Scholars Journal of Dental Sciences

OPEN ACCESS

Abbreviated Key Title: Sch J Dent Sci
ISSN 2394-4951 (Print) | ISSN 2394-496X (Online)
Journal homepage: https://saspublishers.com

Effect of Different Cavity Dimensions and Curing Systems on Cuspal Deflection of some types of Composite Resin Restorations

Mohamed M. A Hanbola[1*], Mohmad Salah Zeglam[1], Adnan Mahmoud Benkhalil[1]

[1]Conservative and Endodontic Department, Faculty of Dentistry, Tripoli University, Restorative Specialists at PHCC, Qatar

DOI: 10.36347/sjds.2022.v09i03.002 | **Received:** 18.02.2022 | **Accepted:** 26.03.2022 | **Published:** 30.03.2022

***Corresponding author**: Mohamed M. A Hanbola
Conservative and Endodontic Department, Faculty of Dentistry, Tripoli University, Restorative Specialists at PHCC, Qatar

Abstract **Original Research Article**

The cuspal deflection of different composite resin restorations cured with different systems and restoring different cavity dimensions were investigated using a total 60 freshly extracted human maxillary premolars. These teeth were divided into three main equal groups, based upon the tested restorative materials. Group (I) used T-Econpm Plus, Group (A1) (II) used Filtek Z250 XT (A2), and Group (III) used Filtek P90 (A3). Each group was subdivided into two subgroups based upon the prepared cavity dimensions. Each subgroup was further subdivided into two groups whether cured with Halogen (C1), or LED (C2). MOD cavity with two different dimensions, each restorative material was packed according to the manufacturer's instructions and cured. Dye penetration technique was used and specimens were sectioned in mesiodistal direction and examined by stereomicroscope. Collected data was statistically analyzed. The result showed T-Econom plus had statistically significant higher microleakage value, while Filtek P90 had statistically significant lower microleakage value. There was no statistically significant difference between groups cured with Halogen and LED. It can be concluded that silorane based composite, LED curing system, and smaller cavity dimension could significantly decreased cuspal deflection.

Keywords: Cuspal deflection, silorane based composite, maxillary premolar.

INTRODUCTION

Using of composite as restoration for posterior teeth became more common, as there is an increased patients' demand for esthetic concern. However, the major drawback of composite restoration is the high polymerization shrinkage of the composite material; as linear shrinkage ranges from 0.2 to 2% [1] and volumetric shrinkage ranges between 0.9 and 5.7 % [2]. Polymerization shrinkage can lead to restoration detachment from the tooth surface, or may induce enamel micro-cracks. Hence, secondary caries and postoperative hypersensitivity due to bacterial infiltration via microleakage may occur [3]. When bond strength between the adhesive and tooth is strong enough, tooth structure may experience shrinkage stress, resulting in a cusp deflection [4]. Cusp deflection is the result of interactions between polymerization shrinkage stress of composite and compliance of cavity wall and is a common biomechanical phenomenon observed in teeth restored with composites [5, 6].

MATERIALS & METHODS

Various materials used in the present study are presented in Table 1.

Specimens Preparation

Each tooth used in cuspal deflection measurement was mounted vertically in a plastic ring with acrylic resin, leaving 2 mm of the root surface exposed to mimic the support of alveolar bone in a healthy tooth. MOD cavity preparation was carried out by using round bur in gaining axis in central groove at depth 2 mm for subgroup B1 and at 1mm for subgroup B2. Lateral extensions were performed by fissure carbide bur including all pits and fissures of occlusal surface. Width of MOD cavity was 3mm for subgroup B1 and 1.5mm for subgroup B2. Width and depth of prepared cavity were measured during preparation by using a digital caliper to obtain accurate cavity dimensions. Cavo-surface angle of final preparation was 900. After completion of cavity preparation, it was cleaned by spraying with air spray and dried using compressed air. Then a hard plastic ball was cemented to each cusp tip by using adhesive techniques to be considered as "reference points", distance between plastic balls was measured by using digital micrometer and considered "initial measurement".

