EVALUATION OF TWO METHODS OF FISSURE TREATMENT

BEFORE SEALANT PLACEMENT ON

DIFFERENT CARIES LEVELS

by

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Finally, I would like to thank all persons at the School of Dentistry who influenced my life in their own special ways.

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INTRODUCTION

For many years it has been recognized that the occlusal pits and fissures of posterior teeth are highly susceptible to caries. Numerous techniques and methods have been advocated to prevent occlusal pit-and-fissures caries. Fluoride has been the material of choice for preventing smooth surface caries; however, it has been less effective in reducing pit-and-fissure caries.[1-3] Kronfeld[4] has stated that fissures are formed due to the early retardation of amelogenesis in predetermined areas between the cusps, and given that fissures occur regularly and normally in perfectly formed molars and premolars, the high incidence of caries in the fissures cannot be taken as proof that fissures are "defects." The American Dental Association emphasizes the use of dental sealants as an effective preventive method in controlling occlusal pit-and-fissure caries.[5]

There are many questions that are unanswered regarding the use of dental sealants. According to Gift,[6] out of 100 dental practitioners, only 15 percent to 20 percent said they use dental sealants in their practice. In the dental profession, a controversy exists about the effectiveness of and need for dental sealants.[7] Another important question is to find which is the most effective method prior to placing the dental sealant, using air abrasion sandblasting,[8] enlarging the occlusal fissures with a bur,[9] or using no additional method prior to placing the dental sealant.

This study represents an attempt to answer the question – which fissure pretreatment is most effective in terms of microleakage and depth of penetration?

REVIEW OF LITERATURE

HISTORY OF OCCLUSAL CARIES

The history of occlusal caries goes back more than 100 years to when G.V. Black[10] reported that more than 40 percent of all caries in the permanent teeth occur in the occlusal pit and fissure surfaces. Paynter et al.[11] stated in their study that the presence of pits and fissures that harbor food and microorganisms is the single most important factor in determining whether caries occurs.

EARLY ATTEMPTS AT REDUCING
OCCLUSAL PIT-AND-FISSURE
CARIES

Different methods have been studied and tried to effectively reduce occlusal pit-and-fissure caries. In 1923 Hyatt proposed a radical method for preventing occlusal pit-and-fissure caries. In this study, prophylactic odontotomy, the technique that involves blocking the occlusal pit and fissure by the mechanical preparation of teeth, was used.[12] The cavity preparations were restored with amalgam in an attempt to be more conservative than would otherwise be possible. Klein and Knutson[13] treated occlusal surfaces of first molars with silver nitrate so as to prevent extension of occlusal caries lesions and concluded that this technique did not arrest existing caries; there was no difference between the caries rate of treated and untreated teeth.

HISTORY OF DENTAL SEALANTS

By definition, the term pit-and-fissure sealant is a resin composite material placed in the occlusal pits and fissures of teeth. This resin material protects the susceptible pits

and fissures by reducing food collection and causative microorganisms and thereby reduces the formation of dental caries.[14] In a 1955 classic *in-vitro* study, Buonocore[15] demonstrated that acrylic resin can be bonded to the enamel surface when enamel was etched by 85-percent phosphoric acid for 60 seconds. In an *in-vivo* study by Cueto,[16] the author concluded that the bonding of the acrylic resin needs a clean enamel surface etched by 35-percent phosphoric acid. Phosphoric acid created microporosities that helped to promote retention of the resin to the tooth surface. In 1965, Bis-GMA resin was introduced in the market by Bowen.[17] Bis-GMA is used in all of the dental sealant systems approved by the American Dental Association.[18]

CLASSIFICATION OF DENTAL SEALANTS

Dental sealants are classified according to their method of polymerization, their content, and their color. Polymerization can be accomplished by self-curing (autopolymerization), or light curing with a visible blue light, and ultraviolet light.[19] In ultraviolet light, the ethers initiate the peroxide systems. The first dental pit-and-fissure sealant utilizing ultraviolet light was introduced in 1971. Ketones are used in visible light curing systems. The autopolymerization initiator and an accelerator are mixed for the reaction to happen.[20] Barrie et al.[21] in a *in-vivo* study concluded that unfilled dental sealants were retained in teeth by 88 percent when compared with filled dental sealants, which were retained in 81 percent over two years of clinical study. Unfilled sealants adjust in occlusion on their own versus filled sealants that need some occlusal adjustments.[22]

Colored, transparent, and translucent dental sealants are available in the market. Many dentists believe that colored sealants won't be accepted by patients because the materials are opaque and can be seen, but, in fact, they have the opposite reception. The patients can check periodically on the sealant and they are satisfied.[22] Also, colored dental sealants have the advantage when it is necessary to replace the sealant due to caries because the visibility prevents unnecessary removal of healthy tooth structure.

Glass ionomer sealants are gaining popularity due to their fluoride-releasing property. Studies have shown mixed results in terms of their retention and fluoride release. Skrinjaric et al.[23] concluded that the retention rate of glass ionomer sealant treated with heat during the setting time was significantly lower than the retention of conventional composite resin. The heating procedure during the setting of glass ionomer sealants cannot be recommended as routine treatment in clinical practice.

In the study performed by Subramaniam et al.,[24] they evaluated the retention of glass ionomer used as a fissure sealant when compared with a self-cure resin-based sealant. They concluded the retention of the resin sealant was superior to that of the glass ionomer sealant.

GUIDELINES FOR DENTAL SEALANTS

One way to determine pit-and-fissure sealant placement is to consider the caries risk assessment of the patient. Also, it is important for the clinicians to determine which teeth need to be sealed; the following are the recommendations based on the evidence gathered in the systematic review:[25]

1) Sealants should be placed on all permanent molar teeth without cavitation (i.e., permanent molar teeth that are free of caries, permanent molar teeth that have deep pit-and-fissure morphology, permanent molar teeth with sticky fissures, or permanent molar teeth with stained grooves) as soon as eruption and isolation can be achieved.

2) Sealants should not be placed on partially erupted teeth or teeth with cavitation or caries of the dentin.

3) Sealants should be placed on the primary molars of children who are susceptible to caries (i.e., those with a history of caries).

4) Sealants should be placed on the first and second molar teeth within four years after eruption.

5) Resin-based sealants should be preferred, until such time as glass ionomer cements with better retention capacity are developed.

6) Sealants should be placed as part of an overall prevention strategy based on assessment of caries risk.

