Effect of Sono-abrasion in the Microleakage of a Pit and Fissure Sealant

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Purpose: To assess the microleakage of a pit and fissure sealant after preparing enamel with sono-abrasion, used alone or associated with acid etching. This technique was compared with classical enamel preparations i.e. acid etching and diamond bur associated with etching.

Materials and Methods: Ninety 3rd molars were used. In the mesial halves, the fissures were prepared with sono-abrasion and acid etching for 15 seconds. Then, the samples were randomly assigned to three groups of 30. They were either treated with acid etching alone (group 1), widened mechanically with a bur and etched for 15 seconds (group 2) or prepared with sono-abrasion alone (group 3). Then, the resin-based sealant was applied according to the manufacturer's recommendations. The teeth were thermocycled and placed in a 1% solution of methylene blue. The teeth showing microleakage and the means of infiltration were assessed with an image analysis system.

Results: The poorest results were obtained with sono-abrasion alone which showed a greater number of specimens with microleakage (73.3%) ($p < 0.001$). They also showed the highest mean of microleakage (0.85 ± 0.79 mm vs 0.1 ± 0.26 for acid; 0.35 ± 0.85 for bur associated with etching $p < 0.0001$); and 0.19 ± 0.45 for sono-abrasion associated with etching.

Conclusion: No significant difference was noted between the three types of enamel preparation using etching. Sono-abrasion can be used for preparing dental enamel prior to sealing the tooth but it does not eliminate the need for etching.

Key words: sealant, sono-abrasion, microleakage, SEM

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Sealants prevent caries (Mertz-Fairhurst, 1984; Ripa, 1985; Borem and Feigal, 1994) by forming a physical barrier between the surface of the tooth and the oral environment, therefore preventing initiation of dental caries lesions. According to the NIH consensus statements, with respect to sealing in decay, there is no evidence that placing a sealant over 'small lesions' results in progression of decay. Rather, it appears that enamel carious lesions will not progress if sealed (Going et al, 1978; Mertz-Fairhurst et al, 1986). If a carious lesion is suspected, an invasive technique is recommended (Nunn et al, 2000). This technique has been suggested to provide better results because it widens and deepens the pits and fissures, eliminates organic material and plaque, and exposes a more reactive tooth enamel, therefore enabling a thicker layer of sealant (Garcia-Godoy and de Araujo, 1994; do Rego and de Araujo, 1996). This 'invasive' technology, has already been tested with diamond or carbide bur both *in vitro* (De craene et al, 1988; Seppa and Forss, 1991; Garcia-Godoy and de Araujo, 1994; Xalabarde et al, 1998; Theodoridou-Pahini et al, 1996; Zervou et al, 2000; Geiger et al,

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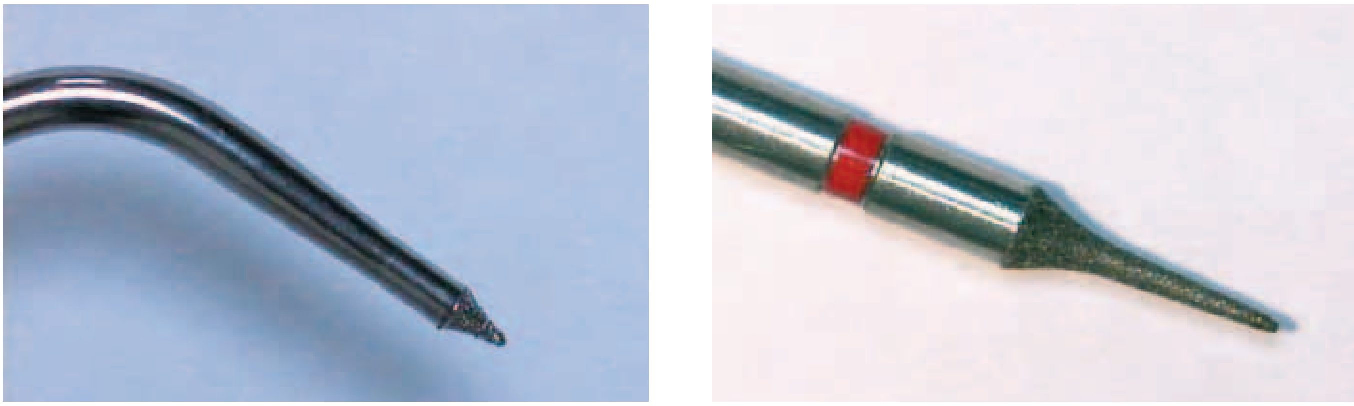


