All-in-one adhesive를 이용한 치면열구전색술식이 전색재의 미세누출에 미치는 영향에 대한 연구

윤희훈 · 이재천 · 김정욱 · 김종철 · 한세현 · 이상훈

서울대학교 치과대학 소아치과학교실 및 치학연구소

국문초록

본 연구는 all-in-one adhesive를 사용하여 전색하는 술식을 통상적인 탈회 술식 및 single-bottle 결합제를 이용하여 전색하는 술식과 비교하여 법랑질과 전색재 사이의 미세누출의 차이를 알아보고자 하는 것이다. 75개의 제3대구치를 5군으로 나누어 1군을 대조군으로 하여 only Etching(1군), Adper™ Single Bond™(2군), Adper™ Prompt™ L-Pop(3군), AQ-bond(4군), One-up bond F(5군)로 처리한 후 전색재 도포 후 열순환을 시행한 뒤 미세누출도를 검사하여 다음과 같은 결론을 얻었다.

1. All-in-one adhesive를 사용한 3, 4, 5군은 1군에 비해 유의성있게 높은 평균미세누출도를 보였다($p<0.05$).
2. 가장 낮은 평균미세누출도는 2군(0.14)에서 보였고 1군(1.05), 3군(1.65), 4군(2.85), 5군(3.05) 순으로 증가하였다.
3. All-in-one adhesive를 사용한 3, 4, 5군중에서 3군은 4, 5군에 비해 통계적으로 유의성있게 낮은 평균미세누출도를 보여주었지만($p<0.05$) 1군과 2군에 비해 유의성있게 높은 평균값을 보여주었다($p<0.05$).
4. 4군과 5군 사이의 평균미세누출도는 통계적으로 유의성있는 차이를 보이지 않았다($p>0.05$).
5. 주사전자현미경관찰결과 all-in-one adhesive를 사용한 3, 4, 5군은 1, 2군에 비해 레진돌기가 짧고 불규칙하게 관찰되었다.

주요어 : 치면열구전색재, 산부식, All-in-one adhesive, Single-bottle adhesive, 미세누출

I. Introduction

The occlusal surface is at high risk for caries, especially for those newly erupted molars where anatomical characteristics cause difficult access for cleaning procedures and where incomplete maturation of enamel adds to susceptibility[1].

The sealing of pits and fissures with resinous materials as a method to prevent carious lesions was investigated over several years ago by Buonocore[2], who demonstrated that the structure of the enamel surface can be modified by an 85% solution of phosphoric acid.

Several studies[3-6] have shown the effectiveness of dental sealants in decreasing caries increment on sealed occlusal surfaces. However, problem in sealant application can cause leakage or partial or total loss leading to sealant failure that can be expected to be 5-10%/yr[6]. In the event of any appreciable loss, the exposed surface becomes equally susceptible to caries as a sealed control tooth.

Sealant failures are caused mainly by technique problems during application, most often identified as being salivary contamination after acid etching has

교신저자 : 이 상 훈

서울특별시 종로구 연건동 28-1
서울대학교 치과대학 소아치과학교실
Tel : 02-760-3819
E-mail: musso2snu.ac.kr

been accomplished[7]. Hitt and Feigal[8] showed that hydrophilic bonding materials that contain water, may, when applied under a sealant, minimize the bond strength normally lost when a sealant is applied in a moist environment.

The early generation of adhesive systems involved clinical techniques that were complex for many practitioners[9]. Simpler adhesive systems have appeared. Self-etching primers are applied for 20 seconds, air dried, and then covered with a light-cured adhesive layer. Some systems require only one bonding step, saving clinical time and eliminating several bonding steps in which mistakes could occur. These have been called all-in-one adhesives, because they etch and simultaneously infiltrate resin monomers into dentin. All-in-one adhesives are applied for 20 to 30 seconds, dried, and light cured. In this system, primer and adhesive are combined.

If etching effect of all-in-one adhesives is not different from that of conventional etching systems, these systems can be usefully applied to sealant application without several technical problems. The purpose of this study was to examine differences in microleakage of enamel-sealant interface when all-in-one adhesives were used compared with conventional acid etching and single-bottle adhesive system.

