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INFLUENCE OF HYGROSCOPIC EXPANSION ON CUSPAL DEFLECTION OF TOOTH COMPOSITE RESTORATION (AN IN VITRO STUDY)

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ABSTRACT

Purpose: This study evaluates the effect of hygroscopic expansion on the cusp deflection of tooth composite restoration.

Materials and Methods: Eighty (80) human premolars extracted for orthodontic reasons stored in normal saline were used. Large Mesiooccluso distal cavity (MOD) cavity was prepared. The specimens were divided into two main groups (40 each). each main group divided into two groupsaccording to bonding used (G-bond & composite consensual adhesive) each group (20 each), subdivided into four equal subgroups as follows: group A: Using low shrinkable resin composite (Filtek™ P90 Silorane shade A2; 3M ESPE,St Paul, MN, USA) with its adhesive system. group B: Using low shrinkable composite (Filtek P90 Silorane shade A2; 3M ESPE) with Gbond (GC, Tokyo, Japan). group C: Using Filtek™ Z350 (3M ESPE) composite with Gbond (GC). group D: Using Filtek Z350 (3M ESPE) composite with Adhe SE (Ivoclar Vivadent , Schaan, Liechtenstein). Specimens were stored in water for four time interval (immediate, 1, 2, 4&12) weeks. Each group was further divided into equal subgroup (5 teeth per each) according to immersion in normal saline. Cuspal deflection was detected by Universal measuring microscope (Carl Zeiss, Jena, Germany) and Universal horizontal metroscope (Universal Langenmesser; Carl Zeiss). The buccal and lingual cusp movements were recorded for 2000 s and the measured value (as a function of time) was stored on a computer through a data acquisition board. The buccal and lingual cusp movements were recorded again after the specimens were immersed in deionized water. The results were statistically analyzed using ANOVA followed by Student–Newman–Keuls post hoc tests.

Results: The cavities which restored with the silorane (P90) resin-based composites recorded less cuspal deflection than the methacrylate-based (Filtek Z350) group the cavities which restored with silorane (P90) resin-based composites and bonded with its consensual adhesive recoreded the least cuspal deformations. cuspal deformation of the restored teeth gradually decreased, reversing the shrinkage deformation. The two hydrophobic resin composite restored teeth showed a gradual decrease of the shrinkage deformation due to hygroscopic expantion.

Conclusion: Polymerization shrinkage deformationwas compensated by hygroscopic expansion within 4 weeks in teeth restored with a hydrophobic resin composite, while a hydrophilic restorative over-compensated polymerization shrinkage within 1 week causing tooth expansion.

KEYWORDS: Cuspal deflection, Hygroscopic expantion, Low shrinkable composite, silorane, laser horizontal microscope.

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INTRODUCTION

Nowadays patients seek better color-matching restorations and composite resins to satisfy this need[1]. The major disadvantage of visible light-cured composites is polymerization shrinkage. This shrinkage can result in gap formation between the composite material and tooth structure [2] These is believed to cause microleakage, postoperative sensitivity, recurrent caries and eventual loss of the restorations [3,4]. When the adhesive strength exceeds the contraction stress, the restoration maintains an internal tension that pulls the cavity walls together, reducing the intercuspal distance (i.e., cuspal deflection) [5]. The magnitude of this inward cuspal movement appears to depend mainly on the cavity size, type, and the type of composite used [6-8]. Cuspal deflection may result over time in micro-cracks propagation, enamel cracks, crazing, ultimate decrease in fracture resistance of the restored tooth, and, in extreme cases, cusp fracture [9–11]. Cuspal deflection can be perceived clinically by the patient as postoperative sensitivity. It is also expected that absorption of water will be accompanied by hygroscopic expansion of composite which may be able to compensate for the effect of polymerization shrinkage and relieve stresses [12].In contrast to the rather rapid polymerization contraction and stress development, the hygroscopic relief will proceed slowly and might even take days [13,14]. The rate and magnitude of hygroscopic expansion of a resin material depends on several variables such as the nature of the resin, the type of filler, filler loading, filler matrix adhesion and the volumetric ratio between the filler and matrix [15–17].

