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FRACTURE RESISTANCE OF PREMOLARS RESTORED WITH BULK FILL RESIN COMPOSITE VERSUS INCREMENTALLY PACKED RESIN COMPOSITE: IN VITRO STUDY

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ABSTRACT

Objectives: To evaluate fracture resistance of premolars restored with bulkfill resin composite restorative material or incrementally-packed resin composite after 24 hours and after one month storage.

Methods: 40 freshly extracted maxillary premolars were chosen, mounted in acrylic resin blocks and grouped into group A_1 and A_2, referring to the type of composite resin restoration to be used after preparing standardized MOD cavities which were bulkfill (Tetric N-Ceram Bulk) and incrementally-packed (Tetric N-Ceram) (control) respectively. Each of which was subdivided into S_1 and S_2 according to the storage period which was either 24 h or 30 days respectively in normal saline. All specimens were subjected to compressive axial loading until fracture in Instron Universal Testing Machine. Three Way ANOVA followed by Tukay's post-hoc test were used for statistical analysis.

Results: There was no statistically significant difference in fracture resistance values of teeth restored either by bulkfill or incrementally-packed resin composite. Different storage periods also had no statistically significant effect on the fracture resistance values of teeth restored with either type of resin composite.

Conclusions: Within the limitations of this study it can be concluded that fracture resistance of restored premolars was not affected by either the type of resin composite used nor by the storage period.

Clinical significance: Bulkfill resin composite can be used as a comparable filling material to the conventional type.

KEY WORDS: Bulkfill, Additive composite, Incremental packing.

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INTRODUCTION

For over 50 years, dental composites have replaced dental amalgam which has been a faithful servant for both the clinician and the patient. This is because of the raising concept of esthetic dentistry. However, resin composite is not the magic solution for all the problems of esthetic dentistry. It has some drawbacks which still need improvements regarding its composition and technique of application. ***Ferracane, (2011) and Jackon, (2011)***

One of the major obstacles which faces resin composite application is its incremental packing, 2mm thickness maximum. So, it's considered technique sensitive. As experienced by almost all clinicians, placement technique can be the fine line between success and failure when it comes to direct composite resin restorations. ***Jackon, (2011)*** An unsuccessful layering technique can result in many problems; including the risk of incorporating air bubbles or contaminants between composite layers and failure in bonding between the increments. Nevertheless, long chair time is an inevitable result of the conventional layering technique. ***Jackon, (2011) and Dionysopoulos et al, (2016)***

Hence, in an attempt to reduce the time and effort needed for packing posterior composites, bulk-fill resin composite materials have been introduced to fill the cavity up to 4 mm with a single increment. ***Roggendorf et al, (2011) and Didem et al, (2014)*** For that to be achieved, bulk-fill materials have been strengthened with certain modifications in their composition to increase the penetration of visible light through them; these modifications can be concluded in increased filler size and novel photoinitiators. ***Dionysopoulos et al, (2016)*** Therefore, this study aimed at measuring the fracture resistance of premolars restored with a recent type of bulk-fill resin composite in comparison with that of a conventional incrementally-packed restorative resin composite material.

MATERIALS AND METHODS

A total of 40 sound, freshly extracted human maxillary premolar teeth, age range from 20-35 years were used in this study. The chosen teeth were atraumatically extracted for orthodontic purposes. Selected teeth were then stored in normal saline at room temperature until they were used for maximum of two months after extraction. **(Loguercio et al, 2011)** No preservatives were used because of the probability of altering the protein content of dentin that might in turn interfere with the bonding process. **(Fleming et al, 2007)** Teeth bucco-palatal and mesio-distal dimensions were standardized during the selection procedures. **(Figure 1 & Figure 2)**

