Spot-etch technique and other adhesive strategies for provisional veneers

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Cinthia Studzinski dos Santos, MS
PhD student, Graduate Program in Dentistry, Federal University of Pelotas, Brazil

Gustavo França Bertholdo de Souza, MS
PhD student, Graduate Program in Dentistry, Federal University of Pelotas, Brazil

Laura Lourenço Morel
Undergraduate student, Graduate Program in Dentistry, Federal University of Pelotas, Brazil

Noéli Boscato, DDS, MS, PhD
Professor, Department of Restorative Dentistry, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Brazil

Rafael Ratto de Moraes, DDS, MS, PhD
Professor, Department of Restorative Dentistry, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Brazil

Giana da Silveira Lima, DDS, MS, PhD
Professor, Department of Restorative Dentistry, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Brazil

Correspondence to: Prof Giana da Silveira Lima
Graduate Program in Dentistry, Federal University of Pelotas, 457 Gonçalves Chaves Street, Pelotas, RS, Brazil 96015-560; Tel: +55 53 32226690; Email: gianalima@gmail.com

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Abstract

Aim: The objective of the present study was to evaluate the influence of different adhesive strategies regarding shear bond strength (SBS) of provisional resin-based materials bonded to the enamel surface as well as on the enamel surface roughness.

Materials and methods: Bovine incisors were randomly divided into six groups ($n = 10$) according to the adhesive strategy used: BR$_{\text{Control}}$ (bis-acrylic resin); Spot-etch+BR (spot-etch + bis-acrylic resin); Spot-etch$_{\text{SB2}}$+BR (spot-etch + adhesive + bis-acrylic resin); Spot-etch$_{\text{Z350Flow}}$+BR (spot-etch + flowable composite resin + bis-acrylic resin); SBU+BR (universal adhesive + bis-acrylic resin); Spot-etch$_{\text{SBMP}}$+Z350 (spot-etch + adhesive + composite resin). The enamel surface roughness was determined by a surface profilometer. An SBS test was performed in a universal testing machine, and failure modes were classified under magnification. The SBS data were analyzed by one-way analysis of variance (ANOVA). A paired *t* test was used for enamel surface roughness intragroup comparisons, and the Friedman one-way repeated measures analysis of variance by ranks was used for differences in enamel surface roughness between groups, with the Tukey post hoc test ($a = 0.05$).

Results: BR$_{\text{Control}}$ had the lowest SBS values (MPa), with a significant difference ($P \leq 0.001$) from the other groups. Spot-etch+BR had the highest SBS values but with no significant differences from the other groups in which the spot-etch technique was also used. Adhesive failure mode was predominant for all groups. BR$_{\text{Control}}$ had the lowest surface roughness difference, significantly different ($P = 0.001$) from all the other groups.

Conclusions: Spot-etch and other adhesive strategies could be applied to increase the SBS values of provisional restorations to enamel compared with no surface pretreatment. However, the adhesive strategy may change the enamel surface roughness, revealing the importance of cleaning the tooth surface.

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Keywords

bisphenol A-glycidyl methacrylate, composite resin, dental esthetics, dental etching, dental materials, dental veneers, temporary dental restoration

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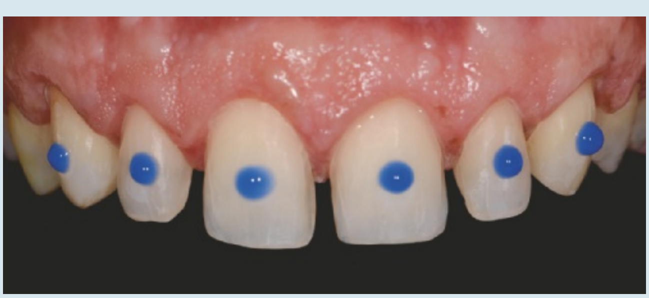

