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Original Research

Cuspal Movement and Microleakage in Premolar Teeth Restored with Posterior Restorative Materials

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Abstract:

Background: With the increase in various resin-based composites with varying monomeric formulations and fi llers had led to a significant number of problems, and one of such is postoperative pain. Clinician is in a dilemma what to select and what not to. The latest nanocomposite is there for a short while that no individual research is available currently, hence, this study was undertaken.The aim of this present study was to assess the cuspal deflection at each stage of polymerization for the incremental restoration of standardized large (mesio occlusal distal [MOD]) cavities with three posterior restorative resins. And also to assess the cervical microleakage.

Materials and Methods: 18 extracted upper premolar teeth were selected. Teeth were divided into three groups (A, B, and C), each group consisting six teeth, large (MOD) cavity preparation was done. Groups A, B, and C were restored with P60, Filtek supreme (3M, ESPE), and ormocer material (Admira: Voco). The lingual cusps of the extracted teeth were approximated to the receptor of a compactor - deflection measuring gauge, following each stage of polymerization using light emitting diode curing light a measurement of the cuspal deflection was recorded. The restored teeth were prepared for microleakage testing and were examined under stereomicroscope at ×25 for the extent of the cervical gingival microleakage.

Results: The cuspal deflection was the greatest for Filtek P60 and least for filtek supreme - nanocomposite with ormocer ranked between the two. For the microleakage, none of the materials were identified as producing less gingival microleakage.

Conclusion: The lesser cuspal deflection values with filtek supreme nanocomposite could be due to resin chemistry and also filler particle size. Hence, this nanocomposite could be the first choice of material for use in large esthetic restorations.

Key Words: Cuspal deflection, light emitting diode curing unit, microleakage, nanocomposite, ormocer

Introduction

Never has science witnessed such a turmoil where every minute detail in restorative dentistry is literally scanned, dissected, pondered over, and then aznalyzed. Earlier times people were only bothered about removing the carious lesion and then restoring the defect. Contacts and contours were analyzed, slowly as the failure of such treatment began surfacing ideas, concepts were changed.

Today, as we stand at the brink of a supernova sort of explosion in materials and techniques in dentistry, microleakage, a growing concern to every clinician is being evaluated to the deepest core. Various methods have been devised to detect microleakage apart from detecting it; certain factors are evaluated namely debonding of composite, effect of light curing intensity, and technique sensitivity of the procedure. Now apart from this, cuspal deflection is also concerned as reported. As with placement of each increment of composite results in polymerization shrinkage; this study recorded the cuspal deflection at each stage of polymerization.[1,2]

The introduction of various co-monomers namely triethylene glycol dimethacrylate (TEGDMA) in the resin system has increased the cuspal deflection during polymerization and hence, may be professed by the postoperative pain in patients and bacterial microleakage will follow the tooth restoration resulting in interfacial debonding and it could ultimately lead to marginal staining, pulpal inflammation or necrosis, and possibly secondary caries.[1,2] However, various formulations have been tried, like the elimination of TEGDMA and incorporation of urethane dimethacrylate (UDMA) derivatives of Bis-GMA, like Bis-EMA in an attempt to decrease polymerization shrinkage.[1] The manufactures of Filtek P 60 report that it shrinks 25% less than its counterparts, which uses less amounts of TEGDMA and also the differences in the monomer constituents.[3]

The latest of composite restorative material, which is introduced recently into the market, is the nanocomposite,

which uses a combination of resin chemistry and reported to have decreased polymerization shrinkage by the manufactures,[4] and also limited research and data are reported in the dental literature. Ormocers have been employed by different scientific disciplines, and they are under development for use in dental applications. Ormocer (acronym – for organically modified ceramics) are characterized by inorganic and organic copolymers. The alkoxylsilyl group of the silane form an inorganic SI-O-SI network by hydrolysis and polycondensation reaction while the metha acrylate groups photochemically induce organic polymerization, which may reduce polymerization stresses so decreased polymerization shrinkage.[1,5] Hence, in this study, Filtek Supreme, a nanocomposite was used in addition to the Ormocer and Filtek P60. The latest curing units in the market are light emitting diode (LED), which offer various curing regimes "soft start curing" is one of them. Soft start curing approach is to allow better viscoelastic flow of the dental composite during polymerization, so decreasing the overall polymerization shrinkage and microleakage.[2] The hypothesis of the study is the latest nanocomposite with decrease in filler particle size, increase in volume of the filler loading and the alteration in the resin chemistry will have reduced cuspal deflection (polymerization shrinkage) and microleakage.

