

Microleakage at the cervical margin of Class II composite restorations with different intermediate layer treatments

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국문초록

치경부변연에서 중간층 수복이 구치부 2급 복합레진의 미세누출에 미치는 영향에 관한 연구

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복합레진에 의한 구치부 2급 외동의 수복에서 치은부 변연이 법랑 백아 경계 하방에 위치하는 경우 복합레진의 중합 수축에 의한 응력은 변연부의 폐쇄능력을 저하시키고 이로인한 미세누출은 2차적인 우식이나 슬후과민증을 일으켜 임상에서의 성공을 위협한다. 본 연구에서는 2급 외동에서 복합레진으로 수복하기 전에 치은 변연부를 중합수축에 의한 응력을 완화시킬 수 있는 것으로 알려진 몇가지 재료들을 중간층으로 먼저 충전한 후 충전용 복합레진으로 충전한 뒤 치은부 변연에서 이들 중간층과 치질 사이의 미세누출의 정도를 비교하였다.

20개의 발거된 구치의 근, 원심면에 각각 상자 모양의 2급 외동을 형성하고 40개의 외동을 무작위로 10개씩, 4개의 군으로 나누었다. 1군은 중간층의 수복없이 Clearfil SE Bond과 Clearfil AP X로 충전하였으며, 2, 3 및 4군은 중간층으로 각각 Revolution, Dyract 그리고 Fuji II LC를 먼저 충전한 후 1군과 동일한 방법으로 복합레진을 충전하였다. 충전된 시편은 열순환후 2% methylene blue 용액에 12시간 침잠시킨 후 색소의 침투도를 stereomicroscope로 관찰하였으며 실험결과는 Kruskal Wallis non parametric independent analysis 및 Mann Whitney U test로 통계분석하여 다음의 결론을 얻었다.

1. 레진강화형 글라스아이오노머를 중간층으로 먼저 수복하고 복합레진으로 충전한 경우에서 더 적은 미세누출을 보였다($p < 0.05$).
2. 유동성 레진과 콤포머를 중간층으로 수복한 경우와 복합레진만으로 수복한 경우는 미세누출에 있어서 유의한 차이를 나타내지 않았다($p > 0.05$).

Key words : 복합레진, 중간층 수복, 미세누출, 치은부변연

I. INTRODUCTION

Tooth colored posterior restorations are now chosen as the first choice of caries treatment by many patients. Most popular tooth colored restoration is the direct composite. The current composites have been improved, demonstrating proper wear resistance for the posterior regions.

When all margins of composite restorations are located in enamel, satisfactory esthetics and longevity have been reported in small restorations¹⁻⁴. But in larger restorations where cervical margins are located in dentin, long term success is more difficult to attain^{5,7}. Despite significant improvements in adhesive dentin bonding, polymerization shrinkage continues to rupture the

*This paper was supported by Konkuk University in 2002

resin tooth bond, producing a gap. The ensuing microleakage into this gap results in postoperative sensitivity and increased risk of secondary caries^{8, 10)}.

Techniques proposed to eliminate this leakage have included incremental placement, clear matrices and reflecting wedges, beta quartz inserts, the use of autopolymerizing composite, pulsed/stepped curing, and sandwich techniques incorporating other materials as an intermediate layer¹¹⁾.

Intermediate layer of restorative material has been suggested as a means to improve both marginal integrity and adaptation of the high viscosity composite to cavity walls. Restorative materials advocated for this purpose have included flowable composites, compomers, autopolymerizing composites, and conventional and resin modified glass ionomer cements¹²⁾.

Flowable composites have reduced physical properties when compared to standard restorative composites, suffer from greater polymerization shrinkage, possess an increased coefficient of thermal expansion, and are not recommended for use in high stress applied locations. But used as an intermediate layer, their proposed mechanism of reducing microleakage is related to their increased elasticity, which is thought to compensate for the polymerization contraction stresses of the final restorative composite¹³⁾. Additionally, flowability of this material is able to fill the corner of cavities more efficiently.

Glass ionomers including resin modified glass ionomers have many excellent physical properties which are long term molecular bonding to dentin and enamel, bacteriostatic action, thermal expansion similar to that of enamel and dentin, and a slow setting reaction with low setting shrinkage¹⁴⁾.

Compomers are purposed to offer less stress at the resin dentin interface because of their slower initial setting reaction. Additionally postplacement expansion of compomers from water sorption is believed to offset their initial shrinkage¹⁵⁾.

If using any of these intermediate layers prior to placement of a composite, they could be helpful to eliminate microleakage.