DIFFERENT TECHNIQUES OF PREPARING TEETH PRIOR TO PLACEMENT OF DENTAL SEALANTS

There have been various studies done and documented on caries-preventing and retention qualities of pit-and-fissure sealants.[26-28] The preventive effects of pit-and-fissure dental sealants are maintained only when the dental sealants are bonded micromechanically and are intact.[29]

For adequate and long-term retention of the pit-and-fissure dental sealants, the enamel should be clean and free of salivary contamination. It is necessary to maximize the surface area for bonding by tight micromechanical adhesion to the enamel surface.[30-32] Conditioning the surface of the enamel with phosphoric acid is the standard method for preparing the enamel surface before pit-and-fissure sealant placement.[32]

Different pretreatment methods have been investigated with the intention of enhancing the effectiveness of etching the enamel surface and improving sealant retention, and the tight micromechanical adhesion to enamel surface essential for their success. However, to date there has not been a gold standard for cleaning pits and fissures prior to the application of etchant and sealant. A report from the American Dental Association Council on Scientific Affairs stated: "There is limited evidence and inconclusive evidence in favor of using air abrasion as a cleaning method before acid etching to improve sealant retention. Also, there are conflicting results in mechanical preparation with bur."[33] Many dental practices use pumice slurry with a rotary instrument in a low-speed handpiece to clean the tooth.[34] Use of 0.1 N sodium hydroxide has been shown to be effective in removing the surface debris and leaving a uniform etching pattern on the enamel surface.[35] Research has demonstrated that air polishing teeth prior to etching results in higher tensile bond strengths of pit-and-fissure dental sealants.[36]

However, Pope et al.[37] proved in their study that pumice is not the effective method of cleaning and completely removing the debris and organic matter especially located in the deep pits and fissures. Brown et al.[38] and Borrow et al.,[39] in their respective studies, concluded that even after using the etchant and rinsing the tooth

thoroughly, the debris and organic matter remain in the deeper parts of pits and fissures, which eventually prevent the conditioning of enamel and thereby reduces the dental sealant penetration.[38,39]

Recently, a study done by Hatibovic-Kofman et al.[40] on air abrasion sandblasting with 50-µm aluminum oxide concluded that it is a conservative and efficient method of pretreatment to mechanically roughen the enamel surface to remove the residual debris and organic matter from the deeper pits and fissures. Another study done Ellis et al.[41] proved that a combination of air abrasion sandblasting with 50-µm aluminum oxide and phosphoric acid etching showed better results than acid etch conditioning without air abrasion. Mazzoleni et al.[42] used different methods of mechanical brushing, air abrasion, and intensive bur FG 40D4 for surface preparation before sealant placement. They concluded that the air abrasion system (Kinetic Cavity Preparation), which used alpha alumina abrasive particles ranging from 27 µm to 50 µm at a variable pressure, was the superior method among the three methods. The air abrasion technique preserved the tooth surface better from microleakage.

An approach for managing borderline or questionable carious fissures by partially eliminating the fissures with a dental bur has been suggested. Use of a round bur prior to placement of dental sealant in the occlusal pit and fissure was studied by Wright et al.,[43] and they concluded that superior sealants were obtained when the tooth surfaces were prepared by bur, compared with air abrasion, and conventionally prepared surfaces. In a study done by Chan et al.[44] extracted mandibular molars were treated with brushing, pumicing, bur preparing, and air abrasion before application of fissure sealants, and they concluded that among the four groups, the air abrasion method and ¼ round bur

demonstrated significantly better marginal sealing than the control group (no preparation).

No studies have been done directly comparing the degree of microleakage of sealants following the preparation of pits and fissures with acid-etch only, bur preparations followed by acid etch, and air abrasion followed by acid etch on different levels of incipient carious lesions. It is evident in research that placing pit-and-fissure sealants on early (noncavitated) carious lesions in children, adolescents, and young adults have been proven to reduce the percentage of lesions that progress.[4] We assessed how mechanical preparation using a ¼ round bur, or air abrasion with 50-µm aluminum oxide affects the penetration and microleakage of sealants. Teeth with carious lesions of different severity were selected by a calibrated examiner using the International Caries Detection Assessment System (ICDAS) criteria. The ICDAS is a novel caries diagnosis system developed as a result of an international effort to create a new set of criteria that focuses on small changes due to early caries lesions developing in the enamel.[46]

NULL HYPOTHESIS

There is no difference in the microleakage and depth of penetration of dental sealants when teeth are prepared with air abrasion using 50-µm aluminum oxide or using a ¼ round bur on sound or incipient caries lesions levels (ICDAS code 0 through 2) when compared with no preparation at all.

ALTERNATIVE HYPOTHESIS

There will be less microleakage and more depth of penetration of dental sealants when teeth are prepared with air abrasion using 50 µm of aluminum oxide or using a ¼

round bur on sound or incipient caries levels (ICDAS code 0 through 2) when compared

with no preparation at all.

MATERIALS AND METHODS

This was an *in-vitro* experimental double blind study. Teeth were obtained from the Oral Health Research Institute (OHRI) (IUPUI/Clarian IRB #0306-64). Teeth were assigned an ICDAS code 0, 1, or 2 by a calibrated examiner (Figures 1-3). The worst code of the fissure was used to classify the surface. The selected teeth were cleaned, and they remained in 1.0-percent thymol at all times. After ICDAS codes were assigned, teeth were randomly assigned to the treatment of air abrasion, bur, and control. There were three divisions of specimens, and these were subdivided into three groups per division.

EXPERIMENTAL DESIGN

Figure 4 shows an overall view of the design in the form of a flowchart.

GROUPS 1, 2, and 3 (DIVISION I)

Each group had 15 teeth.

Group 1: The occlusal surfaces of Group 1 of ICDAS code 0, or sound, were treated with air abrasion using a Sandstorm Expert (Vaniman Manufacturing Co., Fallbrook, CA) (Figure 5) using 50-µm aluminum oxide (National Keystone Products, Cherry Hill, NJ) with an air pressure of 60 psi.

Group 2: The occlusal surfaces of Group 2 of ICDAS code 0, or sound, were treated with a ¼ round tungsten carbide bur (SS White Burs, Inc., Lakewood, NJ) using a slow-speed handpiece. The bur dimensions (0.5 mm) were used as the standard for maximum width and depth into the fissure (see Figure 6 and explanation of the technique

in the section titled ¼ round bur method). If the fissure had any softened enamel, demineralization, or signs of decay deep into dentin, the tooth was discharged and another tooth was selected.

Group 3: The occlusal surface of Group 3 of ICDAS code 0, or sound, received no pretreatment on the fissure and was used as the control.

All the groups were then etched with 35- to 37-percent phosphoric acid for 15 seconds (Ultradent, South Jordan, UT). Teeth were rinsed with water for 15 seconds, dried with air for 15 seconds to obtain a matte chalky surface, sealed with an opaque sealant (Delton, DENTSPLY International, Milford, DE), and light cured (Demetron/Kerr, Middleton, WI) (Figure 8) for 30 seconds.

GROUPS 4, 5, and 6 (DIVISION II)

Each group had 15 teeth.

Group 4: The occlusal surfaces of Group 4 of ICDAS code 1 were treated with air abrasion (Sandstorm Expert, Vaniman) using 50-µm aluminum oxide (National Keystone Products) with an air pressure of 60 psi.

Group 5: The occlusal surfaces of Group 5 of ICDAS code 1 were treated with a ¼ round tungsten carbide bur (SS White Burs, Inc.) (Figure 6) using a slow-speed handpiece. The bur dimensions (0.5 mm) were used as the standard for maximum width and depth into the fissure (see Figure 6 and explanation of the technique in the section titled ¼ round bur method). If the fissure had any softened enamel, demineralization, or signs of decay deep into dentin, the tooth was discharged and another tooth was selected.

Group 6: The occlusal surface of Group 6 of ICDAS code 1 received no pretreatment on the fissure and was used as control.

All the groups were then etched with 35- to 37-percent phosphoric acid for 15 seconds (Ultradent). Teeth were rinsed with water for 15 seconds, dried with air for 15 seconds to obtain a mate chalky surface, sealed with an opaque sealant (Delton, DENTSPLY) (Figure 7), and light cured for 30 seconds (Figure 8).

GROUPS 7, 8, and 9 (DIVISION III)

Each group had 15 teeth.