Materials and Methods

The total of 18 extracted upper premolar teeth were selected, each tooth was fixed with chemically cured resin. Micrometer screw gauge was used to measure the maximum bucco lingual width of each tooth was measured, and the accurate value is 10 μm. The dimensions were used to distribute the specimens into three groups (A, B, and C), each group consisting six teeth, cavity preparation was done (i.e.,) large mesio occlusal distal (MOD) cavity according to standardized specifications.

Groups A and B were restored with P60 and Filtek supreme (3M, ESPE), respectively, with conjunction bonding system (Scotch Bond 1; 3M ESPE). The teeth belong to Group C were restored using an ormocer material (Admira: Voco) along with bonding agent Admira bond (Voco). The lingual cusps were approximated to the receptor of a compactor-deflection measuring gauge following cavity preparation in all extracted teeth. Teeth were restored after evaluating the baseline measurement with the mesial approximal box, layering the composite in increments against a sectional matrix wedged firmly against the approximal aspects of the teeth. The placement was carried out in triangular increments following which each increment was cured using a LED unit for 40 s duration. During each stage of polymerization, the cuspal deflection measurement was recorded.

Vertical section of all restored teeth was made via mid-sagittal in a mesio-digital plane. Tooth sections belong to all three groups were absorbed in 0.25 % basic fusion dye for 24 h. All tooth sections belong to three groups were equipped for microleakage testing and thermocycled. These sections were examined under stereomicroscope at ×25 magnification, and the degree of the gingival cavosurface microleakage was recorded. Accordingly, the degree of cervical margin microleakage was scored, is mentioned in Table 1. Descriptive statistics were carried out using ANOVA technique and Tukey's paired group *post-hoc* comparison procedure test. The resultant microleakage data were analyzed using nonparametric one-way ANOVA (Kruskal–Wallis) test at the 5% significance level.

Results

The present study evaluated the cuspal deflection at each stage of polymerization for the incremental restoration of large mod cavities with 3 posterior restorative resins and also assessed the cervical microleakage. The mean cuspal deflection of MOD cavities restored with different resin-based composites (Table 2).

Overall mean (standard deviation) cuspal deflection was the highest for Group A (Filtek p 60) 15.03 ± 3.87 μm and least for Group B (Filtek supreme-nano composite) 10.73 ± 3.04 μm, with Group C (Admira-Ormocer) 12.43 ± 3.13 μm ranked in between the three products overall. One-way ANOVA followed by Tukeys HSD *post-hoc* paired group comparison procedure showed significant differences ($P < 0.05$) for Group A Filtek P60 compared with Group B Filtek supreme - nanocomposite, however between Group B Filtek supreme and Group C Admira there were no significant differences ($P > 0.05$). And in between Group A Filtek P60 and Group C Admira there were no significant differences seen ($P > 0.05$).

The cervical microleakage scores for each posterior filling material used in this study (Table 3). The examination of the gingival microleakage results was revealed none of the groups were detected with a complete leakage of free cervical dentin cavosurface margin. The results of the microleakage for the three test groups were subjected to statistical analysis were found to be not significant among all groups by nonparametric one-way ANOVA procedure.

Table 1: Scores were mentioned based on penetrance of the dye.

0	No evidence of dye penetration
1	Superficial penetration, not beyond the ADJ
2	Penetration beyond the ADJ but not the cervico – Axial line angle
3	Penetration along the axial wall
4	Penetration into the pulp chamber

ADJ: Amelo dentinal junction

Table 2: Mean palatal cuspal deflection measurements of MOD cavities restored with different resin-based composites.

Product	Mean overall cuspal deflection (μ)
Group A: Filtek P60	15.3 (3.87)
Group B: Filtek Supreme	10.73 (3.04)
Group C: Admira	12.43 (3.13)

MOD: Mesio occlusal distal

Table 3: The cervical microleakage scores for each posterior filling materials.

Samples	Group A	Group B	Group C
	Filtek P60	Filtek supreme	Admira
1	4	4	0
2	2	1	1
3	3	0	1
4	0	3	3
5	1	2	4
6	2	2	2

Discussion

The cavity preparations utilized in the current investigation during placement of Filtek P60, Filtek supreme, and ormocer material were large MOD cavities, with the preparations being designed to favor possible cuspal movement and to weaken the rest of the tooth structure.[1] Nevertheless, these cavities could be considered to be a replacement of typical amalgam restorations and in the present scenario, the number of restorations currently placed in clinical practice are increased. Since, for example, the advent of improved bonding systems and matrix systems have made the use of composite restorations more viable.[1] The popularity of their restorations was accepted by in high with by dentists and patients since they are more aesthetical.[1,2]

Formerly, a direct current differential transformer (DCDT) was used to measure at the linear displacement of cusps. A study done by Jantarat *et al*. compared the use of DCDTs with a linear variable differential transformer and variations were found in both mesurement.[6] Their results was perhaps to be expected given the potential differences in morphology among teeth. In the current study, the size of the teeth used was closely controlled, with the differential mean bucco-palatal width which has been kept <5% among groups.

