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Class II Restorations with Margins below the CEJ

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ABSTRACT

Introduction: Historically, Class II restorations using resin composite with margins below the dentino-enamel junction (dej) have fared poorly in investigations, exhibiting significant dye penetration along the marginal interfaces. In all reports located by the authors the gingival margins of sub-CEJ restorations have been finished, even though in actual practice this is not feasible in the vast majority of cases.

Purpose: The purpose of this study was to examine the effect of finishing on gingival margins located below the cemento-enamel junction of Class II resin composite restorations.

Materials and Methods: Class II resin composite restorations with margins below the dej were placed in 40 extracted human molars using a dentin-enamel adhesive, a flowable resin composite, and a universal microhybrid resin composite restorative material. In all groups the adhesive was light activated for ten seconds and the restorative resin composite was light activated for ten seconds. The flowable increments were 1 mm in thickness and the restorative resin composite increments were 2 mm in thickness. In groups 1, 3, and 4 the flowable was light activated for ten seconds while in group 2 the flowable was light activated for 40 seconds. In groups 1, 2, and 4 the sub-CEJ margins were finished with

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finishing discs while in group 3 the sub-CEJ margins were unfinished. In group 4 the dentin adhesive was reapplied following finishing procedures. All groups were immersed in dye for 24 hours.

Results: The two groups in which the margins were finished exhibited varying degrees of dye penetration. There was no dye penetration in the unfinished and the resealed groups.

Conclusions: It was concluded that the finishing procedure itself causes damage to the resindentin interface, which allows dye penetration to occur. This could potentially explain why resin adhesive materials have fared so poorly in Class II in vitro investigations, which is not the common clinical experience.

CLINICAL SIGNIFICANCE

It is likely that, in clinical situations in which high-quality materials are used properly, Class II restorations with margins below the CEJ perform better than is indicated by research. In most clinical situations it is not feasible to finish Class II margins below the CEJ. However in those cases in which access is available to finish Class II margins on dentin, resealing with the adhesive is highly recommended.

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INTRODUCTION

esin composite dentistry has **N**expanded enormously over the last few decades. During the direct placement of resin restorations, the resin is polymerized in situ. In the process of polymerization, resin composite is accompanied by shrinkage.^{1,2} During the shrinkage process, shrinkage forces place stresses along restoration interfaces.³ These shrinkage forces can result in marginal discrepancies.^{1,4} It is generally accepted that when these marginal discrepancies occur along the gingival margins of Class II restorations it can be discerned by immersing restored teeth in dye solutions and examining them. Margins of Class II restorations by necessity frequently end up below the enamel-dentin margin. Dye penetration studies

done on Class II resin-composite restorations have, over time, consistently shown that margins placed above the CEJ have performed better than those margins placed below the CEJ.5-11 Given the reported findings, it might reasonably be expected that these types of restorations would fare poorly, but experience of the authors in private practice suggests otherwise. The current study focuses on the variables that could affect clinical results. A pilot study indicated that the finishing process itself could have an effect on dye penetration. This is important because all Class II studies having margins below the CEJ located by the authors have had the margins finished, even though this is not feasible in the vast majority of cases in actual practice. The purpose of this report is to examine the effects of

finishing on the dye penetration of Class II resin restorations below the dentin-enamel junction.

METHOD AND MATERIALS

Forty recently extracted intact human molars were used for this study. The roots were sealed with the application of a one-bottle resin acetone-based adhesive followed by application of a flowable resin composite over the apex. The resin adhesive and the flowable resin composite were light activated separately. Standard Class II restorations, 4 mm wide and 4 mm in mesio-distal dimension, were placed with the margins 1.5 mm below the CEJ with an 1156 carbide fissure bur. Examples of the preparations may be seen in Figures 1 and 2. A size Large Composi-tight sectional matrix (Garrison Dental Solutions, Spring



Figure 1. An interproximal view of a typical Class II preparation.



Figure 2. An occlusal view of a typical Class II preparation.

Lake, MI, USA) was held in place over the cavity prep to reproduce the placement of a matrix in vivo. The cavity was rinsed and dried. A one-bottle resin adhesive (Simplicity, Apex Dental Products, Sandwich, IL, USA) was applied to the cavity. The cavity was dried with compressed air for 5 seconds. Simplicity 1 was applied to the cavity and agitated gently for 10 seconds. Three brushfuls of Simplicity 2 were then applied to the cavity. The cavity was dried thoroughly for 5 seconds. Three more brushfuls of Simplicity 2 were applied and the cavity was dried gently for 5 seconds. The adhesive was light activated for 10 seconds. All resin materials were light activated for

