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REVIEW ARTICLE

EFFECT OF DELAYED LIGHT POLYMERIZATION OF DUAL-CURED COMPOSITES ON THE MICROLEAKAGE OF CLASS II RESTORATIONS: A STEREOMICROSCOPIC STUDY

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ABSTRACT

Aims: This in vitro study was carried out to determine the effect of delayed start of light polymerization of a dual-cured composite base on the microleakage of Class II open-sandwich composite restorations.
Settings and Design: Teeth were randomly divided into 5 groups according to the method of polymerization of the dual-cured composite base: (A) self-cured, (B) light-cured immediately, (C) light-cured 30 seconds after placement, (D) light-cured 60 seconds after placement, and (E) light-cured 120 seconds after placement. A top layer of light-cured composite was placed and cured. Restorations were stored for 1 week at 37°C and 100% relative humidity, subjected to 500 thermocycles between 5^0C and 55^0C with 15 seconds of dwell time and immersed in a 1% aqueous solution of methylene blue for 24 hours. Samples were sectioned mesiodistally, dye penetration was done and finally evaluated under a stereomicroscope.
Statistical analysis used: Kruskal Wallis Test
Conclusions: Within the limitations of this in-vitro study it can be concluded that delayed, rather than immediate, light polymerization of the dual-cured composites base reduced microleakage in Class II open-sandwich restorations.

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INTRODUCTION

Posterior composite resins have gained considerable importance due to increasing demand for aesthetics and long term functioning of restorative materials in stress bearing areas. Composite resins offer several advantages over amalgam like more conservative preparations, increased wear resistance, reparability and lower coefficient of thermal conductivity. However, composite resins are technique sensitive materials with several disadvantages. Of these, polymerization shrinkage is probably the greatest problem. This shrinkage can create contraction forces that may disrupt the bond resulting in marginal failure and subsequent microleakage. This leads to secondary caries which is the predominant reason for replacement of composite resin restoration. (Demarco and Ramos, 2001) Another weak link of Class II composite resin restorations is microleakage at gingival margin of the proximal box (Aguiar and Santos, 2002). Therefore, for a successful clinical outcome, a non- shrinking composite resin would be an ideal material. Since no such material exists that is truly non-shrinking, these problems can be overcome by an optimal combination of placement techniques, high intensity curing lights, choice of material, and light curing method to reduce the shrinkage stresses. One clinical approach to overcome some of these disadvantages is to use glass ionomer cement as a base under composite restoration. This is also referred to as a sandwich restoration. This provides the advantage of physiochemical bonding, hydrodynamics, fluoride release, antimicrobial effects and biocompatibility (Coelho Santos *et al.*, 2004). However, this technique showed high early clinical failure rates. The main reasons for failure were partial or total dissolution of the conventional glass ionomer cement and fracture of the resin composite overlay. Modified open sandwich techniques, using resin-modified glass ionomer cement, polyacid-modified resin composite, or flowable resin results from the reduction in free volume within the monomer structure as it transforms into a tightly packed polymer. Reduced shrinkage and polymerization contraction stress at the tooth-restoration interface have been identified as key factors for improved marginal cavity adaptation (Kuijs *et al.*, 2003). These materials were supposed to act as a stress-absorbing barrier in the sandwich technique because of their low modulus of elasticity and their ability to reduce the fracture rate of the restoration, with less dissolution. An open sandwich is one

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where a material such as dual cure composite, glass ionomer cement, or resin modified glass ionomer is placed as a base in the proximal box (Koubi *et al*., 2009), over which light cured composite resin is placed to complete the restoration. The type of composite resin used in the proximal box may play a critical role in the marginal adaptation of a Class II posterior composite restoration. During the polymerization process, composites shrink as a result of the change from a liquid to a solid state by the conversion of monomer molecules into a polymer network linked through shorter covalent bonds. Bulk contraction results from the reduction in free volume within the monomer structure as it transforms into a tightly packed polymer (Cornelis *et al*., 2005). Chemically or self-cured composites demonstrate the lowest amount of internal stress to the tooth structure when polymerizing and a lower polymerization rate, which may result in better adaptation of the restoration (Deborah *et al*., 2000). The technique investigated in this study uses dual-cured composites as the initial base or liner for direct Class II posterior composite restorations. Dual-cured systems have been demonstrated in vitro to have better properties, such as improved bond strength, modulus of elasticity, hardness, color stability, and low solubility, than self-cured systems (Kinomoto and Torii, 1999). These enhanced properties play a significant role when considering selection of materials exposed to the oral environment for posterior restorations. A recent study demonstrated that the self-cure mode produces lower polymerization contraction stress than the light-cure mode when using the same dual-cured composite material. 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.

