# Comparison of three different preparation methods in the improvement of sealant retention

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*The purpose of this* in vitro *study was to evaluate the effect of three invasive fissure preparation methods in the retention of sealant on the surfaces of permanent molars. One hundred and eight extracted caries-free human molars were used in this study, which were divided into 3 groups according to the fissure preparation: laser, air abrasion and bur. In addition, each of these three groups was further divided into 2 additional groups to isolate those in which a bonding agent would be used from those in which a bonding agent would not be used. After the accomplishment of the different treatments, samples from all the 6 experimental groups were submitted to two different bond strength tests: (i) shear bond strength test and (ii) tensile bond strength test. Bond strengths were determined by the dividing fracture load and a statistical test ANOVA was used to evaluate significant differences. The results showed that laser improved the sealant retention when compared with air abrasion preparation when the bonding agent was used. The use of bonding agent increased the sealant retention in all methods except for tensile bond strength when air abrasion was used as the preparation method.*

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## INTRODUCTION

The occlusal surface of the first permanent molar is the tooth surface most vulnerable to dental decay[1]. The high susceptibility may be attributed to the complex morphology of pits and fissures, which are considered to be (i) an ideal site for the retention of bacteria and food remnants, (ii) a difficult area for film bacterial removal, and (iii) a region with greater concentration of carbonates.

The development of pit and fissure sealant associated with the use of etching agent on the dental surface revolutionized the preventive and restorative dentistry. Since Buonocore's initial proposition of the acid etching technique[2], sealants of various types have been used to prevent occlusal caries[3-4-5-6], including Bis-GMA resins, polyurethane sealants containing inorganic fluoride compounds, and polyacrylate materials.

According to some reports, it is unquestionable that sealants are effective in preventing pit and fissure from developing dental caries[7-8]. The use of a sealant forms a physical barrier between the surface of the tooth and the oral environment.

In spite of sealant materials proven efficacy and relative ease of application, retention, and therefore, longevity, continues to be a challenge. Unfortunately, studies have shown that sealant retention rates decline to 85% after one year, and to 50% after five years[9].

Sealant longevity is not only influenced by the type of sealant, but also by the procedure used for the fissure preparation. The use of an invasive technique before sealant application has suggested higher retention rates[10-11-12]. The purpose of this study was to evaluate the effect of three invasive fissure preparation methods in the retention of sealant on the surfaces of permanent molars.

## MATERIALS AND METHODS

The sample for this *in vitro* study consisted of 108 extracted human permanent molar teeth with no caries. Teeth were stored in a refrigerator in a 0.9% physiological saline solution until required for the study. A caries detector dye was used to confirm that samples were free of caries. According to Al-Sehaibany *et al.*[13] caries detector dye is a reliable diagnostic tool for occlusal carious lesion.

Teeth were cleaned by means of a rubber cup with slurry of pumice. After air-drying, a drop of caries detector dye was applied on the occlusal surface. All teeth were rinsed and dried with oil-free air for 15 seconds. The teeth that had blue stains on the surfaces were not included in this study.

All 108 teeth were mounted in a cylindrical acrylic block and randomly divided into three groups according to the fissure preparation: laser, air abrasion, and bur. In addition, each of these three groups was further divided into two additional groups to isolate those in which a bonding agent would be used from those in which a bonding agent would not be used.

The six final experimental groups had the following characteristics:

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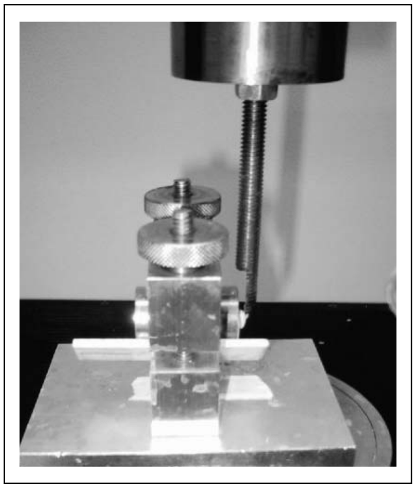