10 seconds with an Ultralume 5 light-generating unit that has a power density of 800 mW/cm² (Ultradent, South Jordan, UT, USA). Following adhesive application, a layer of a flowable resin composite (Titan, shade A2, Apex Dental) approximately 1 mm in thickness was placed to cover the entire pulpal floor of the cavity. It was then light-activated for either 10 or 40 seconds. The cavity was then filled with 2 mm thick horizontal increments of Z100 resin composite (shade A2, 3M Dental Products, St. Paul, MN, USA), and each increment was light activated for 10 seconds. Following resin composite insertion the occlusal margins of the restorations

underwent simulated occlusal adjustment with a fine egg-shaped diamond bur. Then the restorations were divided into four groups. In group 1, the proximal margins of the restorations were polished dry with a medium grit Soflex XT polishing disc (3M Dental Products). In group 2, the flowable resin composite was lightactivated for 40 seconds, and the proximal margins were finished dry with the polishing discs. In group 3, the proximal margins received no finished efforts, reproducing what is the most common clinical experience. In all but isolated cases, the margins of Class II restorations are not accessible to either discs or burs. The



Figure 3. An example of a specimen from Group 1 in which the margins were finished.



Figure 4. A specimen from Group 2 in which the margins were finished.

TABLE 1. DYE	PENETRATION SCORES	FOR THE FOU	IR GROUPS	EXAMINED.
	Group 1	Group 2	Group 3	Group 4
Dye penetration	n 0.48 (0.27)	0.29 (0.35)	0.0	0.0

restorations in group 4 were placed and then finished as in group 1 but subsequently to the polishing the single-bottle resin no-rinse adhesive Simplicity was reapplied to the areas that were affected by the polishing treatment and light activated for 10 seconds.

Following these treatments the teeth were immersed for 24 hours in 0.5% basic fuchsin dye at a bath temperature of 37C. Following removal from the bath the teeth

were rinsed under running tap water for 3 minutes and allowed to dry for 24 hours. They were sectioned in a mesio-distal direction through the middle of the restoration and examined for dye penetration. Dye penetration was measured as a function of the percent the dye penetrated along the pulpal floor that is, the restorations were imaged, magnified on a computer monitor and using a digital pixel ruler, the dye penetration was measured as a function of the entire length of the cavity floor and expressed as a fraction. Both sides of the sectioned teeth were scored.

RESULTS

The results can be seen in Table 1. Group 1 exhibited the greatest amount of dye penetration, receiving a mean score of 0.48 (0.27). An example is seen in Figure 3. Dye penetration was seen in all specimens in group 1. Group 2 exhibited a mean dye penetration of 0.29 (0.35). (An example is seen in Figure 4.) Four out of the ten specimens in group 2 had no dye penetration. Both group 3 and group 4 exhibited a mean dye penetration of 0.0. None of the specimens exhibited any dye penetration





Figure 5. An example from Group 3 in which the interproximal margins were unfinished.

Figure 6. An example from Group 4 in which the margins were finished and a resin adhesive was reapplied subsequent to the finishing procedure.

in either group. An example from group 3 is seen in Figure 5, and a specimen from group 4 is seen in Figure 6. *T*-tests were run between groups to determine levels of significance. Groups 1 and 2 had significantly more dye penetration than groups 3 and 4 ($p \le 0.05$). There was no significant difference between groups 1 and 2 ($p \ge 0.05$).

DISCUSSION

The results seen in group 1 are consistent with historical reports examining dye penetration. Microleakage, or dye penetration along the restoration interface, has long been a specter in resin restorative dentistry. Early on it was believed that simple resin shrinkage was responsible for lack of marginal adaptation. Recently it has been shown to be a more complex problem.

The apparent inability to seal sub-CEJ margins in Class II restorations has been a vexing and lasting obstacle. There have been many efforts investigating the effects of various techniques on the integrity of this interface. Great strides have been made in dentin bond strengths over the last 25 years but it has been reported that there is no relationship between bond strengths and marginal gap formation.^{12,13} Various layering methods for Class II resin restorations have been investigated, and none have been shown to have much of an effect on dye penetration.^{14–19} Gharizadeh and colleages investigated differing resin activation methods and found that lightconducting instruments could improve resistance to dye penetration.²⁰ Sensei and colleages examined different types of light-generating units and found no difference in dye penetration between varying types of units.²¹

Most efforts searching to find a technique that assures the seal of the Class II resin restoration with margins below the CEJ have proven unsuccessful. Some efforts have been made to try to understand what procedures and materials might improve the dye penetration resistance of Class II resin restorations below the CEJ. A number of reports have indicated that contraction stress is responsible for Class II subgingival marginal discrepancies.²²⁻²⁴ Yet indirect restorations have not been shown to resist dye penetration significantly better than direct restorations.²⁵ This is particularly surprising because the amount of contraction stress at the gingival interface is expected to be much less with indirect restorations than in direct restorations as the amount of resin polymerizing in situ is far less in indirect restorations than in direct restorationsthat being limited to the luting material itself.