MATERIALS AND METHODS

Fifty freshly extracted human permanent mandibular molars with fully developed roots were collected for use in this study. Teeth selection criteria included teeth which were recently extracted for periodontal reasons, teeth with intact clinical crowns and those removed intact while extracting. Teeth which were grossly decayed, teeth which fractured while extracting, teeth with cracks or craze lines or incipient proximal caries were excluded from the study.

Cavity Preparation

Conservative Class II cavities were prepared on both mesial and distal surfaces. The bucco-lingual width of the cavities was 3mm and depth was 1.5mm. The gingival seat was placed approximately 1.5mm apical to cemento-enamel junction.

Restoration and Grouping of Specimens

The restorative technique is as follows: 2 mm of flowable dual cure composite was placed gingivally as the first increment and cured, followed by placement of the composite resin. The teeth will be randomly divided into two groups based on the dual cure materials used.

Group 1: 50 Mesio-occlusal cavities were restored with Multi-core flow followed by placement of composite resin, Tetric Evo ceram.
Group 2: 50 Disto-occlusal cavities will be bonded with Rebilda DC. Followed by restoration with the composite resin, Tetric Evo ceram.

Each group was further divided into 5 subgroups of 10 teeth each, according to the delay in the start of light polymerization of the dual-cured composite.

Group A: Self cure of the dual cure flowable base after placement.
Group B: Dual cure flowable base light cured immediately after placement.
Group C: Dual cure flowable base light cured 30 seconds after placement.
Group D: Dual cure flowable base light cured 60 seconds after placement.
Group E: Dual cure flowable base light cured 120 seconds after placement.

Rest of the cavity was filled with restorative composite in increments and cured. OPTILUX 400 light (Demetron) with continuous energy mode of polymerization for 40sec was used to cure composite resin increments. Restorations were stored for 1 week at 37°C and 100% relative humidity, Thermocycling was done for 500 cycles at 5^oC and 55^oC with a dwell time of 15 seconds. The teeth were then painted with 2 coats of nail varnish, except for 1.5mm beyond the margins of CEJ. penetration was scored as follows Table 1.

Staining, Sectioning and Microscopic evaluation

The teeth were soaked in freshly prepared 1% methylene blue for 24hours. After removal from the dye, the samples were cleaned under running tap water. The specimens were sectioned mesiodistally through the centre of the restorations with double face diamond discs to obtain two sections from each tooth. The sections were then observed under a stereomicroscope at 10X magnification and extent of dye. penetration was scored as follows

Specimens were immersed in 1% methylene blue dye for 24 hours after which they were rinsed, sectioned, and observed under a stereo-zoom microscope and extent of dye penetration was ranked and graded.

Results were statistically analyzed

RESULTS

Stereo-microscopic analysis was done to analyze the degree of dye penetration. Statistical analysis was done using Kruskal Wallis analysis test.

There was a statistically significant difference between microleakage at different levels of cure mode. The highest degree of leakage was obtained for samples that were allowed to self cure (group A). Leakage of these samples was significantly higher than all other cure modes.