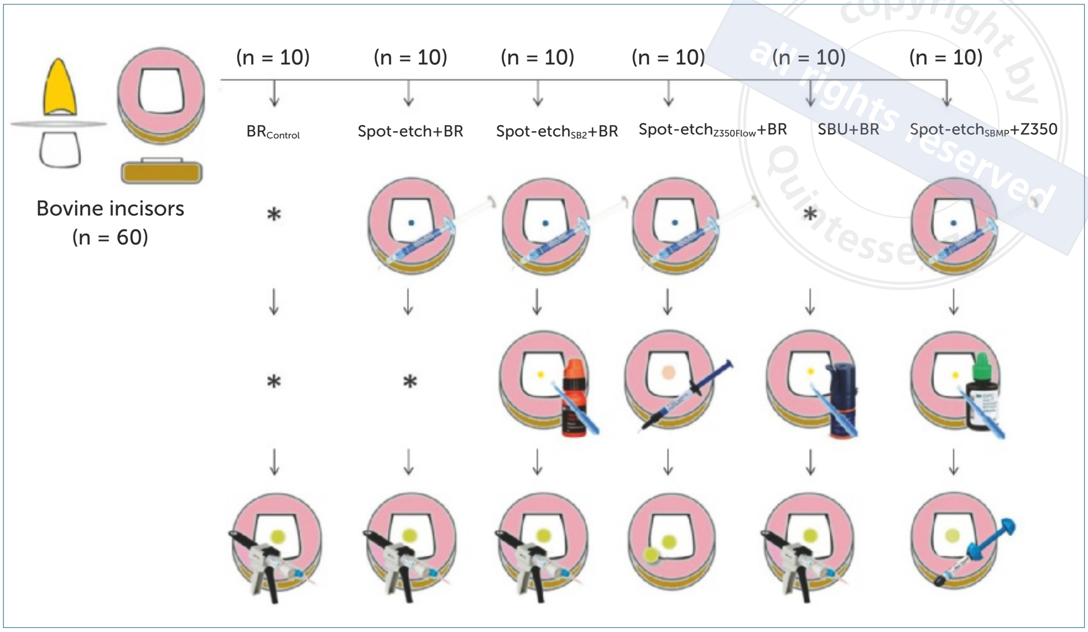

Fig 1 Description of adhesive strategies used in the present study. $BR_{Control}$: bis-acrylic resin; Spot-etch+B: spot-etch + bis-acrylic resin; $Spot\text{-}etch_{SB2}$+BR: spot-etch + adhesive + bis-acrylic resin; $Spot\text{-}etch_{Z350Flow}$+BR: spot-etch + flowable composite resin + bis-acrylic resin; SBU+BR: adhesive + bis-acrylic resin; $Spot\text{-}etch_{SBMP}$+Z350: spot-etch + adhesive + composite resin.

Introduction

Provisional restoration is an important procedure that is necessary to protect prepared tooth structure from the oral environment and promote function and esthetics during the time period until replacement with the definitive dental restoration takes place.[1] It is also an excellent tool for diagnosing and evaluating the treatment plan as it provides predictability through a temporary restoration that resembles the definitive one. Mechanical, physical, and handling properties must be considered when selecting the material for the provisional restoration in each clinical case, taking tooth preparation and rehabilitation into consideration.[2,3]

Bis-acrylic resin is a flowable material often used for fabricating a diagnostic mock-up on the tooth surface through the use of a silicone guide obtained from the diagnostic wax-up.[4] This provisional resin-based material offers advantages such as ease of manipulation, low polymerization shrinkage, minimum exothermic reaction, and good mechanical properties.[5-9] Composite resin is also often used as a provisional material during laminate veneer procedures, mainly due to its practicality and availability in clinical practice.[1]

Bis-acrylic–based provisional restorative material has mainly been used on preparations where it will be primarily retained by the adhesive interface.[10] Since bis-acrylic resin does not adhere to the dental structure, clinicians often apply the material as a set to multiple teeth with a silicone guide. However, this application impairs oral hygiene, and detachments or fractures of the provisional restoration may occur.[11] Therefore, some adhesive strategies could be used to maintain the integrity of the provisional restoration for a minimum period of time, avoiding complications and discomfort for the patient and ensuring pulpal and periodontal health until the definitive restoration is placed.[12-14]

Figure 1 shows the adhesive strategies used in the present study.

