To evaluate and compare the effect of different light-curing modes and different liners on cuspal deflection in premolar teeth restored with bulk filled or incrementally filled composite measured at different time intervals

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Abstract

Aim: The aim of this study is to evaluate and to compare the effect of different light-curing modes and different liners on cuspal deflection in premolar teeth restored with bulk filled or incrementally filled composite measured at different time intervals.

Materials and Methods: The study was divided into two parts (Part 1-different curing modes, Part 2-different liner) each with sixty extracted human upper premolar teeth with standardized large mesio-occlusal-distal cavities prepared. Each part was divided into two groups according to the composite used (Group A-Filtek Z350 XT, Group B-Sonic fill). Each group was then divided into three subgroups according to the light-curing modes (soft-start, pulse, and continuous curing mode) and liner (Filtek Z350 XT Flowable, Vitremer) used. The cuspal deflection was then measured with a digital micrometer gauge and subjected to statistically analysis using analysis of variance and Tukey’s post hoc test.

Results: Sonic fill composite, resin-modified glass ionomer cement (RMGIC) liner and curing with soft-start/pulse curing mode had significantly lower cuspal deflection compared to Filtek Z350 XT, flowable liner, and continuous curing mode, respectively.

Conclusion: Sonic fill composite, RMGIC liner under the restorations and composites cured with soft start/pulse curing mode resulted in reduced cuspal deflection.

Keywords: Curing mode; cuspal deflection; liners; sonic fill composite

INTRODUCTION

Major advancements in esthetic dentistry have resulted in a general replacement of silver amalgam for composite resins not only as a successor for failed or unesthetic amalgams but as the first-choice material to restore the teeth.

Current light-cured composite resins offer superior esthetics, better mechanical properties, and good bonding to tooth structure.

Recently, with booming interest for a ubiquitous restorative material, nanofilled composites have been introduced. Nanocomposites contain small filler particles (0.005–0.01 µm) and high filler loading which makes nanofill highly polishable with good physical properties and wear resistance.

Further development due to the addition of polymerization boosters and light initiators enable the clinicians to place

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some materials in bulk increments of up to 4 mm, thereby eradicating the need for technique-sensitive layering practice.

However, despite these advancements, polymerization shrinkage of composite still remains a challenge. Cuspal deflections of up to 50 µm were recorded using a variety of techniques such as photography,\(^1\) strain gauges,\(^2\) interferometry,\(^3\) linear variable differential transformers.\(^4\)

Hence, a recent method to decrease the polymerization shrinkage without affecting the degree of conversion is controlled polymerization (slower curing) which allows stress relaxation compared to high-intensity lights. In addition, modern dentistry is using liners to counteract the cusp deformation.

To date, no studies have evaluated the effect of different light-curing modes and different liners on cuspal deflection. Therefore, the current study aimed to evaluate and compare the effect of different light-curing modes and different liners on cuspal deflection after placement of bulk filled and incrementally filled composite measured at different time intervals.

**MATERIALS AND METHODS**

**Teeth selection**
One hundred and twenty large maxillary premolars, extracted for orthodontic purposes that on observation were free from caries, cracks, or hypoplastic defects were chosen and stored in 1% chloramine-T. An ultrasonic scaler was used, and all calculus deposits were removed.

**Cavity preparation**
All specimens were vertically fixed in a custom-made jig of acrylic resin. The resin extended up to a point almost 2 mm below the amelocemental junction. Filtek Z350 XT flowable composite (3M ESPE, USA) was adapted to the cusp tips as reference balls using standardized etching and bonding procedures for intercuspal distance measurements. Standardized large mesio-occlusal-distal cavities were prepped using diamond fissure burs (SS white) in a high-speed handpiece with water coolant and changed for every five preparations.

**Sample distribution**
The teeth were divided into two sets of 60 teeth each for respective methodologies, i.e.,

Part 1-To evaluate the effect of curing modes on cuspal deflection

Part 2-To evaluate the effect of liner on cuspal deflection

Each part was divided into two Groups A and B according to the composite used. Each group then divided into three subgroups according to the light curing modes and liner used.