Table 1: Show the materials used in this study

Material trade name	Category	Composition	Manufacturer & Batch no.
T-Econom Plus	Hybrid composite	-Dimethacrylate and TEGDMA* (22%wt), Inorganic fillers (76 wt %) (barium glass, silicon dioxide, ytterbium triflouride and mixed oxides) -Additives, initiators, stabilizers, pigments (2wt%)	Ivoclar Vivadent AG, Leichtenste 31758
T-Econom bond	Primer and bond	Bis-GMA##,HEMA,*** dimethacrylates copolymer, initiator, water, ethanol.	Ivoclar- Vivadent, Schaan, Leichstenstein, Switzerland 31669
Filtek Z250 XT	Nanohybrid composite	Filler: zirconia/silica (60 vol %) Its matrix is composed of Bis-GMA, UDMA, and Bis- EMA##*. The filler is zirconia /silica with particle size range of 0.01 µm to 3.5 µm. The inorganic filler loading is about 60% vols	3M ESPE dental products St. Paul, M, U.S.A 55144
Adper single bond 2	Primer and bond	HEMA, 2- hydroxyl ethyl methacrylate	3M ESPE Dental Product St. Paul, MN, USA 270619
Scotchbond etchant	Acid Etcahant	37% Phosphoric acid in water	3M ESPE Dental Product St. Paul, MN, USA 261433
Filtek P 90	Low shrinkable posterior composite restorative	Silorane resin, Initiating system: camphorquinone, iodonium salt, electron donor, Yttrium fluoride, Stabilizers, Pigments Silorane resin, Quartz filler, 55 % volume, 0.1-2µm	3M ESPE Dental Product St. Paul, MN, USA 433586
Adhesive Self-Etch Primer	self-etching Primer especially for P90 composite	Phosphorylated methacrylates, Vitrebond™ copolymer, BisGMA, HEMA, Water, Ethanol, Silane-treated silica filler, Initiators, Stabilizers	3M ESPE Dental Product St. Paul, MN, USA 330836
Adhesive Bond	self-etching bond especially for P90 composite	Hydrophobic dimethacrylate, Phosphorylated methacrylates, TEGDMA, Silane- treated silica filler, Initiators , Stabilizers	3M ESPE Dental Product St. Paul, MN, USA 313983

*****TEGDMA:*** *Triethyline glycol dimethacrylate*
**** ***Bis-GMA:*** *Bisphinol a diglycidyle ether dimethacrylate. ******HEMA:*** *2-hydroxyethyle methacrylate.*
*******UDMA:*** *Urethane dimethacrylate. ****** ***Bis-EMA:*** *Bisphinol ethyl dimethacrylate.*

Procedure of Bonding & Application of Used Composite

A. T-Econom and Filtek Z250

Acid etching gel (Scotchbond etchant, 3M ESPE Dental Product St. Paul, MN,USA) was applied to fill the cavity, and to cover cavo-surface margins completely, then left for 20 seconds and washed for 10 seconds by using water spray. Cavity was gently air-dried till it has slightly wet surface and shiny appearance. Two coats of bonding agent was applied using micro-brush to paint all cavity walls and margin, and air-dried for 5 sec to evaporate any excess solvent. The bonding agent was light-cured using Halogen light-curing unit for 30 sec. or LED light-curing unit (normal mode), for 20 sec., according to manufacturer’s' instructions.

B. Filtek P90

Samples which were restored by Filtek P90, its bonding procedure was done by self-etching primer, which was applied and left for 15 seconds, air-dried and then light-cured for 10 seconds according to manufacturer’s′ instructions. The bonding agent was applied and left for 10 seconds to allow evaporation of solvent and penetration of bonding agent, and then air dried and cured according to manufacturers' instructions either with Halogen or LED curing systems. Occlusal aspect of restorations was carved before polymerization to mimic the normal occlusal anatomy of a maxillary premolar tooth. Composite resin was cured using either Halogen for 30 sec., or LED light-curing unit for 20 sec. according to manufacturer’s instructions. Polymerizing light was calibrated every 5 curings and verified periodically to ensure constancy of light output power.

C. Restoration Finishing

The finishing burs (Shofu SF 201 Ra) system was used for the finishing of all restorations. Sof-Lex system was used for polishing of all restorations. Samples were polished with different grits discs as manufacture instruction starting by medium disc for 10 seconds at 10000 rpm in a low-speed handpiece, followed by fine and superfine disc for 15 seconds at 30000 rpm in a low-speed handpiece; this procedure was done in a dry field. At end of the procedures, samples were rinsed with running tap water for 10 seconds and air dried for five seconds by using a gentle air spray.

D. Measuring Cuspal Deflection

Samples were stored in deionized distilled water in a glass tube at 37º C for 15 minutes after polymerization of composite; Intercuspal distance between plastic balls was measured. Both arms of micrometer are placed at the contact point between the ball and cusp tip. All measurements were carried out by the same operator and ten consecutive measurements were recorded for each specimen and mean value of measurements for each tooth was recorded as ‘final measurement’. The cuspal deflection was obtained by calculating the difference between measurements recorded initially and that recorded finally [11].

Figure 1: Digital micrometer

Figure 2: Specimen mounted in acrylic and reference balls cemented to cusp tips

RESULTS

Comparisons between cuspal deflection of restorative materials

Cuspal deflection value for all the tested restorative materials T-Econom Plus, Filtek Z250XT, and Filtek P90 ranged between (2.116 ± 0.21µm) and (22.08± 2.38µm); highest value was recorded from samples restored with T-Econom Plus, prepared cavity dimension was 3×2 mm (width× depth), and cured with Halogen, (A1B1C1). Lowest cuspal deflection value was recorded from samples restored with Filtek P90, prepared cavity dimension was 1½×1 mm (width× depth), and cured with LED, (A3B2C2). These data are presented in Table (2).

