Assessment Of Cusp Deviation In Tooth Restored With A New BIS-GMA Free Composite Resin.

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Abstract: Aim: The purpose of this study was to evaluate the cusp deviation of teeth that had been repaired using a novel free Bis-GMA composite resin. **Materials and Methods**: Eighty freshly removed premolars (n=80) with Class II (MOD) cavities were employed in the study. The teeth will be separated into two equal groups (n=40) based on the kind of composite resin utilised, with each major group broken into two equal subgroups (n=20) based on the adhesive system. Subgroup a: Admira low-shrinkage composite resin with Futurabond DC adhesive system. Subgroup b: Admira, a low-shrink composite resin with G-bond. Subgroup c: Grandio Bis-GMA Containing Resin Composite with G-bond (subgroup c). Subgroup d: Futurabond DC with Bis-GMA Containing Resin Composite (Grandio). A universal measuring microscope and a laser horizontal metroscope were used to measure cusp deviation. **Results:** The considerable increase in cuspal deviation of cavities repaired using Bis-GMA Containing Resin Composite (Grandio) over the low shrinkage composite resin Admira was expected. **Conclusion:** Due to changes in the organic matrix of the material, Admira (Ormocer) has a good effect on limiting cusp deviation when compared to traditional Bis-GMA Containing Resin Composite (Grandio).

Keywords: cusp deviation, A Free Bis-GMA Resin Composite (Admira), A Bis-GMA Containing Resin Composite (Grandio), laser metroscobe, G-bond

1. Introduction

Resin Composite restorations with its adhesive technique are currently the most popular restorations. Due to its mechanical qualities' resemblance to the dentin of tooth tissue, several investigations have been speculated to enhance the properties of composite resin restorative materials since its inception in 1960 (1). Despite its greater cosmetic potential, simplicity of administration, and mechanical qualities, there are issues with employing Bis-GMA-containing composite resin for dental repair. Polymerization shrinkage strains are likely to occur following composite resin curing and vetrification. Post-operative discomfort and sensitivity, marginal degeneration, caries recurrence, cusp deviation, and even broken tooth syndrome can all be caused by polymerization contraction and subsequent strains (2). For evaluation, a non-contained Bis-GMA resin composite was developed, with the goal of lessen shrinkage strains during polymerization and improve biocompatibility (3). Depending on the matrix composition and curing processes, typical resin composites used in restorative dentistry can shrink up to 6% in volume (4&5). Ormocer, an organically modified ceramic with an inorganic foundation of silicon dioxide and polymerizable organic chemicals, has recently been created as a new type of resin matrix for dental composites. It combines the hardness of the glass with the qualities of the resin (6). Cuspal deviation of tooth walls caused by large MOD cavities has been proven to sag teeth and make them more susceptible to fracture. Experiments have been undertaken on the effect of restorations on strengthening the residual tissue and the weakening of teeth caused by mesio-occlusal-distal (MOD) cavity preparation (7). Reduced shrinkage and better mechanical capabilities equivalent to those of methacrylate-based composites are two significant benefits of this novel restorative material (8). Furthermore, the absence of Bis-GMA and other common methacrylates will alleviate any concerns about cytotoxicity, since they will be regarded inert, enhancing biocompatibility (9). Even if no fracture occurs, cusp deviation will adversely damage the tooth/restoration interface, producing in microleakage and caries recurrence (10). When compared to the methacrylate-based restorative materials, the novel Ormocer-based material (Admira) showed the smallest polymerization shrinkage but a mixed mechanical performance (Grandu). Furthermore, methacrylate-based restorative materials showed reduced flexural strength and fracture toughness, but increased fracture toughness. When compared to the methacrylate-based restorative materials, the novel Ormocer-based material (Admira) showed the lowest polymerization shrinkage but a mixed mechanical performance (Grandu). Furthermore, the methacrylate-based restorative materials showed lower flexural strength and fracture toughness than the Ormocer-based material, but better compressive strength and microhardness (11). The goal of this study was to compare the cusp deviation of a Bis-GMA resin composite (Admira) restorative material to a Bis-GMA resin composite that included Bis-GMA (grandio).

Materials and methods:

Materials: Materials used in the study are listed in the following table.