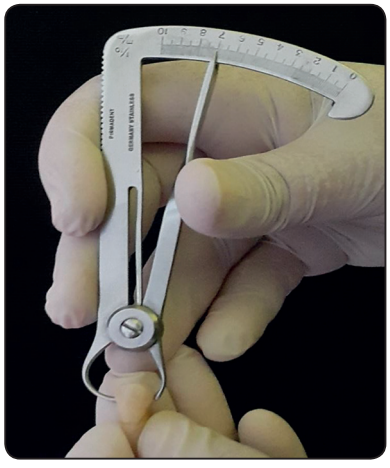

Fig. (1)

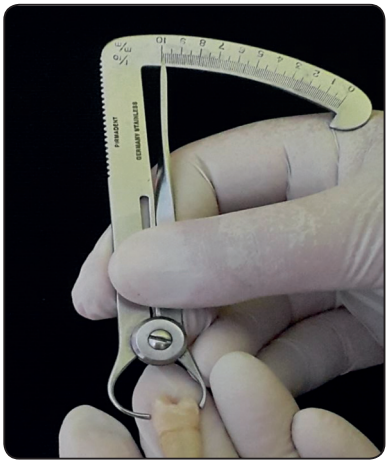

Fig. (2)

The teeth included in the study were numbered and randomly allocated into two main groups (20 teeth each) by the aid of an independent clinician. After that, each main group was further randomly distributed into two subgroups (10 teeth each). It seemed impractical to conceal the two interventions by blinding the original containers, since two completely different techniques would be used to pack resin composite. However, the specimens were blinded from those assessing the outcome by placing them in sealed, light-proof sequentially numbered containers.

The main groups (20 teeth each), were named A_1 and A_2 according to the type of resin composite applied inside the prepared cavities. Bulk-fill resin composite was applied in group A_1 and incrementally-packed resin composite was applied in group A_2. Each group was subdivided into subgroups (S_1&S_2) according to storage period which would be either 24 hours or one month respectively. Each subgroup was formed of 10 specimens with a total of 40 specimens.

Each of the 40 upper premolars selected for this study was mounted in a transparent auto-polymerized acrylic resin block. With the usage of a dental surveyor, teeth were positioned so that their long axis was vertically parallel to the mold side and their occlusal surface was parallel to the plane of the acrylic resin mold. Standardized Mesio-Occluso-Distal cavities were centralized, drawn with water-resistant pencil and prepared in 40 teeth. The cavity walls were cut parallel to the long axis and no proximal step was prepared. **(Figure3& 4)** The cavities were cut under copious air water spray using a rose head bur **(Mani DIA-Burs, number BR-41)** for gaining access then a cylinderical fissure bur **(Mani DIA-Burs, number SF-41)**. Each was mounted in high speed hand piece **(Ti-Max, NSK, Germany)** rotating at 250 000 rpm. Each bur was utilized for the completion of only three preparations and then discarded **(Sujana et al, 2010)**. The bucco-palatal width was 1/3 the inter-cuspal distance, in the average of 3±0.5 mm with parallel facial and palatal walls and 90 degrees cavosurface angle. The cavity depth was 4mm from the cavosurface angle that was standardized by attaching a stopper 4 mm from the tip of the fissure bur **(Cara et al, 2007)**. Depth of the cavities was confirmed as it was measured at the end of preparation with a periodontal probe. Widths of buccal and palatal cusps, 3±0.5 mm were confirmed after cavity preparation using a caliper **(Nova, England)** After preparing the 40 teeth, the phosphoric acid etchant, N-Etch **(Ivoclar Vivadent dental product, Liechtenstein)** was applied first to enamel margins for 15 seconds and then to enamel and dentin for another 15 seconds with a total etching time for enamel equals 30 seconds and 15 seconds for dentin according to manufacturer's instructions. **(Figure 5)** Then, the etchant was

Fig. (3)