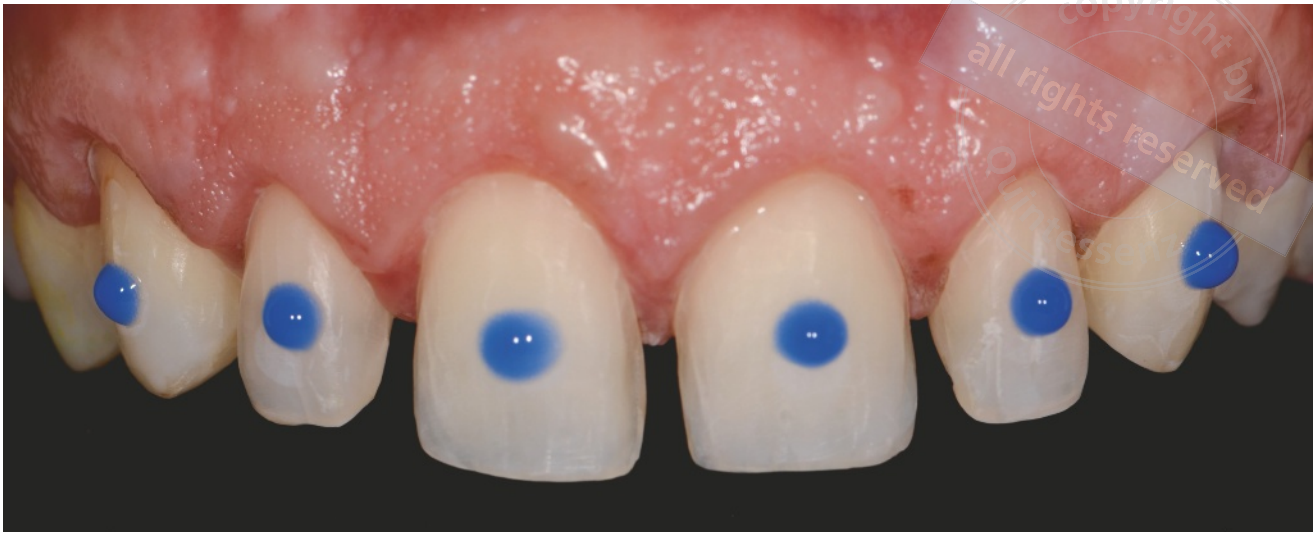

Fig 2 Spot-etch technique in which a small spot area of the prepared tooth is etched with phosphoric acid.

Fig 3 Tooth surface after the spot-etch technique. Note the opaque appearance of the etched areas.

Fig 4 Adhesive system application on spot-etched areas.

Different adhesive strategies have been used to adhere bis-acrylic resin or composite resin provisional restorations to the prepared tooth surface, including the so-called spot-etch technique. This is mainly used in clinical situations involving a prepared tooth with extremely low retention (such as a provisional restoration to a single laminate veneer).[15] In this procedure, a small spot area of the prepared tooth is etched with phosphoric acid (Fig 2).[16] Due to the lack of studies evaluating the adhesive performance of provisional restorations with bis-acrylic resin or composite resin, clinicians apply different techniques according to their personal preferences based on clinical experience. Some apply only the spot-etch technique, others combine it with the use of an adhesive,[17] while others use only a single adhesive layer.[1,4,18,19] A clinical step-by-step description of the spot-etch technique is represented in Figures 2 to 9.