Table 1. Investigation design

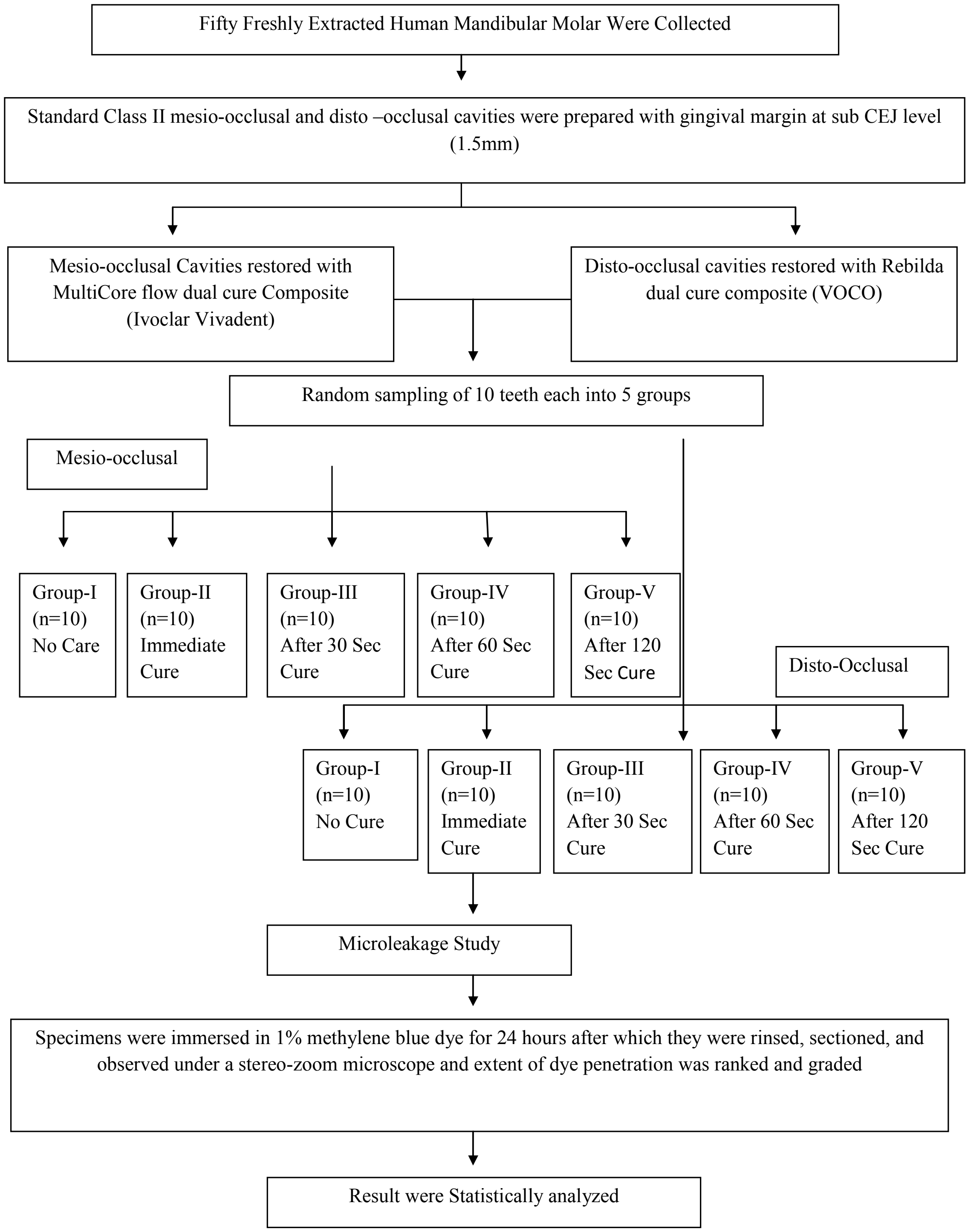

Table 2. Scoring scale for gingival marginal Microleakage

	Marginal leakage
0	No dye penetration
1	Dye penetration extending less than half of the gingival wall length.
2	Dye penetration extending more than half of gingival wall length but not including the axial wall.
3	Dye penetration to full extension of gingival wall including axial wall.

Table 3. Study group

GROUP A:	Self cure of the dual cure flowable base after placement.
GROUP B:	Dual cure flowable base light cured immediately after placement.
GROUP C:	Dual cure flowable base light cured, 30 seconds after placement.
GROUP D:	Dual cure flowable base light cured, 60 seconds after placement.
GROUP E:	Dual cure flowable base light cured, 120 seconds after placement.