Ⅱ. Materials and Methods

■ Tooth selection

Seventy-five extracted permanent third molars were obtained from Seoul National University Dental Hospital. All of the teeth in this study had occlusal surface free of carious lesion. The teeth were stored and refrigerated in 0.1% thymol solution.

Once all the teeth had been collected, they were thoroughly rinsed and the root surfaces were scaled to remove any remaining tissue.

■ Randomization into groups

They were randomly divided into 5 groups of 15 each. All fissures were cleaned for 15 seconds using disposable rotating bristle brush in a slow-speed, contra-angle handpiece. The teeth were rinsed with air-water spray, dried using compressed air.

Group 1 (only etching) : The teeth were etched with 37% phosphoric acid for 15 seconds, followed by an air-water rinse of 5 seconds.

Group 2 (Adper™ Single Bond) : The teeth were etched with 37% phosphoric acid for 15 seconds, followed by an air-water rinse of 5 seconds. Adper™ Single Bond was brushed on the etched enamel surface and vigorously air-dried for 5 seconds and then light-cured for 20 seconds with visible light curing unit.

Group 3 (Adper™ Prompt™ L-Pop) : According to the manufacturer s instruction, Adper™ Prompt™ L-Pop was applied onto teeth surfaces with a saturated microbrush and rubbed in for 15 seconds. Thin air stream was then applied to create even, shiny film and was followed by a 10 seconds polymerization.

Group 4 (AQ-Bond) : According to the manufacturer s instruction, the adhesive was applied for 20 seconds and the solvent was evaporated using gentle air blow for 3-5 seconds and second coat applied. And then the bonding agent was blowed gently until the coat was dried evenly and cured for 10 seconds.

Group 5 (One-up Bond F) : According to the manufacturer s instruction, the adhesive was applied and after 20 seconds it was cured for 10 seconds.

The Ultraseal® XT plus™ (Ultradent product Inc., USA) was applied to the occlusal pits and fissures of all the teeth according to the manufacturer s instructions. The sealant was cured for 20 seconds using visible light curing unit(3M dental product, USA).

Each sealant was checked with an explorer for complete coverage and retention.

■ Thermocycling

All teeth were thermocycled in distilled water at between 5℃ and 55℃ for 500cycles with dwell time of 30 seconds and a draining time of 10 seconds between cycles. After thermocycling, two layers of nail varnish were placed within 2mm of the margins of all sealants. All teeth were mounted in clear acrylic resin block. The teeth were then immersed in 1% methylene blue solution for 24 hours at 37℃ to allow dye penetration into possible gaps between enamel and sealant.

■ Measurement

Upon removal from the dye, the teeth were rinsed with distilled water. Two buccolingual sectioning cuts parallel to the long axis of each tooth were made,

Table 1. Adhesive systems used in this study

System	Composition	Manufacturer
Adper™ Single Bond	HEMA, polyacrylic acid, Bis-GMA, alcohol	3M-ESPE, USA
Adper™ Prompt™ L-Pop	Liquid 1(red blister) : Methacrylated phosphoric esters, Bis-GMA, Initiators based on camphoroquinone, Stabilizers Liquid 2(yellow blister) : Water, HEMA, Polyalkenoic acid, stabilizers	3M-ESPE, USA
AQ-Bond	AQ Bond base Methacrylate monomer(MMA, 4-META, urethane dimethacrylate, 2-hydroxyl methacrylate), Acetone, Water AQ bond sponge Sodium p-toluenesulfinate	Sun Medical Co. Japan
One-Up Bond F	Bonding Agent A Methacryloxyalkyl acid Phosphate, MAC-10 Bonding Agent B Monomer, Water, Fluoro-alumino-silicate glass, Borate catalyst	Tokuyama Co. Japan

yielding 3 sections and 4 surfaces per tooth for analysis. Low speed saw (Isomet™, Bueher, USA) was used.

The depth of dye penetration by single examiner blinded to the treatment regimen using a binocular microscopy(Olympus, SZ-PT, Japan).

Measurements were recorded in scoring method.

Score 0 = no microleakage

Score 1 = microleakage extending up to one-third the depth of the sealants

Score 2 = microleakage extending between one-third and two-thirds the depth of the sealants

Score 3 = microleakage extending over two-thirds of the sealants

Score 4 = microleakage extending underlying fissure

One-way ANOVA was used to evaluate the statistical significance of the results.