This study evaluated the effect of hygroscopic expansion on the cusp deflection of tooth composite restoration.

METHODS

Sixty (80) human premolars extracted for orthodontic reasons stored in normal saline were used. The selected teeth were placed 3 mm below the cementoenamel junction in an acrylic mold with dimensions of 15 mm internal diameter, 25 mm external diameter, and 20 mm height. The teeth set in the acrylic mold were fixed with a vice and a large Mesio-occluso-distal (MOD) cavity was prepared as seen in fig (1). The mesio-distal proximal box was extended 0.5 mm bucco-lingually, and the width of the axial and gingival walls of the box was 1 mm. The width and depth of the pulpal wall of the MOD cavities was 2 × 3 mm. The reference point for cavity depth was the central groove. The reference point for measuring the specimens before and after the procedure was two metal tips (cut from dental needle C-K Ject, Korea, Queens Singapore) for each specimen (0.5 × 4 mm) that was fixed (using Clearfill SE Bond) horizontally and perpendicular to the long axis of the specimen at the cusp tip of the tooth, one buccally and the other lingually. The end of this tip was located beyond the buccal and lingual tooth contour by 2 mm in order to be attached to the microscope probes during cusp deflection measurement. The specimens were divided into two main groups (40 each). The first main group was restored with hydrophilic resin composite (Silorane) while the second main group was restored with a hydrophobic resin composite (Z 350). Each main group divided into two groups (n = 20) according to bonding used (G-bond & composite consensual adhesive) then each group subdivided into four equal subgroups (5 teeth per each) as follows: **Group A:** Using low shrinkable resin composite (Filtek™ P90 Silorane shade A2; 3M ESPE,St Paul, MN, USA) with its adhesive system. **Group B:** Using low shrinkable composite (Filtek P90 Silorane shade A2; 3M ESPE) with G-bond (GC, Tokyo, Japan). **Group C:** Using Filtek™ Z350 (3M ESPE) composite with G-bond (GC). **Group D:** Using Filtek Z350 (3M ESPE) composite with Adhe SE (Ivoclar Vivadent, Schaan, Liechtenstein). Specimens were stored in water for four time interval (immediate, 2 weeks, 4 weeks & 12weeks). Materials used in this study are shown in table (1). Cuspal deflection was detected by Universal horizontal metroscope (Universal

-Langenmesser; Carl Zeiss) as seen in (Fig 2). The buccal and lingual cusp movements were recorded for 2000s and the measured value (as a function of time) was kept on a computer through a data acquisition board. The results and the difference between groups were statistically analyzed using one-way analysis of variance (ANOVA) followed by pair-wise Newman–Kuels (NK) *post-hoc* test at the significance level of P= 0.05.

RESULTS

When the teeth restored with composite resin, the buccal and lingual tooth surfaces moved inward. After water immersion of the restored teeth, the cuspal deformation of the restored teeth gradually decreased, reversing the shrinkage deformation. There was significant difference between the groups. The two hydrophobic resin composite restored teeth showed a gradual decrease of the shrinkage deformation. The cavities which restored with the silorane (P90) resin-based composites recorded less cuspal deflection than the methacrylate-based (Filtek Z350) group. Also the cavities which restored with silorane (P90) resin-based composites and bonded with its consensual adhesive recorded the least cuspal deformations. Collected data that revealed differences in cusapal deflection measurements are seen in table (2) and also illustrated by the histogram in fig (3).