Table IV. Group comparison

	Group	N	Mrsn	Std.Deviation	Minimum	Maximum
N	No cure	10	2.5000	.52705	2.00	3.00
	Imm cure	10	1.4000	1.07497	.00	3.00
	30 Sec	10	.6000	.69921	.00	2.00
	6o Sec	10	.8000	.78881	.00	2.00
	120Sec	10	.6000	.69921	.00	2.00
DO	Nocure	10	2.5000	.52705	2.00	3.00
	Imm cure	10	1.8000	.91894	1.00	3.00
	30 Sec	10	1.9000	.87560	1.00	3.00
	60 Sec	10	1.2000	1.22927	.00	3.00
	120Sec	10	1.0000	.94281	.00	3.00

Table V. Intergroup comparison Statistic

Group	time		Immcure nocure	Sec30-nocure	Sec60-nocure	Sec120-nocure	Sec30 Immcure
MO	No cure	Z	-2.414	-2.701	-2.701	-2.836	-1.807
		P	.016 sig	.007 hs	.007 hs	.005 hs	.071
DO	No Cure	Z	-1.732	-1.730	-2.136	-2.570	-.107
		P	.083	.084	.084	0.01 hs	.915

Fig. 1. Final specimen before composite placement

Fig. 2. Final prepared specimens in there respective groups

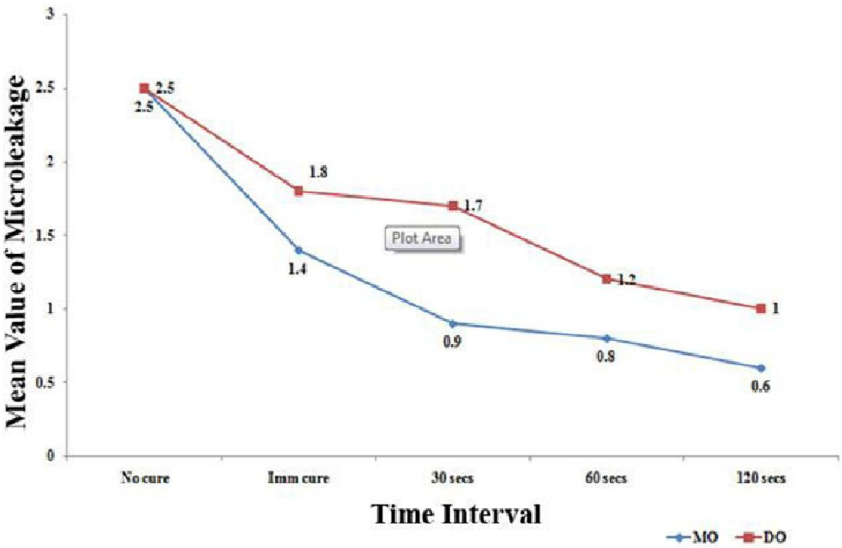

Fig. 3. Plot graph comaparing mesio-ocusal and disto-ocusal groups

The lowest degree of microleakage was obtained for samples that had a 120-second delay (group E) before light curing, followed by those that had a 60-second delay (groupD), 30-second delay (group A), and those that were immediately cure (group B). Microleakage recorded from samples light-cured after a120-second delay (group E) was significantly lower than self-cured (group A) groups. The difference between the microleakage of the samples light-cured after 120 seconds (group E), Immediate (group B), 30 seconds (group C), and 60 seconds (group D) was not statistically significant. When the mesio-occlusal group and disto-occlusal group are compared, the mesio–occlusal group that is restored with Multi core flow dual cure composites showed less microleakage when compared to disto-occlusal group, which was restored with Rebilda dual cure composites.