■ SEM examination

Infiltration patterns of the adhesive materials were investigated. Sectioned specimens immersed into 6mol HCl for 24 hours to totally remove the calcified component, washed with distilled water. After dehydration procedure, the specimens were mounted to aluminum sturbs with silver paint and sputter coated with gold-palladium, then examined with scanning electron microscopy (JEOL, Tokyo, Japan).

Ⅲ. Results

A total of 300 sections were examined for microleakage. The summary data were reported in Table 2.

The mean microleakage scores are listed in Table 3 and Fig 1. The result showed the lowest mean score of Group 2 and showed the highest mean score of Group 5. In order of decreasing mean microleakage score the Groups were Group 5〉 Group 4〉 Group 3〉 Group 1 〉 Group 2 (Table 3).

Table 4 showed the results of statistical analysis. All the groups that used all-in-one adhesives (Group 3, 4, 5) showed significantly higher mean score than Group 1. Among all-in-one groups, Group 3 showed significantly lower mean microleakage score than other group but showed significantly higher mean score than both Group 1 and Group 2. There was no statistically significant difference($p>0.05$) between Group 3 and Group 4.

In the SEM examination, Group 2 showed more fine infiltration pattern than Group 1. Group 3, 4, and 5 showed more shallow resin tag than Group 1. Among all-in-one groups, Group 3 showed more regular etching pattern than Group 4 and 5 (Fig. 2USA6).

Table 4 showed the results of statistical analysis. All the groups that used all-in-one adhesives (Group 3, 4, 5) showed significantly higher mean score than Group 1. Among all-in-one groups, Group 3 showed significantly lower mean microleakage score than

Table 2. Frequencies of microleakage scores measured in each group

Group		1	2	3	4	5
score	0	16	37	13	3	4
	1	32	21	17	10	5
	2	7	2	17	9	7
	3	3	0	4	9	12
	4	2	0	9	29	32
Total		60	60	60	60	60

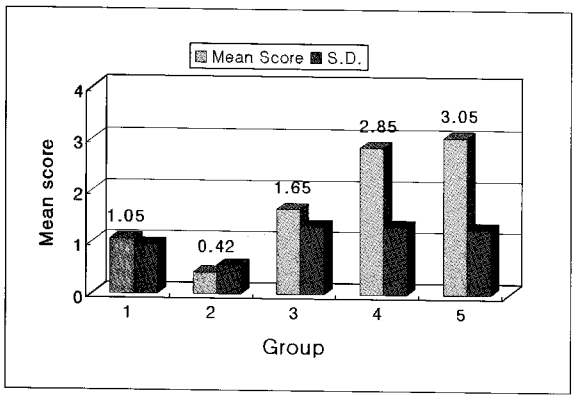

Fig. 1. Mean microleakage scores in each group.

Table 3. Mean microleakage scores in each group

Group	1	2	3	4	5
N	60	60	60	60	60
Mean	1.05	0.42	1.65	2.85	3.05
S.D	0.95	0.56	1.31	1.31	1.27

Table 4. Statistical comparison between groups on the microleakage scores

Comparison	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1		S	S	S	S
Group 2			S	S	S
Group 3				S	S
Group 4					NS
Group 5					

*S statistically significant ($p<0.05$)
*NS statistically not significant ($p>0.05$)

other group but showed significantly higher mean score than both Group 1 and Group 2. There was no statistically significant difference($p>0.05$) between Group 3 and Group 4.

In the SEM examination, Group 2 showed more fine infiltration pattern than Group 1. Group 3, 4, and 5 showed more shallow resin tag than Group 1. Among all-in-one groups, Group 3 showed more regular etching pattern than Group 4 and 5 (Fig. 2~6).

Ⅳ. Discussion

The high occurrence of carious lesions in occlusal surfaces of posterior teeth, mainly in the first year of eruption, results from plaque accumulation on pits and fissure, creating favorable conditions to bacterial development and demineralization of dental enamel[6,10].

The effectiveness of sealants hinges on their ability to isolate pits and fissures from the combination of bacteria, their nutrients, and acidic metabolic products[2-6]. The role of sealants, applied on occlusal surfaces, would be to modify the cariogenic factors, impeding the stagnation of microorganisms and organic materials on the dental surface, creating a physical barrier to the acid conditions that causes caries.

