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A Study of Microleakage in Class II Composite Restorations Using Four Different Curing Techniques

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Clinical Relevance

For bonded direct Class II restorations, the use of transparent matrices or metal matrices combined with light conducting instruments, such as light tips, should be favored because marginal leakage is significantly lower when compared to using metal matrices alone.

SUMMARY

There are several incremental techniques for the placement of posterior composites in Class II cavities that were introduced to overcome clinical failures associated with these restorations. This study evaluated microleakage in Class II cavities restored with four different curing techniques.

On 40 non-carious, freshly extracted human premolars, Class II cavities were prepared following a standard pattern in which the mesial cavities had a cervical margin 1.0 mm above the CEJ, and for distal cavities, 1.0 mm below the CEJ. The specimens were randomly divided into four groups. Each cavity surface was conditioned with 35% phosphoric acid and rinsed to remove the excess water, followed by a dental bonding agent (PQ1) being used for all the cavities. The teeth were then restored with a fiber reinforced resin-based composite (Neulite F), using four different techniques: Group 1, metal matrix with wooden wedge; Group 2, transparent matrix with reflective wedge; Group 3, metal matrix with wooden wedge and light tip and Group 4, metal matrix with wooden wedge and bio-glass cylinder. Then, the restorations were finished and polished, rebonded, thermocycled (2000 times, 5°C to 55°C, 30 second dwell time), stained, sectioned vertically and viewed under a stereomicroscope (40x). They were then scored on a 0-4 scale based on microleakage at the gingival margins. The data were analyzed using the Kruskal-Wallis and

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Mann-Whitney U tests. The results showed that Group 1 demonstrated the most leakage, while the other three groups showed less leakage than Group 1. There was no significant difference between the enamel and dentin gingival margin groups. As a result of these findings, the authors concluded that restoration with metal matrices, using light conducting instruments, results in significantly less microleakage at the gingival margins of Class II resin composite restorations.

Table 1: *Experimental Design of the Study*

Light-conducting Instrument	Type of Wedge	Type of Matrix	Group (n=10)
-	wooden	metal	1
-	reflective	transparent	2
Light tip	wooden	metal	3
Cylindrical glass	wooden	metal	4

Figure 1a. *Light tip.*

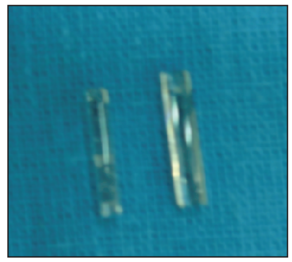

Figure 1b. *Cylindrical glass for light conduction.*

INTRODUCTION

Resin composite is coming into widespread use as the material selected to restore posterior teeth. The suitability of this type of restoration has been limited by the shrinkage inherent in its polymerization.[1] The result is a marginal gap at the tooth-restoration interface, as demonstrated by Brännström and others.[2] In addition, Brännström and Vojinovic[3] showed the deleterious effect of irritation following infection by bacteria growing in the gap between the restoration and the cavity wall.

The acid-etch technique introduced by Buonocore permits resin composite to bond to enamel.[4] The efficacy of the bond has been confirmed by two studies, one by Phair and Fuller[5] and the other by Hembree.[6] Unfortunately, despite the significant increase in bond strength values reported over the years, the occurrence of microleakage and gap formation, mostly at the dentin/composite interface, did not seem to decrease at a similar rate.[7-8] A recent study demonstrated that the percentage of dentinal gaps in a composite restoration placed *in vivo* may vary between 14% and 54% of the total interface, depending on the materials and techniques used.[9]

Despite improvements in the physical properties of the materials used, composite placement is relatively complex when compared with amalgam placement. The ability to achieve adequate contacts and appropriate proximal contour, decreasing sensitivity and recurrent decay, color matching and adequate curing in a relatively short period of time, presents a challenge.[10]

The recent introduction of new composites, matrix retainers, wedges and contact–forming instruments has resulted in techniques to expedite and provide more predictable composite placement.

This study examined the effect of different composite placement and curing techniques on the microleakage of a posterior composite restoration.

METHODS AND MATERIALS

Forty freshly extracted human, non-carious pre-molars (maxillary first and second) were used for this study. The extracted teeth were cleaned thoroughly to remove both hard and soft deposits and were stored in saline solution at room temperature. Standardized Class II mesial and distal simple box cavities were created in each tooth, with the cervical margins of mesial cavities finished approximately 1 mm above the CEJ, and for distal cavities, 1 mm below the CEJ. The dimensions of the cavity were 3 mm in the buccolingual dimension at occlusal; 4 mm in the buccolingual dimension at the gingival floor and 2 mm mesiodistally. A 0.5 mm width bevel was placed on the cavosurface buccal and lingual margins of all boxes. In distal cavities, a 0.5 mm depth gingival lock was prepared. All the preparations were made by means of a medium-grain high-speed diamond bur (835/008, Teez KavanLTD, Tehran, Iran) with water coolant; the bur was replaced after every five preparations. After cavity preparation, each tooth was mounted between two artificial teeth in a cold cure acrylic cast to simulate the geometric configuration of the approximal site.