Table 2: Mean cuspal deflection value of the tested restorative materials

Group	Mean cusp.def. value
T-Econom 3×2 halogen	23.03 [a]
T-Econom 3×2 LED	21.145 [a]
T-Econom 1½×1 halogen	16.96 [b]
T-Econom 1½×1 LED	14.73 [b]
Filtek Z250 3×2 halogen	12.267 [b]
Filtek Z250 3×2 LED	11.86 [b]
Filtek Z250 1½×1 halogen	10.31 [c]
Filtek Z250 1½×1LED	8.33 [c]
Filtek P90 3×2 halogen	5.253 [c]
Filtek P90 3×2 LED	4.145 [c]
Filtek P90 1½×1 halogen	3.155 [c]
Filtek P90 1½×1 LED	2.126 [d]

Comparisons between cavity dimensions

The cuspal deflection value for both the prepared cavity dimensions B1 (3×2 mm width× depth) and B2 (1½×1 mm width× depth) was ranging from (2.126 ±0.22µm) to (23.03 ±2.41µm). The highest value was recorded for the specimens which their cavity dimension was (3×2 mm width× depth) (B1), restored with T-Econom Plus (A1) and cured with Halogen (C1). The lowest cuspal deflection value was recorded for cavity dimension (1½×1 mm width× depth) (B2) restored with A3 (Filtek P90) and cured with LED (C2).

Comparisons between the curing systems

The cuspal deflection value for both the used curing systems Halogen (C1), and LED (C2) was ranging from (2.126 ±0.22) µm to (23.03 ±2.41µm). The highest value was recorded for the specimens which cured with Halogen (C1), their cavity dimension was (3×2 mm width× depth) (B1), and restored with A1 (T-Econom Plus) (A1). Lowest cuspal deflection value was recorded for the specimens which was cured with LED (C2), their cavity dimension was (1½×1 mm width× depth) (B2) restored with Filtek P90 (A3).

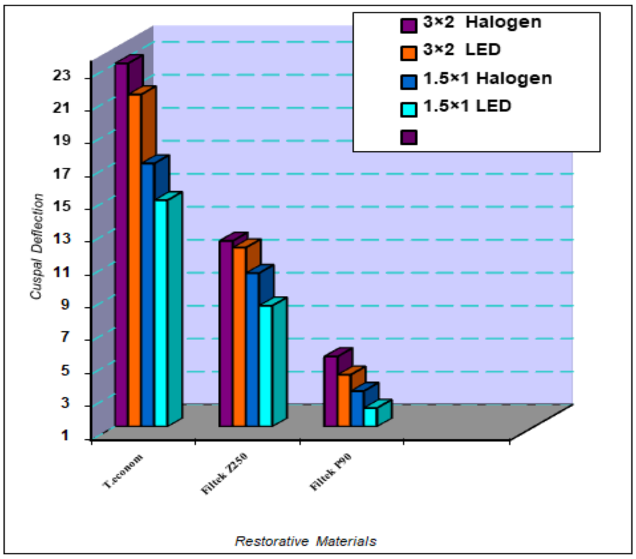

Figure 3: Histogram showing cuspal deflection of the tested restorative materials (T-econom, Filtek Z250, and Filtek P90)

DISCUSSION

The present study revealed a statistically significant difference between microleakage values of tested restorative materials. Polymerization shrinkage of composites in a cavity generates stress that can be transmitted via an adhesive interface to adjacent dental tissues, when the bond strength between the adhesive and tooth is strong enough, tooth structure may experience shrinkage stress, resulting in a cusp deflection [7]. Cusp deflection is a result of interactions between polymerization shrinkage stress of composite and compliance of cavity wall, it is a common biomechanical phenomenon observed in teeth restored with composite [8]. Degree of cuspal deflection depends on restoration size, cavity design, stiffness and flow of composite, bonding system applied, placement technique, light curing intensity, and curing mode [9].

In this study, MOD cavities were prepared in premolars because its causes potential cuspal deflection, larger the cavity size, greater cusp deflection [10]. This is in agreement with a study [11] demonstrated that

MOD cavity created highest cuspal deflection values. This finding may be explained by two postulations: *First*, there was less tooth structure left in large cavities, which mean more flexibility of cusps and more compliance with composite shrinkage. As cavity preparation becomes wider and deeper, strength of prepared tooth is considerably reduced and tooth becomes more flexible [12]. *Second postulation*, is the greater total volume of composite needed for restoration of large cavities results in a higher shrinkage force [13]. In the present study, matrix band was placed without using a retainer in order to avoid any tension on cusps, as its placement may interfere with the presence plastic balls in the samples [7].