TABLE (1) list of materials which were used in this study:

Product name	**Category**	**Manufacturer**	**Batch number**
Filtek™ (P90) Silorane shade A2	Low shrink posterior restorative micro-hybrid resin composite	3M ESPE,St Paul,MN,USA	N213226
Silorane adhesive System	self-etch primer	3M ESPE, St Paul,MN,USA	N270409
	Adhesive – Bond	3M ESPE, St Paul,MN,USA	N268149
Filtek™ Z350 shade A2	micro-hybrid resin composite	3M ESPE,USA	N171967
G-BOND	one- step self-etch adhesive	GC, Tokyo Japan	N1010091
AdheSE	one -step self-etch adhesive	Ivoclar Vivadent, Schaan, Liechtenstein	N101113

Fig (1): MOD cavity preparation

Fig (2): Universal horizontal metroscope

TABLE (2) Cuspal deflection of tooth restored with composite restoration under water with different storage times.

Composite	Bonding	immediate	2weeks	4w	12 w
A	Silorane adhesive system	-2.8	-1.2	-0.4	-0.2
B	G-bond	-4.3	-1.6	-0.6	-0.4
C	G-bond	-6.9	-4.2	-2.3	-0.8
D	AdheSE	-5.3	-2.1	-1.1	-0.6

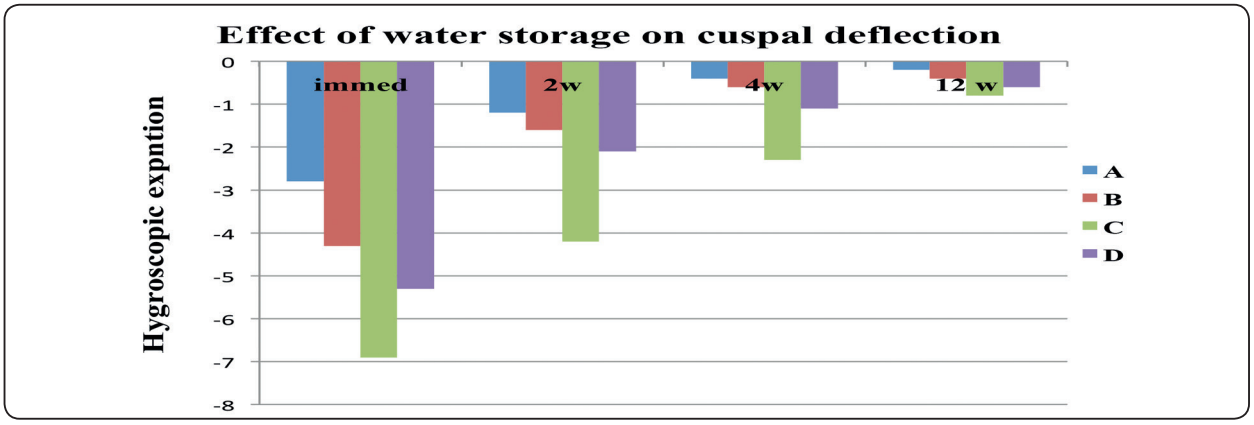

Fig. (3) Histogram of the mean score (5 specimens) of cuspal deflection of tooth restored with composite restoration under water with various storage times.

DISCUSSION

The composite shrinkage creates stresses within the material at the tooth structure interface that might manifest clinically as cuspal deflection, which in turn compromises the synergism of the bond at the tooth restoration interface. These possibly leading to bacterial microleakage and ultimately to marginal discoloration, secondary caries, and pulpal inflammation.[18,19]. Typical resin composites applied in restorative dentistry exhibit volumetric shrinkage values from less than 1% up to 6%, depending upon the formulation and the curing condition.[20,21] Currently, there is a controversy about the category of resin matrix for dental composite based on ring-opening monomers.[22]This hydrophobic composite is derived from the combination of siloxane and oxirane, and thus has the name silorane [23] . The major advantages of this innovative restorative material are its reduced shrinkage and its mechanical properties comparable to those of methacrylate-based composites [24]. On the other hands, there was some problems have been appeared related to nature of these material and its durability in dental field. In the current study, each cavity with each resin-based composite type exhibited cuspal deflection. The significant increase in cuspal deflection of cavities restored with the methacrylate-based (Filtek Z350) compared with the silorane (P90) resin-based composites might be attributed to numerous factors. The ring opening chemistry of the siloranes enables at the first time shrinkage values lower than 1 vol % and mechanical parameters as E-Modulus and flexural strength comparable to those of clinically well