Admira Fusion	Nanohybrid ORMOCER** based resin composite	Matrix:Resin ORMOCER® Filler: glass ceramics, Silicon oxide Nano filler
Grandio	Nano hybrid Bis-GMA-	Resin matrix: based on dimethacrylates, \ contains Bis-GMA and TEGDMA *** Inorganic filler
Futurabond DC	Dual-curing universal	Organic acids, Bis-GMA, HEMA,BHT(butyle-, amine, catalysts
Vococid etchant	Etchant gel	35% phosphoric acid. Silica. water
HEMA: 2-hydroxyethyl-methacrylate. BIS-GMA: bisphenol-a-diglycidyl-ether-dimethacrylate. TEGDMA: tri-ethylene-glycol-dimethacrylate. UDMA: Urethane dimethacrylate. Bis-EMA: bisphenol A polyethylene glycol diether dimethacrylate.		

***Table 1:-** materials used in the study.*

Methods: The research employed 80 human premolars excised for orthodontic reasons and preserved in normal saline.

Specimen preparation:
In an acrylic mould with dimensions of 17 mm internal diameter, 28 mm exterior diameter, and 18 mm height, the chosen teeth were inserted 3 mm below the cementoenamel junction. A vice was used to secure the teeth in the acrylic mould, and a large Mesioocclusо distal cavity (MOD) cavity was created [Figure 1]. The axial and gingival walls of the mesio distal proximal box were 1 mm wide, and the box was expanded bucco lingually by 0.5 mm. The pulpal wall of the MOD cavities measured 2 to 3 mm in breadth and depth. The middle groove served as a reference point for cavity depth. Two metal tips (cut from dental needle C K Ject, Korea, Queens Singapore) were fixed (using scothbond universal 3M, ESPE, Germany) horizontally and perpendicular to the long axis of the specimen at the cusp tip of the tooth, one buccally and the other lingually, as a reference point for measuring the specimens before and after the procedure (figure 2). To be attached to the microscope probes during cusp deflection measurement, the end of this tip was placed 2 mm beyond the buccal and lingual tooth contour.

***Figure 1:** MOD cavity for standardization*

***Figure 2**: reference points*

Grouping of specimens:
Specimens were sorted into two primary equal groups based on the type of resin composite used, and then further separated into four equal subgroups as follows: Subgroup A: Admira Fusion, a low shrinkable resin composite using Futurabond DC as an adhesive. Subgroup B: G-bond with a low shrinkable resin composite Admira. Subgroup C: G-bond with a Bis-GMA Containing Resin Composite Grandio. Subgroup D: Futurabond DC with a Bis-GMA Containing Resin Composite (Grandio).

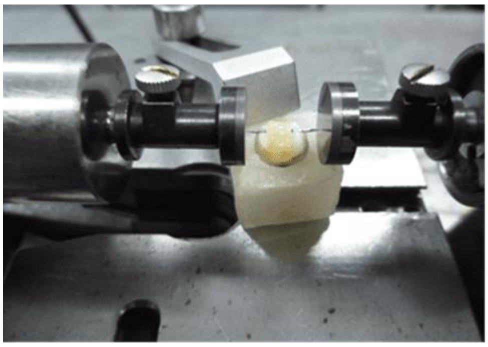
Restorative procedures:
Etching gel containing 37 percent phosphoric acid was applied to the prepared cavity enamel for 15 seconds, washed off with water for 10 seconds, and then gently air dried for 5 seconds. The universal adhesive was chosen as a dual-cure universal adhesive in a single-dose administration system (Futurabond DC, Voco, Germany). By pushing the tab, the bonding agent is triggered, forcing the liquids to join within the box. After perforating the foil with the brush, the bonding agent was mixed. The bonding agent is then rubbed in for 20 seconds and applied uniformly to all cavity surfaces. The adhesive coating was gently dried for at least five seconds with oil-free air to eliminate any solvents, then light cured for 10 seconds according to the manufacturer's specifications, using a light emitting diode curing unit (LED) (figure 3) with a light intensity of 1470 mW/cm2 (3M Elipar Deep Cure-S LED Curing Light USA).

