ORIGINAL RESEARCH

Role of delayed light polymerization of a dual-cured composite base on marginal adaptation of class II posterior composite open-sandwich restoration

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ABSTRACT

Objective: To determine the effect of delayed light polymerization of a dual-cured composite base material on the marginal adaptation of class II composite restoration.
Materials and Methods: 35 extracted human molar teeth were used to prepare class II mesio-occlusal or disto-occlusal slot preparations with gingival margins at the CEJ. The teeth were restored using an open-sandwich technique with a 2mm base increment of dual-cured composite, and divided into 5 groups based on the mode of the polymerization of the dual-cured composite base: Group A – self-cured after placement (5 mins), Group B – light-cured immediately after placement, Group C – light-cured 30 seconds after placement, Group D – light-cured 60 seconds after placement, Group E – light-cured 120 seconds after placement. Then a top layer of a light-cured composite resin is placed to complete the restoration. The teeth were thermocycled and immersed in 1% aqueous solution of methylene blue for 24 hours. Sectioning of the teeth and scoring under stereomicroscope was done. Data will be statistically evaluated using the kruskal wallis 1-way ANOVA.
Results: Statistical analysis using kruskal wallis 1-way ANOVA showed that the dual-cured composite light polymerized 1 minute after placement exhibited the least microleakage.
Conclusion: Delayed light polymerization of the dual-cured composite base reduced the microleakage in class II open-sandwich restorations.

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INTRODUCTION

With increasing demand for esthetic procedures and concerns regarding mercury toxicity, the popularity of posterior composite restoration has increased. However, its inherent polymerization shrinkage and subsequent side effects, such as cuspal deflection, defects in the margin and internal surface, and resulting secondary caries, have not been solved.[1]

To reduce polymerization shrinkage stress, and to improve marginal adaptation, numerous dental materials and methods were proposed for placement of direct composite resins.

- Incremental composite placement[2]
- Low elastic modulus liners[3]
- Stepped or ramped light curing[4]

The open-sandwich technique for placement of class II posterior composite restoration has all layers of restorative material exposed to an oral cavity at the proximal margins, which are areas of primary concern for long-term clinical success.[5]

The directed-shrinkage technique is described as the use of a self-cured resin as the first increment in the base of a class II composite followed by a light cured composite resin to complete the open-sandwich restoration.[6] The hypothesis of this clinical method suggested that the warmth of the tooth would enhance polymerization closest to the tooth and inhibit shrinkage from the preparation walls as seen in light-cured composite resins.[7]

The dual-cured composites have several advantages over the self-cured counterparts like, updated delivery systems, lower viscosity, control over placement and setting times, which simplify the adaptation of these materials to the pulpal floor

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and the proximal box.[7] A recent study demonstrated that, when using the same dual-cured composite material, the self-cure mode produces a lower polymerization contraction stress than the light-cure mode.[8]

Delaying light polymerization of a dual-cured composite and allowing for some initial conversion by the self-cure mode of the material may reduce the polymerization rate, polymerization shrinkage and associated stresses of light curing and, therefore, improve the marginal seal of class II composite resin restorations.[7]

Atlas and co-workers[7] found that, delayed polymerization reduced microleakage when polymerization was delayed 30-60 seconds after placement. The null hypothesis of this study is that, delayed light polymerization will have no effect on the marginal adaptation of the dual-cured composite base material utilized in this study.

MATERIALS AND METHODS

35 extracted human molar teeth were used to prepare class II mesio-occlusal or disto-occlusal slot preparations with gingival margins at the CEJ. The cavity width was standardized as 2mm with a marking on the straight fissure bur, which was used to prepare the cavities. A dual-cured bonding agent (Rebilda-DC) was mixed and applied, which was air-dried for 5 seconds and light-cured for 20 seconds as per the manufacturer's instructions [Figure 1].

The teeth were restored using an open-sandwich technique with a 2mm base increment of dual-cured composite (Rebilda-DC, VOCO, Germany) in the proximal box. The teeth were now divided into 5 groups based upon the mode of the polymerization of the dual-cured composite base: Group A – self-cured after placement (5 mins), Group B – light-cured immediately after placement, Group C – light-cured 30 seconds after placement, Group D – light-cured 60 seconds after placement, Group E – light-cured 120 seconds after placement. The cavities were then restored with a top layer of light-cured composite (Polofil supra, VOCO, Germany) to its anatomic form.

Figure 1: Materials used in this study

The curing light with a continuous mode of polymerization (800mW/cm^2) was used to cure each composite layer. Restorations were stored for 1 week at 37° C, 100% relative humidity and thermocycled (500 cycles, 5° C and 55° C, 15 seconds dwell). The teeth were then coated with nail varnish and immersed in a 1% aqueous solution of methylene blue for 24 hours at 37°C. Samples were sectioned mesio-distally, and dye penetration at enamel, dentin and cementum margins was scored under a stereo microscope (40x magnification) using an ordinal scoring system: 0 = no penetration, 1 = enamel penetration, 2 = gingival dentin penetration, 3 = axial dentin penetration.

Mann-Whitney tests were performed to compare the effects of bonding agent and curing modes on microleakage scores. To determine statistical significance, $P \leq 0.05$ was used.

RESULTS

Microleakage scores of the groups are listed in [Table 1]. Statistically, there was a significant difference between microleakage at different levels of cure-mode (P=0.05). Pairwise, multiple comparisons were performed using the Mann-Whitney test [Table 2].

