

Microleakage of Class-V Composite Restorations with Different Bonding Systems on Fluorosed Teeth

Çiğdem Küçükeşmen^a, DDS, PhD
Hayriye Sönmez^b, DDS, PhD

ABSTRACT

Objectives: To examine the effects of dental fluorosis and total and self-etch bonding systems on microleakage of Class-V composite restorations in permanent molar teeth.

Methods: Teeth were classified as three main groups according to Thylstrup-Fejerskov Index (TFI) as TFI=0, TFI=1-3 and TFI=4. Total and self-etching/bonding procedures were determined for each main group. Total-etching procedures were acid-etching for 30s and acid-etching for 60s with Single Bond/total-etch bonding system. Self-etching procedure was applied with Prompt-L-Pop/self-etch bonding system. 63 box-shaped Class-V cavities (4x2x2 mm) were prepared on mid-buccal/palatinal/lingual surfaces of teeth for totalling nine test groups (n=7). Restorations with composite material (Charisma) polymerized with halogen unit for 40s. Teeth were thermocycled between +5°C - +55°C (x500), immersed in 0.5% basic-fuchsin solution (37°C, 24h) and separated longitudinally in bucco-lingual direction. Dye penetration was examined under stereomicroscope (3.2x10).

Results: Microleakage levels were higher in teeth of TFI=4 than TFI=0 occlusally or cervically (P<.05). In TFI=0; total-etched teeth for 30s have statistically shown more leakage than total-etched teeth for 60s occlusally or cervically (P<.05). In TFI=4; microleakage levels were significantly higher for 30s than 60s cervically (P<.05). For all TFI levels, microleakage was commonly increased with self-etch system than total-etch system (P<.05). Generally, higher leakage was present at cervical margins than occlusal margins (P<.05).

Conclusions: Microleakage has increased by severity of dental fluorosis. Generally, more leakage was observed in total-etched teeth for 30s than 60s. Microleakage was commonly higher in self-etched teeth than total-etched teeth. More leakage was present at cervical margins than occlusal margins. (Eur J Dent 2008;2:48-58)

Key words: Class-V restorations; Composites; Dental fluorosis; Microleakage.

INTRODUCTION

Anti-cariogenic and positive effects of fluorides

^a Assist. Prof., Department of Pedodontics, Faculty of Dentistry, Suleyman Demirel University, Isparta, Turkey.

^b Prof., Department of Pedodontics, Faculty of Dentistry, Ankara University, Ankara, Turkey.

■ Corresponding Author: Çiğdem Küçükeşmen
Süleyman Demirel University, Department of Pedodontics,
Faculty of Dentistry, 32260 Çünür, Isparta, Türkiye.
Phone : +90 537 415 11 10
Fax: +90 246 237 06 07
E-mail: kucukesmencigdem@gmail.com

on teeth and carious lesions were proved in dentistry.¹⁻⁴ However, common using of fluoride-containing products such as foods, soft drinks, supplements and some dental materials have resulted in increased prevalence of dental fluorosis in many countries over the past few decades.⁵⁻⁸ Dental fluorosis is also endemic in several parts of the world.⁹⁻¹¹

Fluorosed enamel is characterized by an outer hypermineralized surface and porosity of subsurface layer.⁹ Fluorosed teeth sometimes

need to be restored for functional or aesthetic reasons.⁶ Composite resin applications may be practiced for the treatment of moderately or severely fluorosed teeth.⁵ Composite restorations often depend largely on micromechanical retention obtained from etched enamel with the acid-etching technique which was first described by Buonocore.¹² Hypermineralized surface of fluorosed enamel is difficult to acid-etch.¹³ Bonding of restorations on fluorosed teeth involves etching the acid-resistant enamel and may necessitate prolonging the etching time.⁹

Microleakage is the marginal permeability to bacterial, chemical and molecular invasion at the interface between the teeth and restorations. It may cause discoloration, recurrent caries and pulpal pathology.¹⁴ It was decreased by use of acid-etching technique^{15,16} and bonding systems.^{15,17,18}

Recently, bonding agents may be classified as total-etch (TE) and self-etch (SE) bonding systems according to their application steps. TE bonding systems are consisted of two or three application steps. First step includes an acid-etching procedure. Following steps are composed by separated or combined applications of primer and adhesive solutions. SE bonding systems have self-etching efficiency on tooth structures. 2 step SE adhesives rely on the use of a separate self-etching (which is combined to the priming step) before application of the resin.¹⁹⁻²¹

Our null hypothesis is that, dental fluorosis and different etching/bonding procedures may affect microleakage levels of Class V composite restorations on permanent teeth. The purpose of this in-vitro study was to examine the microleakage of Class-V composite resin restorations using total and self-etch bonding systems on fluorosed permanent molar teeth.