However, the sealants do not have any pharmacological action. Success depends on a firm adhesion with the enamel surface, isolating pits and fissure of the oral cavity[10].

The application process for conventional sealant placement involves placement of the etching material, a wait time and rinsing and drying totaling approximately 30 seconds[11]. After this treatment, the tooth must be maintained in an isolated, dry condition so that etched enamel is not contaminated with saliva. Following drying, sealant is placed and either allowed to self-polymerize or is purposefully exposed to the curing light. Thus, there are many different, time-consuming steps involved with conventional sealant placement.

Recently, a new type of all-in-one adhesive system has been marketed[12-15]. These products utilize a combination of acidic resins that simultaneously demineralize both enamel and dentin and then are polymerized directly in the tooth. Thus, there is no rinsing or drying required, and the time to maintain a dry felid is lowered compared to conventional methods. Once this adhesive system is polymerized, a sealant can be directly placed and cured. The time involved with placement of sealants using all-in-one system may be less than conventional methods, sav-

ing both patients and clinician valuable chair.

Gillet D et al.[16] demonstrated that there was no significant difference between conventional etching vs self-etching primer and the Prompt L-pop was very efficient vs phosphoric acid in obturating the pits & fissures. If the results are true, these systems can be usefully applied to sealant application without several technical problems.

But our results contrasted with above study. Our study showed that all the groups using all-in-one adhesives had more microleakage than control group. Among all-in-one groups, Group 3 showed significantly lower mean microleakage score than other group but showed significantly higher mean score than both Group 1 and Group 2.

This may result from difference of acid form used in each bonding systems. A self-etching primer contains acidic functional monomers, such as 4-AET, phenyl-p and MDP. The etching effect of these systems is related to the acidic monomers or organic acid solutions that may interact with the mineral component of tooth substrate and enhance monomer penetration[17].

Pashley and Tay[14] demonstrated microtensile bond strength of the three all-in-one adhesive were all significantly lower than conventional etching, but not different from one another. They concluded that etching efficacy was important contributing factor in bonding of self-etching adhesives to unground enamel.

There have been few reports dealing with the shear bonding strengths of all-in-one adhesive systems used in present study. Miyazaki et al.[18] obtained, with Prompt™ L-pop, AQ bond, One-up bond F applied bovine enamel, each shear bond strength of 21.7Mpa, 12.1Mpa, 13.0Mpa.

Among all-in-one groups, Adper™ Prompt™ L-Pop showed significantly lower mean microleakage score than other group. This result may be related to the result of bonding strength.

One study[11] showed the similar result. The study concluded that use of the specific acidic resin primer in lieu of conventional acid etching(whether cured prior to or subsequent to sealant placement) demonstrated greater incidence of microleakage and would not be advocated over traditional etching procedures. But, the study used only one all-in-one adhesive (Prompt™ L-Pop) and sample size was smaller than this study. We compared three other all-in-one adhesives that currently marketed and used the Adper™ Prompt™ L-Pop that had enhanced properties instead of Prompt™ L-Pop .

But these all-in-one adhesives were relatively new materials, more studies about mechanical properties of these systems are required.

The depth of the etching pattern and the amount of surface enamel removed during etching depend on the type of acid, acid concentration and composition of the surface enamel.

From the morphologic observation by SEM in this study, applying the all-in-one adhesive did not create a deep enamel pattern like applying phosphoric acid did. However, specific etching pattern may not be a critical factor in determining enamel bond strength[18]. Creating the etching pattern required for stable enamel bond seems to differ among the bonding systems used and other factors, such as age, site and amount of mineral removed from the tooth[19] .

Among the all-in-one groups, Adper™ Prompt™ L-Pop showed deeper and more regular pattern than Group 4, 5. This may explain that Group 3 had lower mean microleakage score.

One example of caries susceptibility combined with sealant difficulty is the newly erupted permanent first molar[6]. The tooth is commonly carious within 2 years of emergence through the tissue. In fact, many first permanent molars have fissures that are questionable or that are diagnosed with incipient caries as they erupt.

Salivary contamination during sealant placement has been suggested as a main factor responsible for sealant failure[6-8,20-22]. In this circumstance, adhesive resins have been used successfully in combination with or as sealants alone[6-8, 21-24].

