Microleakage evaluation of restorations prepared with air abrasion

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Abstract

Purpose: The objective of this in vitro study was to measure and compare microleakage around preventive resin restorations prepared conventionally or with air-abrasion, in the presence or absence of Acid etching.

Methods: One hundred extracted human non carious molars were assigned to each of four groups. Group A: fissures opened with a high speed handpiece, etched, and restored with composite and sealant. Group B: fissures opened with KCP 1000 and restored with composite and sealant. Group C: fissures opened with KCP 1000, etched, and restored with composite and sealant. No adhesive was used for groups A,B, or C. Group D: fissures opened with KCP 1000, adhesive resin was applied, cured, and restored with composite and sealant. All teeth were thermocycled, stained with silver nitrate, sectioned and viewed with a computer linked measuring microscope. Measurements were recorded in relative percentages and absolute millimeters.

Results: One-way ANOVA and two sample independent t-test showed no statistical significance between groups A and C, or between groups B and D. Statistically significant differences were found among groups A and B, groups A and D, groups B and C, and groups C and D (P<0.0001).

Conclusion: The use of air-abrasion alone does not provide adequate sealability of preventive restorations. (Pediatr Dent 21:311-315, 1999)

In 1943, Robert Black introduced a new method of cavity preparation in hopes of finding an alternative to the slow belt driven handpiece. His research led to the development of air-abrasion, which was not only an alternative to the current methods of cavity preparation but could also be used for dental prophylaxis.[1] Subsequently, the Airdent, an air-abrasion machine based on Blacks's original concept, was marketed by the S.S. White Company, in 1953. The lack of vibration, pressure, and unpleasant sounds normally associated with rotary instruments made air-abrasion more acceptable to patients although it was dismissed by practitioners for a variety of reasons.

A new generation of air-abrasion machines are being used today. Several improvements have been added while maintaining the same operating principal. The technique, similar to the one proposed by Black in the 1940's, utilizes kinetic energy from alumina particles propelled by an air stream; hence it is referred to as Kinetic Cavity Preparation (KCP). Seven air-abrasive units are currently marketed: the KCP 1000™ PAC, KCP 1000™, Whisper Jet, KCP 2000™ and KCP 2000™ (Corpus Christi, Texas). Plus by American Dental Technologies Inc. (Corpus Christi, Texas) the Microprep Associate and Director by Sunrise Technologies, and Kreativ by Kreativ.

The effects of air-abrasion cavity preparation on human enamel and dentin has been investigated under scannning electron microscopy (SEM). When compared to high speed burs, air-abrasion produced rounded margins and uniform abrasion with less stress, microchipping, and cracking.[2] Other preliminary investigations explored the effects of the KCP 2000 on bonding of restorative materials to enamel and dentin,[3-9] pulpal response, [10,11] dentin permeability,[12] and microleakage. [13,14]

The relationship between air-abrasion and microleakage has received limited attention. Few studies have examined microleakage of restored teeth prepared with air-abrasion and they have yielded conflicting results. Eakle et al. looked at microleakage in teeth prepared with air-abrasion versus those prepared in the conventional method where the restoration was placed by acid etching enamel and dentin. They concluded that composite and sealants placed in cavities that were prepared using air-abrasion only lacked the seal obtained with acid etching. [13] A similar study by Davis et al. compared microleakage under occlusal sealants prepared with air-abrasion versus acid etching. A non-treatment group served as the control. Their results showed significantly greater microleakage for both the non-treatment and air-abraded specimens when compared to the acid etched group.[15] Conflicting results have been reported by Keen et al. who showed similar degrees of microleakage between bur and air-abrasion prepared specimens.[14] Similarly, a study by Wright et al. found no statistically significant difference in microleakage for teeth acid etched or air-abraded prior to sealant placement.[16]

The manufacturers of the air-abrasive devices claim that their use reduces or eliminates the need for acid etching. It would seem that the degree of microleakage that may result following air-abrasion tooth preparation is still unknown. The objective of this in vitro study was to measure and compare microleakage at preventive resin restorations where the cavity had been prepared conventionally or with air-abrasion, with or without acid etching.