MATERIALS AND METHODS

In study, freshly extracted, non-carious, fluorosed molar permanent teeth were used. All teeth were cleaned, polished and immersed in distilled water containing 0.1% thymol solution, and stored in distilled water in room temperature until used. Teeth were classified according to Thylstrup-Fejerskov Index (TFI)^{22,23} (Figure 1) and separated into 3 main groups as TFI=0, TFI=1-3 and TFI=4.

Two different bonding systems with different

etching procedures were used;

- Single Bond (SB) (3M, St Paul, MN, USA, Lot no: 55144) / TE system: SB was applied with different etching times of 30 seconds (s) and 60s with a 35% phosphoric acid etching-gel (Multipurpose Etching Gel; 3M, USA, Lot no: 20020613).

- Prompt-L-Pop (PLP) (ESPE, Germany, Lot no: 118642) / SE system: PLP was directly applied without etching step separately.

All etching and bonding procedures were shown in Table 1. Group names were coded as 0/1/4 and a/b/c where numbers represent the TFI scores. Small letters represent the bonding procedure including acid etching of enamel for 30s and application of SB total etch bonding system (a), acid etching of enamel for 60s and application of SB total etch bonding system (b) and application of PLP self-etching bonding system (c).

Totally nine test groups were determined (n=7). All test groups were shown in Table 1. A total of 63 standardized, box-shaped Class-V cavities were prepared (sizes: 4 mm length x 2 mm width x 2 mm depth) on the mid-buccal and mid-palatinal/lingual surfaces of the randomly selected teeth by the same researcher. A high speed dental torque (KaVo Super Torque, Lux 2, 640 B, P 294779, Germany) and fissure diamond burs (North Bel, FG Coarse, lot no. 200000011267, Italy) were

Thylstrup-Fejerskov Index (TFI)

<p>TFI=0: Normal view of enamel; translucent and shiny.</p> <p>TFI=1: White, thin, opaque lines on enamel surfaces.</p> <p>TFI=2: White, snowy and cloudy areas on incisal regions or cusps.</p> <p>TFI=3: Connected wide opaque lines and cloudy areas on enamel surfaces.</p> <p>TFI=4: A significant opacity on all enamel surface.</p> <p>TFI=5: Pittings (<2mm) on opaque enamel surface related to local loss of outer enamel.</p> <p>TFI=6: Connected pittings and breaking of facial enamel on incisal regions or cusps.</p> <p>TFI=7: Irregular loss areas on enamel surface (half and half).</p> <p>TFI=8: Commonly loss of enamel (more than half).</p> <p>TFI=9: Generalized loss of outer enamel (much more than half), alteration of anatomical shape of tooth, remained cervical opaque enamel and dark-brown coloured tooth structure.</p>

Figure 1. The criteria used for indexing.^{22,23}

used. Burs were renewed after each five cavity preparations. Cavity margins were placed in enamel. Enamel margins were beveled with a 45° angle. The depth of cavities was millimetrically standardized using a periodontal probe.

A composite resin restorative material (Charisma; Heraeus-Kulzer, lot no.110067, Shade A2, Germany) was placed into the cavities with bulk-technique and polymerized using a halogen light unit (Hilux 200, Benlioglu Dental, Turkey, 450 mW/cm²) for 40s. All specimens were immersed in water at 37°C for 24 hours after finishing and polishing procedures with a polishing set (Soft-lex polishing discs; 3M, St Paul, Minneapolis, USA). Teeth were then thermocycled between water baths held at +5°C and +55°C with a transfer

time of 10s and a dwell time of 30s for 500 cycles. A double coated nail varnish was applied to the whole surface of the teeth except for the restorations and approximately 1 mm of tooth surfaces adjacent to the restorations. Then, all specimens were immersed in 0.5% basic-fuchsin solution for 24 hours at 37°C. After removal from the solution, the teeth were rinsed in tap water and embedded vertically in autopolymerizing acrylic resin blocks (Orthocryl EQ, Dentaurum, Germany) and separated in a bucco-lingual direction through the centre of each tooth with a water-cooled diamond saw (Micracut Precision Cutter, Metkon, Turkey). The specimens were evaluated under a stereomicroscope at 32X magnification (Leica, MZ12/AG, Switzerland, CH 9435) for dye penetration. Dye penetration scores at cavity walls were determined occlusally and cervically according to Alavi and Kianimanesh²⁴ (Figure 2). Kruskal-Wallis H-Test, Mann-Whitney U-Test and Wilcoxon Signed Range Test were used for statistical evaluation of results (P<.05).