The specimens were randomly assigned to four different groups (n=10) according to the type of restoration (Table 1). The material combination included a hybrid fiber reinforced posterior composite (Nulite F, NSI Dental Pty Limited, Hornsby, Australia), together with an adhesive bonding agent (PQ1, Ultradent, South Jordan, UT, USA). In Groups 1, 3 and 4, metal matrices (Tofflemire matrices, 0.05 mm thin, No 1001/30, Kerr Hawe SA, Bioggio, Switzerland) were used in combination with wooden wedges (Wedges turquoise, MINI, No 822/05, Kerr Hawe SA). In Group 3, a light

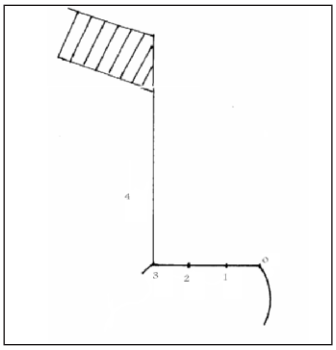

Figure 2: *Diagram of microleakage evaluation criteria.*

curing tip (Light-tip, c-type, Denbur, Inc, Oakbrook, IL, USA) (Figure 1a) was used, and in Group 4, a cylindrical piece made of glass (Bio-glass, Par-e-Tavous Institute Research in Glass & Ceramics, Mashhad, Iran) (Figure 1b) was used to transmit light from the light curing unit to the gingival floor. In Group 2, transparent matrices (Lucifix-Premolar bands, No 775, Kerr Hawe SA) were used with transparent wedges (Adapt Luciwedges Medium, No 732, Kerr Hawe SA).

Following acid etching of all enamel and dentin walls with 35% orthophosphoric acid (Ultra-Etch, Ultradent) for 15 seconds, the teeth were rinsed with copious amounts of water for 30 seconds. Excess water was then removed with a cotton pellet, keeping the remaining dentin slightly moist. A single coat of bonding agent was applied to cover the dentin and enamel walls. The material was gently air thinned, then light cured for 20 seconds. All materials were used according to the manufacturer's instructions. All specimens were treated with a standard resin composite curing light (Coltolux 50, Coltene/Whaledent Inc, Cuyahoga Falls OH, USA). The matrices and wedges were applied to the teeth, then, the resin composite was applied in increments approximately 1.5-2 mm thick. In Group 2, the first layer was initially cured through the translucent wedge, followed by the occlusal (in each case for 40 seconds). In Group 1, curing was carried out from the occlusal, with all subsequent layers being light cured for 40 seconds. In Group 3, a light tip was used to cure the first layer, and the remaining layers were cured in the same manner as Group 1. In Group 4, a cylindrical piece of glass (1 mm in diameter and 7 mm high) was used to cure the first layer, with the remaining layers being cured in the same manner as Group 1. All the restorations were then finished with Sof-Lex (3M ESPE, St Paul, MN, USA) fine and ultra-fine finishing disks. The gingival margins of all the restorations were then rebonded (10 second acid etching, 20 second washing, air drying, applying one layer of PQ1 adhesive bonding agent, air thinning and 20 second curing).

Following the restoration procedure, the teeth were stored in saline at 37°C for one week and thermocycled in a thermal cycling machine (MCT2-AMM instrumental, CA, USA) for 2000 cycles at 5°C and 55°C, with a dwell time of 30 seconds in distilled water and a 20-second transfer time. The apices were sealed with epoxy resin (Araldite, Brascola Ltda, Sao Bernardo do Campo, Brazil) and coated with two applications of fingernail polish up to 1 mm from the restoration margins. All the teeth were immersed in freshly prepared 0.2% basic fushin for 24 hours at 37°C, then washed in water. All the teeth were mounted in epoxy resin. Finally, each tooth was sectioned vertically through the center of the restoration with a diamond disk (KG Sorensen Ind Com Ltd, São Paulo, Brazil) at low speed.

Microleakage at the gingival margin was evaluated by two observers using an optical stereomicroscope (Meiji Techno Co, LTD, Iruma-gun Saitana, Japan) at 40x magnification and scored using the following criteria:

0–no dye penetration.

1–Dye penetration that extended up to 1/3 of the preparation depth.

2–Dye penetration greater than 1/3, up to 2/3 of the penetration depth.

3–Dye penetration extending to the axial wall.

4–Dye penetration past the axial wall (Figure 2).

The results were analyzed using the Kruskal-Wallis and Mann-Whitney U tests.

RESULTS

Table 2 shows leakage scores for the different curing techniques and gingival margin locations.

The Kruskal-Wallis test showed significant differences among the leakage scores of the different curing techniques both in enamel and dentin ($p<0.05$).

The Mann-Whitney U tests for samples showed:

- All of the restorative modes studied leaked more when located within dentin gingival margins as opposed to margins in enamel; however, the difference was not statistically significant (Table 3).