Bonding agent under sealant on wet contamination yielded bond strengths equivalent to the bond strength obtained when sealant was bonded directly to clean, etched enamel. Bonding agent used without contamination yielded bond strengths significantly greater than the bond strength obtained when using sealant alone without contamination[8].

This study showed that Group 2 using Single Bond™ had the lowest mean microleakage score. This result supports many similar studies.

Fritz UB et al.[22] showed that the single-bottle adhesive was relatively insensitive to salivary contamination. A clinical study[24] showed that single-bottle bonding agents protect sealant survival, yielding half the usual risk of failure for occlusal sealants and one-third the risk of failure for buccal/lingual sealants.

The composition of the 5th generation of adhesive agents (single-bottle systems) may be particularity adequate for enamel bonding, especially in the presence of moisture contamination[7]. Solvents, like ethanol, present in the Single Bond™ composition, are able to remove any residual moisture from the etched enamel, carrying the resin monomers into close adaptation with the surface. In addition, these single-bottle adhesives contain hydrophilic monomers that enhance surface wetting and resin penetration. For Single Bond™, the hydrophilic monomer is represented by HEMA, a small molecule with a low molecular weight that presents a high diffusion rate.

Moreover, although the enamel is essentially inorganic, it contains a relatively small, inert, organic component that may be important for sealant adhesion[21]. Dentinal bonding agents are bifunctional molecules with a methacrylate group that bonds to the resin(sealant) by chemical interaction and a functional group that bonds either the inorganic or organic constituents of dentin and enamel.

However, the use of bonding agent as intermediate layer had several problem[25]. Use of bonding agent would tend to increase the time and the cost of the sealant application procedure, thus should be carefully weighed before adoption.

This study showed that use of Adper™ Single bond™ as intermediate layer between enamel and sealant significantly enhanced microleakage. But we did not apply the circumstance of salivary contamination.

Etchant penetration goes hand-in-hand with sealant penetration. The sealant that penetrates the best, with all other factors remaining equal, may be the sealant that will be retained the longest and, therefore, may be the sealant that will prevent the initiation, or the spread, of caries the longest. If we are to use penetrating agents within sealants, then we also must provide a way to etch the fissure walls as deeply as possible. The present trend of using self-etching adhesives may well be of enormous benefit to sealant application if they can etch pit and fissure effectively as conventional one.

But this study did not show desirable results. This may result from demineralization capacity of self-etching system. However, if the quality of materials will be enhanced the result will show more desirable outcomes.

In present, we concluded that all-in-one system must not be used with sealant and suggested that more study such as bonding strength test would be recommended since only microleakage test used in this study did not represent the quality of all-in-one adhesives.

Ⅴ. Conclusion

We examined differences in microleakage of enamel-sealant interface when an all-in-one adhesives was used compared with conventional acid etching and single-bottle adhesive system and concluded as follows :

1. Group 3, 4, 5 using the all-in-one adhesive system showed significantly higher microleakage score than Group 1($p<0.05$).
2. The lowest mean microleakage score was Group 2(0.41) followed by Group 1(1.05), Group 3(1.65), Group 4(2.85) and Group 5(3.05).
3. Among Group 3, 4, 5 using all-in-one adhesives, Group 3 showed significantly lower mean microleakage score than other group($p<0.05$) but showed significantly higher mean score than both Group 1 and Group 2($p<0.05$).
4. There was no statistically significant difference ($p>0.05$) between Group 4 and Group 5.
5. In SEM examination, all the groups using all-in-one adhesives showed shorter resin tag than Group 1 and 2.

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Explanations of Figures

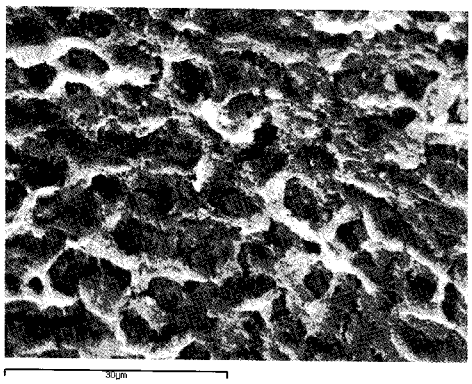

Fig. 2. SEM of Group 1 (X2000) (Control).