Figure 3: *light curing unit.*

The initial 1.5 millimeter layer of composite was applied to one of the cavity's proximal surfaces with a gold-plated composite applicator (American Eagle composite SET, United States) and light cured for 20 seconds as directed by the manufacturer. The second layer of composite was applied and light cured for 20 seconds to repair the cavity's other proximal surface. The last two-millimeter layer was applied to the pulpal floor, slightly overfilling the remaining cavity mesially, distally, and occlusally to generate suitable mesiodistal and occlusal contour, inclines, and ridges of occlusal anatomy, and then light cured for 20 seconds using Tofflemire matrix (DDP, stainless steel, 2018, Pakistan) During the resin composite packing, a technique is used to give the repair its form. Finishing and polishing have been completed.

Testing procedures: Cuspal deflection was observed using a Universal measuring microscope (Carl Zeiss, Jena, Germany) [Figure 4] and a Universal horizontal metroscope (Carl Zeiss, Universal Langen messer) [Figure 5].

(Fig. 4): *Universal measuring microscope*



(Fig. 5): *Universal horizontal metroscope*

The motions of the buccal and lingual cusps were recorded for 1800-2000 seconds, and the measured value (as a function of time) was saved on a computer through a data collection board.

Figure 6: *Data acquisition board*

At room temperature 201°C, the sample was calibrated using an engineering and surfaces metrology method developed by a national institute for standards (ESM-NIS). The data was collated and statistically analysed after that (Fig.7).

Figure 7: *Room temperature during measureme*

Statistical analysis:
To compare the tested materials, dentin depth, and storage duration, an independent t-test was utilised. When the ANOVA values were significant, a one-way ANOVA test across the eight groups was used to examine the effect of interaction between various factors, followed by a Duncans post hoc test for pair-wise comparison between the means. 0.005 was chosen as the significant threshold. IBM® SPSS® Statistics Version 20 for Windows was used to conduct the statistical analysis.

Results:
Inter-cuspal distance test results (Mean ± SD) including cuspal deflection measured in micrometers are summarized in Table 2

Variable	Inter-cuspal distance (µm)		Cuspal deflection(µm) Difference
	Before	After	
Group A Admira Fusion with its adhesive Futurabond DC.	12.6126±0.46	12.5988±0.47	134
Group B (Admira, with G-bond.)	12.8398±0.49	12.8038±0.5	359
Group C (Resin Composite Grandio, with G-bond.)	12.6652±0.36	12.6238±0.35	413
Group D (Resin Composite (Grandio), with Futurabond DC.)	11.8110±0.6	11.7702±0.61	407

Table 2:- *cuspal deflection measured in micrometers*

It was found that group C recorded the highest cuspal deflection mean value (413 ± 22 µm), followed by group D (407 ± 38 µm) and then group B (359 ± 31 µm). Meanwhile, group A recorded the lowest cuspal deflection mean value (134 ± 29 µm).

Figure (8) *Bar chart of inter-cuspal distance mean values for all groups measured before and after composite insertion.*

Change in cuspal deflection over time Cuspal deflection (µm) for Admira composite resine and Grandio composite resin are presented in Figures 9,10,11&12 and table 3&4