Fig 1 Material: Bur and sono-abrasive tip used. Tapered fissure diamond bur used for enlarging occlusal fissures prior to sealant application in the Komet prophylactic kit. The sono abrasive tip n° DS 062 A, was especially designed to prepare occlusal fissures. Its working part reaches 1.8 mm, as measured by our image analysis system. It works in a contact mode, directly in the fissure.

2000; Salama and Al-Hammad, 2002) and *in vivo* (Lygidakis et al, 1994; Shapira and Eidelman, 1986; Garcia-Godoy and de Araujo, 1994). Recently it has been studied with different technologies proposed for enamel preparation such as air-abrasion (Zyskind et al, 1998; Chan et al, 1999; Wright et al, 1999; Kanellis et al, 2000; Hatibovic-Kofman et al, 2001; Blackwood et al, 2002; Salama et al, 2002; Lupi-Pegurier et al, in press) or laser (do Rego et al, 1999; Walsh, 1996; Borsatto et al, 2001; Lupi-Pegurier et al, 2003).

Although sono-abrasion is mainly used for minimal preparation of approximal surfaces (Wicht et al, 2002; Krejci et al, 1998; Hugo, 1999), it could also be used in the preparation of pits and fissures before sealing. However, no study has previously been published concerning this topic and it was found interesting to assess the possible contribution of sono-abrasion in this field of preventive dentistry. The purpose of this study was to assess the microleakage of sealants placed after sono-abrasion followed, or not, by acid etching, and to compare its performance with that obtained after classical enamel preparations; acid etching alone; or mechanical widening of fissures with a diamond bur associated with acid etching.

MATERIALS AND METHODS

Preparation of Specimens

Ninety 3rd molars, newly erupted, were collected and stored in distilled water at 4°C. Each tooth was brushed, cleaned with distilled water at room temperature and carefully examined before the preparation procedure to ensure they were free of caries or other macroscopic defects. Occlusal surfaces were polished using a low-speed handpiece and a brush without pumice.

In the mesial halves of the 90 teeth, the fissures were prepared with a sono-abrasion apparatus (Piezzon® 400 (EMS, Nyon, Switzerland)) (Fig 1). Then, the samples were conditioned with a 37% gel of acid etching (H_3PO_4, 3M Dental Products, St Paul, MN, USA) for 15 seconds, thoroughly rinsed for the same time and dried with oil-free air until chalky white. Then, the teeth were randomly assigned to three groups of 30 each (Fig 2). In group 1, the fissures in the distal halves were only etched for 15 sec. In group 2, the distal fissures were widened mechanically with a diamond bur (KOMET: kit 4279, bur # 8392 314 016) (Fig 1). The preparations were confined to the enamel to an approximal depth of 0.5 mm and the fissures were etched for 15 sec. In group 3, the distal halves were treated with sono-abrasion alone, without etching. Then, the sealant (Clinpro® , 3M Dental Products, St Paul, MN, USA) was applied on all the fissures, according to the manufacturer's instructions. It was light-cured for 20 seconds (Curing light XL 3000, 3M Dental Products, St Paul, MN, USA). Hardening and retention of all sealants were tested with an explorer. Immediately after curing, the teeth were placed in distilled water for 24 hours and thermocycled (500 x, 5°C – 55°C, dwell time 30 seconds, Thermocycler 60 Biomed, Munich, Germany). The apices were sealed with composite resin (Z100, 3M