**RESTORATIVE PROCEDURE**

**In Part 1**

**Group A**

Etching was performed (37% phosphoric acid) for 15 s, followed by rinsing for 30 s. The cavity was dried with light surges of air to leave visible glistening moist surface. Two sequential coats of Optibond S (Kerr Corporation, USA) were applied for 15 s followed by gentle air-drying and light curing for 10 s. A universal metal matrix band/retainer was placed around each prepared tooth. A sole increment of Sonic Fill composite (Kerr Corporation, USA) (shade A2) was placed, and the restoration was light-cured from the occlusal for 10 s. After removal of the matrix band, the restoration was cured for 10 s from both the lingual and buccal aspects. Curing of the samples was done according to the mode for that subgroup. The intensity of light was verified after each restoration with a radiometer (Satelec, Acteon, France).

Subgroup 1: Pulse curing mode (full power of 1100 mW/cm\(^2\) in a pulsation mode with 10 successive flashes and rest period of 250 ms between flashes).

Subgroup 2: Soft start curing mode (soft start for 10 s from 0 to 1100 mW/cm\(^2\), then full power during 10 s).

Subgroup 3: Continuous curing mode (full power of 1100 mW/cm\(^2\)).

Group B: Etching and bonding (Adper single bond 2 adhesive, 3M ESPE, St. Paul, USA) was done similar to Group A. Filtek Z350 XT (3M ESPE, USA) (shade A2) was placed with horizontal increment of 2 mm in mesial proximal box followed by distal proximal box. Then, the occlusal box was restored with horizontal increment of 2 mm followed by 1 mm till the cavosurface margin and each increment cured for 20 s. Curing of the samples for each subgroup was done as described for Group A.

**In Part 2**

**Group A**

Subgroup 4: Application of Vitremer primer (3M ESPE, USA) for 30 s pursued by gentle air drying and light curing for 20 s. Vitremer powder (shade A3) and liquid (1:1) were blended and placed in increment of 1 mm on the pulpal, axial, and gingival walls and light cured for 40 s. Sonic fill composite was then placed as described previously.

Subgroup 5: Etching and bonding were done. Filtek Z350 XT flowable liner (shade A3) was applied in thickness...
Table 1: Comparison of Cuspal Deflection between subgroup and within subgroup at different time interval for Part 1 of the study

| Group A | At 5 min | At 24 hrs | At 1 week | At 2 weeks |
|---------|----------|-----------|-----------|------------|
| Subgroup A1 (n=10) | 14.20±1.76,A,a,** | 7.20±1.83,A,a,** | 4.20±1.08,A,a,** | 0.60±0.64,A,a,** |
| Subgroup A2 (n=10) | 13.80±1.76,A,a,** | 11.00±1.12,A,a,** | 6.40±1.08,A,a,** | 4.00±1.08,A,a,** |
| Subgroup A3 (n=10) | 25.00±2.75,A,a,** | 13.00±1.63,A,a,** | 7.90±1.60,A,a,** | 6.00±0.82,A,a,** |

*P value Intergroup (ANOVA) <0.001

| Group B | At 1 week | At 2 weeks |
|---------|-----------|------------|
| Subgroup B1 (n=10) | 18.00±1.60,A,a,** | 7.30±0.95,A,a,** |
| Subgroup B2 (n=10) | 18.00±1.60,A,a,** | 11.00±1.26,A,a,** |
| Subgroup B3 (n=10) | 28.40±4.20,A,a,** | 17.40±2.22,A,a,** |

*P value Intergroup (ANOVA) <0.001

\*\*\* = P<0.05, P<0.01, P<0.001 respectively for comparisons between Groups A and B (Independent samples *t*-test)

Table 2: Comparison of Cuspal Deflection between subgroup and within subgroup at different time interval for Part 2 of the study

| Group A | At 5 min | At 24 hrs | At 1 week | At 2 weeks |
|---------|----------|-----------|-----------|------------|
| Subgroup A4 (n=10) | 9.00±1.41,A,a,** | 5.00±1.83,A,a,** | 2.10±0.88,A,a,** | 0.50±0.53,A,a,** |
| Subgroup A5 (n=10) | 13.00±1.66,A,a,** | 8.00±1.25,A,a,** | 5.00±1.25,A,a,** | 2.00±0.67,A,a,** |
| Subgroup A6 (n=10) | 25.00±2.75,A,a,** | 13.00±1.63,A,a,** | 7.90±1.60,A,a,** | 6.00±0.82,A,a,** |