Group 7: The occlusal surfaces of Group 7 of ICDAS code 2 were treated with air abrasion (Sandstorm Expert, Vaniman) (Figure 5) using 50-µm aluminum oxide (National Keystone Products) with an air pressure of 60 psi.

Group 8: The occlusal surfaces of Group 8 of ICDAS code 2 were treated with a ¼ round tungsten carbide bur (SS White Burs, Inc.) (Figure 6) using a slow-speed handpiece. The bur dimensions (0.5 mm) were used as the standard for maximum width and depth into the fissure (see Figure 6 and explanation of the technique in the section titled ¼ round bur method). If the fissure had any softened enamel, demineralization, or signs of decay deep into dentin, the tooth was discharged and another tooth was selected.

Group 9: The occlusal surface of Group 9 of ICDAS code 2 received no pretreatment on the fissure and was used as the control

All the groups were then etched with 35- to 37-percent phosphoric acid for 15 seconds (Ultradent). Teeth were rinsed with water for 15 seconds, dried with air for 15

seconds to obtain a mate chalky surface, sealed with an opaque sealant (Delton,

DENTSPLY) (Figure 7), and light cured for 30 seconds (Figure 8).

AIR ABRASION METHOD

The tooth was held at a distance of ~2 mm at one fixed spot and treated with air

abrasion sandblasting 50 µm. One fissure was treated for 10 seconds so that if the tooth

had more than one fissure of interest, then these were treated as well.

¼ ROUND BUR METHOD

The tooth was fixed to the base, and by using a magnifying glass, the bur was

inserted using a level. It was calibrated to measure when the bur (Figure 6) entered 0.5

mm into the enamel.

THERMOCYCLING AND DYE PENETRATION

Following the sealant placement, the teeth were thermocycled (Figure 9) for 5000

cycles between two water baths having a 45°-C temperature differential. A 5°-C bath and

a 50°-C bath were used with a 30-second dwell time and a transfer time of 10 seconds.

Thermocycling was done to simulate the oral environment. Following a week of storage

in artificial saliva (OHRI-SOP L021, OHRI, Indianapolis, IN), two layers of

impermeable varnish were applied to the non-occlusal surfaces of the teeth. The teeth

apices were then sealed with wax. The specimens were immersed in 1.0-percent

methylene blue dye at 37° C for 24 hours. The teeth were then cleaned; the crowns were

exposed by cutting the root sections with an Isomet low-speed saw (Buehler, Lake Bluff,

IL) (Figure 10), and the teeth were mounted on 2 x 2 acrylic slabs. Marks were followed

before cutting the tooth for locating the fissures; two cuts were made on the occlusal

surface of the tooth in the bucco-lingual direction. The sectioned surfaces were viewed

under a microscope linked to the computer. Images were captured using X20

magnification (Nikon SMZ1500, Nikon, Tokyo, Japan) (Figure 11). A digital image of

the objective micrometer was captured on the computer to use in measuring the sectioned

images of teeth (Figure 12). ImageJ software (ImageJ, Bethesda, MD) was used to

measure sealant penetration. The sectioned surfaces were then assessed for sealant

penetration and microleakage, and the correlation between fissure type and sealant

penetration (Figures 13A-13S).

STATISTICAL ANALYSIS

The sample size justification of within-group standard deviation estimated to be

32 percent was based on the study by Kersten et al.[47] We conservatively estimate four

sides from two cuts made per specimen and a correlation between specimens of 0.5.

With a sample size of 15 specimens per group, the study will have 80-percent power to

detect a difference of 27 percent between any two groups, assuming two-sided tests each

conducted at a 5-percent significance level. Therefore, 135 human first, second, and third

molar teeth of 0 through 2 ICDAS codes were collected under an IUPUI/Clarian IRB-

approved protocol from OHRI.

RESULTS

A total of 371 cut, sectioned surfaces of teeth were examined under microscope for sealant penetration, microleakage, and fissure type. The average sealant penetration in each group of air abrasion, bur, and control from the ICDAS code 0, 1, and 2 is shown in Figure 14 and Table I. Although no statistically significant difference was noticed, the average highest sealant penetration was observed in the treatment groups of bur (361µm) for the ICDAS code 0 followed by air abrasion (294 µm) for the ICDAS Code 0. The least average sealant penetration was observed in the treatment group of the control (184 µm) for the ICDAS Code 0.

The effects of group (air abrasion, bur, and control), ICDAS codes (codes 0-2), and fissure type (U, V, Y, and W) on sealant penetration percentage were compared using ANOVA. The micromorphological types of the fissure system were classified as 1) U-type, 2) V-type, 3) Y-type, and 4) W-type. These fissure types were based on Duangthip et al.[46] in a study of effects of fissure cleaning methods (Figure 15). Fissure type had a significant effect on sealant penetration (p = 0.0001): V- and U-shaped fissures had better sealant penetration compared with Y- and W-shaped fissures. The sealant penetrated to a better depth in V- and U-shaped fissure types than in Y- and W-shape fissure types (Tables II-IV).

The analyses were performed on a transformation of the sealant penetration percentage commonly used for calculated percentages: $\sin^{-1}(p^{1/2})$. The effects of group, ICDAS, and fissure type on sealant penetration percentage were compared using

ANOVA, and comparison of all groups revealed no significant difference on the sealant penetration (Figure 14 and Table I).

The effects on microleakage were compared using generalized estimating equation (GEE) methods applied to logistic regression. Higher microleakage was noticed in the air abrasion group as compared with the bur and control groups. ($p = 0.0004$). Also, ICDAS Code 0 showed less microleakage when compared with ICDAS Code 1 and 2 (Figures 16 and 17).

The air bubbles, which blocked the penetration of dental sealant further into the fissure, were considered in this study. The effects on air bubbles were compared using GEE methods applied to logistic regression. The groups of air abrasion, bur, and control did not have a significant effect on air bubbles ($p = 0.384$) (Figure 18). ICDAS codes did not have a significant effect on bubbles ($p = 0.056$) (Figure 18). The micromorphology of fissure type was not necessarily the causative factor for air bubbles in the study. Hence, fissure type did not have a significant effect on bubbles ($p = 0.051$).

FIGURES AND TABLES

FIGURE 1.   Image of tooth categorized as ICDAS Code 0.

FIGURE 2.   Image of tooth categorized as ICDAS Code 1.

FIGURE 3.   Image of tooth categorized as ICDAS Code 2.
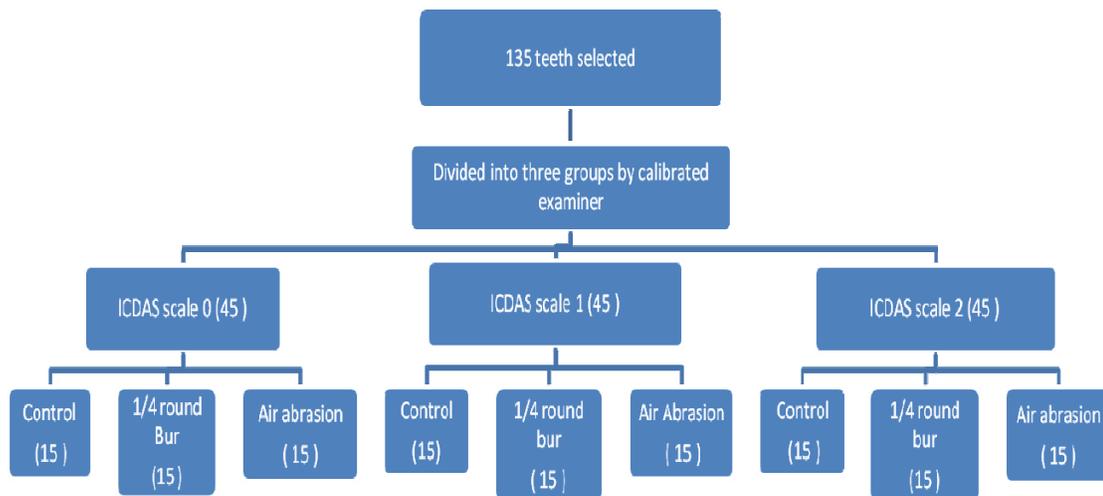
FIGURE 4.   Flowchart showing overall view of experimental design.