The concept of using glass ionomers to bond

composite resins to dentin was first introduced by McLean for Class III and Class V cavities¹⁶⁾. Some authors^{16, 18)} tested this group of materials in an open sandwich technique to seal the cervical cavity margins in Class II restorations. This concept failed clinically when conventional glass ionomers were used, mainly because of continuous loss of materials¹⁶⁾. But recently introduced resin modified glass ionomers and compomers show improved mechanical and physical properties and better control during clinical handling¹⁷⁾. Some studies have indicated that these materials may improve the marginal adaptation of Class II restorations when an open sandwich technique is used^{18, 19)}. Whether resin modified glass ionomers or compomers should be used for such restorations is difficult to decide, for different factors have to be considered when selecting a material for sandwich restorations.

The purpose of this study was to determine whether intermediate layers of flowable composite, compomer and resin modified glass ionomer prior to placement of condensable composites would eliminate or significantly decrease microleakage at the gingival margin of Class II direct posterior composite restorations placed on dentin.

II. MATERIALS AND METHODS

1. Materials

Twenty extracted caries free human molars were chosen. The teeth were cleaned with scalers and stored in physiological saline until use.

Composite resin selected as experimental material was Clearfil AP X (Kuraray Medical Inc., Okayama, Japan) and Clearfil SE Bond (Kuraray Medical Inc., Okayama, Japan) was used as dental adhesive system.

Intermediate layer materials used in this experiment were flowable resin (Revolution; Kerr Corp., Orange, CA 92867, U.S.A.), resin modified glass ionomer cement (Fuji II LC; GC Co., Tokyo, Japan) and compomer (Dyract; Dentsply/Detrey, Konstanz, Germany).

2. Preparation of the specimens

Forty box shaped Class II cavities without retention lock were prepared on the mesial and distal surfaces of each tooth with cylindrical diamond bur by use of a high speed handpiece and copious water cooling. The bucco lingual width of these cavities was 3 mm and the gingival wall depth was 1 mm. The carvosurface margin at the gingival floor of all cavities was apically placed approximately 1 mm from the cemento enamel junction. No bevels were prepared and internal line angles were rounded. The prepared cavities were randomly assigned to four groups.

3. Restorative Procedures

In all specimens, a Tofflemire matrix band and a soft metal band were placed on each tooth. The matrix was tightened and held by finger pressure against the gingival margin of the cavity so the preparations would not be filled above the gingival margin.

Restorative resin used in this experiment was Clearfil AP X (Kuralay Medical Inc., Okayama, Japan) regardless of intermediate materials.

Group I, which was control group, didn't receive an intermediate layer prior to placement of condensable composite resin. Clearfil SE Bond Primer was applied to the entire cavity wall. After 20 seconds, primed wall was dried with mild air flow. After then, Clearfil SE Bond Bond was applied, air flowed gently, and light cured for 10 seconds from the occlusal aspect using a visible light. Using horizontal incremental insertion technique, each cavities were filled with a maximum thickness of 2 mm per increment of Clearfil AP X, and then were light cured for 60 seconds from the occlusal aspect.

In group II, Revolution (Kerr Corp., Orange, CA 92867, U.S.A) was used as intermediate layer. After treatment of adhesive system of Clearfil SE Bond (Kuralay Medical Inc., Okayama, Japan), Revolution was restored on gingival part of cavities prior to restorative resin restoration and light cured for 60 seconds from occlusal aspect.

In group III, Dyract (Dentsply/Detrey, Konatantz, Germany) was used as intermediate layer. After etching with 37% phosphoric acid on cervical part of cavities, one layer of Prime & Bond NT (Dentsply/Detrey, Konatantz, Germany) was applied on gingival third of cleaned cavities and light cured for 10 seconds. And then Dyract was restored on gingival part of cavities prior to restorative resin restoration and light cured for 60 seconds from occlusal aspect.

In group IV, Fuji II LC (GC Co., Tokyo, Japan) was used as intermediate material. Specimens was cleaned for 10 seconds with GC Dentin Conditioner (GC Co., Tokyo, Japan), rinsed and dried. Mixed cement was placed on gingival part of cavities by disposable syringe and light cure of 60 seconds was done.

In experimental groups, each intermediate materials were restored within 2 mm thickness approximately and up to carvosurface margins. Filling method of composite restoration was same as control group.

Following restoration, the matrix band was removed. Finishing and polishing of the restorations were performed with fine grit diamond burs and Enhance polishing system (Dentsply/Detrey, Konatantz, Germany) immediately after curing and removal of the matrix band.