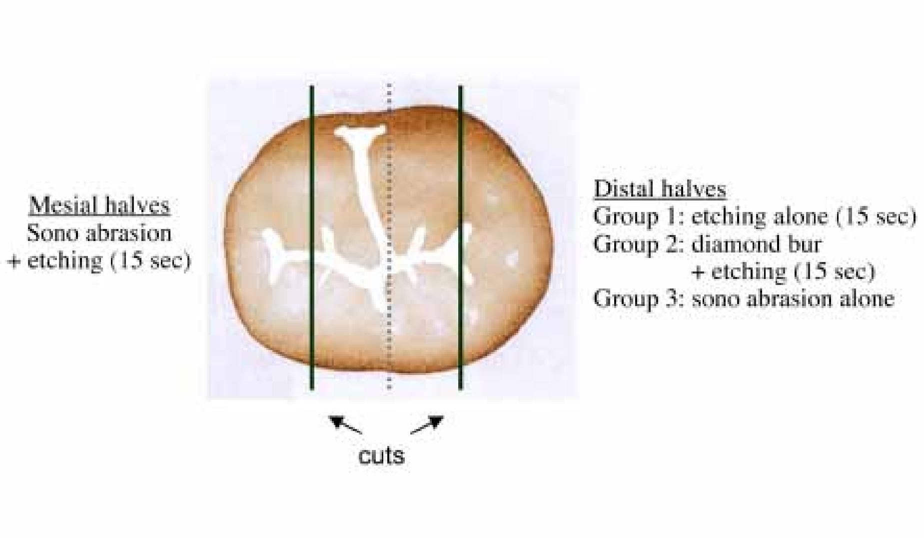


Fig 2 Method for the preparation of specimens. The interrupted line indicates the line of demarcation between the sono-abrasion and etching prepared (left) and the other prepared part (right) of the occlusal surface.

Dental Products, St Paul, MN, USA) and the samples were coated with two coats of an acid-resistant varnish (V33, Domblans, France) to prevent dye penetration, everywhere except for over the sealant and leaving a 1 mm rim of the tooth structure surrounding it. The samples were immersed in a 1.0% methylene blue solution, and stored for 24 hours. They were rinsed with tap water and embedded into clear casting epoxide resin (Buehler® Ltd., Lake Bluff, IL, USA). Finally, they were sectioned in the middle of each half, in the bucco-lingual direction using a low-speed water cooled diamond saw (Isomet® , Buehler Ltd., Lake Bluff, IL, USA) (Fig 2).

Microleakage Measurements

The extent of microleakage was assessed with a digital image analyzer (Color video camera CCD-IRIS Sony, Japan; 50 mm macro lens, Olympus, Japan) using the Visilog 5.3 program (Noesis, Saint-Laurent, Quebec, Canada). The microleakage was observed on blind coded samples after the imaging system was calibrated to a millimeter ruler. Methylene blue penetration at the enamel-sealant interface was recorded in millimeters. The mean value of the penetration observed in the two interfaces was used for statistical analysis providing one sole value of penetration for each kind of enamel treatment.

SEM Observations

In order to assess the effect of sono-abrasion with and without etching on the enamel surface in the pits and fissures, an approximal surface of a mandibular molar was cross-prepared. It was dried in an oven at 37°C, sputter-coated with gold and examined by SEM (Jeol LV 2003, Jeol Ltd, Tokyo, Japan). The 4 surfaces were photographed at a magnification factor of x3500 for all the specimens.

Statistical Analysis

Qualitative data (presence of microleakage, or not) were subjected to McNemar test for qualitative paired data for comparisons within the same groups. Chi-square test was used to compare the percentage of teeth showing microleakege between the different groups. Quantitative data (microleakage, expressed in mm of dye penetration) were compared inside the same groups (paired samples t-test) and between groups (ANOVA-Bonferroni test). The significance level was set at 0.05. The SPSS 11.0 program was used for all the analyses.