The present study aimed to evaluate adhesive strategies used to bond provisional veneer restorations to the tooth enamel. What was evaluated was the influence of different adhesive strategies on shear bond strength (SBS) of provisional resin-based materials (bis-acrylic resin or composite resin) to the enamel surface with low mech-

Fig 5 Application of the bis-acrylic resin on the silicone barrier, previously obtained by the diagnostic wax-up of the clinical case planning.

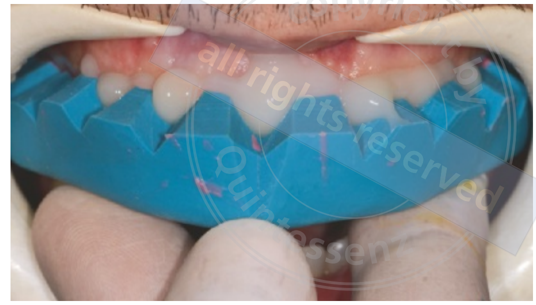

Fig 6 Insertion of the silicone barrier on the tooth surfaces prepared to receive ceramic veneers.

Fig 7 After waiting for a period of time for the bis-acrylic resin to set, the excesses are removed.

anical retention and also on enamel surface roughness after provisional restoration removal. The null hypothesis was that adhesive strategies would not influence provisional restoration SBS values to enamel and would not affect the enamel surface roughness.

Materials and methods

The present in vitro study investigated the following parameters: 1) SBS and failure modes of provisional restorations in the enamel after different adhesive strategies; and 2) Enamel surface roughness from readings performed before and after the SBS test. Table 1 provides an overview of materials used in the study and their compositions. The number of specimens required in each group was determined by sample size one-way analysis of variance (ANOVA) calculation (SigmaPlot 12.0). To determine whether there were statistical differences between groups with the power of 0.9 and alpha error probability of 0.05, 10 specimens would be required in each group. The same specimen from the SBS test was used in the surface roughness assessment.

Sixty permanent bovine central incisors extracted for noncommercial reasons were collected and stored in distilled water at 4°C for no longer than 30 days before use.[20] They were mechanically cleaned and had their roots removed. Disinfection was carried out with immersion in 0.5% T-chloramine solution for 7 days in a refrigerator. The teeth were embedded in acrylic resin (Clássico, São Paulo, Brazil) filling in cylindri-

Fig 8 Photopolymerization of the adhesive system applied using the spot-etch technique.

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Fig 9 Final aspect of the mock-up on the tooth surface prepared using the spot-etch technique.

Table 1 Description of materials and their compositions, manufacturers, and lot numbers

Product	Composition	Manufacturer	Lot
Protemp 4 A1 shade	Bis-GMA, UDMA, TEG-DMA, Bis-EMA 50 nm silanized amorphous silica	3M ESPE, São Paulo, Brazil	1723600361
Filtek Z350 XT Flowable A3 shade (Z350 Flow)	Silane-treated ceramic, substitute dimethacrylate, bis-GMA, silane-treated silica, TEG-DMA, ytterbium fluoride, dimethacrylate functionalized polymer, titanium dioxide	3M ESPE, São Paulo, Brazil	N938119
Filtek Z350 XT A3 shade (Z350)	Bis-GMA, UDMA, TEG-DMA, bis-EMA, non-aggregated 20 nm silica filler, non-aggregated 4 to 11 nm zirconia filler, aggregated zirconia-silica cluster filler	3M ESPE, São Paulo, Brazil	739379
Single Bond 2 (SB2)	Dimethacrylate resins, HEMA, polyalkenoic acid copolymer, filler, ethanol, water, initiators	3M ESPE, São Paulo, Brazil	N855670
Single Bond Universal (SBU)	MDP phosphate monomer, dimethacrylate resins, HEMA, polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane	3M ESPE, São Paulo, Brazil	3480110
Scotchbond Multi-Purpose Adhesive (SBMP)	Bis-GMA, HEMA, tertiary amines, photo-initiator	3M ESPE, São Paulo, Brazil	N928619
Phosphoric acid 37%	Phosphoric acid, surfactant, 200 aerosil, deionized water, pigment	Dentsply, São Paulo, Brazil	296288J

