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Impact of Different Light Curing Modes on the Cuspal Deflection of Maxillary Premolars Restored with Nanohybrid Resin Restoration: An in Vitro Study

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***Abstract*---**INTRODUCTION: The influence of various light-curing modes may lead to polymerization shrinkage resulting in contraction stresses in composite resin. These stresses leads to linear movement of the cusp tips of the tooth as a result of interactions between

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polymerization shrinkage stress of the composite and adherence of the cavity wall of the tooth. That may lead to restoration failure. AIM: Comparative evaluation of the effect of different light-curing modes on the cuspal deflection of class II Mesio-occlusal-distal cavity restored with Nano-hybrid composite resin restorative material. METHOD: Thirty-six standardized MOD preparations were prepared on maxillary first premolars. Three groups(n=12) were divided according to different light-curing modes of Blue phase LED curing light- Group 1: soft-start curing mode; Group 2: pulse curing mode; Group 3: continuous curing mode. 1mm diameter glass beads were fixed to each cusp tip as a reference point for intercuspal distance to measure initial cuspal deflection for each group. MOD Preparations were etched and bonded with adhesive resin to provide micromechanical attachment and restored with Nano-hybrid composite restoration using the incremental technique. The cuspal deflection was then measured with the Digital micrometer gauge and the mean difference was measured for each group. The data were statistically analyzed using a one-way ANOVA test analysis of variance and post-hoc Tukey's test. RESULT: The mean cuspal deflections for Group 1: 0.059, Group 2: 0.033, and Group 3: 0.035. The intergroup comparison revealed a statistically significant difference. CONCLUSION: Nano-hybrid composite cured with Soft start curing mode of blue phase LED curing light showed the least cuspal deflection when compared to continuous curing mode and pulse curing mode.

***Keywords*---**blue phase, light curing modes, cuspal deflection, digital micrometer.

Introduction

Rising interest in esthetic restorations have produced an increase in the demand for posterior composite restorations with major advancements in esthetic dentistry replacing silver amalgam and with the improvement in the light emitting technology [1]. Cuspal deflection is described as a biomechanical phenomenon resulting in linear motion of the tooth's cusp tips due to interactions between the polymerization shrinkage stress of the composite and compliance with the tooth's cavity wall. [2] Clinically, cuspal movement can be manifested as polymerization shrinkage stresses that may compromise synergism at the composite-tooth interface, which may lead to bacterial microleakage, pulpal irritation, secondary caries and post-operative sensitivity resulting in the restoration failure.[3]

In 1995, Mills provided to substitute the Halogen light curing units with the use of light-emitting diode (LED) curing devices to polymerize resin composites. Conventional halogen light curing units have been associated with increased cuspal deflection which was susceptible to degradation of the intensity output. [6] LEDs claimed to have the following benifits over the frequently used halogen light healing units, do not require a filter to produce blue light, generate high light intensity, produce low heat, consume low energy and shorten treatment time. Despite the improvement with the use of high light intensity, the resin matrix's shrinking stress is increased by shortening the time required to reach the composite resin's gel point.

In an effort to minimize the impacts of polymerization shrinkage, distinct radiant exposure times and protocols were suggested. Therefore, the recent attempt to reduce the polymerization shrinkage is the development of light-emitting technology to produce the Blue Phase LED light-curing unit with three different light curing modes. It is based on poly-wave technology with the optimal spectrum of a camphor quinone photoinitiator (400-500 nm) with different light-curing modes of greater intensity.[7]

The degree of cuspal deflection depends on factors such as light curing intensity and curing modes, cavity design, type of composite material and its placement techniques.[4] The amount of cuspal deflection is influenced by the size and configuration (C-factor) and the highest cuspal deflection values have been reported for class II mesio-occlusal-distal cavities [5]. Also besides, New material developments such as micro-hybrid resin composites, purely nano-filled resin composites have been introduced but the clinical problems still persist. [13] Hence Nanohybrid composites have been introduced which is based on nano-optimized technology for an esthetic restorative procedure. The current study aimed to compare and evaluate the effect of different light-curing modes of blue phase LED light-curing unit on the cuspal deflection of class II Mesio-occlusal-distal cavity restored using Nano-hybrid restorative material.