accepted methacrylate based composites [25]. The novel resin is considered to have combined the two key advantages of the individual components: low polymerization shrinkage due to the ring-opening oxirane monomer and increased hydrophobicity due to the presence of the siloxane species. The silorane composite polymerizes by a cationic ring-opening process.

The silorane-based composite revealed a decreased water sorption, solubility and associated diffusion coefficient compared with conventional methacrylate-based composites [26]. Regarding the effect of resin composite materials (P90 and filtek Z350) on adhesive system (G-bond) results revealed that there was a statistical significant difference ($P<0.05$), moreover the interaction between group A(P90 with its adhesive) and group D(Filtek Z350 with adhese adhesive), interaction between group A(P90 with its adhesive) and group C(Filtek Z350 with G-bond) and the interaction between group B(P90 with G-bond) and group D(Filtek Z350 with adhese adhesive) results also showed that there was a statistical significant difference ($P<0.05$); this may be explained by a fact that the decreased polymerization kinetics of the oxirane compared with the methacrylate-based monomers generated a temporary excess of free volume that enhanced the mobility of the polymer chains within the system and, as a result, the polymerization efficiency of the cationic ring-opening monomers compared with the free radical species was increased. The associated 'living' nature of the cationic polymerization may be manifested as an increased stress relaxation of the polymerizing resin based composite and the associated decrease in cuspal flexure compared with the cavities restored with Filtek Z350. However, the effect of polymerization shrinkage associated with differences in polymerization mechanism between the free-radical and cationic resins cannot be directly related to the magnitude of shrinkage stress at the tooth/restoration interface since stress is not a characteristic property of the material [27]. Regarding interaction between group C(Filtek Z350 with G-bond) and group D(Filtek Z350 with adhese adhesive) results revealed that there was no statistical significant differences ($p>0.05$). However there was a statistical significant differences ($P<0.05$) between group A(P90 with its adhesive system) and group B(P90 with G-bond). The new low-shrinkage resin composite showed compatibility only with its dedicated adhesive. The strength of the adhesive dentine interface (bond strength) must be high enough to withstand functional stress. The characteristics of acidic monomers determine the ability of self-etch adhesives to etch enamel and dentine. The etching potential of self-etch adhesives is related to their pH value, though other factors including the application procedure, viscosity and solubility of the adhesives and monomer diffusion dynamics will contribute to HL thickness [28,29]. Voids were consistently found throughout the G Bond adhesive layer and may be due to the lack of HEMA and phase separation. G Bond does not contain HEMA, a low viscous monomer that increases dentine wetting and solubility of other adhesive monomers that may account for short and thick resin tags. Furthermore, acetone, a co-solvent in G-Bond, may induce phase separation and precipitation of adhesive components due to the changing water : acetone ratio during evaporation[30]. This lead to formation of hybrid layer of comparable thickness to two step self- etch adhesive (silorane adhesive system) but might be of lower strength hence, cannot withstand functional and shrinkage stresses which leads to more cusp deflection. The cavities which restored with the silorane (P90) resin-based composites and bonded with its consensual adhesive recorded the least Cuspal deformations due to this bonding contain Hema which is hydrophilic caused significant expansion of the tooth (positive deflections), which continued to increase slowly during the water storage and lead to Restoration surfaces was expanded

CONCLUSION

Cuspal deformation was decreased by hygroscopic expansion in teeth restored with a hydrophobic resin composite, while a hydrophilic composite restoration show over-compensated the polymerization shrinkage causing tooth expansion.

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Conflicts of interest

There are no conflicts of interest.

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