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Methods

A KCP 1000™ Whisper Jet (American Dental Technologies Inc., Corpus Christi, Texas) donated by Patterson Dental for trial use in the Division of Pediatric Dentistry Graduate Clinic was used to carry out the study. One hundred extracted human molars were obtained from the Division of Oral and Maxillofacial Surgery at the University of Minnesota and Metropolitan Oral and Maxillofacial Surgeons clinic in Edina, Minnesota. All teeth included in the study were examined with an explorer and judged to be non-carious. The teeth were thoroughly rinsed and stored in distilled water at room temperature.

All specimens were mounted individually. Once mounted, each sample was arbitrarily assigned a number from one to one hundred. Using a simple, random design, 25 molars were assigned to each group.

The following protocols were used to prepare teeth in each of the four groups:

Group A: A 330 bur in a high speed handpiece was used to open all occlusal fissures. Scotchbond Multipurpose Etchant® (35% phosporic acid) by 3M (St Paul, MN) was applied with a syringe, according to the manufacturer's specification, to the prepared occlusal surfaces for 15 seconds. This was followed by a 15 second rinse ensuring that all etchant had been removed. Each specimen was dried with oil-free compressed air until a chalky white appearance was obtained. Specimens were restored to within 1 mm of the occlusal cavosurface margin with Z100® posterior composite by 3M (St Paul, MN) and cured for one minute. Light cured white sealant, Concise®, by 3M (St Paul, MN) was then applied and cured for one minute.

Group B: Preparations were cut with the KCP 1000 Whisper Jet settings on fine particle (50um) and air pressure of 120 psi as recommended by the manufacturer for etching. The end of the handpiece was held at a distance between 1-5 mm from the occlusal surface. Following the preparation, these specimens were not rinsed or dried, but immediately restored with composite and sealant and the same curing time as in Group A.

Group C: Similar preparations were made with the KCP as in Group B. Following preparation, etchant was applied for 15 seconds, rinsed for 15 seconds and dried with oil-free compressed air until a chalky white appearance was obtained. Specimens were then restored with composite and sealant as in the previous groups.

Group D: Teeth were prepared with the KCP as in group C above. Following preparation, a thin layer of Scothcbond Multipurpose Adhesive Resin® by 3M (St Paul, MN) was applied to the cavities with a brush and cured for 10 seconds according the manufacturer's recommendation. All specimens were then restored with composite and sealant as above. Specimens in all four groups were stored in distilled water at room temperature for future use. Specimens were thermocycled in distilled water a 5° C and 55° C for 500 cycles. Each cycle consisted of 60 seconds at 5° C, 10 second draining time, 60 seconds at 55° C, and a final 10 second draining time.

All specimens were subjected to the silver nitrate staining technique described by Wu et al.[17] The teeth were prepared by sealing the apices with glass ionomer cement. Three layers of nail varnish were applied to within 1 mm of restoration margins. All specimens were immersed in a 50% silver nitrate solution for two hours in a dark room. Then, they were individually rinsed with distilled water for one minute and placed in a photodeveloping solution under fluorescent light for six hours. After staining and developing, all specimens were sectioned bucco-lingually into three sections. This provided eight interfaces for examination (Fig 1). Cut surfaces were then examined by an independent evaluator blind to the conditions of the study with the use of an Olympus SZH10 (Tokyo, Japan) stereomicroscope under 120X magnification. Using Optimas Version 4.1 (Edmans, Washington), an image analysis program, the examined sections were reflected onto a computer screen. Measurements were then recorded in both absolute millimeters and relative percentages, as judged by the evaluator.

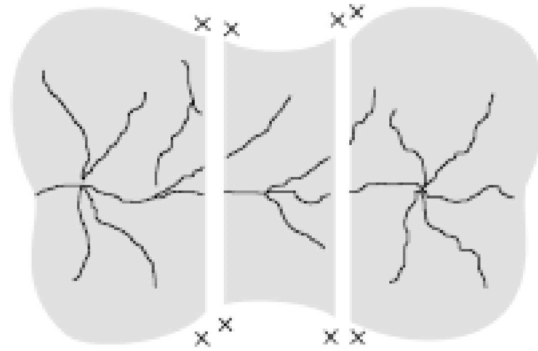
Fig1. Sectional cuts made for the purpose of microleakage measurements. X=indicates points of measurements which totaled eight per tooth.