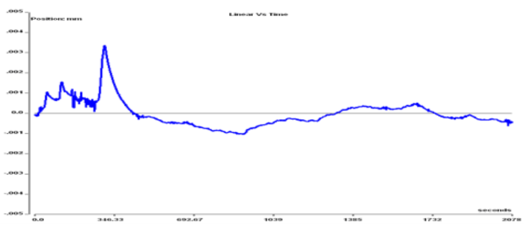


Figure 9 *gropup A (Admira Fusion with its adhesive Futurabond DC.)*

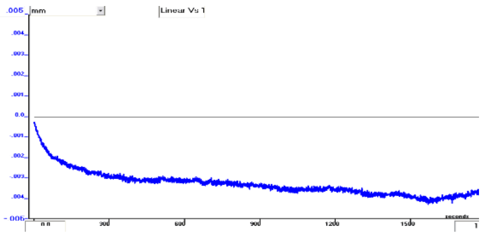


Figure 10: *Group B (Admira, with G-bond.)*

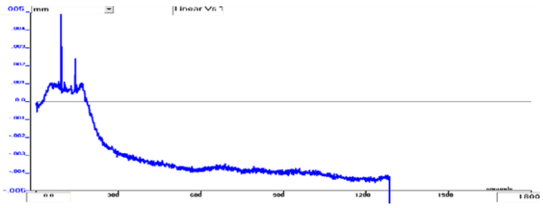


Figure 11: *Group C (Resin Composite Grandio, with G-bond.)*

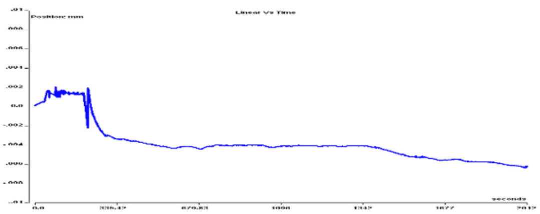


Figure 12: *Group D ((Resin Composite Grandio with Futurabond DC.*

Changes in cuspal deflection over time of gropup A (Admira Fusion with its adhesive Futurabond DC were 3.5 µm at 5.7 min after curing, −0.7 µm at 11.5 min, −0.5 µm at 17.3 min, 0.4 µm at 23 min, 0.2 µm at 28.2 min, and −0.8 µm at 34.6 min, while those of Group D (Resin Composite (Grandio), with Futurabond DC.) were −3.4 µm at 5.5 min after curing, −4.3 µm at 11.18 min, −4.1 µm at 16.7 min, −3.9 µm at 22.3 min, −5.3 µm at 27.9 min, and −6.3 µm at 33.5 min. Changes in cuspal deflection over time of Group B (Admira, with G-bond.)were −2.9 µm at 5.7 min after curing, −3.1 µm at 11.5 min, −3.5 µm at 17.3 min, −3.9 µm at 23 min, and −4 µm at 28.2 min, while those of Group C (Resin Composite Grandio, with G-bond.) were −2.9 µm at 5.5 min after curing, −3.8 µm at 11.18 min, −4.1 µm at 16.7 min, −9.7 µm at 22.3 min, and −9.9 µm at 27.9 min.

Time	**Admira Fusion with its adhesive Futurabond DC.**	**Resin Composite (Grandio), with Futurabond DC.)**
5 minutes	3.5	-3.4
11 minutes	-0.7	-4.3
17 minutes	-0.5	-4.1
23 minutes	0.4	-3.9
28 minutes	0.2	-5.3
34 minutes	-0.8	-6.3

Table 3: *The mean changes in the cuspal deflection (µm) for Admira composite resin and Grandio composite resin groups.*

Time	**Admira composite resin** with G-bond	**Grandu composite resin** with G-bond
5 minutes	- 2.9	- 2.9
11 minutes	- 3.1	- 3.8
17 minutes	- 3.5	- 4.1
23 minutes	- 3.9	- 9.7
28 minutes	- 4	- 9.9

Table 4: *The mean changes in the cuspal deflection (µm) for Filtek P90 with G-bond and Filtek Z350 with G-bond.*