DISUSSION

The increasing demand for esthetic restorations has lead to many advances in resin adhesive systems. This has also led to an increase in their use in posterior teeth (Deborah *et al*., 2000). Posterior composites resins have several advantages like being tooth colored, mercury free, thermally non conductive and bond to tooth structure with the use of adhesive agents. Despite the remarkable developments in the technology of the resin composite restorative materials, clinical failures of resin restorations are still reported, particularly when resin composites are placed in stress bearing areas. Poor marginal adaptation along the cervical margins, secondary caries, material fracture and inadequate wear resistance under masticatory loads have been established as the common clinical problems of posterior resin composite restorations (Ferracane, 2008; Ferracane, 1994). Payne [35] has described microleakage, especially at the cavosurface margin of the proximal box of Class II restoration as the ―Achilles Heel‖ of restorative dentistry. The problem of microleakage has been largely demonstrated mainly below the cemento-enamel junction in several studies (Beznos, 2001). This is because bonding to dentin is far more difficult and less predictable than bonding to enamel because dentin is less mineralized, about 75% as opposed to enamel which is 98% mineralized. Moreover, dentin has a more complex histologic pattern such as tubular structure. The use of organic dyes as tracers is the oldest and most common method of detecting leakage in vitro. The advantage of the staining technique includes precision in evaluation of marginal seal and its ability to reveal an existing microgap (Cagidiaco and Ferrari, 2005). In addition to its ability to detect linear penetration and a direct reading of the penetrated marker by microscope, the main advantage of this method is its simplicity. It can be performed even in small laboratories without any special equipment. Methylene blue is a dark green crystalline powder which is odourless, water soluble and has a molecular weight of 373.92. It has the ability to penetrate into dentinal tubules resulting in an area of stained dentin which can be measured using image analysis. Methylene blue in various concentrations has been the most commonly used tracer for several decades (Spanberg *et al*., 1997). In the present investigation 1% methylene blue dye was utilized to evaluate microleakage in invitro samples. Many techniques have been proposed and tested to address the problem of microleakage in Class II restorations. These include the incremental technique 27, three sited technique (Beznos, 2001), directed shrinkage technique, Resin modified glass ionomer as gingival increment (Koubi *et al*., 2009), insertion of precured composite inserts, new modified incremental curing technique. These techniques reduced but did not completely eliminate microleakage. In dual cure the adhesive chemical intiator will accelerate polymerization of the chemically cured composite in contact with the adhesives itself. The composite curing will be directed toward the cavity wall and counteract the tendency of composites to shrink toward the center of the mass. This curing ―towards the tooth is enhanced by the tendency of chemically cured composites to begin polymerizing in the warmest area of the preparation, namely the tooth-restoration interface[1]. Currently, open sandwich techniques using alternative materials at the gingival margins of Class II restorations have gained popularity with the use of glass ionomer, resin modified glass ionomer cement and resinous materials placed as the first layer or gingival increment 8. (Attar *et al*., 2004) Therefore in this study, a dual-cured composite resin material placed on the gingival seat which was below the CEJ (Koubi *et al*., 2009; Alan M. Atlas and Padma Raman, 2009) and the resin material was placed as the first increment layer of 2mm (Malmstrom and Schlueter, 2002; Chuang and Jin, 2004) and cured at different time intervals, followed by placement of composite resin was investigated. Incremental technique was used in this study using horizontal layering (Aguiar and Santos, 2002).

Results suggested that restorations cured after 120 seconds after placement showed the least microleakage at the CEJ margin. The same dual-cured material which was allowed to self cure showed highest microleakage, indicating behavior similar to a light-cured composite with regard to polymerization shrinkage stresses. It has been suggested that upon polymerization of a light-cured composite in a large Class II composite restoration, the greatest stresses occur in the proximal box (Alan 2009). Polymerization shrinkage stress may be reduced to a certain extent by letting the self-polymerization mode of the dual-cured composite initiate, thereby slowing the polymerization reaction velocity before the final light-polymerization procedure. The results of this study are supported by a recent study suggesting that choice of a low contraction-stress composite resin and modification of its placement are significant determinants in reduction of microleakage and better clinical outcomes in Class II direct restorations (Sillas Duarte, 2008). The present samples were subjected to thermocycling of 500 cycles1 to evaluate micro leakage 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. Samples that were light-cured after a 120 second delay had the lowest degree of microleakage. This study did not show a statistically significant difference between microleakage scores of samples that were light-cured after 30 seconds, 60 seconds, and immediate cure. However, all 3 groups performed better than the self-cured groups. Delayed light polymerization may reduce polymerization shrinkage and stresses at final conversion and therefore enhance clinical success of posterior, composite resin restorations. 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.

Conclusion

The following conclusions can be drawn from the present study:

1. Delayed light polymerization of the dual-cured composite base rather than immediate light polymerization reduced micro leakage at the gingival margin and proximal walls in Class II open-sandwich restorations.
2. Samples that were light-cured after a 120 second delay had the lowest degree of microleakage and the self cure group which set by chemical cure alone, showed highest leakage which was significantly different in both the groups irrespective of materials used. However, 30 second, 60 second, and the immediate cure groups showed leakage which was not statistically significant.
3. The mesio-occlusal group (Multi core flow) showed lesser microleakage score when compared to the disto-occlusal group (Rebilda). However, it was not statistically significant.

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