- | | |
|---|---|
| 0 | No dye penetration. |
| 1 | Dye penetration at the 1/3 initial side of the cavity wall. |
| 2 | Dye penetration at the 2/3 middle side of the cavity wall. |
| 3 | Dye penetration at the 1/3 last side of the cavity wall. |
| 4 | Dye penetration at the axial wall. |

RESULTS

Significant differences were present between groups named 0, 1 and 4 occlusally and cervically according to Kruskal-Wallis Test (Table 2) (P=.000). Comparisons between all test groups and the

Figure 2. The scoring method of dye penetration according to Alavi and Kianimanesh.²⁴

Table 1. All test groups according to TFI levels / bonding / etching procedures with codes (n=7).

TFI levels	Bonding / etching procedures		
	Groups a	Groups b	Groups c
Groups 0	Group 0a	Group 0b	Group 0c
Groups 1	Group 1a	Group 1b	Group 1c
Groups 4	Group 4a	Group 4b	Group 4c
Groups 0: Non-fluorosed teeth in TFI=0			
Groups 1: Fluorosed-teeth in TFI=1-3			
Groups 4: Fluorosed-teeth in TFI=4			
Groups a: SB total-etch bonding system / 30s acid-etching procedure			
Groups b: SB total-etch bonding system / 60s acid-etching procedure			
Groups c: PLP self-etch bonding system / no acid-etching procedure			

Table 2. Statistical differences between teeth in three levels of TFI for occlusal and cervical margins according to Kruskal-Wallis Test (P<.05 = *).

	Chi-Square	df	P
Occlusal	34.52	8	.000*
Cervical	47.21	8	.000*

statistical differences were shown occlusally and cervically according to Mann Whitney U Test (Table 3) ($P < .05$).

Microleakage was generally found less in groups named b than groups named a. There were significant differences between group named 0a and group named 0b for both occlusally ($P = .037$) and cervically ($P = .015$). Difference was not significant between group named 1a and group named 1b occlusally ($P = .054$) or cervically ($P = .091$). Statistically less microleakage was observed in group named 4b than group named 4a cervically ($P = .015$). Microleakage levels were commonly increased in groups named c than groups named a and than groups named b occlusally ($P < .05$). The significant differences were between group named 0c and group named 0a ($P = .03$), between group named 0c and group named 0b ($P = .002$) occlusally. There were not significant differences between group named 1c and group named 1a ($P = .1$) and between group named 4c and group named 4a ($P = .473$) and between group named 4c and group named 4b ($P = .08$) occlusally. There was significant differences between group named 1c and group named 1b ($P = .007$). The significant differences were present between group named 0c and group named 0a ($P = .037$) and between group named 0c and group named 0b ($P = .002$) and between group named 1c and group named 1b ($P = .001$) cervically. There were statistically significant differences between group named 0b and group named 1a ($P = .002$), between group named 0b and group named 1b ($P = .037$) and between group named 0b and group named 1c ($P = .001$) occlusally. Significant differences were found between group named 0b and group named 4a ($P = .001$) and between group named 0b and group named 4b ($P = .002$) and between group named 0b and group named 4c ($P = .002$) occlusally. Differences were not significant between group named 0a and group named 1a ($P = .054$) and between group named 0a and group named 1b ($P = .1$) occlusally. The significant difference was present between group named 0a and group named 1c ($P = .007$) occlusally. Differences were not significant between group named 0a and group named 1a ($P = .872$) and between group named 0a and group named 1b ($P = .091$) cervically. The significant difference was present between group named 0a and group named 1c ($P = .006$) cervically.

Statistically significant differences were present between group named 0a and group named 4a ($P = .004$) and between group named 0a and group named 4c ($P = .001$) cervically. There were significant differences between group named 0b and group named 1a ($P = .015$) and between group named 0b and group named 1c ($P = .001$) cervically. The differences were statistically significant between group named 0b and group named 4a ($P = .001$) and between group named 0b and group named 4b ($P = .004$) and between group named 0b and group named 4c ($P = .001$) cervically. Statistically significant differences were present between group named 4c and group named 0c ($P = .001$), and between group named 4c and group named 1c ($P = .02$) cervically. There were significant differences between group named 4c and group named 4a ($P = .02$) and between group named 4c and group named 4b ($P = .001$) cervically. Statistically significant difference was present between occlusal and cervical margins ($P = .000$). All results and statistical differences were shown in Table 2-6 and Figures 3 and 4.

