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Original Research

Evaluation of fracture resistance of two new nano hybrid composites with and without SDR Liner- An in vitro study

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ABSTRACT:

Background: Various treatment options are indicated for the restoration of teeth with mesio-occlusal-distal cavities. To minimize the formation of interfacial stresses, several clinical techniques have been suggested such as placement of stress absorbing intermediary layers and by changes in filler technology & monomer chemistry. **Methods:** Freshly extracted forty intact maxillary premolars (for orthodontic purpose) without caries were selected. Forty teeth were randomly divided into 4 groups of 10 teeth in each group. Group I (n=10) - CERAM X SPHERE TEC With SDR liner, Group II (n=10) - FILTEK Z 250 With SDR LINER, Group III (n=10) - CERAM X SPHERE TEC (2mm increments), Group IV (n=10)- FILTEK Z 250 (2mm increments).Standard MOD cavities were prepared and restored. These specimens were stored in distilled water at 25°C for 1 week. Specimens tested in a universal testing machine. Mean was calculated for each group. A One Way Analysis Of Variance (ANOVA) was used to compare the forces at which fracture occur between the study groups. Pair wise comparison of between the study groups was done using Tukey Post hoc test at a 95% significance level. **Results:** There was no statistically significant difference ($p< 0.05$) among all the groups. However the groups with SDR liner group-I (1.29), group-II (1.30) showed better performance when compared to groups without liner group-III (1.18), group-IV (1.185). **Conclusion:** Within the limitation of this in vitro study, it can be concluded that nanocomposite restoration with liner displayed fracture resistance values similar to incrementally placed nanocomposite without liner.

Key words: Nano hybrid composite, SDR, Fracture Resistance, Universal testing machine

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INTRODUCTION:

Over the years, composite resins with different formulations have been introduced, to improve properties of resin composites, the posterior teeth are considered to be under high impact forces. They become susceptible to fracture when a significant amount of the tooth structure is lost, and the remaining fragile tissue needs to be supported. The structural integrity, strength, quality, and quantity of dentine affect and maintain the remaining structure to retain and support the restoration.[1]

Transfer of stresses occurs differently in intact teeth versus a restored tooth.[2] The fracture resistance of restored teeth depends on several factors, such as cavity design, type and magnitude of stress, restoration, and the placement technique. [3,4]

Various treatment options are indicated for the restoration of teeth with mesio-occlusal-distal (MOD) cavities. A wide variety of restorative modalities, each with its indications, advantages, problems, and challenges exist.[5] In recent years, materials with properties more similar to dentin (such as composites) have been preferred for restoring teeth.[6] Especially In large cavities, composite restorations are a more secure and accurate option for posterior teeth as an aesthetic alternative to crowns or onlays with relatively low cost. [7,8]

To minimize the formation of interfacial stresses, several clinical techniques have been suggested, like decreasing the C-factor by using a selected layering technique, to use stress-reducing curing methods such as the soft-start curing and placement of stress absorbing intermediary layers in sandwich techniques and by changes in filler technology and monomer chemistry.[9]

Incremental layering technique has been the widely used placement technique, in a way to combat polymerization shrinkage. However, there were certain drawbacks such as the incorporation of voids, difficulty in placement of increments in small cavities, interlayer contamination, increased operational time, and difficulty in maintaining isolation.[8]

Based on the rationale that bulk-fill composites would reduce the effort and time needed for layering while placing in posterior composites restorations, eliminating the possibility of occurrence of voids between the layers. They enable placement up to 4 mm increment and can be used in one step without negatively affecting polymerization shrinkage kinetics and macro mechanical properties.[10]

SDR (Dentsply, York, USA), a low viscosity bulk-fill composite manufactured for posterior restorations, which can replace the missing dentin structure has been introduced in recent years. It is suitable to be used as a base in Class I and II restorations. They can be placed as 4mm increments as open or closed dentin replacement beneath a conventional resin composite. The flowable feature of SDR allows the material to adapt to the cavity walls and intimate the shape of the preparation.[11]

Liners play a crucial role in minimizing polymerization shrinkage stress by elastic bonding concept, thus increase the longevity and favorable outcome for composite restorations.[9] SDR consist of Patented urethane dimethacrylate, a polymerization modulator, is chemically embedded in the backbone of the resin composite, which results in a slower modulus development, allowing for stress reduction without decreasing conversion rate[13] .