Method

The current in vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India. This study was carried out on 36 intact human maxillary first premolars which were extracted for the orthodontic purpose. The carious teeth, any fracture or craze line, teeth with incomplete root formation and teeth with attrition involving cuspal edge were excluded from the study. The surface debridement of the teeth was done with an ultrasonic scaler to remove plaque and calculus. A glass bead of diameter 1 mm approximately was fixed on each cusp tip as a reference point to determine intercuspal distance. Using molten modeling wax, each tooth was mounted vertically.

Figure 1: glass beads fixed to cusp tips as reference point

Before tooth preparation, the initial intercuspal distance of unaltered tooth was first measured between the reference points using Digital Micrometer (Mitutoyo, Japan). Each tooth was subjected to standardized large MOD cavity preparation, with the parallel walls using a diamond fissure flat-ended bur (SS White SSW SF 51C) in a high- speed handpiece with water coolant. Standardized uniform cavity design was selected for the tooth preparation having a depth of 4mm from the buccal cusp tip to the pulpal floor and width of 2/3rd of the intercuspal distance. To minimize the preparation variation, the slot MOD cavities were prepared without proximal boxes.

Figure 2: standardized class ii mod cavity design without proximal boxes
DEPTH – 4 mm; WIDTH – 2/3RD OF THE INTERCUSPAL DISTANCE

The samples were divided into three groups (n=12) according to different light-curing modes of Blue Phase LED light-curing unit(SHOFU):

1. GROUP 1: Continuous curing mode (Full power of 1100Mw/cm2)
2. GROUP 2: Soft start curing mode (Soft start for 10s from 0 to 1100Mw/cm2, then full power during 10s)
3. GROUP 3: Pulse curing mode (Full power of 1100Mw/cm2 in a pulsation mode with 10 successive flashes and a rest period of 250ms between flashes)

After tooth preparation, uniform etching and bonding procedure was subjected to all the samples. The etching was performed using 37% phosphoric acid gel (N-Etch Ivoclar, Vivadent marketing, India) for 15 seconds and rinsed for 15 seconds and gently dried with cotton pellet to maintain moist dentin surface. Two coats of adhesive (Tetric N- Bond Ivoclar Vivadent marketing, India) was applied for 15 seconds to the etched surface by slow agitation of the applicator, followed by gentle air pressure for 5 seconds to evaporate the solvents and was then light-cured for 20 seconds according to different light-curing modes of Blue Phase LED light-curing unit.

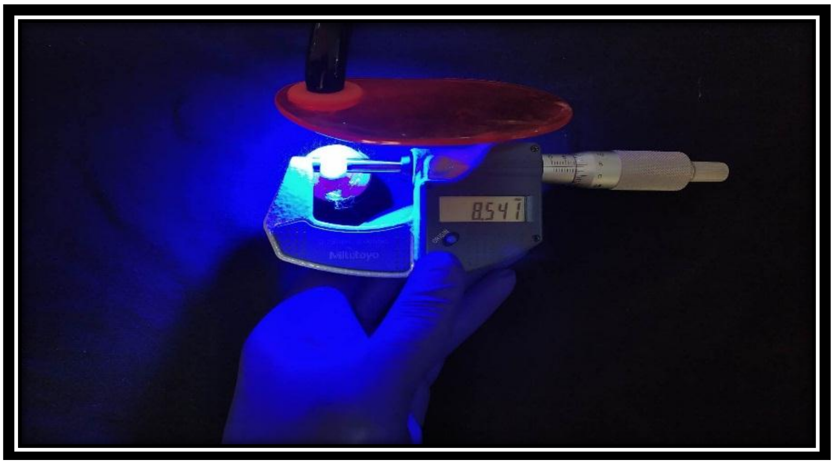

Figure 3: measurement of intercuspal distance using digital micrometer

Final intercuspal Distance was then recorded for each group after 24 hours using Digital Micrometer (Mitutoyo, Japan). The mean intercuspal distance was achieved for each group by calculating the difference between initial and final readings.