Bis-EMA: ethoxylated bisphenol A glycol dimethacrylate; Bis-GMA: bisphenol A glycidyl methacrylate; HEMA: 2-hydroxyethyl methacrylate; MDP: 10-methacryloyloxydecyl dihydrogen phosphate; TEG-DMA: tri-ethylene-glycol-dimethacrylate; UDMA: 1.6-bis(methacryloyl-2-ethoxycarbonylamino)-2,4,4-trimethylhexane

cal plastic molds. The labial surface of each tooth was wet grounded with two different silicone carbide (SiC) abrasive papers (400 and 600 grit; Norton, São Paulo, Brazil). Specimens were polished with each SiC paper for 60 s in a polishing machine (Arotec, São Paulo, Brazil) until a flat enamel surface was obtained. Prophylaxis was performed with pumice paste before starting any procedure.

The teeth were numbered from 1 to 60, randomized with a random sequence obtained from the random.org website, and allocated into six groups (n = 10) according to the adhesive strategy used. Figure 1 summarizes all the adhesive strategies used and their sequence. All materials were used as recommended by the manufacturer. The same trained operator (CSS) performed all adhesive strategy procedures, as follows:

1. $BR_{Control}$: No surface treatment was performed on the enamel surface. Bis-acrylic resin (Protemp 4; 3M ESPE, São Paulo, Brazil) was dispensed via an auto-mixing cartridge system into a silicone mold with a cylindrical orifice (5-mm diameter x 2 mm) positioned on the center of the flat enamel surface. A preset weight (300 g) was applied for 5 min over the bis-acrylic resin and tooth specimen to guarantee standardization.
2. Spot-etch+BR: Phosphoric acid 37% (Dentsply, São Paulo, Brazil) was applied for 30 s through a cylindrical orifice (1.5-mm diameter) on a double-sided tape matrix simulating a standardized area corresponding to the mean size of a maxillary incisor. The enamel surface was cleaned with air-water spray for 30 s, and then air dried for 20 s. Subsequently, the bis-acrylic resin was applied exactly as previously described.
3. $Spot\text{-}etch_{SB2}$+BR: The spot-etch technique was performed as described above. Then, with the double-sided tape matrix in position, an etch-and-rinse adhesive (SB2;Single Bond 2; 3M ESPE) was rubbed on for 20 s with a microbrush (KG Sorensen, São Paulo, Brazil), air dried for 20 s, and light cured for 20 s with a light-curing device emitting approximately 1300 mW/cm^2 (Valo; Ultradent, São Paulo, Brazil). Subsequently, the bis-acrylic resin was applied as previously described.
4. $Spot\text{-}etch_{Z350Flow}$+BR: After performing the spot-etch technique, a silicone mold was inserted into the center of the flat enamel surface and flowable composite resin (Z350 Flow; Filtek Z350 XT Flowable; 3M ESPE) was dispensed on the center of the mold, then a preformed bis-acrylic resin disk was cemented on (5-mm diameter x 2 mm). The set was light cured for 40 s.
5. SBU+BR: Self-etch adhesive (SBU; Single Bond Universal; 3M ESPE) was applied with a microbrush for 20 s, dried for 20 s, and light cured for 20 s through a cylindrical orifice (1.5-mm diameter) on a double-sided tape matrix glued to the enamel surface. Then, the bis-acrylic resin was applied as described above into a silicone mold (5-mm diameter x 2 mm) positioned on the center of the flat enamel surface.
6. $Spot\text{-}etch_{SBMP}$+Z350: The spot-etch technique was performed as previously described. Subsequently, the bond of the adhesive system (SBMP; Scotchbond Multi-Purpose; 3M ESPE) was applied for 20 s and then light cured for 20 s. Then, an enamel composite resin increment (Z350; Filtek Z350 XT; 3M ESPE) was applied into a silicone mold (5-mm diameter x 2 mm) on the center of the flat enamel surface, covered with a polyester strip, and light activated for 40 s.