*P value Intergroup (ANOVA) <0.001

| Group B | At 1 week | At 2 weeks |
|---------|-----------|------------|
| Subgroup B4 (n=10) | 12.70±1.40,B,b,** | 8.20±0.79,B,b,** |
| Subgroup B5 (n=10) | 18.30±1.57,B,b,** | 11.10±1.29,B,b,** |
| Subgroup B6 (n=10) | 28.40±4.20,B,b,** | 17.40±2.22,B,b,** |

*P value Intergroup (ANOVA) <0.001

\*\*\* = P<0.05, P<0.01, P<0.001 respectively for comparisons between Groups A and B (Independent samples *t*-test)

of 1 mm and light cured for 20 s. Sonic fill composite was then placed as described previously.

Subgroup 6: The specimens did not receive any liner and Sonic fill composite was placed as described previously.

**Group B**

Subgroup 4: Vitremer was applied; etching and bonding were done. Filtek Z350 XT was placed with horizontal increment of 2 mm in mesial proximal box followed by distal proximal box. Then, the occlusal box was restored with horizontal increment of 2 mm till the cavosurface margin and each increment cured for 20 s.

Subgroup 5: Etching and bonding were done. Filtek Z350 XT flowable liner (shade A3) was applied in thickness of 1 mm and light cured for 20 s. Filtek Z350 XT was then placed as described above.

Subgroup 6: The specimens did not receive any liner and were restored with Filtek Z350 XT as described previously.

**MEASUREMENT OF CUSPAL DEFLECTION**

The teeth were stored in an incubator (37°C, 100% relative humidity) except when measurements were to be recorded. Ten calibrations were recorded for each tooth, and the mean was considered as the reading of that specimen. The cuspal deflection was achieved by calculating the difference between “initial” and other readings recorded at different time intervals (5 min, 24 h, 1 week, and 2 weeks) with a digital micrometer gauge (Mitutoyo, Japan; resolution 1 μm).

**Statistical analysis**

Mean cuspal deflection and standard deviation for each group are shown [Tables 1 and 2]. The one-way analysis of variance (ANOVA) was applied to see the difference between the groups. The Tukey’s post hoc test was performed to confirm the results of ANOVA test between each group. P = 0.05 has been considered as statistically significant. Data analysis was done using SPSS version 15.0 (SPSS Inc., Chicago, IL) statistical analysis software.

**RESULTS**

The cuspal deflection at all-time intervals irrespective of the composite, mode of curing, and liner used decreased over a period.

The cuspal deflection in Group B was significantly higher as compared to those in Group A at all the time intervals in both Part 1 and 2 of the study.

In Part 1 of the study, on intragroup comparison at all-time intervals, subgroup A3 had significantly higher cuspal deflection compared to both Subgroup A1 and A2 (P < 0.001); however, the difference between subgroup A1 and A2 was not significant. Similarly, subgroup B3 had significantly higher cuspal deflection...
as compared to both Subgroup B1 and B2 ($P < 0.001$); however, the difference between subgroup B1 and B2 was not significant.

In Part 2 of the study, on intragroup comparison at all time intervals, subgroup A6 had significantly higher cuspal deflection as compared to both subgroup A4 and A5 ($P < 0.001$) whereas, subgroup A5 had significantly higher cuspal deflection as compared to subgroup A4 ($P < 0.01$). Similarly, subgroup B6 had significantly higher cuspal deflection as compared to both subgroup B4 and B5 ($P < 0.001$) whereas subgroup B5 had significantly higher cuspal deflection as compared to subgroup B4 ($P < 0.01$).

**DISCUSSION**

Cuspal deflection is a usual biomechanical event seen in teeth restored with composites as a result of interrelation between the polymerization shrinkage stress of the composite and the conformity of the cavity wall.