Statistical analysis

Mean cuspal deflection for each group was calculated and the One-Way ANOVA test was applied for the analysis of the significant difference between the groups. Intergroup comparison was done by the Post hoc Tukey's test. A p-value of <0.001 was considered statistically significant.

Results

Table 1
Initial readings, final readings and cuspal deflection (initial readings- final readings) in different groups using One-was ANOVA test

GROUPS	INITIAL READINGS mean (mm)	FINAL READINGS mean (MM) At 24 hours	DIFFERENCE (Initial-Final) Mean (mm) a	Welch statistics(*)/F (ANOVA)	P-value
GROUP 1	7.564 (SD = 0.547)	7.504 (SD=0.552)	0.059 (SD= 0.020)	11.651 (initial)	<0.001 (initial)

GROUP 2	7.925 (SD= 0.418)	7.890 (SD= 0.417)	0.033 (SD= 0.001)	12.138 (final)	<0.001 (final)
GROUP 3	8.454 (SD=	8.419 (SD= 0.380)	0.035 (SD=0.020)	6.971* (Difference)	0.005 (difference)

[Table 1] represents the initial and final mean intercuspal distance of the three groups and the mean cuspal deflection that occurred in each group. All three groups were associated with a significant cuspal deflection. The comparison between the different groups revealed that the mean cuspal deflection was highest in Group 1 (Continous curing mode) and least in Group 2 (Soft-start curing mode).
There was a highly significant difference of mean cuspal deflection when group 1 is compared with group 2 and group 3 but there was no statistically significant difference between group 2 and group 3.

Table 2
Post-hoc Tukeys test applied for the comparison of cuspal deflection between all the groups

INITIAL READING (mm)	**Group 1**	**Group 2**	**-0.3605**	**0.185582**	**0.143**
		Group 3	-.8905000*	0.185582	**<0.001**
	Group 2	Group 3	-.5300000*	0.185582	**0.02**
FINAL READINGS (mm) at 24 hours	Group 1	Group 2	-0.38608	0.186338	0.111
		Group 3	-.9144167*	0.186338	**<0.001**
	Group 2	Group 3	-.5283333*	0.186338	**0.021**
The difference in 24 hours	Group 1	Group 2	.0255833*	0.007458	**0.005**
		Group 3	.0239167*	0.007458	**0.008**
	Group 2	Group 3	-0.00167	0.007458	0.973

P<0.001 consider statistically significant

Discussion

Cuspal deflection is a common biomechanical phenomenon seen in teeth restored with composites as a result of interaction between the polymerization shrinkage stress of the composite and the conformity of the cavity wall.[8] Cusp Deflection is clinically important as polymerization shrinkage stresses can initiate failure at the composite restoration-tooth interface, which can cause microcracks, bacterial leakage, post-operative sensitivity, and secondary dental caries which in turn leads to restoration failure and requires re-restoration.[3] Nano-hybrid composite restorative material was used in the study as they have a smaller filler particle size (0.005-0.04 microns) compared to micro-filled and micro-hybrid composites and there is alteration in the resin chemistry of nano-hybrid composites which leads to reduced cuspal deflection and microleakage.[9]

In this study, to reduce the undesirable effects of polymerization shrinkage, a Horizontal incremental technique was used for reducing the bulk of composite cured with each other and maximizing the ratio of C-factor. It is known that the overall size of the cavity configuration influences the resulting shrinkage stress and degree of cuspal deflection.[5] Even though the incremental technique has been recommended for sufficient light penetration, its drawbacks include the likelihood of trapping voids or contamination between the layers and the increased time required to place the restoration. Many different insertion techniques are recommended but the most appropriate technique is inconclusive and many questions remain as the modulus of the elasticity varies between teeth which can affect the degree of cuspal flexure.