After 14 days of storage in distilled water at 37°C, the SBS test was performed by using a universal testing machine (DL 500; EMIC, São Paulo, Brazil). A knife-edge at a crosshead speed of 1 mm/min was used to place a load on specimens until fracture occurred. Specimens were mounted on a test machine with the restoration–tooth interface parallel to the knife-edge (0.2-mm diameter). Shear force was applied until debonding. SBS values were calculated in Megapascal [MPa] units, considering the peak failure load divided by bonded surface area (1.5-mm diameter).[21,22] The mode of each failure was determined with a stereomicro-

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Table 2 Shear bond strength test (mean ± standard deviation [MPa]) and failure mode (n = 10)

Groups	Shear bond strength (SBS) [MPa]	Failure mode		
	Mean ± SD	Cohesive	Mixed	Adhesive
$BR_{Control}$	4.30 ± 1.79^{b}	0	0	10
SBU+BR	40.11 ± 12.45^{a}	0	1	9
Spot-etch_{SB2}+BR	45.77 ± 7.00^{a}	0	3	7
$\text{Spot-etch}_{Z350Flow}$+BR	46.58 ± 12.48^{a}	0	1	9
Spot-etch_{SBMP}+Z350	48.40 ± 10.85^{a}	0	1	9
Spot-etch+BR	52.58 ± 11.11^{a}	0	0	10

SD: standard deviation
One-way ANOVA test: same superscript letters indicate no statistical difference in values ($P > 0.05$).

scope at 40x magnification and divided into three distinct categories: cohesive failure (fracture within the base or material); adhesive failure (separation at the base/material interface or within an adhesive layer); and mixed failure (combination of interfacial separation and partial cohesive failure of the base and/or materials).[23]

The average surface enamel roughness (Ra) was determined by a surface profilometer (Surfcoder SE1200; Kosaka Laboratory, Tokyo, Japan) at two time periods: initial (after specimen polishing: Ra_i); and final (after performing the SBS test: Ra_f). The device was calibrated, and each specimen was coupled to a reading device. The cut-off value was 0.8 mm, 0.5 mm percussion of measure, conducted at 0.5 mm/s. Demarcations in the cylindrical plastic molds were made to guide the same reading position in the same specimen and Ra [µm] was obtained through three readings.[24] Surface roughness difference was obtained by subtracting the final enamel surface roughness value (Ra_f) from the initial value (Ra_i).

Statistical analysis

SigmaPlot 12.0 software was used for the statistical analysis. Data were analyzed by a blinded evaluator (GSL) for normal distribution and homogeneity of variance based on the Shapiro-Wilk test. SBS data were analyzed by ANOVA, followed by the Tukey post hoc test, when needed. The paired *t* test was used for enamel surface roughness intragroup comparisons at baseline and after the SBS test. The Friedman one-way repeated measures analysis of variance by ranks was used to analyze the difference of enamel surface roughness (Ra_f–Ra_i) among different adhesive strategies, by using the Tukey post hoc test. The results of the SBS tests were correlated with the Ra data through the Pearson correlation. A significance level of 5% was adopted for all statistical tests.

Results

The results of the SBS test for each experimental group are summarized in Table 2. The spot-etch technique presented the highest SBS values, regardless of the associated use of adhesive layer or flowable composite resin. $BR_{Control}$ presented the lowest SBS values, which were significantly different from the other groups ($P \leq 0.001$). Spot-etch+BR presented the highest SBS values but with no significant differences from the other groups that also used the spot-etch technique: Spot-etch_{SBMP}+Z350; $\text{Spot-etch}_{Z350Flow}$+BR; and Spot-etch_{SB2}+BR. Addi-

Table 3 Enamel surface roughness before and after adhesive procedures and the shear bond strength test [µm]