**Figure 1.** Shear Bond Strength Test

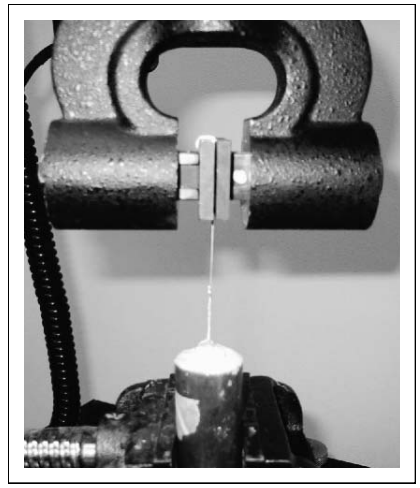

**Figure 2.** Shear Bond Strength Test

*G1-A*: Pits and fissures were prepared using a 1/4 round carbide bur in a high-speed handpiece. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. The sealant Embrace (Pulpdent, Corp.; Watertown, MA, USA) was applied overfilling the fissure and then light cured (20s).

*G1-B*: Pits and fissures were prepared using a 1/4 round carbide bur in a high-speed handpiece. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. An application of bonding agent Excite (Ivoclar Vivadent Inc.; Amherst, NY, USA) was done with a hand-held brush. The sealant Embrace (Pulpdent Corp.; Watertown, MA, USA) was then applied overfilling the fissure and photo cured together with the bonding agent (20s).

*G2-A*: Pits and fissures were prepared using Match 5.0 (Kreativ, Inc.; Albany, OR, USA). It operates using 27.5 mm aluminum oxide particles for 5-10 seconds at 40-60 psi, micropulse™ mode, and beam intensity of 2-4 gm/min. The handpiece measured 0.011 in. in diameter at the tip orifice. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. The sealant Embrace (Pulpdent Corp.; Watertown, MA, USA) was applied overfilling the fissure and then light cured (20s).

*G2-B*: Pits and fissures were prepared using Match 5.0 (Kreativ, Inc.; Albany, OR, USA). It operates using 27.5 mm aluminum oxide particles for 5-10 seconds at 40-60 psi, micropulse™ mode, and beam intensity of 2-4 gm/min. The handpiece measured 0.011 in. in diameter at the tip orifice. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. An application of bonding agent Excite (Ivoclar Vivadent Inc.; Amherst, NY, USA) was done with a hand-held brush. The sealant Embrace (Pulpdent Corp.; Watertown, MA, USA) was then applied overfilling the fissure and photo cured together with the bonding agent (20s).

*G3-A*: Pits and fissures were prepared using the Er,Cr:YSGG laser (Waterlase™ System, Biolase Technology, Inc.; San Clemente, CA, USA). It operates at a wavelength of 2.78 nm and pulse duration of 140 to 200 microseconds with a repetition rate of 20 Hz. The power output can be varied from 0 to 6 watts. The laser energy is delivered through a fiberoptic system with an adjustable air/water spray. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. The sealant Embrace (Pulpdent Corp.; Watertown, MA, USA) was applied overfilling the fissure and then light cured (20s).

*G3-B*: Pits and fissures were prepared using the Er,Cr:YSGG laser (Waterlase™ System, BioLase Technology, Inc.; San Clemente, CA, USA). It operates at a wavelength of 2.78 nm and pulse duration of 140 to 200 microseconds with a repetition rate of 20 Hz. The power output can be varied from 0 to 6 watts. The laser energy is delivered through a fiberoptic system with an adjustable air/water spray. The enamel was etched with 37% phosphoric acid gel (20s) and rinsed with air/water spray (15s). Teeth were then dried with moisture-free and oil-free air. An application of bonding agent Excite (Ivoclar Vivadent Inc.; Amherst, NY, USA) was done with a hand-held brush. The sealant Embrace (Pulpdent Corp.; Watertown, MA, USA) was then applied overfilling the fissure and photo cured together with the bonding agent (20s).