All restored teeth were stored in physiologic saline for 1 week. The teeth were thermocycled for 600 cycles from 5 55°C using a dwell time of 30 seconds.

4. Dye Leakage Test

All tooth surfaces were applied two coats of fingernail polish except for a 1.5 mm surrounding the carvosurface margin. After drying, the specimens were immersed in a 2% methylene blue solution for 12 hours and rinsed with tap water for 12 hours.

5. Evaluation of Microleakage

All teeth were embedded in auto polymerizing acrylic resin (Orthodontic resin; Dentsply/Detrey,

Konstanz, Germany) and sectioned longitudinally in a mesio distal direction coincident with center of restorations using a slowly rotating diamond saw (Isomet™, Buehler Co., Lake Bluff, IL, U.S.A.). The sectioned surfaces were analyzed under a stereomicroscope (SZ PT 40, Olympus Optical Co., Ltd., Tokyo, Japan) at ×25 magnification. For the purpose of dye penetration analysis, only the gingival floor of the interface was considered. The following leakage scores were attributed, according to the severity of dye penetration: 0 = no evidence of dye leakage; 1 = dye penetration to less than half the cavity depth; 2 = dye penetration to the full cavity depth; 3 = dye penetration to the axial wall and beyond.

6. Statistical Analysis

Differences between the frequency of the dye leakage scores in the experimental groups were subjected to statistical analysis with Kruskal Wallis non parametric independent analysis and Mann Whitney U test. Corresponding p values were considered significant at values less than 0.05.

III. RESULTS

Figure 1 is photographs of specimens representing the microleakage scores. Results of dye leakage test and mean rank of Kruskal Wallis test are shown in table 1.