A recent development in the composites is the application of nanotechnology. It is incorporation of nanofiller particles in RC (resin composite) and bonding systems. Nanotechnology is known as the production and manipulation of materials and structures in the range of about 0.1–100 nanometers by various physical or chemical methods. Nanotechnology allows high filler load in the resin matrix. Higher filler load supports mechanical strength and reduces polymerization shrinkage of a composite. Nano-hybrid and nanofilled resin composites are two types of resin composites referred to under the term "nanocomposite".[12]

In this study new nanohybrid composites were used either as single increment or as an overlay for SDR liner. They are Ceram.x Sphere TEC and Filtek Z250 XT.

The null hypothesis of this study is that there is no difference in the fracture resistance of teeth when restored with two different nanohybrid composites with and without SDR liner.

The aim of this in vitro study was to analyze the fracture resistance of teeth with MOD preparations restored using two new nanohybrid composites with and without SDR liner.

METHODOLOGY:

Freshly extracted forty intact maxillary premolars (for orthodontic purpose) without caries were selected. Teeth were examined to detect craze lines or cracks and any structural deformities were excluded from the study. Root surfaces of the teeth were dipped into melted wax to simulate periodontium, to a depth of 2 mm below the cementoenamel junction which produces a thin layer and then they were vertically embedded in polyvinyl cylinders which contain self-cure acrylic (to simulate the alveolar bone).

Forty teeth were randomly divided into four groups of 10 teeth in each group.

- Group I (n=10) CERAM X SPHERE TEC WITH SDR liner
- Group II (n=10) FILTEK Z 250 WITH SDR LINER
- Group III (n=10) CERAM X SPHERE TEC (2mm increments)
- Group IV (n=10) FILTEK Z 250 (2mm increments)

The tested materials and their components are listed in Table1.

Standard MOD cavities were prepared by a single operator. The occlusal isthmus width was maintained as 1/3rd of the intercuspal width with a pulpal depth of 3 ± 0.2 mm. The proximal box cavities were prepared with a gingival seat width equal to 1.5 ± 0.2 mm and with an axial wall height of 2 ± 0.2 mm in an occlusal-gingival direction. A periodontal probe was used as a guide for better harmony among cavities. Teeth were prepared using a no — 245 tungsten carbide bur. A universal Tofflemire matrix band and retainer was applied before each restorative procedure.

Cavities were etched with 37% phosphoric acid for 15 seconds, followed by water rinse for 30 seconds. Prime and bond NT bonding agent was applied and light-cured for 20 seconds.

Groups I & II: Etching and bonding procedure was similar to that of Group III & IV. SDR liner is applied by gun up to 2mm and light-cured for 20 sec. Occlusal capping of 1mm with CERAM X sphere TEC in the group-I and Filtek Bulk Fill Posterior Restorative material in group-II was placed and light-cured for 30 sec.

Group III & IV: Incremental placement technique: The proximal boxes were filled first using one horizontal and two oblique increments, each increment measuring 2 mm in thickness. The occlusal cavity was filled using two oblique increments. Photoactivation was done for 30 s from the occlusal aspect.

All composite restorations were photo-activated again for 40 s from the buccal and lingual aspect after removing the matrix bands. Finishing and polishing procedures were initiated 10 min after final curing. These specimens were stored in distilled water at 25°C for 1 week.

Mechanical testing:

The specimen were individually tested in a universal testing machine (Aimil system, Nellore) at a crosshead speed of 0.5 mm/ min, using a steel 2 mm diameter round-headed rod mounted in the moving arm which was in contact with the center of the occlusal surface of the restored tooth during fracture test. All specimens were loaded by compression until they fractured. The ultimate fracture load was recorded in newton.

Statistical analysis:

Mean (± standard deviation) was calculated for each group. Data obtained was analyzed by using the Statistical Package for Social Sciences (SPSS version21) software. A One Way Analysis Of Variance (ANOVA) analysis was used to compare the forces at which fracture occurs between the study groups. A pairwise comparison between the study groups was done using the Tukey Post hoc test at a 95% significance level. There was no statistically significant difference ($p < 0.05$) among all the groups. However, the groups with SDR liner (group-I (1.29), group-II (1.30))showed better performance when compared to groups without liner(group-III (1.18), group-IV (1.185)).