FIGURE 5.   Image of Sandstorm Air Abrasion Sand-
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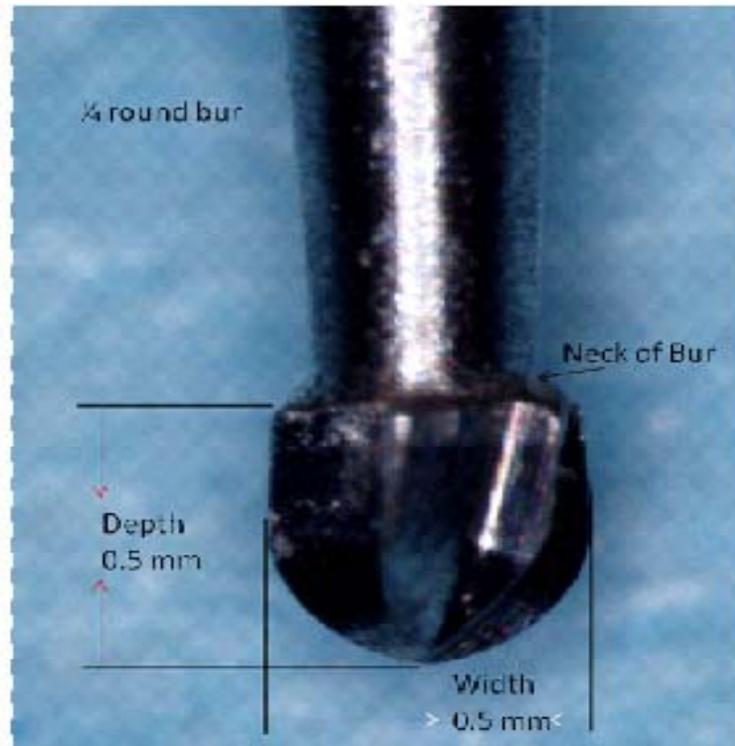
FIGURE 6.   Image of ¼ tungsten carbide bur.

FIGURE 7.   Image of sealant kit.

FIGURE 8.   Image of Demetron visible curing light.

FIGURE 9.   Image of thermocycling unit.
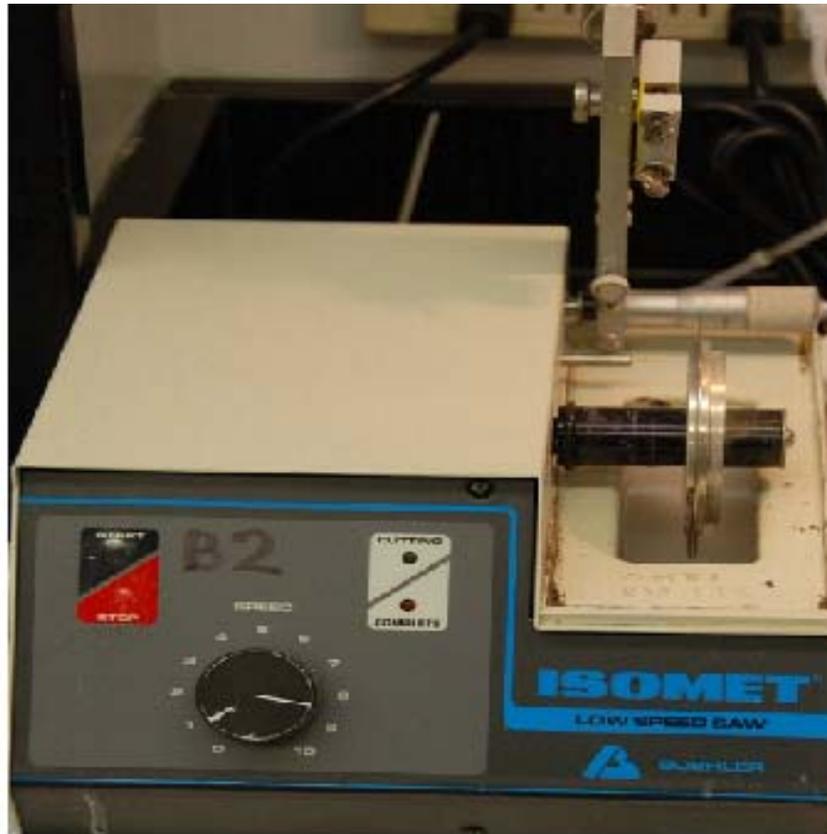
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FIGURE 11.   Image of Nikkon SMZ 1500 Microscope used to take
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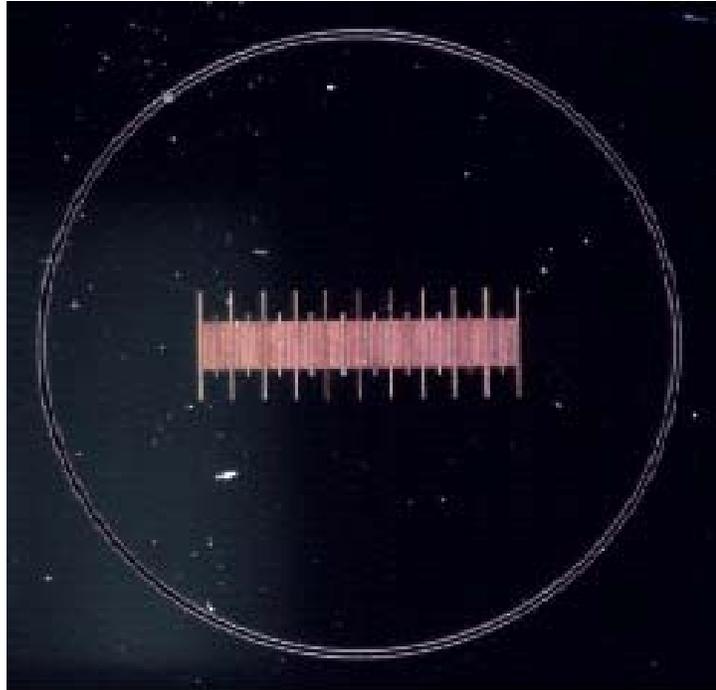
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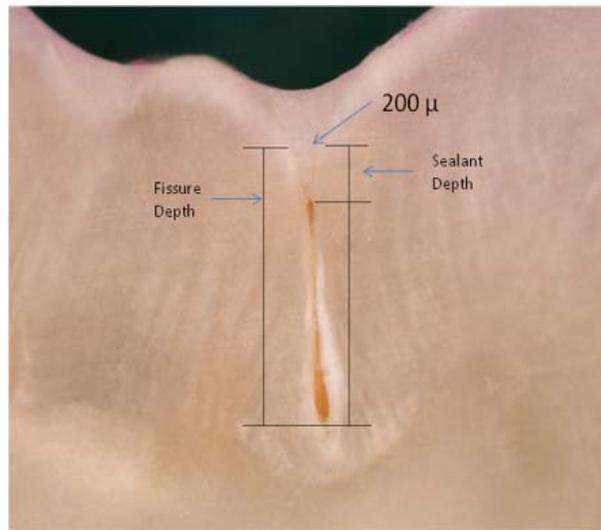
Figure 13A.   Digital image depicting the microleakage and
                   sealant penetration performed.