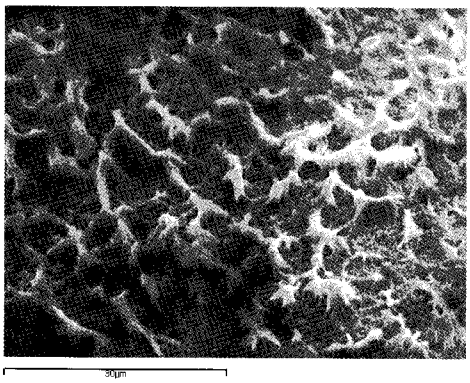

Fig. 3. SEM of Group 2 (X2000) (Adper™ Single Bond).

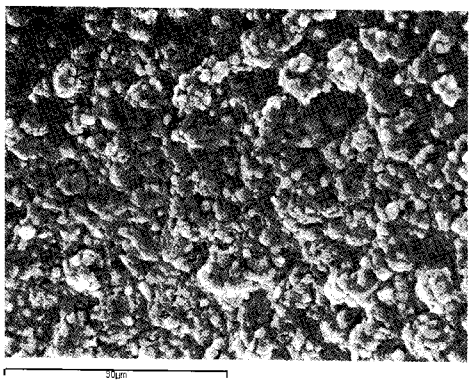

Fig. 4. SEM of Group 3 (X2000) (Adper™ PromptTM L-Pop).

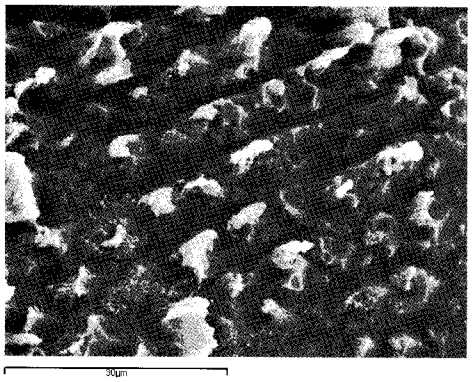

Fig. 5. SEM of Group 4 (X2000) (AQ-Bond).

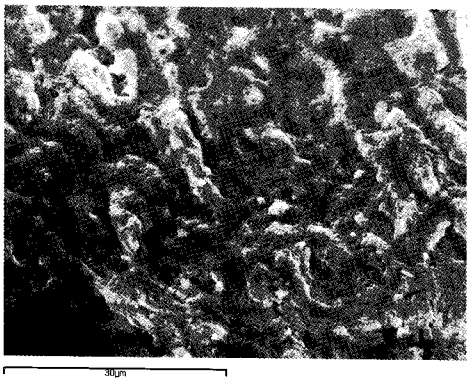

Fig. 6. SEM of Group 5 (X2000) (One-up Bond F).

Abstract

THE EFFECT OF SEALING PROCEDURE USING ALL-IN-ONE ADHESIVE ON MICROLEAKAGE OF PIT AND FISSURE SEALANT

Hee-Hun Yoon, Jae-Cheon Lee, Jung-Wook Kim, Chong-Chul Kim,
Se-Hyun Hahn, Sang-Hoon Lee

Department of Pediatric Dentistry, College of Dentistry and Dental Research Institute, Seoul National University

The purpose of this study was to examine differences in microleakage of enamel-sealant interface when all-in-one adhesives were used compared with conventional acid etching and single-bottle adhesive system. Seventy-five extracted permanent third molars were randomly divided into 5 groups and treated with only Etching, Adper™ Single Bond™, Adper™ Prompt™ L-Pop, AQ-bond and One-up Bond F each. After sealant application, the samples were thermocycled and the degree of microleakage was determined. The results were as follows :

1. Group 3, 4, 5 using the all-in-one adhesive system showed significantly higher microleakage score than Group 1($p<0.05$).
2. The lowest mean microleakage score was Group 2(0.41) followed by Group 1(1.05), Group 3(1.65), Group 4(2.85) and Group 5(3.05).
3. Among Groups using all-in-one adhesives, Group 3 showed significantly lower mean microleakage score than the other groups($p<0.05$) but showed significantly higher mean score than both Group 1 and Group 2($p<0.05$).
4. There was no statistically significant difference($p>0.05$) between Group 4 and Group 5.
5. In SEM examination, all the groups used all-in-one adhesive showed shorter resin tags than Group 1.

Key words : Sealant, Acid etching, Single-bottle adhesive, All-in-one adhesive, Microleakage