The influence of cavity dimension and restoration methods on cusp deflection of premolars in composite restoration has been investigated [14], and it was concluded that cusp deflection increased with increasing cavity dimension. Additionally, a study [11] investigated the influence of cavity type and size of composite restorations on cuspal flexure and cuspal deflection, and concluded that deflection was significantly affected by amount of dental tissue loss. The results of current study concerning that silorane based composite gave lower cuspal deflection values, in agreement with a study reported that because of free radical polymerization of methacrylate-based composites, monomer molecules come closer to each other during polymerization process, resulting in volumetric shrinkage ranges from 2%-5% and stresses around tooth-restoration interface which in turn produce powerful forces that can separate the restoration from the tooth at the weak bonding interface. This polymerization shrinkage is an intrinsic property of the resin matrix; therefore, a new resin matrix system is desirable to reduce volumetric shrinkage [15].

CONCLUSION

Silorane based composite, LED curing system, and smaller cavity dimension could significantly decrease the cuspal deflection.

REFERENCES

1. Song, Y. X., & Inoue, K. (2001). Linear shrinkage of photo-activated composite resins during setting. *Journal of Oral Rehabilitation*, *28*(4), 335-341.
2. Opdam, N. J. M., Roeters, F. J. M., Feilzer, A. J., & Verdonschot, E. H. (1998). Marginal integrity and postoperative sensitivity in Class 2 resin composite restorations in vivo. *Journal of dentistry*, *26*(7), 555-562.
3. Carvalho, R. M. D., Pereira, J. C., Yoshiyama, M., & Pashley, D. H. (1996). A review of polymerization contraction: the influence of stress development versus stress relief. *Operative dentistry*, *21*(1), 17-24.
4. Segura, A., & Donly, K. J. (1993). In vitro posterior composite polymerization recovery following hygroscopic expansion. *Journal of Oral Rehabilitation*, *20*(5), 495-499.
5. Meredith, N., & Setchell, D. J. (1997). In vitro measurement of cuspal strain and displacement in composite restored teeth. *Journal of dentistry*, *25*(3-4), 331-337.
6. Jantarat, J., Panitvisai, P., Palamara, J. E. A., & Messer, H. H. (2001). Comparison of methods for measuring cuspal deformation in teeth. *Journal of dentistry*, *29*(1), 75-82.
7. Santos, M. J. M. C., & Bezerra, R. B. (2005). Fracture resistance of maxillary premolars restored with direct and indirect adhesive techniques. *J Can Dent Assoc*, 718, 585.
8. Jantarat, J., Panitvisai, P., Palamara, J. E. A., & Messer, H. H. (2001). Comparison of methods for measuring cuspal deformation in teeth. *Journal of dentistry*, *29*(1), 75-82.
9. Abbas, G., Fleming, G. J. P., Harrington, E., Shortall, A. C. C., & Burke, F. J. T. (2003). Cuspal movement and microleakage in premolar teeth restored with a packable composite cured in bulk or in increments. *Journal of dentistry*, *31*(6), 437-444.
10. González López, S., Sanz Chinesta, M. V., Ceballos García, L., de Haro Gasquet, F., & González Rodríguez, M. P. (2006). Influence of cavity type and size of composite restorations on cuspal flexure. *Medicina Oral, Patología Oral y Cirugía Bucal (Internet)*, *11*(6), 536-540.
11. González López, S., Sanz Chinesta, M. V., Ceballos García, L., de Haro Gasquet, F., & González Rodríguez, M. P. (2006). Influence of cavity type and size of composite restorations on cuspal flexure. *Medicina Oral, Patología Oral y Cirugía Bucal (Internet)*, *11*(6), 536-540.
12. Yamazaki, P. C., Bedran-Russo, A. K. B., Pereira, P. N., & Swift Jr, E. J. (2006). Microleakage evaluation of a new low-shrinkage composite restorative material. *Operative dentistry*, *31*(6), 670-676.
13. Versluis, A. B. A. U. O. M., Douglas, W. H., Cross, M. B. A. U. O. G., & Sakaguchi, R. L. (1996). Does an incremental filling technique reduce polymerization shrinkage stresses?. *Journal of dental research*, *75*(3), 871-878.
14. Lee, M. R., Cho, B. H., Son, H. H., Um, C. M., & Lee, I. B. (2007). Influence of cavity dimension and restoration methods on the cusp deflection of premolars in composite restoration. *Dental materials*, *23*(3), 288-295.
15. Bagis, Y. H., Baltacioglu, I. H., & Kahyaogullari, S. (2009). Comparing microleakage and the layering methods of silorane-based resin composite in wide Class II MOD cavities. *Operative dentistry*, *34*(5), 578-585.