ICDAS CODE 0 Control Group

FIGURE 13B. Sealant penetration.
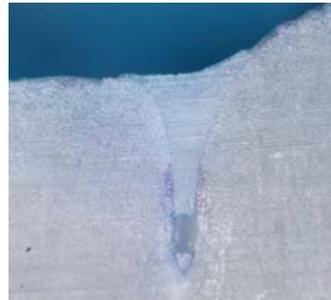
FIGURE 13C. Sealant microleakage.

ICDAS CODE 0 Bur Group
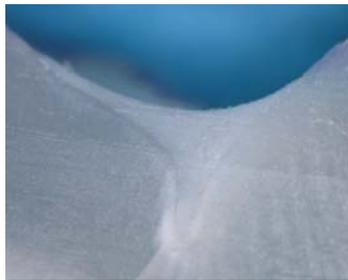
FIGURE 13D. Sealant penetration

FIGURE 13E. Sealant microleakage.

ICDAS CODE 0 Air Abrasion Group

FIGURE 13F. Sealant penetration.

FIGURE 13G. Sealant microleakage.

ICDAS CODE 1 Control Group

FIGURE 13H. Sealant penetration.
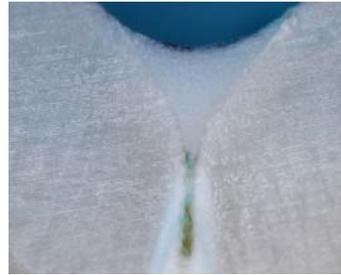
FIGURE 13I. Sealant microleakage.

ICDAS CODE 1 Bur Group

FIGURE 13J. Sealant penetration.
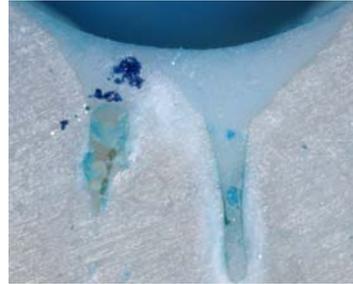
FIGURE 13K. Sealant microleakage.

ICDAS CODE 1 Air Abrasion Group

FIGURE 13L. Sealant penetration.

FIGURE 13M. Sealant microleakage.

ICDAS CODE 2 Control Group

FIGURE 13N. Sealant penetration.

FIGURE 13O. Sealant microleakage.

ICDAS CODE 2 Bur Group

FIGURE 13P. Sealant penetration.

FIGURE 13Q. Sealant microleakage.

ICDAS CODE 2 Control Group

FIGURE 13R. Sealant penetration.
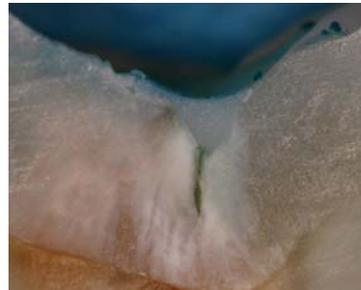
FIGURE 13S. Sealant microleakage.
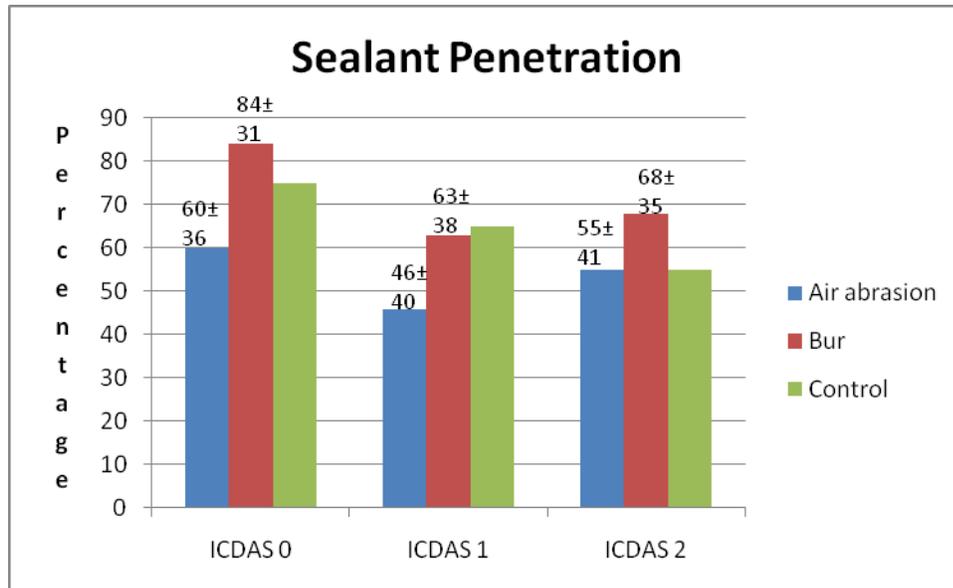
FIGURE 14.   Percentage of sealant penetration in three treatment groups
                 of ICDAS Codes 0, 1, and 2.
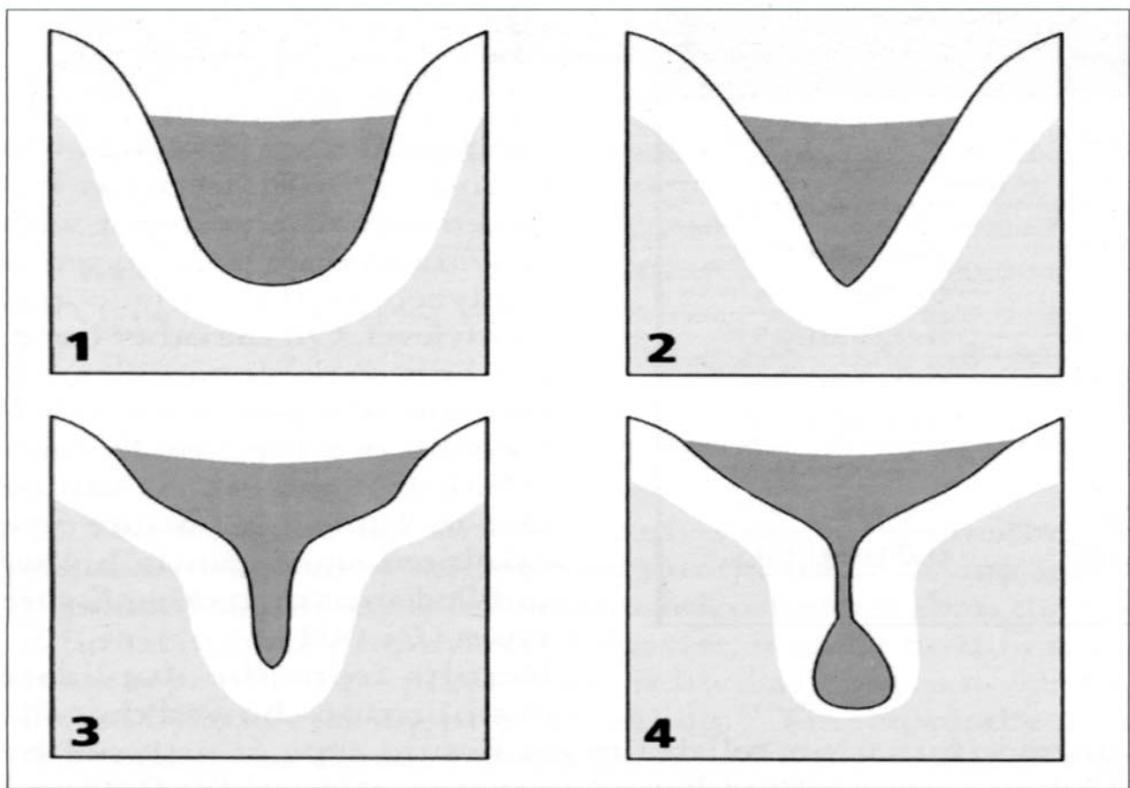
Figure 1. Diagrammatic depiction of the micromorphological types of fissure system.
1=U-type; 2=V-type; 3=Y1-type; 4=Y2-type.