Discussion

Numerous researchers have studied the impact of polymerization shrinkage of resin-based composite materials on in vitro cuspal deviation of recovered teeth [(12-14)]. Because a good reference point on the cusps proved difficult to find, it has been claimed that such contact-displacement measurement methods may provide erroneous findings [(15)]. In the current work, large MOD cavities were created from upper premolars in order to weaken the remaining tooth structure and allow for possible cuspal movement. It may be claimed that the current study's weakening of the palatal and buccal cusps by preparing big MOD cavities was not clinically relevant since the MOD cavities were too large for direct composite fillings. However, since the development of enhanced resin chemistry, filler morphology, and related adhesive systems in contemporary RBC materials, the number of RBC restorations now implanted in clinical practise has grown [(16)]. Furthermore, the rising use of RBC materials for large restorations [(17)], such as the MOD cavities used in the current investigation, has been supported by the toxicity and cosmetic problems of amalgam, as well as the increased chairside treatment time and expense of indirect restorations. The size and design of the cavity [(17)], as well as the mechanical-physical characteristics of the restorative material and the bonding mechanism, all influence the extent of cuspal deflection [(13)]. Admira Fusion (VOCO) is made up mostly of ceramic polysiloxane, which has a low shrinkage (1.25 percent) when compared to other composite resins' organic dimethacrylate monomer matrix. This form of ormocer increases aesthetics, biocompatibility, abrasion resistance, caries resistance, and lowers polymerization shrinkage and surface roughness while reducing polymerization shrinkage and surface roughness. It also eliminates any worries about cytotoxicity that come with traditional monomers like BisGMA and TEGDMA. When compared to methacrylate-based composite resins, this is a significant benefit [18]. 9 The tension created at the tooth/restoration interface is still responsible for the harmful consequences of polymerization shrinkage in vivo, and it can only be generated from a combination of tooth and filling material qualities, restoration geometry, and interfacial adhesive quality [19]. In terms of clinical lifespan, it was suggested that the considerable reduction in cuspal deflection of cavities corrected with Admira fusion resin composite compared to Grandio resin composite would be beneficial. It's possible that a reduction in polymerization shrinkage stress and related adverse consequences such microleakage resulted in a considerable drop in polymerization shrinkage of Admira fusion resin composite compared to Grandio resin composite [19]. As a result, the type of the interfacial interaction between the RBC restorative and the related tooth structure affects polymerization shrinkage stress in addition to the volumetric shrinkage of the restorative material. There was also a statistically significant difference (P0.05) between Admira fusion resin composite and Grandio resin composite with adhese adhesive. This could be explained by the fact that the decreased polymerization kinetics of the oxirane compared to the methacrylate-based monomers generated a temporary excess of free volume within the system, which increased the mobility of the polymer chains within the system and, as a result, the polymerization rate. When compared to cavities repaired with Grandio resin based composite, the accompanying 'alive' character of the cationic polymerization may manifest as higher stress relaxation of the polymerizing resin based composite and the concomitant decrease in cuspal flexure. However, because stress is not a characteristic property of the material, the effect of polymerization shrinkage associated with differences in polymerization mechanisms between free-radical and cationic resins cannot be directly related to the magnitude of shrinkage stress at the tooth/restoration interface [20]. The findings of this investigation were consistent with those of Hamouda I et al[1], who investigated fracture resistance as a result of shrinkage stresses in MOD cavities treated using recent restorative materials. Because it is based on Ormocer technology, which should not be mistaken with glass ceramic fillers in traditional composites, they found that Admira composite resin filling material had the highest fracture resistance when compared to the other restorative materials. Ormocers have a lengthy silicon-based "backbone" onto which carbon-carbon double bond-containing side-chains are attached. Ormocers are a material of interest for use as a matrix for resin composites because the bigger size of the monomer molecule can minimise polymerization shrinkage and wear, as well as monomer leaching. Admira, like other composites, incorporates traditional glass and ceramic filler particles. These three-dimensional polymeric composites have a novel resin fraction that replaces a major portion of the standard composite's organic resin matrix, reducing polymerization shrinkage (1.25 percent by volume). The findings of this study were also consistent with those of Perdiou A et al., 2020, who conducted an in vitro comparison of polymerization shrinkage stress resistance between nano-hybrid composite and ormocer restorations on posterior teeth. The ormocer has a stronger resistance to polymerization shrinkage than the nanohybrid composite, according to the study. It was suggested that the ormocer result had three-dimensionally cross-linked co-polymers with multi-polymerization and no residual unreacted monomers, and that it combined the surface qualities of silicones, the toughness of organic polymers, and the hardness and thermal stability of ceramics [21]. These findings contrasted with those of Klauer E et al., 2018 [18], who investigated the mechanical stability of Bisphenol A-glycidyl methacrylate (Bis-GMA) and Ormocer®-based resin composites and found that Admira Fusion is a promising Bis-GMA-free and Ormocer resin-based material, but it does not perform as well as conventional BisGMA-containing resin composites. Their success might be attributed to the usage of endodontically treated teeth [22].

CONCLUSION
The following findings may be taken within the restrictions of the current study:

1. In MOD cavities produced in premolar teeth, the application of a free Bis-GMA Resin Composite can repair the compromised tooth structure.
2. Using Admira fusion resin based composite to modify the organic matrix or materials formulation of the resin composite has a good effect on cusp deflection control.
3. The shrinkage stress of polymerization was affected not only by cavity configuration parameters, but also by the matrix employed in the composite resin.

RECOMMENDATION
Treatment of the weakend tooth structure may be strengthen using a new low shrinkable resin based composite like Admira with its adhesive system and increase bond strength at tooth restoration interface.

CONFLICT OF INTEREST
The authors deny any conflicts of interest related to this study.

FUNDING
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