DISCUSSION

In this study, the hypothesis was accepted that, dental fluorosis and different etching/bonding procedures affect microleakage levels of Class-V composite restorations on permanent teeth. Microleakage is examined with several in-vitro studies such as dye-penetration tests, chemically agents, compressed air, neutron activation analysis, bacterial studies, radioisotope materials etc.²⁵⁻²⁸. The most frequent using methods are conventional and dependable dye-penetration tests.^{29,30} Basic fuchsin (0.5-2%),^{24,30-33} methylene blue (0.2-2%),³⁴⁻⁴⁰ silver nitrate (50%),^{41,42} crystal violet (0.05%), eritrosin (2%),⁴³ and Rodhamine B (0.2%)⁴⁴ are commonly using dye-penetration solutions.

Recently, more improved another techniques are also used for determining the leakage of dental materials. For example; sliding of dental tissues and examination of leakage with ammoniacal AgNO_3 solutions under scanning electron microscopy (SEM) using the backscattered electron mode⁴⁵ or contemporary field emission in-lens SEM (FEI-SEM)^{46,47} or transmission electron microscopy (TEM).^{45,46,48} Another new examination technique is confocal microscopy. It is for comparing with

Table 3. Statistical differences between TFI / bonding / etching groups according to Mann-Whitney U Test for occlusal and cervical margins (P<.05 = *).

Significant differences between test groups		Values of Mann-Whitney U Test		P<.05 = *	
				Oclusally	Cervically
0a	0b	10.5	7.5	.037*	.015*
	0c	10	10.5	.03*	.037*
	1a	12.5	23.5	.054	.872
	1b	24.5	15	1	.091
	1c	5	5	.007*	.006*
	4a	5	3	.006*	.004*
	4b	12.5	14	.054	.122
	4c	5	0	.007*	.001*
0b	0c	2	1.5	.002*	.002*
	1a	2.5	7.5	.002*	.015*
	1b	10.5	14	.037*	.107
	1c	1	0	.001*	.001*
	4a	1	0	.001*	.001*
	4b	2.5	3	.002*	.004*
	4c	1	0	.002*	.001*
0c	1a	21	13.5	.591	.116
	1b	10	3	.030*	.002*
	1c	16	15	.225	.091
	4a	17.5	9	.298	.020*
	4b	21	21	.591	.53
	4c	14.5	0	.165	.001*
1a	1b	12.5	15	.054	.091
	1c	13	8.5	.1	.028*
	4a	14	6	.122	.013*
	4b	24.5	16.5	1	.253
	4c	12	1	.08	.002*
1b	1c	5	0	.007*	.001*
	4a	5	0	.006*	.001*
	4b	12.5	6	.054	.007*
	4c	5	0	.007*	.001*
1c	4a	22	16.5	.705	.244
	4b	13	12.5	1	.054
	4c	21.5	2	.678	.020*
4a	4b	14	7.5	.122	.015*
	4c	19.5	7.5	.473	.020*
4b	4c	12	0	.08	.001*

Groups (Occlusally)	0a	0b	0c	1a	1b	1c	4a	4b	4c
0a		*	*						
0b	*		*	*	*	*	*	*	*
0c	*	*			*				
1a		*							
1b		*	*			*			
1c		*			*				
4a		*							
4b		*							
4c		*							

Figure 3. Statistical differences between all groups (occlusally) (* = P<.05).

Groups (Cervically)	0a	0b	0c	1a	1b	1c	4a	4b	4c
0a		*	*				*		*
0b	*		*	*		*	*	*	*
0c	*	*			*		*		*
1a		*				*	*		*
1b			*			*	*		*
1c		*		*					*
4a	*	*	*	*				*	*
4b		*							*
4c	*	*	*	*	*				

Figure 4. Statistical differences between all groups (cervically) (* = P<.05).

the current microscopic techniques for examining restorative dental procedures and dental materials and can be considered as being midway between optical and electron microscopy.⁴⁹ This technique that can be used both in the clinic and the high resolution microscopy suite for fluorescent structures within semi transparent materials such as cells and dental hard tissues.^{50,51} The laser scanning type microscope (CLSM) and the real-time direct view of tandem scanning microscopes