The highest degree of leakage was obtained for the samples that were light-cured immediately after the placement (Group B). The lowest degree of microleakage was obtained for samples that had a 60 seconds delay (Group D) before light curing, followed by those with a 30 seconds

Table 1: Microleakage scores

Groups	n=1	n=2	n=3	n=4	n=5	n=6	n=7
A (self-cured)	2	1	2	2	3	3	2
B (light-cured, immediate)	3	3	2	3	2	1	2
C (light-cured, 30 secs)	2	2	1	0	2	1	1
D (light-cured, 60 secs)	1	1	1	0	2	1	2
E (light-cured, 120 secs)	1	1	1	3	2	1	1

Table 2: Pairwise multiple comparison of cure mode (Mann-Whitney test)

Group comparison	Mean difference	Z	*P* Value
A vs B	-0.143	-0.421	0.674
A vs C	0.857	-1.937	0.053
A vs D	1.000	-2.251	0.024*
A vs E	0.714	-1.781	0.075
B vs C	1.000	-2.097	0.036*
B vs D	1.143	-2.353	0.019*
B vs E	0.857	-1.908	0.056
C vs D	0.143	-0.421	0.674
C vs E	-0.143	-0.072	0.943
D vs E	-0.286	-0.524	0.600

*Denotes significant difference

delay (Group C), 120 seconds delay (Group E) and those that were self-curing (Group A). However, the difference between the microleakage of the samples, light-cured after 60 seconds (Group D), 30 seconds (Group C), and 120 seconds (Group E) was not statistically significant.

DISCUSSION

The null hypothesis is rejected, as the results of this study showed that the delayed light polymerization did improve the marginal adaptation of the dual-cured composite base material. The result of this study shows that, a dual-cured composite resin material when placed in the proximal box for class II open-sandwich composite restorations, and light-cured 1 minute after placement, resulted in the lowest microleakage at the CEJ margin. The study corroborates and confirms what was studied by Atlas and co-workers.[7]

When a tooth is restored with composite, polymerization shrinkage occurs directly at the tooth structure and the stress generated could reach upto 10 MPa, leading to a marginal breakdown and gap formation. Microleakage has been implicated as a cause of postoperative sensitivity and as one of the mechanisms by which secondary caries may occur.[9]

There are few studies that have reported on the marginal integrity obtained when using a dual-cured composite as a first increment in the base of a class II open-sandwich composite restoration. The result of this study shows that, a dual-cured composite resin material when placed in the proximal box for class II open-sandwich composite restorations, and light-cured 1 minute after placement, resulted in the lowest microleakage at the CEJ margin.

A reduced amount of polymerization shrinkage stress may result from letting the self-polymerization mode of the dual-cured composite initiate, thereby slowing the polymerization reaction velocity before the final light polymerization procedure. Delayed light polymerization may reduce polymerization shrinkage and stresses at final conversion and, therefore, enhance clinical success of posterior composite resin restorations.[7]

Fusayama Sensei[10] described at the end of 1980, the benefits of directed shrinkage technique, which was ratified by Bertolotti[11] in the 90s. The directed shrinkage technique requires that the self or dual-cured bonding agent not be polymerized. When the self or dual-cured composite contacts the non-polymerized bonding agent, the reaction is accelerated throughout the cavity preparation. When the polymer mass begins to shrink, either by light activation or better still by letting it sit for a minute before proceeding to the next step, it will be held to the cavity walls limiting the shrinkage and allowing for dissipation of tensile forces that try to debond the composite from the tooth.

Additionally, final light polymerization would enhance significant mechanical properties, making the selection of a dual-cured composite an improvement over a self-cured or a light-cured composite at the gingival margin.[7] All of the delayed light-cured groups in this study had significantly lower microleakage than the self-cured group, which may be explained by the improvement in material properties when the composite was ultimately light-polymerized. Thus, delayed light curing of the dual-cured composite optimizes the best qualities of the self-cure mode and the light-cure mode, resulting in an improved clinical performance.

The present samples were subject to thermocycling to evaluate microleakage of the restoration over time rather than immediately after placement. The lower microleakage among the delayed light-cured samples was, therefore, a clinically significant finding.[7]

Samples of all 3 groups, that were light-cured after 30 seconds, 60 seconds and 120 seconds, performed better than the immediate light-cured and self-cured groups, clearly underlining an importance of delaying the start of light polymerization. However, long term clinical trials will be necessary to validate the existing *in vitro* studies on this subject matter.

The other methods used for reducing the polymerization shrinkage of light-cured composites includes, the use of specialized curing lights, incremental placement and flowable composite liners. It has been shown that varying the light intensity over the curing time by using ramped curing intensity lights, stepped curing lights and pulse curing lights, enhances the marginal sealing and cavity adaptation. However, some investigators[12,13] did not find any improvement using these soft-start polymerization methods. This result may be explained by the different concentrations of photo-initiators.

While there is evidence that incremental fill techniques may improve marginal adaptation, a positive effect in terms of lower shrinkage stress due to polymerization in layers can be questioned. This does not imply a layering technique should not be recommended.[14]

And, the use of flowable composites to reduce polymerization shrinkage stress is still being debated and is not widely recommended. It appears, the use of a cured thin layer of any composite produces significant stress reduction.[15]

CONCLUSION

Within the limits of this study, it can be concluded that, the delayed light polymerization of the dual-cured composite base rather than the immediate-light polymerization reduced the microleakage at the gingival margin and proximal walls in class II open-sandwich restorations.

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