Table -1 : The tested materials and their components

Brand name	Composition	Manufacturer
Prime & Bond NT	Di- and Trimethacrylate resins; PENTA (dipentaerythritol Penta acrylate monophosphate); Photoinitiators; Stabilizers; Nanofillers - Amorphous Silicon Dioxide Cetylamine hydrofluoride; Acetone	Dentsply Sirona
Filtek^{TM} Z250	Organic matrix: Bis-GMA, UDMA, Bis-EMA 6 Inorganic particle: zirconium/silica with 85% by weight (60% by volume). Size of particles: 0.01–3.5 mm (mean 0.6 mm)	3M ESPE, St. Paul, MN, USA
ceram.x® SphereTEC™ one universal	poly-urethane-methacrylate as well as bis-EMA and TEGDMA. spherical, prepolymerized SphereTEC™ fillers ($d_{3,50}$≈15 µm), non-agglomerated barium glass ($d_{3,50}$≈0.6 µm) and ytterbium fluoride ($d_{3,50}$≈0.6 µm)	Dentsply Sirona
SDR® – Smart Dentin Replacement	Filler: Barium-alumino-fluoro- borosilicate glass, strontium alumino-fluoro-silicate glass Matrix: modified urethane dimethacrylate resin, ethoxylated bisphenol-A dimethacrylate (EBPADMA), triethyleneglycol dimethacrylate, camphorquinone, butylated hydroxyl toluene, UV stabilizer, titanium oxide, iron oxide pigments. The SDR flow base is covered with at least 2 mm RC.	Dentsply DeTrey, Konstanz, Germany
Bis-EMA 6, bisphenol A-polyethylene glycol diether dimethacrylate; Bis-GMA, bisphenol A-diglycidyl ether dimethacrylate; HEMA, 2-hydroxy- ethyl methacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.		

Table 2 :- comparison of between the study groups

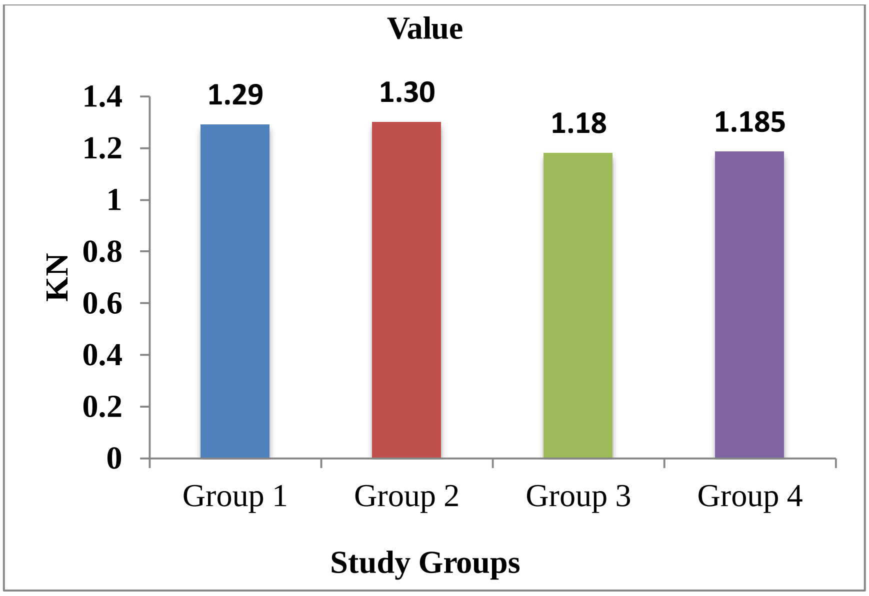
Groups	N	Mean	SD	Min	Max	ANOVA	
						F	p-value
1	10	1.290	0.149	1.05	1.50	2.72	0.06(NS)
2	10	1.300	0.139	1.05	1.50		
3	10	1.180	0.109	1.05	1.35		
4	10	1.185	0.094	1.05	1.35		

*$p<0.05$ statistically significant, $p>0.05$ Non Significant, NS

Table 3:-Pairwise comparison of between the study groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-0.010	0.056	0.99(NS)	-0.160	0.140
	3	0.110	0.056	0.22(NS)	-0.040	0.260
	4	0.105	0.056	0.25(NS)	-0.045	0.255
2	3	0.120	0.056	0.16(NS)	-0.030	0.270
	4	0.115	0.056	0.19(NS)	-0.035	0.265
3	4	-0.005	0.056	1.00(NS)	-0.155	0.145

*p<0.05 statistically significant, p>0.05 Non Significant, NS



Graph 1: Bar diagram showing comparison of between the study groups

DISCUSSION:

Extensive cavity preparations like MOD preparations due to their involvement of tooth structure may lead to cuspal fracture if the tooth is not adequately restored.[1,14] Therefore, to ensure an excellent long-term prognosis, reinforcement of the cavity with the restorative material is necessary to support the remaining tooth structure. Hence special attention has to be paid during the decision-making process of their restorative treatment options.