(TSM) are basically two types of confocal optical microscope.⁴⁹ All confocal scanning optical microscopes are suitable for making high-resolution images of many structures in teeth under near normal conditions. The number of applications widens considerably if the microscope can operate at high speed. The high-frame speed of TSM enables real-time examination of teeth in vivo and experimental procedures examined microscopically on extracted teeth can include

the observation of the fluid flow and application of adhesives.⁵² In addition, new imaging techniques such as multi-photon laser excitation of dyes give the potential of greater depth penetration and improved resolution.⁵¹ All these techniques are more sophisticated, relative and ultra-informative methods for leakage tests. However, these techniques require exhaustive equipments, detailed technical precisions and knowledge and rather expensive hardware. Therefore, using of these more advanced methods may not be easy by all researchers every time.

In this study, a conventional and dependable dye-penetration method with basic fuchsin solution was used for examination of microleakage. It was reported that, basic fuchsin may be prepared in 2% concentration,⁵³ otherwise 0.5% concentration was generally preferred^{24,30-33,54} as in the present study.

One-slice cutting technique is common used in conventional dye-penetration/microleakage examinations under conventional microscopy.^{31-33,37-40,54-60} Also, more sensitive multi-slices cutting technique may be used for leakage studies, but this technique is usually preferred for more improved ultra-microscopical examinations e.g. SEM/TEM or confocal microscopy.^{45-47,49-52} In the present study, conventional one-slice cutting technique was used for conventional dye-penetration/microleakage test. Already, multi-slices cutting technique may not be suitable for fluorosed teeth owing to their hypermineralized and very easily breakable enamel structure because of multi-slices cutting technique requires a series of very thin and smooth slices of tooth structures.

For composite restorations, incremental placement technique has been suggested to reduce microleakage^{28,59} and to produce greater resistance to cuspal fractures.⁶¹ Otherwise, it was reported that, bulk placement technique is also suitable for composite restorations of 2-mm thickness and this technique is commonly used in microleakage studies.^{17,33,34,38,39,42,62} In the present

study, bulk placement technique was used in standardized 2-mm depth of cavities of composite restorations.

Marginal microleakage is an important factor which causes to the clinical failure of restorations.^{14,16} Some determinants may affect the microleakage such as structure of enamel,¹³ acid-etching time,¹⁵ bonding systems,^{17,18} cavity designs and C-factor.^{63,64}

In this study, more microleakage was found in fluorosed teeth than non-fluorosed teeth and microleakage levels increased depending on the severity of dental fluorosis. These higher microleakage levels may be explained by a weaker bonding of composite restorations on fluorosed teeth because of the pitted and detachable fluoroapatite structure of fluorosed enamel which has hypermineralized surface layer and quite extensive subsurface porosity.⁹

In dentistry, using of the acid-etching technique has reduced the microleakage.^{15,16} However, demineralization rates of enamel is affected from the type and concentration of etching agents.^{65,66} Otherwise, the depth of etch of fluorosed teeth is influenced not only by the type and concentration of acid etchants, but also by the etching time and the chemical composition of the enamel. Because the fluoroapatite in the hypermineralized surface layer of fluorosed teeth is more resistant to acid dissolution than the hydroxyapatite in non-fluorosed teeth, it has often been suggested the etching time of fluorosed enamel be doubled.^{6,13,67} Therefore, in the present study, two different acid-etching times were applied on the fluorosed teeth with total-etch bonding system. Etching time of 30s was applied as normal etching time, and etching time of 60s was applied as doubled etching time. In the study, less microleakage levels were observed in total-etch bonding groups with etching time of 60s than total-etch bonding groups with etching time of 30s. These results on etching times of

Table 4. Descriptives for occlusal and cervical margins according to Wilcoxon Signed Rank Test.

Margins	n	Mean	SD	Min	Max
Occlusal	63	1.25	0.82	0	4
Cervical	63	1.81	1.08	0	4

Table 5. Statistical differences between occlusal and cervical margins according to Wilcoxon Signed Rank Test (P<.05 = *).