RESULTS

Percentages of Teeth Showing Microleakage

– Comparisons within groups: The sole significant difference in the frequency of microleakage bet-

Table 1 Teeth that showed microleakage, within each group (*McNemar)*

Mesial halves		Distal halves: Group 1 acid alone – Leakage	Group 1 acid alone – No leakage	Group 2 bur + acid – Leakage	Group 2 bur + acid – No leakage	Group 3 SA alone – Leakage	Group 3 SA alone – No leakage
SA + acid	Leakage	4	3	4	3	5	0
	No leakage	1	22	2	21	17	8
p		0.625		0.998		< 0.0001	

SA = Sono-abrasion
L = Leakage

Table 2 Teeth that showed microleakage, between groups (*Chi-square)*

Mesial halves	Group 1 SA + acid	Group 2 SA + acid	Group 3 SA + acid	p
Leakage	7	7	5	
No leakage	23	23	25	> 0.05
Distal halves	**acid**	**bur + acid**	**SA**	**p**
Leakage	5	6	23	
No leakage	25	24	7	< 0.001

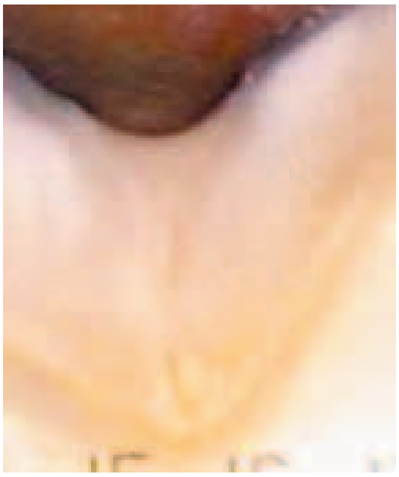
SA = Sono-abrasion

ween the mesial and distal halves occurred in group 3: i.e. sono-abrasion alone (73.3%) versus sono-abrasion associated with acid etching (16.6%). Conversely, in group 1 (16.6% acid alone versus 23.3% SA + acid) and group 2 (20% bur + acid versus 23.3% SA + acid) the number of specimen exhibiting microleakage was comparable (Table 1).

– Comparisons between groups: There was no difference in the frequency of microleakage when the acid etching was performed whatever the preparation (acid alone, bur or sono-abrasion associated with etching). On the contrary, when sono-abrasion was used alone, microleakage was significantly higher (Table 2). Fig 3 shows representative examples of fissures prepared with sono-abrasion.

Means of Dye Penetration

– Comparisons within groups: The microleakage values obtained in groups 1 and 2 showed no significant difference, whereas in group 3 the dye penetration was statistically higher when sono-abrasion was used alone (Table 3).
– Comparisons between groups: When comparing the dye penetration in the mesial halves of each group (Table 3), there was no difference (p = 0.556). This allowed us to give a mean of dye penetration for the 90 teeth prepared with sono-abrasion and acid etching: 019 ± 0.45 mm. On the contrary, the microleakage values after the other kinds of enamel preparation (acid alone, bur associated with acid etching, and sono-abrasion alone), were different (p < 0.0001). The post-hoc



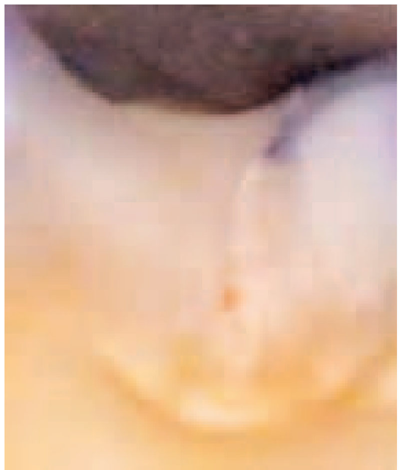


Fig 3 Example of fissures prepared with sono-abrasion. The sono-abrasion tip only affects the entrance of the fissure. Note the characteristic funnel-shaped aspect of the fissure.

No leakage Example of fissure with SA alone. (left)

Leakage Example of fissure prepared with SA + etching. (right)

Table 3 Comparisons intra-groups – Means of Dye penetration (mm) (*t-test for paired data*)

	Group 1		Group 2		Group 3	
	acid	SA + acid	bur + acid	SA + acid	SA	SA + acid
mean	0.096	0.19	0.35	0.24	0.85	0.11
S.D.	0.26	0.42	0.85	0.60	0.79	0.29
p	0.069		0.429		< 0.0001	

SA = Sono-abrasion

tests revealed that sono-abrasion alone showed a significantly higher penetration ($p < 0.05$).

SEM Observations

Compared with the surface obtained after acid etching alone (typical honeycomb appearance), when sono-abrasion alone was performed, the enamel surface looked rough. The surfaces obtained after bur associated with etching and sono-abrasion associated with etching, look like the ones obtained after acid etching (Fig 4).