Taha *et al.* showed that the integrity of teeth is highly dependent on the proximal walls loss and fracture resistance of teeth reduces relatively more than 60% of intact teeth when proximal walls are absent.[15]

One of the goals of adhesive dentistry is to obtain a tight interfacial adaptation. Interfacial gaps may increase the risk of microleakage, debonding, secondary caries, and postoperative sensitivity. Therefore, there is a need for materials and methods which decrease stress formation during placement and curing procedures.[13]

Flowable liners can wet the cavity better than condensable composites as a result of their flowability and also decrease sensitivity due to excellent adaptation to the preparation surfaces. Also, a good adaptation of the composite prevents voids at the interface of restoration. Furthermore, they increase the fracture resistance of restorations due to their stress absorbing characteristic when compared with resin composites alone.

One of the first marketed composites in this material class was the low-viscosity, flowable composite "SDR™ Smart Dentin Replacement" (DENTSPLY DeTrey). It is based on the traditional methacrylate chemistry. However, it contains a UDMA-based polymerization modulator, designed to permit internal reduction of the stress caused by polymerization shrinkage through a slower modulus development in the curing phase without any decrease in the rate of polymerization or degree of conversion.[13]

The polymerization stress was considerably lower for SDR compared to other conventional flowable materials and comparable with that of low-shrinkage resin composites.[13]

SDR™ (filler content: 68 % by weight, 44 % by volume) is indicated for use as a bulk-fill base in

Class I and II direct composite restorations and as a cavity liner. After curing, the SDR has to be covered with a methacrylate-based universal or posterior composite to reconstruct the occlusal anatomy.

The modulus of elasticity and hardness of the flowable material was considerably below the mean values of regular nanohybrid and microhybrid resin composites. Therefore SDR is used to fill the cavity 1 mm short of the occlusal cavosurface and is then covered with a nano-hybrid resin composite.

Filler particles incorporated in the resin matrix has been continuously in focus for improvements over the years. Higher filler load supports mechanical strength and reduces polymerization shrinkage of a composite.

In this study premolars were selected as they are more prone to cusp fractures due to their crown-root ratio, unfavorable anatomical shape, and crown volume.[10]

The two new nanohybrid composites Ceram.x Sphere TEC and Filtek Z250 XT were tested. High fracture resistance values were displayed by both the composite restorations with and without SDR liner. No statistically significant difference ($P > 0.05$) was observed between the two groups. This can be attributed to the presence of nanoclusters and nanomer filler particles in both nanocomposites.

Rosatto et al[17] concluded that the bulk-fill technique has shown to provide lower shrinkage stress, cuspal strain, and higher fracture resistance. The fractures seen with bulk-filled teeth were less catastrophic as compared to the ones with incrementally placed composites.

No significant difference in the mode of fracture among groups was observed. Most of the fractures were mixed, denoting that composite restorations have a viable effect on the reinforcement of remaining tooth structure and hence are in acceptence with previous studies that tested the effect of adhesive materials on tooth structure.

The present study results reveals that there is no significant difference among the fracture strength with and without use of liner. However the group with SDR liner showed comparatively high fracture strength when compared to the group without liner.

SDR liner capped with composites may be able to substitute the time-consuming incremental placement technique in the posterior restorations. However, various variables such as thermochemical factors and variations of magnitude, direction, and intensity of forces that are peculiar to individuals' oral environment and occlusion affect the fracture resistance of restored teeth. Therefore, further long-term clinical studies are required for bulk-filled composites to replace the gold standard incremental placement technique.

CONCLUSION:

Within the limitation of this in vitro study, it can be concluded that nanocomposite restoration with liner displayed fracture resistance values similar to incrementally placed nanocomposite without a liner.

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