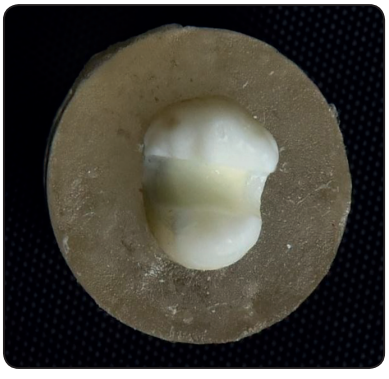

Fig. (4)

rinsed away with water spray for 30 seconds and then dried with a single puff of compressed oil-free air leaving a slightly glossy wet dentin surface. Immediately after that, two coats of Tetric N-Bond **(Ivoclar Vivadent dental product, Liechtenstein)** were applied to all cavity surfaces uniformly with a fully saturated brush tip and agitated for 15 seconds. **(Figure 6)** Gentle stream of air was applied for 5 to 10 seconds for solvent evaporation and to ensure that the adhesive completely covered the enamel and dentin without pooling. Then it was light cured for 10 seconds according to manufacturer's instructions using **3M ESPE Eliparlight** curing unit operating at light intensity of 1200 mW/cm^2 used in standard mode. Matrix band **(SuperMat, Kerr, Switzerland)** was applied. Tetric N-Ceram Bulkfill was properly packed in a single 4 mm increment bulk filling and light cured for 20 seconds according to manufacturer's instructions. Additional curing cycles were done from the buccal and lingual surfaces after the band was removed to ensure total curing of the composite and to simulate the clinical situation. That was done after each 10 specimens. Finishing and polishing were done immediately using a series of diamond composite finishing burs **(Diamond Composite Finishing Kit, Komet, USA)** and finishing discs in descending order from the medium to ultrafine **(Sof-Lex; 3M ESPE, st. Paul, MN, USA.).** Finishing procedures were done under water cooling. Then, polishing was done with diamond paste **(Prisma Gloss, Dentsply, USA).** The same etching and bonding steps were done as previous then Tetric N-Ceram was applied in 2 increments, each of 2 mm thickness (half the cavity depth) and light cured for 20 seconds using the same curing unit as for the adhesive. Finally, finishing and polishing were done as previously.

Restored teeth were immersed in containers filled with saline at room temperature (18C- 23C) for either 24 hours or one month. All specimens were subjected to compressive axial loading until fracture in Instron Universal Testing Machine **(Model 3354, Instron Instruments, England).** Each specimen was placed under the loading arm of the machine, while the cylindrical rod was parallel to the long axis of the tooth. The ball end was contacting both buccal and palatal cusp tips and a small part of the occlusal inclined planes**,** with cross head speed of 0.5 mm/min and load cell 5000 Newton Instron England. All specimens were loaded until fracture and the maximum breaking loads were recorded in kg. Data were recorded using computer software program **(Bluehill 3 software version 3.3)**. The study complies with all regulations of the Research Ethics Committee of the Faculty of Dentistry at Cairo University and an informed consent was obtained.

Data were presented as means and standard deviation (SD) values. Fracture resistance (N) showed parametric distribution so, Two way-ANOVA test was used to study the effect of the

Fig. (5)

Fig. (6)

factors of resin composite material and time on mean fracture resistance (N). Tukey'spost- hoc test was used for pair-wise comparison between the means when ANOVA test was significant. One-Way ANOVA was used to compare between the interactions between variables for mean fracture resistance (N). Independent t-test was used to compare between different resin composite materials within each time and time within each resin composite materials on mean fracture resistance (N). The level of significance was set at $p \leq 0.05$ Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

TABLE (1):

Category	**Product name**	**Composition**	**Manufacturer www.ivoclarvivadent.com**
2 step Etch and rinse Adhesive system	N-Etch	• 37% phosphoric acid etching gel • Thickened with silica	Ivoclar Vivadent dental product, Liechtenstein
	Tetric N- Bond	• HEMA, UDMA, Bis- GMA, phosphoric acid acrylate, catalysts and stabilizers • Ethanol • Silica nanofillers: <1% weight	
Bulk-fill resin composite	Tetric N- Ceram Bulk Fill	**Monomer matrix:** Dimethacrylates (19-21% weight) **Inorganic fillers:** • 75-77% weight or 53-55% volume • Glassfiller: 0.4 – 0.7 micron YbF3: 80 – 120 nm Mixed oxide: 170 – 230 nm • Nano-hybrid • Shade IVA	Ivoclar Vivadent dental product, Liechtenstein
Nano- hybrid resin composite	Tetric N- Ceram	**Monomer matrix:** Dimethacrylates (19-20% weight) **Inorganic fillers:** • 80-81% weight or 55-57%volume • Brium glass, ytterbium trifluoride, mixed oxides and copolymers • 0.4 – 0.7 micron • Nano-hybrid • Shade A2	Ivoclar Vivadent dental product, Liechtenstein