The extent of dye penetration was measured linearly along the tooth-restoration interface. All measurements were taken from the junction of tooth-sealant interface to the first point of termination. One-half the total dimension was assigned to the buccal and lingual portions in those specimens that showed 100% microleakage bucco-lingually. Eight measurements were recorded for each specimen, four buccal and four lingual, and averaged per specimen. These values were then pooled for each group and their mean values were expressed in both absolute millimeters and in relative percentages.

Intra-rater reliability was analyzed by calculating intra-class correlation coefficients from data obtained in a pilot project. One-way analyses of variance (ANOVA) were performed to determine if differences existed among the means of the four

Table 1. Two Sample Independent *t*-test Comparisons Among the Various Groups for Measurements in Absolute Millimeters

Group Comparison	DF	*t*-value	Significance (two-tail)
A vs. B	48	-7.15	<0.0001
A vs. C	48	1.03	0.308
A vs. D	48	-12.83	<0.0001
B vs. C	48	7.51	<0.0001
B vs. D	48	-1.08	0.284
C vs. D	48	-13.72	<0.0001

Table 2. Two Sample Independent *t*-test Comparisons Among the Various Groups for Measurements in Relative Percentage

Group Comparison	DF	*t*-value	Significance (two-tail)
A vs. B	48	-7.09	<0.0001
A vs. C	48	1.08	0.286
A vs. D	48	-11.99	<0.0001
B vs. C	48	7.56	<0.0001
B vs. D	48	-1.33	0.189
C vs. D	48	-12.98	<0.0001

experimental groups. Two sample independent group *t*-tests were used to compare the mean values between groups A, B, C, and D.

Results

Intraclass correlation coefficients for both millimeter and percentage measurements were both 0.99, indicating good reproducibility. The correlation coefficient between linear millimeter and relative percentage measurements was calculated to determine if absolute millimeter and relative percentage measurements yield similar results. The overall average for specimens was 0.97 ($P<0.001$) indicating that, in spite of variation in preparation size, linear millimeter measurements accurately reflected the degree of microleakage between the different groups.

The linear microleakage data shows the extent of both in absolute millimeters and relative percentage for all groups. Tables 1 and 2 show the results for the various two sample independent *t*-tests among the various groups. There were statistically significant differences among the mean values of the four treatment groups for both millimeter and percentage measurements.

The least microleakage was observed in Group A (0.23±0.2 mm; 6±7.0%) and Group C (0.19±0.1mm; 5±3.0%) and the highest amount in Group B (1.54±0.9 mm; 47±28.0%) and Group D (1.77±0.6 mm; 56±20.0%) (Figures 2-7). The observed mean value in Group C was lower than Group A, but the difference was not statistically significant ($P=0.308$, $P=0.286$). Similarly, the observed mean value for group D was higher than Group B although the difference was not statistically significant ($P=0.284$, $P=0.189$).

Statistically significant differences were found comparing Group A versus Group B; Group A versus Group D; Group B versus Group C; Group C versus Group D (all $P<0.0001$).

Discussion

The goal of this study was to determine if restorations placed in teeth prepared with air-abrasion alone have similar sealing properties when compared to conventional acid etched restorations. This was evaluated by assessing the extent of microleakage along the tooth-restoration interface among specimens treated with air-abrasion alone and those treated using conventional techniques. In addition, the effects of air-abrasion in conjunction with either acid etching or an adhesive bond was examined in a similar fashion to determine if any added advantage may be observed.

The results of our study indicate that the greatest degree of microleakage was found in those specimens treated with air-abrasion alone or in conjunction with an adhesive resin. We noted significantly less microleakage in specimens that were acid etched regardless of whether the mode of preparation used a conventional or air-abrasion technique.

There was a significant difference in the degree of microleakage observed between specimens treated with air-abrasion alone versus those that were acid etched regardless of other variables. Air-abrasion by itself did not provide as adequate a seal when compared to acid etching. One possible explanation may be the difference in type of etching patterns or number of resin tags formed resulting from each method. A study by Brockman et al. investigated the effects of air-polishing on enamel by examining the number and pattern of resin tag formations.[18] They also investigated the tensile bond strength of sealants applied to enamel surfaces pretreated with an air-polisher.[19] Both investigations compared the effects of air-polishing with or without etchant to conventional techniques. They concluded that air-polishing alone resulted in many smooth areas with less tag formation. This explains the significantly lower tensile bond strength values yielded with air polishing. However, air-polishing in conjunction with acid etching resulted in the highest number of tag formations and tensile bond strength values. Overall greater numbers of resin tags yielded higher bond strength values and vice versa.