The results of this study revealed that irrespective of the composite, mode of curing and liner used, cuspal deflection reduced over a period (5 min > 24 h > 1 week > 2 weeks). This is in consensus with the previous studies in which it was proclaimed that majority of cusp movement occurs within 5 min and the total or in proximity-total recovery of the initial intercuspal distance is a gradual process that may last for up to 2 weeks and is never complete in medium size and large restorations.[1,5] In principle, a progressive relaxation of internal stress may be produced by the hygroscopic expansion of the composite through its exposure to the oral medium thus contributing to a recovery of the initial situation.[1,2,5]

Intragroup comparison showed that groups restored with sonic fill composite (Group A) had significantly lower cuspal deflection as compared to groups restored with Filtek Z350 XT composite (Group B). According to the literature, increased filler content (83.5 wt%)[7] and decreased percentage volumetric shrinkage of Sonic fill composite (1.6%)[9] might have resulted in lower cuspal deflection as compared to Filtek Z350 XT composite which have filler content of 78.5 wt%[9] and percentage volumetric shrinkage of 1.97%.[10]

Moreover, sonic activation lowers the viscosity of sonic fill composite dramatically up to 87% which is related to special rheological modifiers delivered through Sonic fill handpiece increasing its flowability,[7,11] which might have resulted in the relief of polymerization shrinkage stresses.

In agreement with this, Versluis et al.[12] found significantly increased polymerization stress generation with incremental layering procedure in comparison with bulk-filling technique. The polymerization shrinkage of each supplement will cause some deformity of the cavity, lessening the cavity volume as a result less composite can be placed for the next increment. This results in a cavity which is volumetrically filled with less composite material than the original volume of the cavity resulting in higher stress at the tooth-restoration complex.[13]

The results of our study also comply with those of Abbas et al.[14] Moorthy et al.,[15] who reported that the cuspal deflection was significantly greater with incremental than with bulk cure.

Intragroup comparison (Part 1) showed that subgroups cured with soft-start/pulse curing mode permit more time for molecular reorganization and thus produces reduced polymerization shrinkage compared to those cured with continuous curing mode.[13]

The polymerization reaction comprises three phases: Pregel, gel, and postgel.[16] In the initial phase, contraction of the composite is compensated by its viscous flow. As it reaches the gel phase, the viscous flow is reduced, and stresses are transferred to the tooth structure and bonding interface. Thus, use of lights with low intensity extends the pregel phase with adequate time to flow thus reducing the stresses.[13]

This finding is in agreement with Alomari and Mansour[17] Piccioni et al.,[18] who found that continuous curing mode induced increased cuspal deflection compared to pulse/soft start curing modes.

Intragroup comparison (Part 2) showed that subgroups restored with resin-modified glass ionomer cements (RMGICs) and flowable liners reduced the amount of cuspal deflection, which is in accordance with the findings of Alomari et al.,[2] Castañeda-Espinosa et al., and[19] Kwon et al.[20]

This could be explained on the basis of “elastic cavity wall concept” which states that an elastic intermediate layer absorbs the shrinkage stress generated by higher modulus resin composite, thereby reducing the stress at the restorative-tooth interface.[21] Moreover, the use of liner might reduce the C-factor, i.e., less volume of composite is needed for the restoration resulting in less shrinkage.[2]

High modulus of elasticity (MOE) (5.1 + 1.5 GPa)[22] and high polymerization shrinkage (3.8 vol%)[23] of flowable composite might have resulted in increased cuspal deflection when compared with RMGIC which have MOE of 2.3 GPa[24] and volumetric polymerization shrinkage of 3.49 vol%.[25]
CONCLUSION