FIGURE 15.   Fissure types figure from Duangthip and Lussi, *Pediatric Dentistry* 2003 (used with permission).
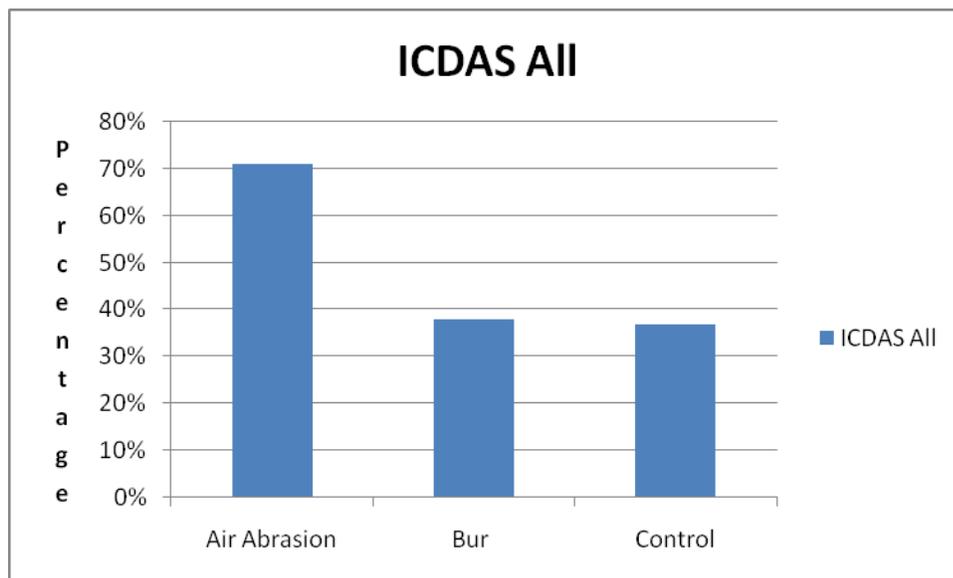
FIGURE 16.   Percentage of sealant microleakage in three treatment groups.
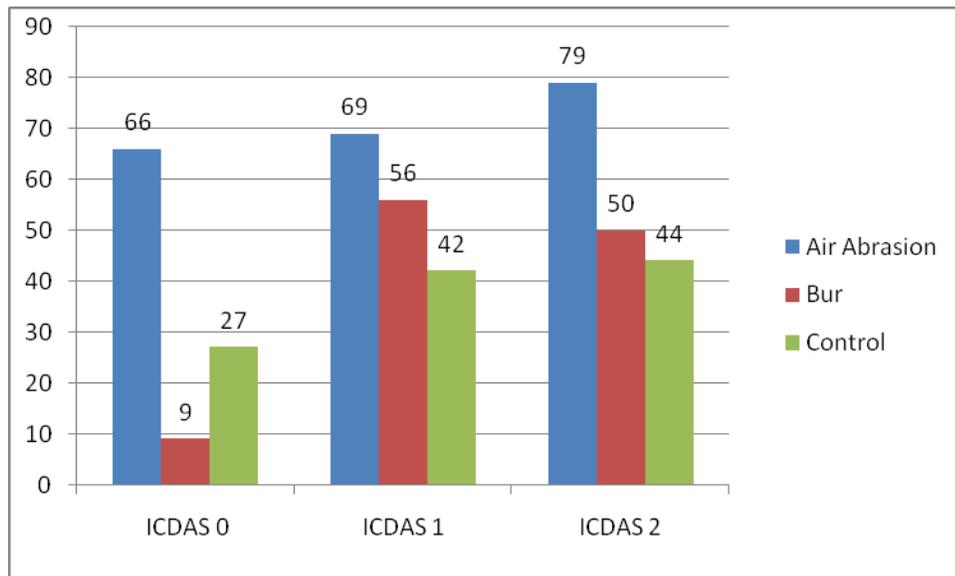
FIGURE 17.   Percentage of sealant microleakage in three treatment groups of ICDAS Codes 0, 1, and 2.
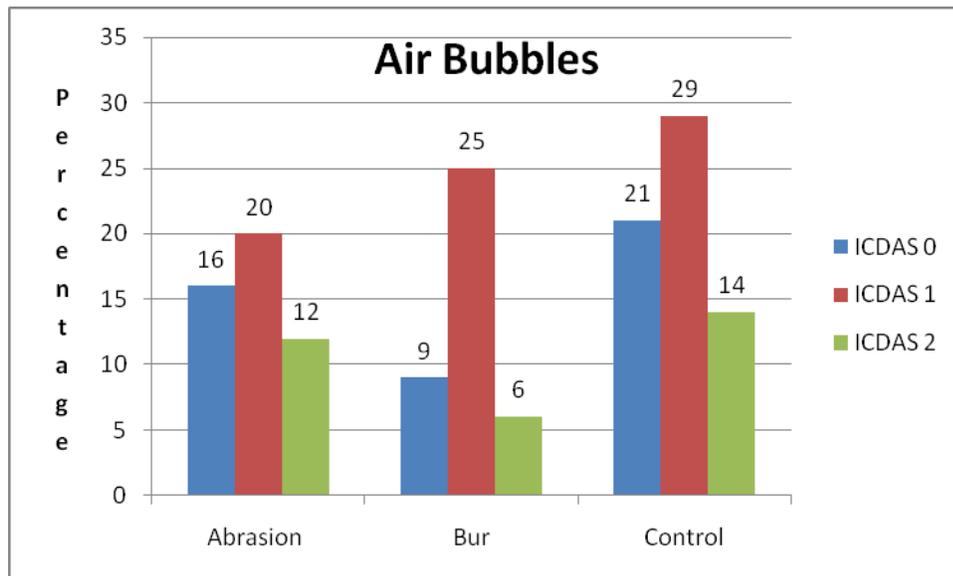
FIGURE 18.   Percentage of air bubbles during sealant penetration.

TABLE I

Results of fissure depth, average sealant
penetration and standard deviation (SD) in
microns of three treatment groups.