RESULTS

Data in **table (2)** show the results of two way-ANOVA for the effect of resin composite material, storage time and interaction between them on the fracture resistance in (N). It reveals that resin composite material has a statistically insignificant effect on mean fracture resistance (N) at p=0.187. Also, time has a statistically insignificant effect on mean fracture resistance (N) at p=0.341. The interaction between them is insignificant at p=0.556.

Interaction between the variables and its effect on mean fracture resistance were introduced in **table (3)** showing a statistically insignificant difference between the tested groups at p=0.391. The highest values are in the specimens restored with incrementally packed resin composite and stored for 24 hours (1458.47±355.31).

The effect of each of the variables on mean fracture resistance was further introduced in **tables (4)** & **(5)** & **(6)** & **(7)**.

TABLE (2):

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Composite	265205.925	1	265205.925	5	0.187 NS
Time	136849.210	1	136849.210	0.932	0.341 NS
Composite × Time	51796.479	1	51796.479	0.353	0.556 NS
Error	5285804.078	36	146827.891		
Total	71538835.838	40			
Corrected Total	5739655.692	39			

df= degrees of freedom S.S. = Sum of Squares Sig. = Significant (Probability level) M.S. = Mean Square
****= Significant at p≤0.05 NS= Non-Significant***

TABLE (3):

		Fracture resistance (N)		p-value
		Mean	SD	
Interaction	Bulk-Fill+One month	1178.64	412.56	0.391 NS
	Bulk-Fill+24 hrs	1223.65	292.87	
	incrementally packed+one Month	1269.52	452.87	
	incrementally packed +24 hrs	1458.47	355.31	

NS= Non-significant *=Significant at p≤0.05

TABLE (4):

	Resin composite				p-value
	Bulk-Fill		Incrementallypacked		
	Mean	SD	Mean	SD	
Fracture resistance (N)	1201.14	348.98	1363.99	407.85	0.187 NS

****= Significant at p≤0.05 NS= Non-Significant***

TABLE (5):

		Composite				p-value
		Bulk-Fill		Incrementally packed		
		Mean	SD	Mean	SD	
Fracture resistance (N)	24 hrs	1223.65	292.87	1458.47	355.31	0.124 NS
	One month	1178.64	412.56	1269.52	452.87	0.645 NS

NS= Non-significant *=Significantat p≤0.05

TABLE (6):

	Time				p-value
	24 hours		One month		
	Mean	SD	Mean	SD	
Fracture resistance (N)	1341.06	339.03	1224.08	424.20	0.341 NS

NS= Non-significant *=Significant at p≤0.05

TABLE (7):

		Time				p-value
		24 hours		One month		
		Mean	SD	Mean	SD	
Fracture resistance (N)	Bulk fill	1223.65	292.87	1178.64	412.56	0.782 NS
	Incrementally packed	1458.47	355.31	1269.52	452.87	0.313 NS

NS= Non-significant *=Significant at p≤0.05

DISCUSSION

The clinical performance of resin composite has been significantly improved over the past decade to provide proper strength, better depth of cure and less polymerization shrinkage. Besides the high esthetics of nano-hybrid resin composite, its micro and macro-mechanical properties have been enhanced to be comparable or even higher than micro-hybrid composite. One reason of such behavior is the chemical nature of the nano-fillers, being predominantly made of crystalline silica and zirconia, and thus harder than amorphous glasses used in micro-hybrid composite. Also, it could be due to the changes that occurred in the organic matrix between the particles as a result of decreased filler size and decreased inter-particle distances. ***(Illie et al, 2013)*** Yet, drawbacks such as technique sensitivity, polymerization shrinkage and prolonged chair time have been an enough motive for further improvements in its placement technique. Hence, some improvements have been introduced in its chemical composition enabling more applicability.