Adhesive strategy	Ra_i [mean ± SD]	Ra_f [mean ± SD]	Ra_f–Ra_i [median; 25/75%]
BR$_{Control}$	0.09 ± 0.02^{A}	0.11 ± 0.02^{B}	0.01; 0.00/0.04^{b}
Spot-etch+BR	0.06 ± 0.02^{A}	0.20 ± 0.06^{B}	0.13; 0.10/0.16^{a}
Spot-etch$_{SB2}$+BR	0.08 ± 0.02^{A}	0.24 ± 0.11^{B}	0.13; 0.09/0.20^{a}
Spot-etch$_{Z350Flow}$+BR	0.07 ± 0.01^{A}	0.25 ± 0.10^{B}	0.15; 0.08/0.25^{a}
SBU+BR	0.07 ± 0.03^{A}	0.31 ± 0.20^{B}	0.23; 0.08/0.44^{a}
Spot-etch$_{SBMP}$+Z350	0.07 ± 0.03^{A}	0.24 ± 0.09^{B}	0.15; 0.12/0.18^{a}

SD: standard deviation
Different superscript lowercase letters in the same column indicate significant differences among adhesive strategies; Friedman repeated measures ANOVA on ranks; $P \leq 0.05$; Different superscript uppercase letters in the same row indicate significant differences between Ra values at baseline and after adhesive strategy by using the paired *t* test; $P \leq 0.05$.

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tionally, all groups using the spot-etch technique showed SBS values similar to the SBU+BR group, in which only a universal adhesive layer was applied before the bis-acrylic resin. The failure mode distribution is presented in Table 2. Adhesive failures were predominantly observed in all groups. Three specimens from the Spot-etch$_{SB2}$+BR group presented mixed failures. No cohesive failure was observed.

Table 3 shows the results for enamel surface roughness (mean ± standard deviation [SD]). At baseline, all groups had similar enamel surface roughness values ($P \geq 0.05$). After the different adhesive strategies and bis-acrylic or composite resin applications, the enamel surface roughness significantly increased in all the groups. BR$_{Control}$ presented the lowest Ra_f values, although without a statistically significant difference from the other groups. All groups presented significant differences considering surface roughness (Ra_i) at baseline, after specimen polishing, and after adhesive procedures and the SBS test (Ra_f). After obtaining Ra_i and Ra_f surface roughness values, differences were calculated by subtracting Ra_f from Ra_i. BR$_{Control}$ presented the lowest difference in surface roughness values (Ra_f–Ra_i) compared with the other groups ($P = 0.001$). The Pearson correlation between SBS and Ra was not significant ($r = 0.34$, $P = 0.008$).

Discussion

The spot-etch technique increased provisional restorative material SBS values to the enamel, and adhesive strategies modified the enamel surface roughness; thus, the null hypothesis could not be accepted. Spot-etch+BR required one additional step prior to bis-acrylic insertion and presented the highest SBS values compared with BR$_{Control}$, which had the lowest SBS values. Probably, the increased SBS values derive from the micromechanical retention created on enamel by phosphoric acid etching. The spot-etch technique also increases the surface permeability, allowing intimate contact between bis-acrylic resin and enamel, thus improving adhesion.[16]

Although in general the SBS values shown in the present study were similar to those found in previous studies that evaluated the SBS of composite resin to enamel,[17,21,22] no previous study has reported the adequate provisional restoration SBS value. Furthermore, excessive SBS values

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might impair the removal of the provisional restoration. The use of adhesive strategies may minimally alter the enamel surface roughness, emphasizing the importance of carefully cleaning the tooth surface before final cementation to eliminate any remaining adhesive or restorative material.[12,13]

