira Fusion	352.72	<0.001*

* Statistically significant at p<.05.

The highest fracture resistance for Beautifil II LS is due to the presence of high-density pre-polymerized fillers,[14] in addition to the oblique incremental technique used. This produces lower residual shrinkage stress along the enamel and composite interface when compared to horizontal increments apart from the perceived C- factors also being low.[14]

Moreover, Admira Fusion is nano- hybrid variety and Beautifil II LS is a hybrid variety with Giomer technology that contributes to its improved performance.[14] This research is one in very few attempts that describes fracture resistance of the Beautifil II LS in comparison with other recent composite materials. Hence, there were only a few studies to support the current findings, thus justifying the need for the study.

The fracture resistance was more in Tokuyama Estelite Sigma Quick when compared to Admira Fusion. Differences in the strength among different composites may be justified due to variation in the chemical composition of their matrix, and the distribution of filler content. A decrease in size and increase in the filler volume are directly proportional to its compressive strength and surface hardness.[15,16]

Mechanical properties of dental composites are significantly increased by incorporation of fibres that prevent crack propagation during the transfer of stress from matrix. The maximum filler loading in Estelite Sigma Quick offers excellent strength and durability- justified by its RAP technology. It also has spherical supra-nano zirconia with silica fillers that show improved physical properties along with being aesthetically demanding.[17]

The least fracture resistance in Admira Fusion is because of the material being Bis-GMA-free and Ormocer®- based, hence does not compete with the mechanical performance of conventional Bis-GMA-containing composites.

Fracture toughness also measures the resistance against the propagation of an already existent crack in the material.[18] It was shown that particles of large size tend to increase the threshold of composites in terms of crack resistance. Moreover, cracks in the composites containing pre-polymerized resin fillers grow at lower stress intensity threshold values. A micro-hybrid has shown to endure higher levels of cyclic stress before the onset of stable crack initiation when compared with a nano-filled composite of smaller particle size.[19] In this study both nano and hybrid varieties of composite were used, of which Beautifil II LS showed higher fracture resistance, justified by its hybrid variety. The reason may be because of the combination of different sizes of the filler materials.

Previous in vitro studies on different application techniques could not establish the best one for enhancing clinical durability,[20] and there isn't enough literature on class of material of giomer, nanohybrid and supra-nano composites. Therefore, we used both horizontal and oblique techniques with these materials. Similarly, as differences in fracture resistance of enamel and dentin bonded composite resin restorations could not be demonstrated,[21] dentinal bonding agent was used in a single layer and cured for the present study.

Ausiello et al[22] concluded that, teeth restored with dentin bonding agent (DBA) and composite have better fracture resistance when compared to other combinations. Hence, in this study, application of DBA was considered prior to the placement of composites.

The specimens were thermos-cycled to preserve the uniformity among the specimens. For the reason that the mean value of fracture resistance obtained for the thermos-cycled silver amalgam specimens was lower than that for the non-thermocycled specimens in a previous study.[23] The possible explanations for the decrease in fracture toughness could be that thermo cycling increases the corrosion of the

material.

Our study is first of its kind to compare the fracture resistance among three novel composites; but an invitro study need not necessarily correlate with the invivo conditions- wherein, masticatory load and forces vary among individuals. Future randomized clinical trails that evaluate the fracture resistance when masticatory forces are applied are recommended.

5. Conclusion

Within the above limitations, our study results conclude that fracture resistance of natural tooth is better than the three composites studied. Further, greater resistance was found for Beautifil II LS, followed by Estelite Sigma Quick and Admira Fusion.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Bindu Madhavi Gosala, Student

Sandya Rani Kollabathula, Student

Mounika Anukolu, Student

Ramakrishna Raju Kanumuri, HOD

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