Table 2: *Frequency of Microleakage Scores*

Situation/Curing Type	Total #	Score 0	Score 1	Score 2	Score 3	Score 4
Enamel/Group 1	10	0	0	0	2	8
Enamel/Group 2	10	9	0	0	0	1
Enamel/Group 3	10	10	0	0	0	0
Enamel/Group 4	10	9	0	0	0	1
Dentin/Group 1	10	0	0	0	0	10
Dentin/Group 2	10	6	3	0	0	1
Dentin/Group 3	10	7	0	2	0	1
Dentin/Group 4	10	5	1	3	0	1

- Groups 2, 3 and 4 presented better results than Group 1 and showed statistical differences from Group 1. Group 1 demonstrated the worst scores with gingival margins both in dentin and enamel ($p<0.001$), although, there was no statistical difference between Groups 2 and 3 ($p=0.739$), 2 and 4 ($p=0.971$) and 3 and 4 ($p=0.739$).

Table 3: *Mann-Whitney Test Showing Insignificant Differences Between the Enamel and Dentin Groups*

Situation/Curing Type	*P* value	Situation/Curing Type
Enamel/Group 1	*P* value=0.480	Dentin/Group 1
Enamel/Group 2	*P* value=0.315	Dentin/Group 2
Enamel/Group 3	*P* value=0.280	Dentin/Group 3
Enamel/Group 4	*P* value=0.190	Dentin/Group 4

DISCUSSION

In recent years, the use of different devices for posterior resin composite restorations has been investigated. Asmussen and Peutzfeldt found that the direction of shrinkage is directed towards the light source.[11] When the filling is cured from the occlusal, it shrinks away from the adhesive zone, where bonding of the restorative material simultaneously occurs. Under these circumstances, damage could occur to the adhesive bond. When the restoration is cured from the proximal, however, this damage may be minimized and microleakage reduced.[12] Neiva and others have suggested that polymerization shrinkage may be one of the major factors directly responsible for marginal leakage at the tooth-restoration interface, while also influencing the longevity of posterior resin restorations.[13] Lutz and others have stated that the use of a transparent matrix and reflective wedges, together with interproximal curing, is indispensable for achieving sufficient polymerization.[14-15] Mullejans and others have shown that, in Class II cavities, resin composite materials can be cured from the proximal surface.[16] This brings about the required degree of polymerization.

However, there are several disadvantages to using transparent matrices. With respect to adaptability, metal matrices are superior, in that they can be better pre-contoured and firmly applied to the tooth surface.[17] Neiva and others claim that this is one of the advantages of metal matrices. From an anatomical viewpoint, metal matrices hold the proximal contour better than their transparent counterparts.[13] Furthermore, transparent matrices are used with reflective wedges. These are very stiff and lack the ability of wooden wedges to adapt themselves to natural anatomic tooth contour. As a result, reflective wedges can make contact to the matrix placed on the tooth at only one point. This permits the development of large gaps between the matrix and tooth at the cervical margin and generates substantial overhang during the filling procedure. It is obvious that a buildup of tooth colored restoration material at the approximal part will be difficult to detect. Even if correctly identified, this excess material is very troublesome to remove and poses a formidable clinical challenge.[13,17]

One disadvantage of a metal matrix that wraps around the facial and lingual surfaces of a tooth is that increments must be initially cured only from the occlusal aspect. After removal of the matrix, the proximal resin composite may be further polymerized from the facial and lingual aspects.[17] An alternative to this layering technique is the use of a conical light curing tip. This technique is designed to ensure adequate proximal contact and minimize the thickness of the resin composite that the light must penetrate.[17] Ericson and others and von Beetzen and others have shown the formation of fewer marginal gaps than in more traditional techniques, as well as improved hardness and decreased porosity.[18-19]

This study investigated the difference between a transparent matrix combined with reflective wedges and a metal matrix combined with wooden wedges with and without using light conducting instruments. Significantly higher leakage was found when a metal matrix and wooden wedge were solely employed. This observation applies to the direction of shrinkage, due to curing being limited to the occlusal aspect. In addition, the authors compared light conducting instruments, such as a conical tip attached to the light wand and an experimental custom-made cylindrical piece of glass, and found that these instruments have been useful for reducing gingival leakage probably due to changing the direction of shrinkage.

In this study, Class II cavities were prepared with either enamel or cementum/dentin gingival margins. According to the results showed in Table 2, composite restorations with dentin gingival margins showed slightly higher leakage scores than those with gingival enamel margins; however, according to the results mentioned in Table 3, these differences were not significant. The authors thought that the insignificant differences might have resulted from rebonding of the gingival margins. The application of a low-viscosity resin to the finished surface and margins of a restoration has been shown to improve the marginal integrity of resin composite restorations *in vitro* and *in vivo*, significantly reducing microleakage *in vitro* and reducing marginal staining *in vivo*.[17]

CONCLUSIONS

Solely using a metal matrix with a wooden wedge (instead of a transparent matrix and a reflective wedge) when restoring Class II cavities with resin composite materials significantly increases marginal leakage.

Using light-conducting instruments, such as a conical tip, significantly reduces microleakage to a level equivalent to that of a transparent matrix and reflective wedge. Dental practitioners should take these results into account when weighing the advantages and disadvantages of both types of matrix and wedge.

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