It is in agreement with the previous studies of KIM and Park et al**.** Comparison of premolar cuspal deflection in bulk or in incremental composite restoration which supports the application of incremental fill technique rather than using bulk fill method.[10] Blue phase LED curing light was used in the study as it decreases the polymerization shrinkage without affecting the degree of conversion in controlled polymerization which allows stress relaxation and shows reduced cuspal deflection. The results of the present study revealed that all three groups were showed significant cuspal deflection. The comparison between the different groups revealed that the mean cuspal deflection was highest with Group 1 (Continous curing mode) and least with Group 2 (Soft-start curing mode). The probable cause might be 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.

The present study results are in agreement with the previous study of Alomari and Mansour Piccioni **et al**. Effect of LED curing modes on cusp deflection and hardness of composite restorations which reveals that continuous curing mode induced increased cuspal deflection compared to pulse/soft start curing modes[11]. An important factor that induces cuspal deflection is the polymerization shrinkage during composite curing. The polymerization reaction consists of three phases: 1) pre-gel phase 2) gel-phase 3) post-gel phase. During the pre-gel phase, the 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, the use of lights with low intensity extends the pre gel phase with adequate time to flow thus reducing the stresses.[12]

Conclusion

Under experimental conditions of this study, it can be concluded that Nano-hybrid composite restorations cured with soft start curing mode of blue phase

LED light-curing unit showed least cuspal deflection and continuous curing mode showed highest cuspal deflection.

References

1. Effect of Different Composite Restorations on the Cuspal Deflection of Premolars Restored with Different Insertion Techniques- An In vitro Study
2. Sakshi Singhal1, Anuraag Gurtu2, Anurag Singhal3, Rashmi Bansal4, Sumit Mohan5
3. Journal of Clinical and Diagnostic Research. 2017 Aug, Vol-11(8): ZC67-ZC70
4. Agarwal, et al.: Effect of curing modes and liners on cuspal deflection, Journal of conservative dentistry 2018
5. Fleming et al. Investigation of polymerization shrinkage strain associated cuspal deflection and microleakage of MOD cavities restored incrementally with resin-based composite using LED light-curing unit, Journal of dentistry 2006
6. Effect of the liner on the polymerization shrinkage stress of light-cured composites. Dent Mater. 2012;28:801-09. Tantbirojn D, Versluis A, Pintado M R, DeLong R, Douglas WH.
7. Tooth deformation patterns in molars after composite restoration. Dental Materials. 2004;20:535–42. El-Badrawy W, Jafarpour S, Jazi HS, Comb D.
8. Effect of composite insertion technique on cuspal deflection using an in the vitro simulation model. Oper Dent. 2012;37(3):299-305.
9. Braga RR, Boaro LCC, Kuroe T, Azevedo CLN, Singer JM. Influence of cavity dimensions and their derivatives (volume and 'C' factor) on shrinkage stress development and microleakage of composite restorations. Dent Mater. 2006;22:818–23. Davidson CL, Feilzer AJ.
10. Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives. J Dent. 1997;25(6):435-40. Feilzer AJ, Gee AJD, Davidson CL.
11. Setting stress in composite resin in relation to the configuration of the restoration. J Dent Res.1987;66(11):1636-39. Ferracane JL, Condon JR. In vitro evaluation of the marginal degradation of
12. Kim ME, Park SH. Comparison of premolar cuspal deflection in bulk or incremental composite restoration methods.Oper Dent. 2011;36(3):326-34
13. Alomari QD, Mansour YF. Effect of LED curing modes on cusp deflection and hardness of composite restorations. Oper Dent 2005;30:684‑9
14. 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
15. Ferracane JL, Condon JR. In vitro evaluation of the marginal degradation of dental composites under simulated occlusal loading. Dent Mater. 1999;15:262