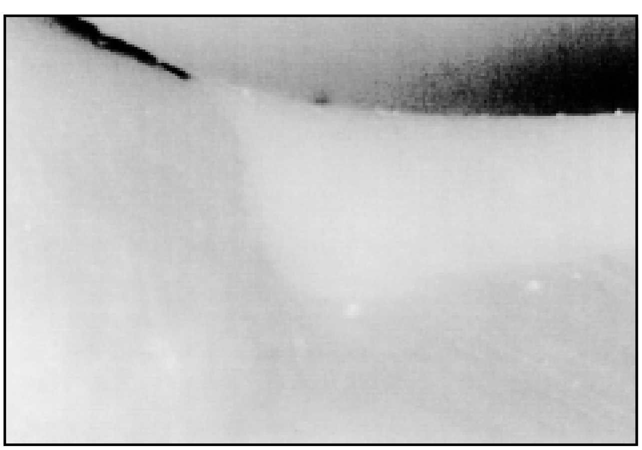

Fig 2. A representative sectional cut from Group A.

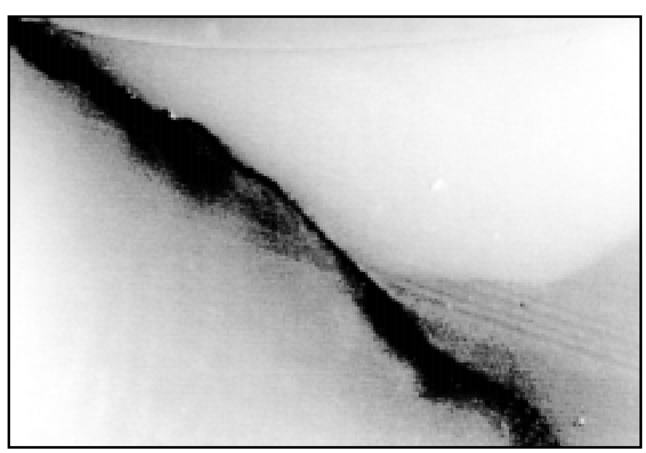

Fig 3. A representative sectional cut from Group B.

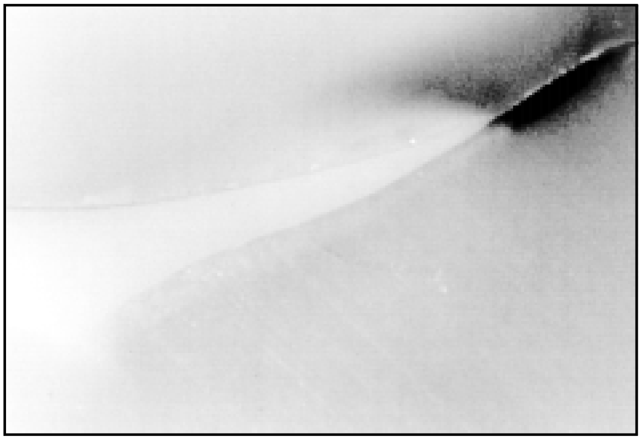

Fig 4. A representative sectional cut from Group C.

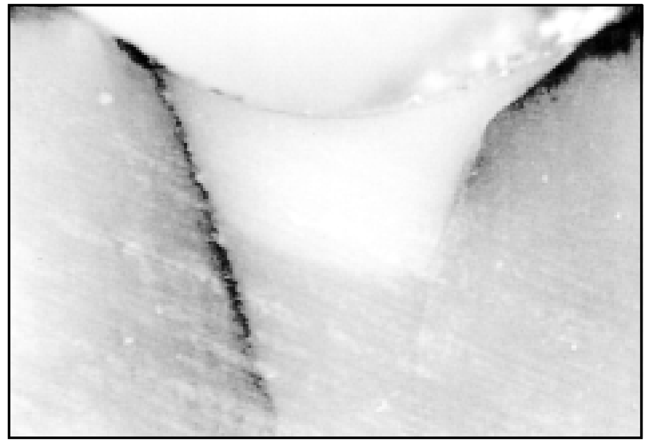

Fig 5. A representative sectional cut from Group D.