Significant differences between occlusal-cervical margins	
Z	- 4.19718
P	.000*

60s and 30s supported the recommendations of previous researchers about doubled etching time on fluorosed teeth.^{6,13,67}

The results of the study indicated that, microleakage scores were generally increased in self-etch groups than total-etch groups. Likewise, more microleakage was found with self-etch bonding systems in some previous studies.^{36,60,62} Bedran de Castro et al⁵⁸ reported that, a self-etching primer system obtained higher values of microleakage compared with an one-bottle total-etch system. Owens and Johnson⁵⁹ observed in their study that, the use of a total-etch system significantly reduced microleakage than a self-etch system. In another study, Salim et al⁶⁹ indicated that, the results suggested the application of a conventional two-bottle bonding system used with a total-etch technique is better than that of a self-etching adhesive system. In a different study, a multi-step total-etch adhesive system exhibited significantly less leakage at the enamel margin than the self-etch adhesive systems.⁵⁷ Brandt et al⁵⁶ reported in their study that, only two self-etch bonding systems between totaling six different self-etch bonding systems could be clinically acceptable alternatives to clinically proven a total-etch bonding system and the other self-etch products showed more microleakage. Deliperi et al³⁹ declared that, significantly more dye-penetration was observed in one-step self-etch adhesive group than another self-etch adhesives and a total-etch adhesive. On the other hand, some other studies indicated that microleakage was not found significantly different between self and total-etch bonding systems.^{41,43,70} Deliperi et al⁵⁵ reported in their study that, microleakage was not affected by the type of adhesive or its application technique. In another study performed by Santini et al,⁷¹ there was no significant difference in leakage between the self-etching groups and a total-etch group in enamel margins. In a study made by Owens et al,⁵⁷ there were no significant difference among the adhesive groups when the dentin margins were evaluated.

The results of the current study have supported the findings of previous studies about more leakage with self-etch bonding systems than total-etch bonding systems.^{36,39,56-60,62,69} Higher leakage scores in the present study may be related with inadequate demineralization of enamel by using self-etching

bonding system. Additionally, the inefficiency of self-etching bonding system on fluorosed teeth may be related on hypermineralized / acid-resistant enamel.

Finally, there are only two microleakage studies on fluorosed teeth in literature.^{68,33} Furthermore, there are not any study comparing total and self-etching/bonding systems or normal and prolonged etching times on microleakage of permanent fluorosed teeth. Therefore, the results of the current study are rather important for;

- Adding more knowledge on microleakage levels of composites on fluorosed teeth.
- Getting some information about microleakage levels of fluorosed teeth with different bonding systems.
- Supporting the suggestions of previous researchers about prolonged etching time on fluorosed teeth for better adhesion.^{6,13,67}

On the other hand, it has been reported that, leakage could not be completely eliminated in composite restorations even though using of total-etch bonding systems yet.^{24,34} Also, in the present study, microleakage could not be absolutely eradicated in spite of using of a total-etch bonding system in fluorosed or non-fluorosed teeth.

Microleakage levels were found higher at cervical margins than occlusal margins of teeth in this study ($P<.05$). More leakage was also reported at cervical margins than occlusal margins in previous studies.^{24,72} The findings of the current study were parallel with their results. This condition may be explained with thinner and weaker structure of enamel at cervical areas.

C-factor is defined as the ratio of the bonded surface area to the unbonded or free surface area.⁶³ It may also play a role in marginal sealing. A high C-factor is a risk in bonding procedure. Because increased polymerization stresses may occur by high rates of C-factor.^{63,64} The box-shaped cavity design was recommended by some previous researchers in their studies to resemble most closely the clinical situation resulting in a C-factor of about 3, where relatively high shrinkage stresses can be expected.^{30,73,74} Box-shaped cavity design was used to determine the C-factor relatively in this study.

This study was performed on examination of microleakage levels of composite restorations with different bonding systems on fluorosed teeth.

It is hoped that, the findings of the current study may help to next restorative studies on fluorosed teeth. However, these findings must be supported with other future researches.

CONCLUSIONS

1. Microleakage was found significant in fluorosed teeth than non-fluorosed teeth. Leakage was affected by dental fluorosis and increased by severity of fluorosis.

2. Generally less microleakage was observed at total-etch bonding groups with 60s etching procedure than total-etch bonding groups with 30s etching procedure. 60s etching procedure has reduced microleakage in particularly TFI=4.

3. Commonly more microleakage was found in all self-etch bonding groups than total-etch bonding groups.

4. Generally more microleakage was observed in cervical margins than occlusal margins.

ACKNOWLEDGEMENTS

This study was made as second part of the PhD Thesis of correspondence author which was performed at Department of Paedodontics, Faculty of Dentistry, Ankara University, in April 2004.

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