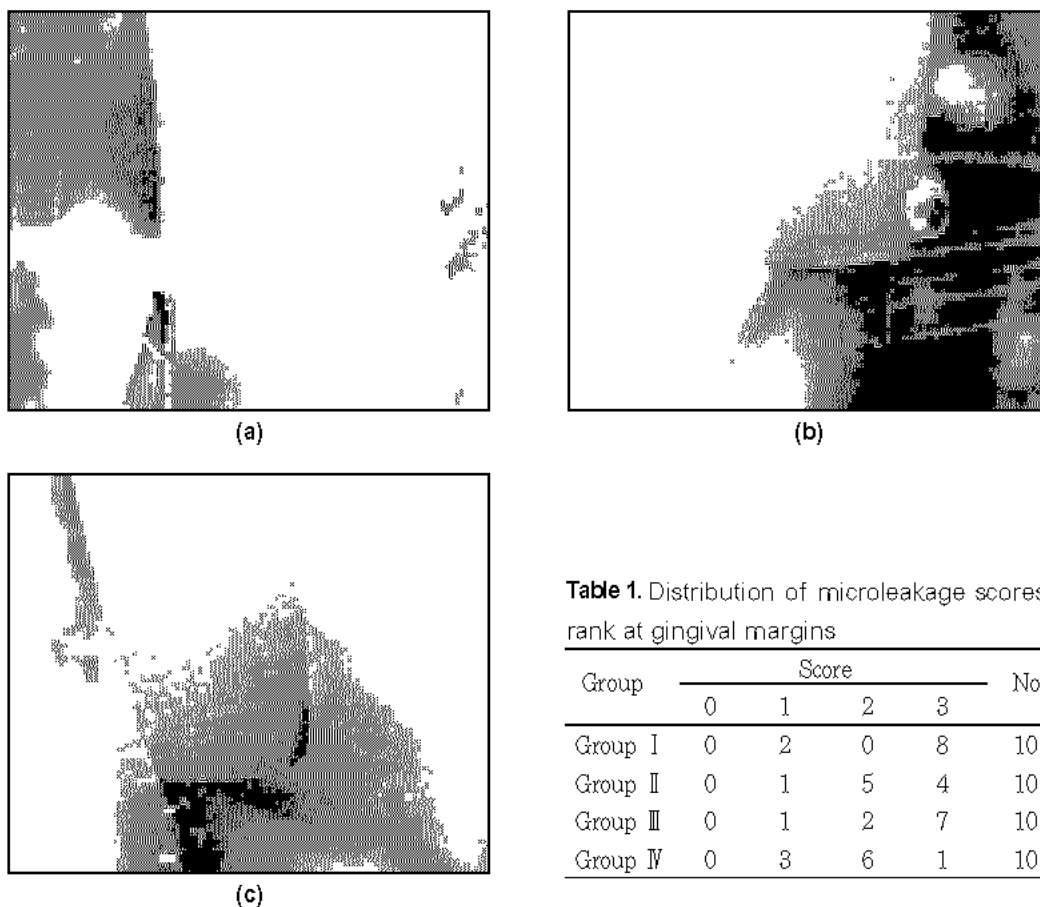


Fig. 1. Scores of microleakage (×25): (a) score 1, (b) score 2, (c) score 3

Table 1. Distribution of microleakage scores and mean rank at gingival margins

Group	Score				No.	Mean rank
	0	1	2	3		
Group I	0	2	0	8	10	25.20
Group II	0	1	5	4	10	19.60
Group III	0	1	2	7	10	24.55
Group IV	0	3	6	1	10	12.65

Table 2. Statistical analysis of microleakage at gingival margin between each group by Mann-Whitney test ($p < 0.05$)

	Group I	Group II	Group III	Group IV
Group I				*
Group II				*
Group III				*
Group IV				

* : significant at 0.05

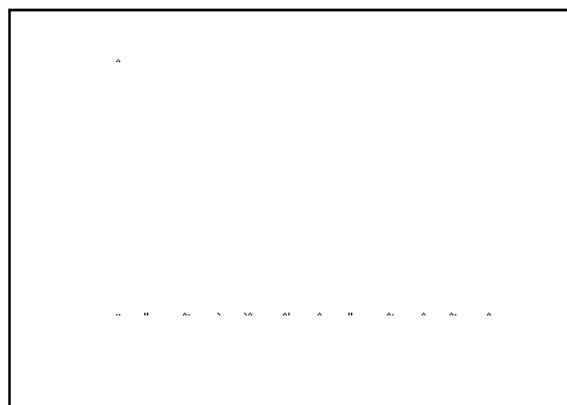


Fig. 2. Mean scores of microleakage of each groups at gingival margins.

Any sample didn't show perfect marginal seal. 80% samples from Group I leaked to the axial wall and in most cases, leakage extended to dentinal tubules. Similarly, Group III leaked to the axial wall in majority of samples (70%). In Group II, 60% samples leaked within gingival wall and in Group IV, only one sample leaked to axial wall.

Figure 2 graphically presents the mean scores in all groups. Group IV which was treated with RMGIC as intermediate layer demonstrated significantly less microleakage ($p < 0.05$). The results by the Mann Whitney test demonstrated statistically significant differences when the comparisons were made between the margins with compomer as intermediate layer and resin modified glass ionomer, the former demonstrated more leakage than the latter two groups ($p < 0.05$) (Table 2).

IV. DISCUSSION

The marginal sealing ability of three different intermediate layer which were applied prior to placement of condensable composites on cervical margins located below CEJ of class II composite restorations, were evaluated in this study. In spite of many advantages, direct composite restorations have been limitedly used because of polymerization shrinkage. The polymerization shrinkage of composites has been reduced but not yet suppressed in commercially available products²⁰. Consequently, stresses induced by

polymerization and their potentially damaging effect on restoration adaptation still restrain a simple and safe application of direct composite restoration technique in large and deep Class II cavities²¹. In many earlier studies^{16, 19}, Class II composite restorations where cervical margins are located on enamel revealed good marginal sealing ability. But cervical margins were located below CEJ, none of the restorative techniques demonstrated a good sealing ability with moderate to severe microleakage.

The finding of this study that all experimental groups and control group showed extensive amounts of dye leakages in cervical margins confirms the results of many other studies^{22, 25}.

According to recommendation of many earlier studies, layer by layer condensation technique was used in present study. But transparent matrix and reflective wedge were not used. The utilization of a transparent matrix is not an easy task due to its greater thickness and lack of rigidity and furthermore many studies showed similar results between stainless matrix combined wooden wedge and transparent matrix combined reflective wedge^{26, 27}.

Flowable composite, predicted to reduce stress at the tooth restoration interface, had weak effect in preventing marginal microleakage. The idea behind the utilization of this type of composite is to take advantage of its flow capacity in filling all parts of the box, facilitated by the rounded line

angles. Another expected advantage is its lower Young's Modulus in comparison with other hybrid composites^{13,20}. This characteristic could contribute to the dissipation of the contraction stresses during the polymerization. Another recent study found that none of three flowable composites were effective in reducing microleakage with gingival margins placed 1.0 mm coronal to CEJ²⁹. In this study, efficacy of flowable composites as intermediate layer to reduce microleakage was mild. Several explanations may be able to account for this result. Flowable composites are widely known to shrink more than condensable composites because of less filler contents. When Stress during polymerization shrinkage goes beyond bonding strength, marginal failure and subsequent microleakage will occur. The utilization of occlusal irradiation could explain the poorer results obtained with this technique. Even though this fact is under argument, occlusal irradiation tends to pull out the composites from the margins, as it shrinks toward the light source and this situation is even worse in deep caries cavities, such as those margins apical to the CEJ.