The first attempt was the flowable bulk fill resin composite such as Surefil SDR (Dentsply

Caulk) that is based on a low viscosity composite. The manufacturers renounced to bisphenol-A-dimethacrylate (Bis-GMA) and only formed the organic matrix out of other less viscous and more flexible dimethacrylates which are UDMA, TEGDMA and ethoxylated EBPDMA. Moreover, Bis-GMA is more hydrophilic than EBPDMA. Thus, the risk of water intake, discoloration and degradation is lowered. ***(Czasch and Illie, 2013*** It can be packed and cured in 4 mm yet; it needs to be covered by a layer of the conventional paste-like composite as a further step. Although flowable composites shrink more than conventional paste-like resin composites, their resulting shrinkage stress is comparatively low. ***(Van Ende et al, 2013)*** Bulk-filling is possible thanks to the stress-relieving internal monomer flow prior to reaching the gel-point which is the point at which stress starts to build up. That is enhanced by a "polymerization modulator" chemically embedded in the resin backbone of the SDR resin monomer; increasing flexibility and thus relaxing the polymerized network without harming the degree of conversion as claimed by its manufacturer. Also, SDR's enhanced translucency promotes light transmittance and thus enables adequate curing efficiency up to 4 mm thickness. Attempts were made to improve bulk fill composite. True bulk fill composite such as Tetric EvoCeram Bulk Fill (Ivoclar Vivadent) has been introduced that offers higher filler loading up to 68 % wt. It offers placement/complete curing of 4 mm thickness without the need to be further covered by a 2 mm layer of conventional composite.

The findings in the present study were that; premolars restored with the incrementally-packed resin composite, Tetric N-Ceram showed higher fracture resistance values than those filled with the bulkfill one, Tetric N-Ceram Bulk. However, it was non-statistically significant. These findings were in agreement with those of ***Fahad et al, 2014*** who reported that fracture resistance premolars restored with incrementally-packed resin composite (Universal Tetric EvoCeram) was higher than those filled with bulkfill one (Tetric EvoCeram Bulk) by a non-statistically significant difference and explained those postulations that even though there were differences in the type and size of fillers and the filler loading, both materials were manufactured with nanotechnology which might have caused the non-statistically significance. Also, ***Illie and Bucuta, 2013*** revealed that several mechanical properties, eg, flexural strength and creep were similar for bulkfill resin composite and nanohybrid incrementally-packed composite. Also, among the findings in this study was that the specimens stored for 24 hours storage period showed higher fracture resistance than those stored for a month by a non-statistically significant difference. So, the factor of time had a non-statistically significant effect on the tested parameter. That is consistent with the results of ***Schmidt and Illie, 2013*** who investigated the effect of aging in three different media, water, artificial saliva and alcohol on the mechanical properties of six different nanohybrid composites. They stated that considering all test parameters, the effect of storage in water on the mechanical behavior of the tested materials was not meaningful as the 24 hours results did not differ significantly from those stored for four weeks. They attributed that to the fact that the substitution of BisGMA and TEGDMA by UDMA lowered the water sorption and hence, increased the measured mechanical properties due to the increased degree of conversion. So, the effect of aging was lower than the effect of the material itself on all test parameters.

It is worth mentioning that the findings in this study might have varied from those of other studies addressing bulk fill composite versus incrementally packed one. It might be attributed to the individual variations in teeth morphology including angulations of cuspal inclines, thickness and structure of enamel, pulp chamber size and inherent.

CONCLUSIONS

Within the limitations of this study, the following Conclusions can be driven:

1. Type of resin composite restorative material used has no influence on the fracture resistance of the restored premolars.
2. Fracture resistance of restored premolars was not affected by the storage period.

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