DISCUSSION

The quest for a perfect sealant is a real challenge, although bond strength is important, microleakage is very important (Borem and Feigal, 1994). In fact, in the presence of any microleakage, the anti cariogenic properties of the sealant are jeopardized and a carious process may begin underneath the sealant (Jensen and Handelman, 1980). Consequently, microleakage is the main factor that affects sealant efficiency (Rudolph et al, 1974; Hicks, 1984). Therefore, the present study evaluated different ways of preparing dental enamel prior to sealing using microleakage since the method of fissure preparation that increases the surface energy seems to be of major importance. The use of a methylene blue dye solution and direct inspection through a camera has been shown to be as informative and reliable as the more elaborate radioactive tracer (Puppala et al, 1996). Quantitative dye penetration measurements were obtained from a special digital analysis system calibrated with a millimeter ruler to estimate the extent of dye penetration. We chose this way of assessing leakage rather than the ranking method used in most studies, to improve the level of precision.

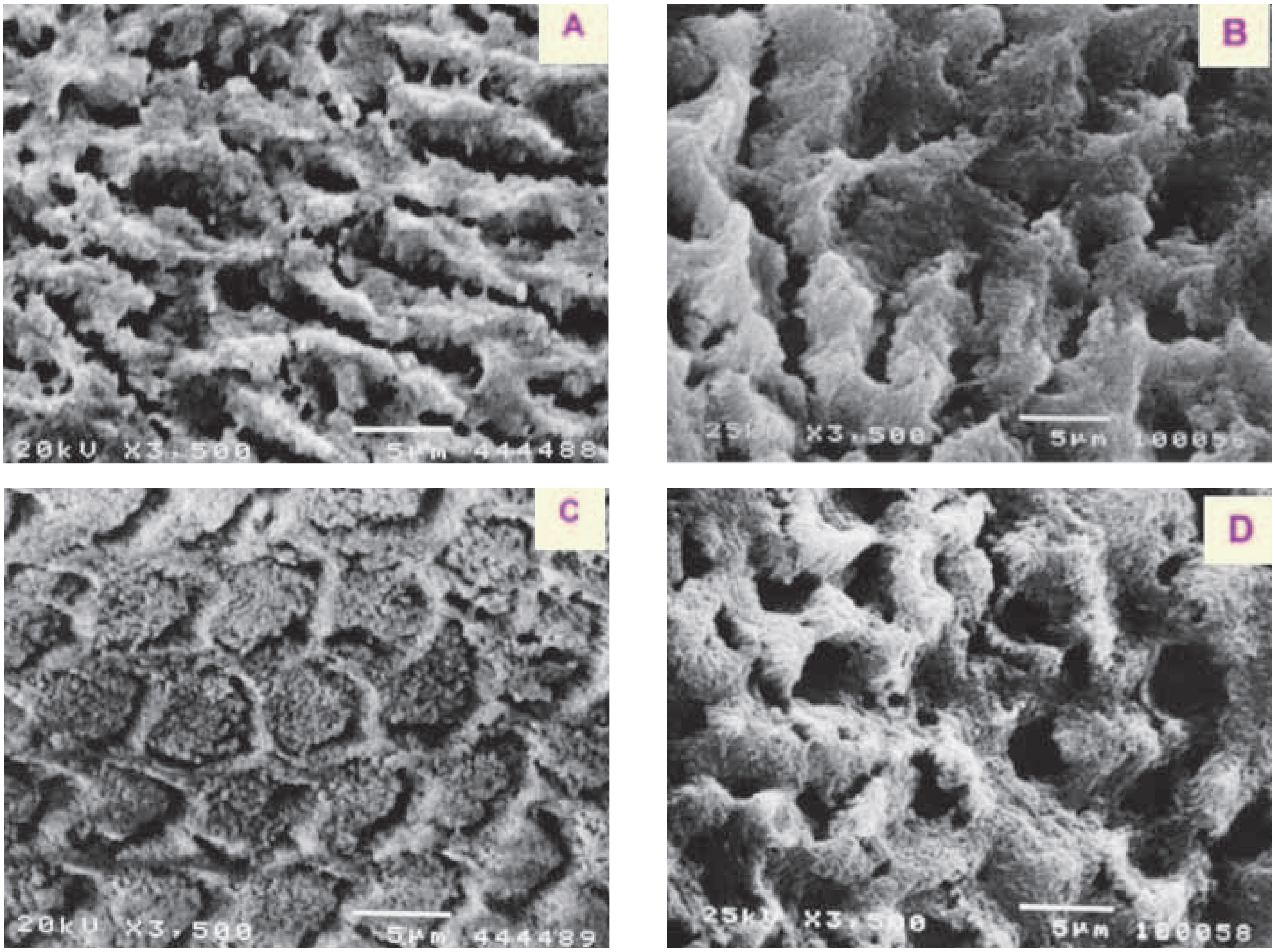


Fig 4 SEM aspect of enamel (X 3500) after different kinds of preparation: A – acid etching alone for 15 seconds; B – sono-abrasion associated with acid etching for 15 seconds, the enamel surface is much more regular than the one obtained after sono-abrasion alone; C – diamond bur associated with acid etching (for 15 seconds), the enamel surface has a typical honeycomb appearance; D – sono abrasion alone, the enamel surface looks rough and disorganized.

Even if several materials for sealing pits and fissures are currently available, we used a single product (Clinpro 3m™), in order to eradicate bias and to facilitate the interpretation of the results. A resin-based material was chosen because special handling requirements, sensitivity to hydration/dehydration, and lack of operator-controlled curing are major drawbacks to using conventional GICs as fissure sealants (Williams and Winter, 1976; Smales, 1981). Moreover, apart from considerations about their potential oestrogenic activity, (Feldman and Krishnan, 1995), the wide use of this type of material, due to convenience of its handling, and to its good clinical record are undeniable pluses (Waggoner and Siegal, 1996).