Samples from all the six experimental groups were submitted to two different bond strength tests: shear bond strength test and tensile bond strength test. For the 60 samples submitted to the shear bond strength test, the crowns were separated from the roots with a diamond disc mounted on a low-speed handpiece. The crowns were embedded to acrylic blocks in such a way that the buccal (inferior molar) or the lingual (superior molar) surfaces faced up.

**Table 1.** Descriptive statistics for the shear bond strength test.

| | | Shear Bond Strength (MPa) | | | |
|---|---|---|---|---|---|
| **Group** | **n** | **Mean** | **SD** | **Min** | **Max** |
| **G1.A** | 10 | 13.4 | 5.1 | 7.9 | 24.1 |
| **G1.B** | 10 | 14.2 | 4.2 | 8.3 | 19.1 |
| **G2.A** | 10 | 11.6 | 2.6 | 8.6 | 17.4 |
| **G2.B** | 10 | 17.1 | 5.6 | 7.9 | 26.1 |
| **G3.A** | 10 | 13.7 | 3.9 | 9.2 | 21.6 |
| **G3.B** | 10 | 17.8 | 5.9 | 11.8 | 31.0 |

**Table 2.** Descriptive statistics for the tensile bond strength test.

| | | Tensile Bond Strength (MPa) | | | |
|---|---|---|---|---|---|
| **Group** | **n** | **Mean** | **SD** | **Min** | **Max** |
| **G1.A** | 8 | 77.7 | 7.5 | 66.2 | 87.7 |
| **G1.B** | 8 | 105.7 | 15.1 | 84.5 | 123.7 |
| **G2.A** | 8 | 91.0 | 16.8 | 63.5 | 112.7 |
| **G2.B** | 8 | 93.8 | 18.2 | 71.2 | 114.0 |
| **G3.A** | 8 | 89.4 | 16.6 | 67.3 | 122.3 |
| **G3.B** | 8 | 119.5 | 14.2 | 96.8 | 139.1 |

For the 48 samples submitted to the tensile bond strength test, the tooth root was anchored in the acrylic block in such a way that the occlusal surface faced up. Before the sealant application, a wire was prepared with Cojet System (3M ESPE; St. Paul, MN USA) to obtain a better adhesion between the wire and the sealant. Afterwards, the wire was inserted into the prepared fissure and the sealant was applied and photo cured.

Specimens were stored in a 0.9% physiological saline solution for 24 hours.

The shear and tensile bond strength tests were performed using an Instron machine (Figure 1 and Figure 2), with a cross-head speed of 1mm/min. Bond strengths were determined by the dividing fracture load and were expressed in MegaPascal (MPa).

## RESULTS

Table 1 and Graph 1 show the descriptive statistics for the shear bond strength test. The highest mean shear bond strength value was obtained from G3.B (laser, with bonding agent) and the lowest mean shear bond strength value was obtained from G2.A (air abrasion, without bonding agent).

The statistical analysis was performed with a two-factor ANOVA test to determine the existence of statistically significant differences and a Scheffé test to identify statistically significant differences.

The evaluation of the difference of shear bond strength values among the three different preparation methods showed that there were no statistically significant differences ($P>0.05$), although laser consistently showed a higher mean shear bond strength value.

The evaluation of the difference of shear bond strength values with and without the use of a bonding agent revealed statistically significant differences ($P<0.05$). Generally, a decrease in shear bond strength values was observed in the subgroups where the bonding agent was not used.

Table 2 and Graph 2 show the descriptive statistics for the tensile bond strength test. The highest mean bond strength value was obtained from G3.B (laser, with bonding agent) and the lowest mean tensile bond strength value was obtained from G1.A (bur, without bonding agent).

A statistically significant interaction was verified between the two investigated variables in the samples submitted to the tensile bond strength test. This interaction required the statistical analysis to be performed with independents one-factor ANOVA tests.