ICDAS/Method	Air Abrasion (SD)		Bur (SD)		Control (SD)	
Code	Sealant Penetration	Fissure Depth	Sealant Penetration	Fissure Depth	Sealant Penetration	Fissure Depth
ICDAS 0	294±196	642±414	361±314	467±427	184±185	371±409
ICDAS 1	207±221	651±380	250±168	528±347	220±223	512±499
ICDAS 2	216±142	645±470	296±174	552±392	235±218	538±397

TABLE II

Sealant penetration based on fissure type in
air abrasion group

Group	ICDAS	Fissure Type	Number	Mean ± SD	
Abrasion	0	All	32	60	36%
		V	13	80	32%
		Y1	11	43	34%
		Y2	8	50	31%
	1	All	35	46	40%
		V	11	62	37%
		U	1	100	
		Y1	20	38	40%
		Y2	2	14	20%
		W	1	17	
	2	All	33	55	41%
		V	13	87	26%
		Y1	13	33	39%
		Y2	7	37	31%

TABLE III

Sealant penetration based on fissure type in
bur group

Group	ICDAS	Fissure Type	Number	Mean ± SD	
Bur	0	All	45	84	31%
		V	13	74	43%
		U	7	100	0%
		Y1	20	86	28%
		Y2	5	77	23%
	1	All	48	63	38%
		V	25	82	31%
		U	2	71	41%
		Y1	15	43	39%
		Y2	6	33	11%
	2	All	36	68	35%
		V	25	75	31%
		U	3	100	0%
		Y1	6	43	30%
		W	2	10	14%

TABLE IV

Sealant penetration based on fissure type in control group

Group	ICDAS	Fissure Type	Number	Mean ± SD	
Control	0	All	52	75	38%
		V	24	86	30%
		U	9	89	33%
		Y1	8	54	44%
		Y2	7	39	30%
		W	4	75	50%
	1	All	55	65	41%
		V	21	87	28%
		U	3	100	0%
		Y1	26	47	41%
		Y2	3	37	37%
		W	2	50	71%
	2	All	35	55	39%
		V	15	76	34%
		Y1	12	34	34%
		Y2	1	14	
		W	7	51	42%

DISCUSSION

In the area of preventive dentistry, many dental materials are used for the prevention of dental caries. In the last few decades, more efforts have been directed toward the prevention of caries through the use of plaque control, fluoride, and dental sealants. Fluoride is economical and effective in reducing caries[48] but the effect of fluoride is least on pits and fissures. When applied to deep, caries-prone fissures, pit-and-fissure sealants penetrate and protect vulnerable areas from the oral environment.[49] Bacteria in deep pits and fissures, and the incidence of caries are reduced after the placement of sealant.[49]

It is well-known in the literature that sealants should be placed on early (non-cavitated) carious lesions in children, adolescents, and young adults to reduce the percentage of lesions that progress. Keeping this aim in the present study, a ¼ round tungsten carbide bur, and air abrasion with 50-um aluminum oxide were used for the first time. Not much work has been done comparing round bur and air abrasion techniques on sound enamel and different incipient caries levels using ICDAS codes 0 through 2.

Our study results showed no significant differences in the sealant penetration among the groups of bur, air abrasion, and control. This was similar in result to the study by Selectman et al., who concluded that the surface preparation, such as air abrasion or pumice prophylaxis, does not play an important role in sealant penetrability.[50] Also, the results were partially similar to those of Chan et al.,[44] who concluded that air abrasion demonstrated better marginal seal. The possible explanation was that prophylaxis with a rubber cup or a pointed bristle brush with pumice does not adequately clean fissures to

allow the etchant to produce a surface area as receptive to bonding as the other methods evaluated. Further, the present study had partially similar results to two studies in which 37-percent gel phosphoric acid was used. They found no difference in sealant penetration after preparing the enamel surface with different viscosity of phosphoric acid.[31] The second study found that pits and fissures filled with sealants did not differ with the use of various fissure cleaning methods.[30]

On the other hand, a study done by Pope et al.[37] had contradicting results. Their study concluded that use of a 0.5-mm round bur revealed very deep penetration of the sealant into the etched enamel, and when compared with other fissure preparation such as rubber cup or pointed bristle techniques, the bur did not produce an enamel surface for deeper sealant penetration. A similar study concluded that the invasive technique of using a ¼ round bur had better marginal adaptation compared with non-invasive techniques, and this proved the importance of preparation before placement of sealants.[51] A possible explanation for sealant adaptability is that sealant easily penetrates into the enlarged artificial fissures and adheres to the walls resulting in better retention. Another possible explanation by Shapira et al.[52] was that the bur widens and deepens the fissure by eliminating organic material, plaque, and a very thin layer of enamel resulting in a thicker layer of sealant with better retention. Craene et al.[51] in their study compared six types of burs: four various design diamond burs and two steel round burs. They concluded that pointed tip burs create less damage to tooth structure and open the fissure without weakening the tooth. Also, the present study compared the sealant penetration among ICDAS Group 0, 1, and 2, and we concluded that ICDAS code 0 has a significant effect on sealant penetration compared with the ICDAS code 1 and 2. ICDAS Code 0

specimens showed an average of 56-percent sealant penetration, whereas ICDAS 1 and 2 came up with averages of 40 percent and 43 percent, respectively.

Sealants are retained onto the tooth micromechanically. The resin tag forms into the porosity created by the phosphoric acid.[15] In spite of ideal conditions during sealant application, it has been reported that there is 5-percent to 10-percent sealant failure per year.[53] Microleakage is defined as clinically undetectable passage of oral fluids. Although microleakage by itself is not the cause for caries progression, microleakage in the areas of plaque accumulation and significant gap size could lead to demineralization of the tooth. Also, oral bacteria are an important concern because they can lead to carious lesions, and consequently the failure of the preventive procedure.[48] A variety of fissure preparation methods have been studied to successfully reduce sealant/enamel interface microleakage, and to improve sealant penetration. In the present study, no microleakage (code 0) was measured in 196 tooth sections of a total of 371 tooth sections examined, and 171 tooth sections had microleakage (code 1). From the results obtained in our study, it was concluded that the air abrasion group with 50-µm aluminum oxide had a higher percentage of microleakage (71 percent) when compared with the bur group (38 percent) and the no-preparation technique (37 percent). The possible reason for higher microleakage could be that the air abrasion technique altered the characteristics of the enamel. But, our results contradicted the findings of Guirguis et al., who concluded that air abrasion alone, without etching, was associated with the greatest degree of microleakage, and that teeth etched in conjunction with abrasion treatment showed the highest number of tag formations.[54] The reduced microleakage reported in their study

was attributed to roughness created by the abrasion, and the larger area available for adhesion.

In the study done by Chan et al.[44] mechanical preparation of fissures with burs is believed to provide certain advantages, such as removal of surface demineralization, creating a higher retention rate, and reducing the risk of microleakage. This could be the possible explanation for less microleakage in the bur group of their study.

Regardless of the groups of air abrasion, bur, and control, in the present study, the ICDAS code 0 had less microleakage when compared with ICDAS codes 1 and 2. One possible explanation for the smaller amount of microleakage following the fissure treatment before sealant placement would be that sound teeth have healthy enamel that create uniform microporosities. This could increase the surface area for retention and adaptability. Teeth with ICDAS codes 1 and 2 could have had plaque, food debris, and demineralized enamel surfaces that would have stymied the creation of uniform microporosities needed for the adhesion of the sealant.[48] Hatibovic-Kofman et al.[40] concluded that bur preparation in conjunction with acid etching was significantly better in terms of reducing microleakage. The possible explanation for this result could be due to preparation depths using the burs. They reported preparing the fissure to the approximate diameter of a ¼ round bur.