To avoid inter-teeth variability or confounding factors linked to the teeth themselves, we adopted a special method where each occlusal surface received two different treatments (Fig 4). The mesial half was prepared with both sono-abrasion and etching and the distal half with one of the three other preparations, according to the group. Although various methods of mechanical preparation have been proposed (De Craene et al, 1988; Garcia-Godoy and de Araujo, 1994) regarding currently-available new methods, such as air abrasion, sono-abrasion or laser, the optional clinical procedure is still not well established, and it seemed interesting to test sono-abrasion alone or associated with acid etching.

Examination of microleakage data revealed a significant difference between the etched samples and the non-etched ones. On the contrary, no statistically significant difference could be seen between the 'etched' groups even if there was a trend for better results with sono-abrasion associated with acid etching. Thus, etching of the fissure prior to the application of a resin sealant onto enamel – and particularly onto sono abraded enamel – proved to be advantageous and promote adhesion (Table 1).

The means of methylene blue dye penetration readings in the three groups exhibited the same trend. Again, sono-abrasion associated with acid etching seemed to yield the best results, whereas sono-abrasion alone provided the poorest (Table 3).

Actually, etching produces microscopic porosities in the enamel into which the unpolymerized sealant flows. The sealant hardens in taglike projections that attach the material to the surface of the tooth. Application of the etchant beyond the fissures increases the surface area for resin bonding to the inclined planes of the cusps, where tagging of sealant into enamel is most effective (Gwinnett and Buonocore, 1972). The topography and the free energy of surface, as well as the contact angle at which the liquid meets the adherent surface are factors that affect bonding (Gwinnett and Matsui, 1967). Now, the fissure area itself has been described as deficient in sealant penetration, caused partly by the entrapment of air and the presence of organic debris not removed by standard prophylaxis procedures (Gwinnett, 1976). It could be hypothetized that the smoothing of the fissure enamel and the absence of debris, which could be more easily removed with the sono-abrasion insert might play a central role in increasing sealant adhesion to enamel. Actually, when SEM observations of enamel are conducted, the surfaces prepared with sono-abrasion associated with acid etching look clean and regular. Futher investigations, such as shear bond strength studies, are required to evaluate the eventual improvement of the adhesion quality when using sono-abrasion and etching.

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