Lengthening the exposure time of the layer inserted first, the flowable resin composite, improved resistance to dye penetration but not significantly so. Whereas in group 1 all restorations exhibited dye penetration, four specimens in group 3 has a score of zero. This may possibly be related to a greater immediate bond strength development consequent to the extended light activation period or it may simply be an incidental experimental finding. The findings in group 3 are important, and they derive from a departure from typical Class II dye penetration investigations. Dye penetration experiments examining Class II margins below the external cemento-enamel junction thus far have had one universal constant: all restorations were finished or polished, but this runs counter to the actual clinical experience. Interproximal Class II margins which are located below the CEI junction are seldom accessible to any sort of finishing, let alone rotary instrumentation. It is a reasonable inclination of the dental researcher to try to create neat and clean marginal junctions even though it departs from the clinical experience. As of the time of this report, the possible consequences of such instrumentation have not been considered in Class II sub-CEJ margins. If the act of finishing itself has an effect on the outcome, then it becomes an item of significance.

Much research has gone into the characteristics of the demineralized layer of the dentin which results following acid treatment. When dentin is etched, rinsed, and dried, it contracts.²⁶ What is not generally recognized is that sound dentin also contracts when it is dried.^{27,28} It is speculated that the process of applying a rapidly spinning polishing abrasive disc or point to the marginal junction cause a rapid drying of the dentin at that interface and that this drying results in a rapid and immediate contraction of the tissue. This contraction causes the resin adhesive to be separated from the dentin abruptly and permits dye to subsequently enter the interface. This mechanism potentially explains the findings of previous investigators and explains why dye penetration continues to occur in spite of increased bond strengths, varying layering techniques, and why indirect resin restorations do not fare any better than direct resin restorations.

The use of glass ionomer liners has been shown generally to improve resistance to dye penetration in Class II resin composite restorations, but they do not eliminate such dye penetration.²⁹⁻⁴² A few reports have suggested that glass ionomer liners do not aid in reducing dye penetration in Class II resin restorations.43,44 The improvement in dye penetration resistance may possibly come as a courtesy of the lower modulus of the glass ionomer liner, allowing it to yield more upon experiencing contraction stresses of the Class II box areas when polishing is occurring. This possibility is currently under investigation. A lower modulus permitting the liner to stretch as the dried dentin contracts would be consistent with the studies of Dewaele and colleagues, who found that rubbery liners

significantly decreased gap formation.⁴⁵ Similarly, it also has been suggested that increased viscous flow of resins may reduce gap formation.46,47 Some previous investigations offer hints that desiccation can affect marginal quality and dye penetration in other classes of resin restorations. Xin and colleagues reported that a brief polishing in a wet condition offered the best resistance to dye penetration in Class V restorations.⁴⁸ Bouschlicher and colleagues reported that desiccation increased dye penetration in Class V restorations.49

None of the specimens in group 4 exhibited any dye penetration. This suggests that resealing the polished areas affected by instrumentation with the resin adhesive is very effective at reducing permeability. As previously noted, finishing of the sub-dej margins of Class II resin restorations is extremely uncommon in the clinical setting. It also suggests that most of the studies in which subgingival margins of resin restorations are subject to finishing procedures strongly depart from the clinical experience. In a sense, this is very good news for the clinician, as it suggests that Class II sub-dej margins in carefully placed restorations are likely better than the experimental data indicates.

On occasion it is possible to have sufficient access to Class II margins

below the cemento-enamel junction. This can be seen in situations in which there is a deep restoration on one tooth, an adjacent tooth has been extracted, and there has been a loss of periodontal tissue. In such examples when sufficient access exists to finish a restoration with margins below the CEJ, then sufficient access also exists to permit the reapplication of the adhesive system to eliminate the permeability caused by the finishing technique.

CONCLUSIONS

The very act of finishing had a significant and negative effect on the marginal integrity of Class II resin composite restorations with margins below the cemento-enamel junction. Restorations placed and finished in a conventional manner exhibited varying degrees of dye penetration. Extending activation time of the flowable first layer resulted in a lesser degree of dye penetration, but not significantly so. Dye penetration was prevented when the sub-CEJ margins remained unfinished. Dve penetration was also prevented when the dentin-enamel adhesive was reapplied and light activated following the finishing procedure. As most posterior resins with margins located below the CEJ do not lend themselves to finishing procedures clinically, restorations placed in vivo likely perform better than laboratory procedures indicate, presuming the clinician is utilizing

high quality materials and inserting them properly. When conditions do permit the finishing of such margins, it is recommended that the dentin-enamel adhesive be reapplied to reduce or eliminate dentinal permeability. It is possible that these findings may extend to Class V restorations that have margins below the CEJ.

This study also suggests that care ought to be taken when handling dye penetration specimens with margins on dentin. Both demineralized and intact dentin shrink when dried, and this can have a potential effect on the integrity of marginal interfaces. Bouschlicher and colleagues have shown that specimens that are allowed to desiccate have increased dye penetration.49 The application of materials used to exclude dye penetration, such as nail varnish, which require a period of drying should be done prior to restoration placement so as not to have a possible role in the dye penetration outcome. Following varnish placement a rehydration period is also recommended.

DISCLOSURE AND Acknowledgements

Dr. Kanca is a consultant for Apex Dental Materials and has an interest in Apex products.

Dr. Greitzer has no financial interest in any of the products mentioned in this article.

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