The effect of adhesive associated with the spot-etch technique on bis-acrylic resin SBS values was evaluated. The spot-etch$_{SB2}$+BR and Spot-etch$_{SBMP}$+Z350 groups had one adhesive layer application and similar SBS values. An additional layer of adhesive systems might increase adhesive thickness without affecting the microtensile bond strength, in addition to requiring further steps.[18] However, three-step or two-step etch-and-rinse adhesive systems can provide enamel-like bond strength as a universal adhesive without pre-etching, which requires fewer clinical steps.[25] The etching process and application of primer reduce enamel microhardness; therefore, clinicians may inadvertently influence it during acid conditioning. Using self-etching primers as opposed to conventional conditioning systems can represent a more conservative approach to enamel conditioning.[26]

Universal adhesives have the versatility of being applied to tooth tissue by etch-and-rinse or self-etch bonding approaches and have potential applicability in different areas of adhesive dentistry. Improved enamel bond strength can be obtained using universal adhesive in etch-and-rinse mode.[19,25] Although this variable was not assessed in the present study, since it implies one more step in the surface treatment procedure, satisfactory SBS values, similar to other groups with spot-etch applications, were observed by using the universal adhesive in self-etch mode (SBU+BR). This result accords with studies that assessed the bonding capacity of a universal adhesive by using the etch-and-rinse and self-etch bonding approaches, finding similar SBS values regardless of the etching approach used.[22] Additionally, the use of the self-etching adhesive system after removing the outermost enamel layer (aprismatic enamel), as in the case of veneer preparations, can increase the bond strength to the enamel.[27]

Spot-etch$_{Z350Flow}$+BR showed high SBS values, indicating that the flowable composite resin used as a luting agent for the bis-acrylic resin after the spot-etch technique showed good bonded interface performance due to its low viscosity and high wettability.[28] This finding corroborates previous studies that evaluated the use of light-cured flowable composite resin to repair provisional restorations made with bis-acrylic.[11,23] Recently, self-adhesive flowable composite resin has been developed, with the main advantage of not requiring a separate adhesive application step. Although the bond strength values are lower than those obtained by conventional adhesives, it may present satisfactory results as a cementing agent for provisional restorations of laminated veneers, reducing treatment time.[29]

Composite resin is indicated for several applications in dentistry, not only for definitive restorations but also for manufacturing provisional restorations such as veneers. Spot-etch$_{SBMP}$+Z350 had SBS values similar to those of bis-acrylic resin for provisional restorations, indicating that this adhesive strategy may also be used for provisional restorations for laminate veneers. Some advantages of the use of composite resin in these cases include its availability in different shades and its lower cost compared with bis-acrylic resin; however, it may demand longer clinical time as it requires technical skill for manual insertion of composite resin and an additional polishing step.[1]

Bovine teeth were used in the present in vitro study, and there are reports in the literature that they can be used as an alternative to human teeth in dental research.[20] It is worth mentioning that this is the first study to perform an in vitro evaluation of the spot-etch technique, showing encouraging results for bonding provisional resin-based materials onto enamel surfaces. However, the findings of the present study should not be directly extrapolated to clinical conditions. Clinical evaluations are required to assess the advantages of the spot-etch technique and other adhesive strategies to bond provisional restorations and also to evaluate whether there is some influence on definitive restoration cementation.

Conclusions

According to the results obtained in the present study, it could be concluded that:

1. All the adhesive strategies used increased the SBS values of bis-acrylic resin to enamel when compared with the control group, where no surface pretreatment was performed.
2. The spot-etch technique is appropriate to increase the SBS of bis-acrylic resin or composite resin to enamel in provisional veneer restorations; however, it may alter the enamel surface roughness.
3. The spot-etch technique before bis-acrylic resin application (Spot-etch+BR) produced high SBS values with fewer steps compared with the other adhesive strategies, which involved – in addition to spot-etching – the application of an adhesive layer or a flowable composite resin layer.
4. The bis-acrylic resin associated with a universal adhesive in self-etch mode (SBU+BR) achieved enamel SBS values similar to the other groups that received the application of the spot-etch technique, which was equally effective to increase SBS.

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Disclaimer

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