On the other hand, Dughanthip et al.[48] and Blackwood et al.[55] found no significant difference in the microleakage when using air abrasion and fissure enameloplasty as the pretreatment methods.

Further, in our study group, ICDAS codes and fissure types had no significant effect on the bubbles formed during the sealing placement procedure.

SUMMARY AND CONCLUSIONS

This *in-vitro* study was conducted to evaluate which of the fissure pretreatment methods is more effective in penetration and retention of dental sealant on different incipient caries levels as classified by ICDAS codes 0, 1, and 2.

In this study, resin-based dental sealants were used to place on the occlusal surfaces of human extracted molars. One hundred and thirty-five specimens were used and randomly divided into three divisions of 45 teeth each. Then, the three divisions were subdivided into three groups of 15 teeth each according to the ICDAS codes of 0, 1, and 2. The first division of 45 teeth was treated by air abrasion with 50-µm aluminum oxide on each fissure for 5 seconds at a constant pressure of 50 psi, at a distance of 2 mm to 5 mm from the occlusal surface to the tip of the nozzle of the unit. The second group of 45 teeth was treated with a ¼ tungsten carbide round bur with a slow-speed handpiece on the area of interest by keeping the depth and width of the bur as a standard in the treatment. The third group of 45 teeth was used as the control, and received no treatment. All three groups were etched for 15 seconds with the 37-percent phosphoric acid, rinsed, and air dried with an air water syringe. The resin-based opaque dental sealant was placed on the conditioned, occlusal surface and light-cured for 30 seconds. All specimens were thermocycled for 5000 cycles; two parallel cuts were made following the marks on the occlusal surfaces along the bucco-lingual direction. The images of cut sections were taken under Nikon SMZ microscope. Using ImageJ software, the cut sections were analyzed for sealant penetration in the fissure and microleakage at the enamel-sealant interface. The analyses were performed on a transformation of the sealant penetration

percentage commonly used for calculated percentages: $\sin^{-1}(p^{1/2})$. The effects of group, ICDAS, and fissure type on sealant penetration percentage were compared using ANOVA. The effects on microleakage and bubbles were compared using GEE methods applied to logistic regression. The effects on dye penetration were compared using GEE methods applied to cumulative logistic regression to account for the ordered categories of the dye penetration scale. In the results of this study, group (air abrasion, bur, and control) did not have a significant effect on sealant penetration (p = 0.195). ICDAS had a significant effect on sealant penetration (p = 0.0113): The effects were greater in the code 0 group than for codes 1 and 2. Fissure type (U, V, Y and W) had a significant effect on sealant penetration (p = 0.0001): Type V and U had greater effects than Y1, Y2, and W (Tables II and III).

MICROLEAKAGE

Group had a significant effect on microleakage (p = 0.0004). The air abrasion group had greater microleakage than the bur and control groups. ICDAS codes had a significant effect on microleakage (p = 0.0022). Microleakage was less in the code 0 group than in the groups for codes 1 and 2. Fissure type did not have a significant effect on microleakage (p = 0.721).

CONCLUSIONS

1) No significant differences in sealant penetration of ICDAS codes 0 through 2 were noted among the three treatment groups after using different fissure treatments.

2) A significant difference in sealant penetration was found between ICDAS code 0 with codes 1 and 2 regardless of fissure treatment.

3) Fissure morphology had a significant influence on the sealant penetration, though it was not a factor for microleakage.

4) The use of air abrasion in combination with acid etching did significantly increase the microleakage compared with the bur and control groups. In other words, the technique of air abrasion combined with acid etching is not better at preserving the tooth surface from microleakage.

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ABSTRACT

EVALUATION OF TWO METHODS OF FISSURE TREATMENT

BEFORE SEALANT PLACEMENT ON

DIFFERENT CARIES LEVELS

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Occlusal pits and fissures are ideal places for caries development. Placement of

dental sealants has been reported to be effective in preventing this process. However, the

effectiveness of dental sealants has been reported to be influenced by clinical factors,

such as preparation and placement techniques. A report recently published by the

American Dental Association on the clinical recommendations for use of pit-and-fissure

sealants included critical evaluation and a summary of relevant scientific evidence on the

use of sealants aimed at assisting clinicians. The report addressed concerns such as:

Does placing sealants over early (noncavitated) lesions prevent progression of the

lesions? Are there any techniques that could improve sealants' retention and

effectiveness in caries prevention? The investigators concluded that there is limited and

conflicting evidence to support that mechanical preparation with a bur results in higher

retention rates in children and recommend that pit-and-fissure sealants should be placed

on early (noncavitated) carious lesions. The purpose of this *in vitro* study was to evaluate

two methods of fissure treatment before sealant placement on different caries levels. In

this study, 135 extracted human molars (ICDAS codes 0 to 2) were collected and ranked

by a calibrated examiner into three groups. These were further divided into three sub-

groups (nine total). Occlusal surfaces were prepared with: 1) a ¼-mm round bur, 2) air

abrasion, and 3) no treatment as a control. All groups were etched with 3.0- percent

phosphoric acid for 15 seconds, rinsed thoroughly, and dried with an air water syringe.

Opaque dental sealants were placed on the etched occlusal surfaces according to the

accepted clinical standards and light-cured for 30 seconds. All groups were

thermocycled for 5000 cycles. The roots of the teeth were painted with nail varnish, root

apices were sealed with wax, and the occlusal surfaces were immersed in 1.0-percent

methylene blue for a full 24 hours. The next day the teeth were cleaned, and the roots

were sectioned to expose the crowns. Crowns were cut along the occlusal surfaces in the

buccolingual direction. The sectioned surfaces were examined under the Nikon SMZ

1500 microscope for sealant penetration in the fissure and microleakage along the sealant

enamel interface. The analyses were performed on a transformation of the sealant

penetration percentage commonly used for calculated percentages: $\sin^{-1}(p^{1/2})$. The

effects of the type of group, the ICDAS code, and the fissure type on sealant penetration

percentage were compared using ANOVA. The effects on microleakage and bubbles

were compared using GEE methods applied to logistic regression. The effects on dye

penetration were compared using GEE methods applied to cumulative logistic regression

to account for the ordered categories of the dye penetration scale. In the findings of

sealant penetration, the group type did not have a significant effect on sealant penetration

(p = 0.195). ICDAS codes had a significant effect on sealant penetration (p = 0.0113)

where ICDAS Code 0 had greater penetration than ICDAS codes 1 and 2. Fissure type

had a significant effect on sealant penetration (p = 0.0001) where fissure types V and U

had greater sealant penetration than Fissure types Y and W. In the findings of micro-

leakage, the type of group had a significant effect on microleakage (p = 0.0004) where

the abrasion group had increased microleakage as compared with the 1/4 round bur and

control groups. ICDAS code had a significant effect on microleakage (p = 0.0022) where

ICDAS code 0 had less microleakage as compared with ICDAS code 1 and 2. Fissure

types V, U, Y, and W did not have a significant effect on microleakage (p = 0.721).

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