Under the conditions of this study, it was consummated that the use of Sonic fills composites, placement of RMGIC liner, and the use of light with low intensity resulted in significantly lower cuspal deflection over a period.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Suliman AA, Boyer DB, Lakes RS. Cusp movement in premolars resulting from composite polymerization shrinkage. Dent Mater 1993;9:6-10.
2. Alomari QD, Boyer DW, Boyer DB. Effect of liners on cuspal deflection and gap formation in composite restorations. Oper Dent 2001;26:406-11.
3. Suliman AA, Boyer DW, Lakes RS. Interferometric measurements of cusp deformation of teeth restored with composites. J Dent Res 1993;72:1532-6.
4. Lutz F, Krejci I, Barbakow F. Quality and durability of marginal adaptation in bonded composite restorations. Dent Mater 1991;7:107-13.
5. Segura A, Donly KJ. In vitro posterior composite polymerization recovery following hydroscopic expansion. J Oral Rehabil 1993;20:495-9.
6. Felizter AJ, de Gee AJ, Davidson CL. Relaxation of polymerization contraction shear stress by hydroscopic expansion. J Dent Res 1990;69:36-9.
7. Sabbagh J. SonicFill System: A Clinical Approach; 2013. Available from: http://www.kerrdental.eu/catalog-files/clinical-articles/0/74/files/SonicFillTM-system-clinical-approach.pdf. [Last accessed on 2015 Nov 01].
8. Thompson JW. SonicFill™ Volumetric Shrinkage. SonicFill™ Portfolio of Scientific Research. Available from: http://www.kerrdental.ru/catalog-files/0/214/files/SonicFill_Portfolio%20%20Scientific%20Research_ru-RU.pdf. [Last accessed on 2015 Nov 01].
9. El-Deeb HA, Ghalab RM, Elsayed Akah MM, Mobarak EH. Repair bond strength of dual-cured resin composite core buildup materials. J Adv Res 2016;7:268-9.
10. Filtek™ Z350XT Universal Restorative System: Technical Product Profile. Available from: http://www.multimedia.3m.com/mws/media/6315470Q/filtek-z350-xt-technical-product-profile.pdf. [Last accessed on 2015 Nov 01].
11. Luu C, Drechsler U. Viscoelastic Change of SonicFill™ when Subjected to Sonic Vibration. SonicFill™ Portfolio of Scientific Research. Available from: http://www.kerrdental.ru/catalog-files/0/214/files/SonicFill_Portalio%20%20Scientific%20Research_ru-RU.pdf. [Last accessed on 2015 Nov 01].
12. Versluis A, Douglas WH, Cross M, Sakaguchi RL. Does an incremental filling technique reduce polymerization shrinkage stresses? J Dent Res 1996;75:871-8.
13. Lim BS, Ferracane JL, Sakaguchi RL, Condon JR. Reduction of polymerization contraction stress for dental composites by two-step light-activation. Dent Mater 2002;18:436-44.
14. Abbas G, Fleming GJ, Harrington E, Shortall AC, Burke FJ. Cuspal movement and microleakage in premolar teeth restored with a packable composite cured in bulk or in increments. J Dent 2003;31:437-44.
15. Moorby A, Hogg CH, Dowling AH, Grufferty BF, Bentetti AR, Fleming GJ, et al. Cuspal deflection and microleakage in premolar teeth restored with bulk-fill flowable resin-based composite base materials. J Dent 2012;40:500-5.
16. dos Santos GO, dos Santos ME, Sampaio EM, Dias KR, da Silva EM. Influence of C-factor and light-curing mode on gap formation in resin composite restorations. Oper Dent 2009;34:544-50.
17. Alomari QD, Mansour YF. Effect of LED curing modes on cuspal deflection and hardness of composite restorations. Oper Dent 2005;30:884-9.
18. Piccioni MA, Baratto-Filho F, Kuga MC, Morais EC, Campos EA. Cuspal movement related to different polymerization protocols. J Contemp Dent Pract 2014;15:26-8.
19. Castañeda-Espinosa JC, Pereira RA, Cavalcanti AP, Mondelli RF. Transmission of composite polymerization contraction force through a flowable composite and a resin-modified glass ionomer cement. J Appl Oral Sci 2007;15:495-500.
20. Kwon OH, Kim DH, Park SH. The influence of elastic modulus of base material on the marginal adaptation of direct composite restoration. Oper Dent 2010;35:441-7.
21. Unterbrink GL, Liebenberg WH. Flowable resin composites as “filled adhesives”: Literature review and clinical recommendations. Quintessence Int 1999;30:249-57.
22. Attar N, Tam LE, McComb D. Flow, strength, stiffness and radiopacity of flowable resin composites. J Can Dent Assoc 2003;69:516-21.
23. Filtek™ Flowable Restorative: Technical Product Profile. Available from: http://www.multimedia.3m.com/mws/media/598213O/filtek-supreme-xt-flow-tpp.pdf. [Last accessed on 2015 Nov 01].
24. Nakamura T, Wakabayashi K, Kuwabara S, Nishida H, Miyazawa M, Yatani H, et al. Mechanical properties of new self-adhesive resin-based cement. J Prosthodont Res 2010;54:59-64.
25. Bryant RJ, Mahler DS. Volumetric contraction in some tooth-coloured restorative materials. Aust Dent J 2007;52:112-7.