The evaluation of the difference of tensile bond strength values among the three different preparation methods showed no statistically significant differences ($P>0.05$) when a bonding agent was not used. However, when a bonding agent was used, the evaluation of the difference of tensile bond strength values among the three different preparation methods showed statistically significant differences ($P<0.05$) between laser and air abrasion preparations. Generally, a decrease in bond strength values was observed in the subgroups where the preparation was done using air abrasion when compared to the subgroups where the preparation was done using laser. No statistically significant difference ($P>0.05$) was found between bur and air abrasion preparations or laser and bur preparations.

The evaluation of the difference of tensile strength values with and without the use of a bonding agent revealed statistically significant differences ($P<0.05$) in the subgroups G1 (bur) and G3 (laser). Generally, a decrease in bond strength values was observed in the subgroups where the bonding agent was not used and when the preparation method was either bur or laser. Although when air abrasion was used, the subgroup where a bonding agent was also used showed mean tensile bond strength higher than in the subgroup where the bonding agent was not used, the difference was not statistically significant ($P>0.05$).

## DISCUSSION

A variety of fissure preparation methods has been used prior to sealant placement in an attempt to successfully maximize retention. Consequently, the search for alternative preparation methods has continued to be a challenge. Many studies reported a better efficiency of sealants when using invasive techniques[14-15]. The parameters directly tested in this study included the method of fissure preparation and the use of bonding agent as an intermediate.

Regarding fissure preparation, there was no significant difference in shear bond strength values among all three preparation methods. This result agrees with findings of Lins *et al.*[16] in which bur and laser preparations were compared. In addition, there was no significant difference in tensile bond strength when a bonding agent was not used. However, a significant difference in tensile strength value was found when a bonding agent was used: laser preparation promoted higher tensile strength value than air abrasion preparation. All other comparisons of tensile strength values when a bonding agent was used showed no significant differences.

According to Cozean *et al.*[17], laser irradiation modifies the enamel surface, improving the bonding forces and promoting a better junction between the bonding agent and the enamel. In line with this result, mean shear and tensile bond strength values in this study were higher for laser preparation than bur preparation. However, the difference was not significant.

The suggestion that a bonding agent has to be placed before the sealant has been regarded as of a debatable value. Some studies have reported that the addition of a bonding agent to the traditional sealant technique has shown an improvement of sealant retention. For instance, results from Dorignac[18] showed that the use of bonding agent under fissure sealants in permanent molars increases the clinical success rate. Tulunoglu *et al.*[19] revealed that the use of an enamel-dentin bonding agent under fissure sealant increased the bond strength and decreased the microleakage. According to Symons *et al.*[20] the use of bonding system could increase the bond strength between sealant and tooth enamel. Hitt and Feigal[21] demonstrated the benefit of adding a dentin-bonding agent between the etched enamel and the sealant as a way of optimizing bond strength in the face of moisture salivary contamination. A recent study by Feigal *et al.*[22] indicated the beneficial effect of single-bottle adhesive systems when used between enamel and sealant. These agents yield half the usual risk of failure for occlusal sealants and one third the risk for buccal/lingual sealants. Finally, studies such as Fritz *et al.*[23] and Choi *et al.*[24] have also confirmed the benefits of bonding agents under sealants on contaminated enamel to increase bond strength.

Those studies' results are in line with results of this investigation which showed that the use of a bonding agent increased shear bond strength values independently of the fissure preparation method used. In the tensile bond strength test a significant difference was found when a bonding agent was employed except in teeth prepared with air abrasion. Although air-abraded teeth showed higher mean tensile bond strength when a bonding agent was used, the difference was not significant.

## CONCLUSION

According to the methods employed and the results obtained in this *in vitro* study, it can be concluded that:

1. Laser preparation improved the sealant retention when compared with air abrasion preparation when the bonding agent was used.
2. The use of bonding agent increased the sealant retention in all methods except for tensile bond strength when air abrasion was used as the preparation method.