The use of sandwich technique implies the use of two different filling materials for one restoration. With the materials used in this study, this also implies the use of two different pretreatment and bonding procedures: one for the resin modified glass ionomer cement(RMGIC) or compomer and the other for the composites. In this study open sandwich technique with resin modified glass ionomer cement resulted in better marginal adaptation on cervical cemental margins as compared with other intermediate layers or composite. The utilization of glass ionomers to microleakage control has been widely studied and compared against several bonding systems. There are many studies demonstrating the superiority of the glass ionomers^{30,31}. Another observation was that RMGIC has superior performance in relation to conventional GIC and compomers^{32,33}. RMGIC reach a chemical maturation far more rapidly than the conventionals, being better able to resist the early polymerization contraction of the composites and also occlusal stresses. However, many clinicians

are uncertain about the correct location of the glass ionomer, extended to the external carvour face margin or held short of it. Recent developments of these groups of materials, it is possible to extend them to the carvosurface margin safely and obtain reliable results³⁴. By Dietrich & others¹⁹, extending the RMGIC to external surface ("Open sandwich") produced better results than maintaining it short of the margin ("Closed sandwich"). But even RMGIC could not prevent an extensive microleakage at the cemental margins of composites. This result could be explained by the fact that initial curing shrinkage values of RMGIC are comparable to those of resin composites. However, when bonded to cavity walls the shrinking of the material results in polymerization shrinkage stress can be reduced by compensating mechanisms. The water uptake of resin modified glass ionomer is substantially higher than that of composites. Furthermore the porosity in hand mixed RMGIC and higher flow may have contributed to lower shrinkage stress. Even if RMGIC didn't show perfect marginal sealing ability, cariostatic ability of that material is helpful to clinical condition that cervical margin is on cement. Another advantage of open sandwich technique on class II is the fact that GIC is less sensitive to contamination by saliva and blood which is frequently occurred in deep cervical restoration³⁵.

Studies with compomers as intermediate layer in class II composite restorations didn't accomplished widely. In several studies, compomer showed favorable effect on microleakage regardless of statistical significance^{11,19,23,36}. But in this study, compomer showed the worst marginal adaptation, which came short of expectation. This result may be based on the distance from curing light. Curing manner of compomer differs from that of RMGIC which can be cured in condition of no curing light. Compomer can't cure without initial curing light. In one recent study, open sandwich technique with compomer showed good marginal sealing ability before mechanical loading. But after mechanical loading this technique showed worse result than the closed technique

and this results were caused by incomplete conversion of resinous monomer to polymer.

In spite of many efforts to eliminate marginal microleakage, complete elimination of the microleakage could never be attained in relation to the cementum/dentin margins. But, the pulp has its own self defense mechanism, such as the production of reparative dentin, sclerosis of dentinal tubules. These reactions could minimize the microleakage effects. Also studies accomplished in laboratory have tendency to overestimate the *in vivo* microleakage results²³⁾. With reference to *in vitro* results, our effort to search for a technique that reduce the microleakage effects must be continued. In connection with intermediate layer treatment, further works must be focused on method to simplify bonding procedures with two restorative materials. Also, not only microleakage but also anticariogenic effect of intermediate layer materials with fluoride releasing effect should be compared in further studies.

V. CONCLUSION

Many techniques have been proposed to eliminate the microleakage which was caused by polymerization shrinkage of direct Class II composite restoration. Among those techniques, the effect of intermediate layer treatment prior to placement of condensable composites were evaluated in this study. Forty box shaped Class II cavities whose cervical margins were placed below CEJ were prepared. Restorative composites and dental adhesive used in this study were Clearfil AP X and Clearfil SE Bond. Group I was restored without intermediate layer and Group II, III and IV were restored with intermediate layers which were flowable resin, compomer and resin modified glass ionomer cement respectively.

Results of this study revealed resin modified glass ionomer as intermediate layer had superior effect ($p < 0.05$) and other intermediate layer had no effect on reducing microleakage ($p > 0.05$).

In the case of Class II direct composite restoration, resin modified glass ionomer cement restoration to cervical portion which margins below CEJ

prior to placement of condensable composites would be advantageous to reduce microleakage.

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