The current study examined the effect of polymerization shrinkage on cuspal movement during the polymerization procedure itself. Causton and team stated the cuspal movements signifying that the stress relief occurred due to the fractures within the tooth structure itself.[7] The cuspal movements detected in the present study are relatively <2% in total over one-week period. This is in accordance with Causton *et al*. results on polymerization of P30 which may be of significant magnitude. This may be sufficient to cause post-operative pain in some patients.[8] Medige *et al*. reported cuspal movement with the adhesive system and the composite itself being the factors when linear strain gauges were utilized to assess cuspal deflection.[9]

TEGDMA increased the polymerization shrinkage of the composite material due to increased concentration of carbon to carbon molecule double bonds (C=C) and, therefore, an increased degree of conversion of the methacrylate bond.[1,2] The replacement of TEGDMA with UDMA provides resin-based composites with higher mechanical properties and derivatives of Bis-GMA, namely Bis-EMA, were also developed to primarily decrease polymerization shrinkage, improve handling, and increase the cross-linking of polymer networks.[1,10]

The manufactures of Filtek P60 reports that it shrinks 25% less than its counterparts due to differences in monomer constituent and volume of reinforcing fillers.[1,2]

It contains 60 and 61% by volume of Zirconia/Silica filler.[3] On the other hand, the latest nanocomposite uses combination of resin chemistry and reported to have decreased polymerization shrinkage by the manufacturers. The nanocomposite contains 78.5% by weight of 2 fillers i.e., nanoparticles and nanoclusters, the nanoparticles are individual filler particles either 20 nm and 75 nm in size; nanoclusters are loosely bound clusters of nanoparticles.[4] Ormocer are characterized by inorganic and organic copolymers and reported by manufacturers of having polymerization shrinkage of 1.97% and it contains 61% by volume of fillers.[5] Total cuspal movement was the greatest with Filtek P60 that utilized TEGDMA which was present in more amount as compared with the other resin-based composite systems, which appeared to maximize cuspal movement and increase postoperative pain on chewing which patients may experience.[1]

Ormocers are reported to have increased fracture resistance and wear resistance compared with the resin-based composites. These are promoted as having total polymerization shrinkage of 1.97% due to the constituent components of inorganic and organic co-polymers and additive aliphatic and aromatic dimethaacrylates.[1,5] However, while decreased polymerization shrinkage and the associated shrinkage stress were evident, but it was not that significant as between Groups A and B.

The Filtek supreme (Group B) which had the least polymerization shrinkage compared with Group A and C, might be due to the resin system, which mainly consists of Bis-GMA, Bis-EMA, UDMA with small amounts of TEGDMA and also the filler content, non-agglomerated/nonaggregated 20 nm nano silica filler and loosely bound agglomerated Zirconia/Silica nanoclusters consist of agglomerates of primary Zirconia/Silica particles with size of 5-20 nm fillers. The cluster particle size ranges of 0.6 to 1.4 μ. The filler loading is 78.5% by weight might lead to decreased polymerization shrinkage values.[1,4]

This study focuses on the cuspal deflection at each stage of polymerization for the incremental restoration of standardized large (MOD) cavities with 3 posterior composite filling materials with variously reported volumetric shrinkage values. The performance of these restorations was investigated by assessing the cervical dentine cavosurface margins for gingival microleakage placed in extracted premolar teeth.

No groups were identified as producing less gingival micro leakage at the cervical dentin cavosurface margin when the results were examined. All groups experienced severe (Grade 4) levels of microleakage that indicates that the curing protocols utilized for these groups and/or the subsequent *in-vitro* thermal stressing regime employed caused bond failure.[11] The volumetric contraction of a restorative resin measured under free or unrestrained test conditions does not correlate directly with measurements of restoration/cavity wall adaptation measurements.[12] The latter wall to wall shrinkage is the clinically important parameter in determining initial cavity seal. Thus, the hypothesis that with a decrease in filler particle size and increase in volume of filler loading in the latest nanocomposite will have reduced the cuspal deflection was accepted.

Conclusion

The investigation concluded that the nanocomposite had reduced the cuspal deflection than other posterior composites was due to the filler particle size, filler volume percentage, and alteration in resin chemistry, could result in a significant reduction in associated cuspal strain on the large MOD cavities. This novel nanocomposite system would be the first material of choice for large esthetic restorations, more *in-vitro* and clinical studies are needed to confirm the laboratory findings.

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