A recent study by Brown et al. yielded similar results.[20] They compared the effects of enamel pretreated with air-abrasion on sealant shear bond strength using sodium bicarbonate or aluminum oxide alone or in conjunction with acid etching. Higher shear bond strengths were obtained when air-abrasion was used in conjunction with acid etching. The lowest bond strengths were seen with the use of air-abrasion alone.

Despite different methodologies in these investigations, the results support our findings. The prophy jet used to carry out the investigations by Brockman et al. and Brown et al. used sodium bicarbonate in a water slurry instead of aluminum oxide. Nonetheless, both elements have been shown to have similar effects on enamel. We speculate that the present findings were due to differences in the number of tags formed and/or etching pattern, which in turn influenced the bond strength obtained with the various pretreatment methods. The number of tags formed and the quality of enamel/resin interface have an effect on the degree of microleakage observed.

Previous studies have shown that the use of a bonding agent enhances the interface between tooth and resin when used with acid etching.[21] Roeder et al. investigated the effects of a bonding agent used in conjunction with air-abrasion on the tensile bond strength of composite to air-abraded enamel. Their results showed higher bond strength when a bonding agent was used.[22] We speculated that by including a group in our study in which specimens were treated with an adhesive resin in conjunction with air-abrasion, the resin may decrease microleakage. Our results, however, showed no added beneficial effect. This is likely due to the minimal etching effects of air-abrasion.

Variations in preparation size were dictated by varying depths of pits and fissures for each tooth sample. This variation in preparation size, if not controlled for, would have influenced the area of observed microleakage. To eliminate possible errors due to the variation in restoration size, relative percentage measurements were assigned by the evaluator. The correlation coefficient between millimeter (linear measurements) and percentage measurements was high (0.97) indicating that linear millimeter measurements also accurately reflected the degree of microleakage between the different groups in this study.

Other preliminary studies have shown variation in tensile bond strength with variation in air pressure and particle size. Their relationship to microleakage is unclear. Additionally, studies have yet to establish the specific type of etch pattern obtained with air-abrasion and how it differs from acid etching. Further studies should also determine if any differences exist in etch pattern and resin tag formation with various particle sizes and air pressures.

Other important aspects of air-abrasion have yet to be examined. One issue that has raised much concern in the dental community is the excessive dust associated with the operation of most air-abrasion machines. During the course of this study adequate control of dust was an ongoing challenge. Despite the fact that aluminum oxide is considered harmless and used in a variety of products ranging from whitening toothpastes to polishing wheels, repeated exposure may have some adverse respiratory effects. It would be beneficial to examine the effects of repetitive exposure to aluminum oxide particles on the health of both the practitioner and the patient.

Conclusions

1. Significant microleakage was observed in all non-etched specimens prepared with air-abrasion.
2. A minimal degree of microleakage was observed in all acid etched specimens prepared with either air-abrasion or conventional techniques.
3. The application of adhesive resin did not reduce microleakage in specimens treated with air-abrasion alone.
4. If air-abrasion is used, it should be used in conjunction with acid etching.
5. The findings of this study do not support the manufacturer's claims which state that the use of air-abrasion reduces or eliminates the need for acid etching.

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Abstract of the Scientific Literature

Long Term Effects of Cranial Radiation Therapy

This was a retrospective examination of the long term effects of cranial radiation therapy (CRT) on attention functioning. Fifty-six survivors of childhood leukemia who had been randomly assigned to a treatment regimen of chemotherapy with or without 1,800 cGy CRT were administered a neuropsychological test battery. Significant differences were found between the irradiated and non-irradiated group in focusing, simple tracking, automatic shifting, problem solving, and sustained attention.

Comments: The pediatric dentist often follows these long-term survivors for many years through adolescence and orthodontics. It is most useful to be aware of these findings and understand the ADHD type of behavioral symptoms that these children may exhibit. LPN

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Long term effects of cranial radiation therapy on attention functioning in survivors of childhood leukemia. Lockwood K, Bell T, Colegrove R: J Ped Psych 24:55-66, 1999.