## REFERENCES


1. Li SH, Kingman A, Forthofer R, Swango P. Comparison of tooth surface specified dental caries attack patterns in US school children from two national surveys. J Dent Res 72:1398-1405, 1993.
2. Buonocore MG. The simple method of increasing the adhesion of acrylic filling materials to enamel surface. J Dent Res 34: 849-53, 1955.
3. Gray GB. An evaluation of sealant restorations after two years. Br Dent J 186: 569-75, 1999.
4. Weintraub JA. Pit and fissures sealants in high-caries-risk individuals. J Dent Educ 65: 1084-90, 2001.
5. Simonsen RJ. Retention and effectiveness of dental sealant after 15 years. J Am Dent Assoc 122: 34-42, 1991.
6. Waggoner WF, Siegal M. Pit and fissure sealant application: updating the technique. J Am Dent Assoc 127:351-361, 1996.
7. Ripa LW. Sealants revisited: An update of the effectiveness of pit and fissure sealants. Caries Res 27: 77-82, 1993.
8. Wendt L-K, Koch G. Fissure sealant in permanent first molar after 10 years. Swed Dent J 12:181-5, 1988.
9. Council on Dental Materials. Instruments and equipment consensus development conference statement on new sealants in the prevention of tooth decay. J Am Dent Assoc 108: 233-36, 1984.
10. Garcia-Godoy F, De Araujo FB. Enhancement of fissure sealant penetration and adaptation – the enameloplasty technique. J Clin Pediatr Dent 19: 13-18, 1994.
11. Shapira J, Eldeman E. Six-year clinical evaluation of fissure sealants placed after mechanical preparation: a matched pair study. Pediatr Dent 8: 204-205, 1986.
12. Shapira J, Eldeman E. The influence of mechanical preparation of enamel prior to etching on the retention of sealants. J Pedod 6: 283-287, 1982.
13. Al-Sehaibany F, White G, Rainey JT. The use of caries detector dye in diagnosis of occlusal carious lesions. The J Clin Pediatr Dent 20: 293-98, 1996.
14. Feldens, E.G et al. Invasive technique of pit and fissure sealant in primary molars: an SEM study. The J Clin Pediatr Dent 18: 187-90, 1994.
15. Rego MA, Araujo MAM. A 2-year clinical evaluation of pit and fissure sealants placed with an invasive technique. Quintessence Int 27: 99-103, 1996.
16. Lin S, Caputo AA, Eversole LR, Rizoiu I. Topographical characteristics and shear bond strength of tooth surfaces cut with laser-powered hydrokinetic system. J Prosthet Dent 82: 451-5, 1999.
17. Cozean C, Arcoria CJ, Pelagalli J, Powell GL. Dentistry for the 21st century? Erbium:YAG laser for teeth. J Am Dent Assoc 128: 1080-7, 1997.
18. Dorignac, GF. Efficacy of highly filled composites in the caries prevention of pit and fissures: two and one half years of clinical result. The J Pedod 11: 139, 1987.
19. Tulunoglu O, Bodur H, Uctasli M, Alacam A. The effect of bonding agent on the microleakage and bond strength of sealant in primary teeth. J Oral Rehabil 26: 436-41, 1999.
20. Symons AL, Chu CY, Meyers IA. The effect of fissure morphology and pretreatment of the enamel surface on penetration and adhesion of fissure sealants. J Oral Rehabil 23: 791-795, 1996.
21. Hitt JC, Feigal RJ. Use of a bonding agent to reduce sealant sensitivity to moisture contamination: an in vitro study. Pediatr Dent 14: 41-6, 1992.
22. Feigal RJ, Musherure P, Gillespie B, Levy-Polak M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: A clinical study of two-bottle and single-bottle systems. J Dent Res 79: 1850-56, 2000.
23. Fritz UB, Finger WJ, Stean H. Salivary contamination during bonding procedures with one-bottle adhesive system. Quintessence Int 29: 567-572, 1998.
24. Choi JW, Drommond JL, Dooley R, Punwani I, Soh JM. The efficacy of primer on sealant shear bond strength. Pediatr Dent 19: 286-288, 1997.