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Mechanical properties of resin based materials for bracket bonding

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Objectives: Orthodontic brackets can be bonded with a variety of materials. The purpose of this study was to investigate, among flow and orthodontic resins, which provides more stable results, considering polymerization stress, elastic modulus and bond resistance.

Materials and methods: One orthodontic resin (Transbond XT) and two flow resins (Filltec Z-350 Flow and Opallis Flow) were used for bonding orthodontic Edgewise metallic brackets to 30 human bicuspids ($n = 10$). All tests were performed with an Instron UTM. Bond strength was tested by shear test at a speed of 0.5 mm/min. Elastic modulus was calculated by flexural modulus with a three point bending test, as described in ISO 4049, and polymerization stress development was measured with an extensometer connected to the Instron machine.

Results: Means were calculated from the test results, for each tested group. One-Way ANOVA test was applied to the results with a confidence level of 95%. For bond resistance, statistically different and higher mean values were found for Transbond XT (26.3 ± 4.1 MPa), while similar and lower values, with no significant difference were found for Z-350 Flow and Opallis Flow (15.6 ± 5.8 and 16.9 ± 8.0 MPa) ($p < 0.05$). Flexural modulus showed higher values for Transbond XT (4.7 ± 2.9 GPa), which was statistically different from the results of Z-350 Flow and Opallis Flow (2.5 ± 0.7 and 2.2 ± 0.3 GPa), with no significant difference between them. The analysis of polymerization stress results found statistically significant differences for all three materials, where Z-350 Flow developed the higher mean value (4.9 ± 0.4 GPa), Opallis Flow reached also a relative high mean value (4.2 ± 0.3 GPa), while Orthodontic resin Transbond XT developed the lowest stress values (2.3 ± 0.1 GPa).

Conclusions: Although significant differences could be found when comparing test results found for the three resins, all the tested materials can be considered proper for orthodontic brackets bonding.

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Biocompatibility of experimental self-etching HEMA-free adhesive systems

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Objectives: HEMA is a monomer widely used in adhesive systems, but its biologic performance has been found as negative, so this study aimed to test others types of monomers in the formulation of adhesive systems. Thus, five dimethacrylates (Bis-EMA 10, Bis-EMA 30, PEG 400, PEG 400 UDMA, PEG 1000) were formulated for use in self-etching adhesives and their biocompatibility analyzed. The control group used contained HEMA. Furthermore, the degree of conversion of each adhesive was calculated.

Materials and methods: First, an in vitro test using 3T3 mouse fibroblast cell culture was performed. The cytotoxic test was made using primers containing 20% or 2% of each monomer. The dilutions were maintained in contact with the cells for a period of 24 h and the survival of these cells was verified photometrically using a MTT assay. Then, a cytotoxic test was performed with the resins as follows: experimental monomers were polymerized and immersed in DMEM for 24 h; the eluate obtained was then inoculated on the 3T3 cell culture for 24 h. Statistical analysis was performed with Kruskal–Wallis' test, followed by the multiple-comparison Dunn's test ($p < 0.05$). Then, the degree of conversion of each adhesive resin was also analyzed and the percentages of conversion obtained were compared among the groups.

Results: Cytotoxic test results of the adhesive systems showed that among primers at 2% only PEG 1000 group had no statistical difference compared to the control group. At 20% there was no difference among Bis-EMA 10, PEG 1000 and the control group. When eluates were tested, no difference was found among Bis-EMA 10, PEG 400 UDMA and the control group. As for the degree of conversion, all groups showed similar values.

Conclusions: Some dimethacrylate monomers like PEG 1000, Bis EMA 10 and PEG 400 UDMA showed satisfactory performance requiring further studies using different concentrations and different cell lines, because these monomers can be promising as components of adhesive systems.

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Effect of CPP-ACP treatment on dentin bond-strength of self-etching adhesives

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Objectives: To evaluate the push-out bond strength of dimethacrylate (Clearfil SE Bond/Filtek Z250; and Adper SE Plus/Filtek Z250) and silorane-based (Filtek P90/Filtek P90) restorative systems following selective dentin pretreatment with a CPP-ACP-containing paste (MI Paste).

Materials and methods: Sixteen bovine incisors were utilized. The buccal surface was wet-ground to obtain a flat dentin area. Standardized conical cavities were then prepared. Adhesive systems were applied according to manufacturer specifications, and the composites were bulk inserted into the cavity. The push-out bond strength test was performed with a universal testing machine (0.5 mm/min) until failure, and failure modes were analyzed by means of scanning electron

microscopy. Data were analyzed using the two-way ANOVA and Tukey's post hoc tests ($p < 0.05$).

Results: For Clearfil SE Bond/Filtek Z250 and Filtek P90/Filtek P90, the dentin pretreatment did not influence the bond strength values. For Adper SE Plus/Filtek Z250, dentin samples treated with MI Paste had statistically higher bond strength values than nontreated specimens. Overall, adhesive failures were the most frequent.

Conclusions: Dentin pretreatment with the CPP-ACP-containing paste did not negatively affect bond strength for Clearfil SE Bond/Filtek Z250 and Filtek P90/Filtek P90 restorative systems, and improved bond strength for Adper SE Plus/Filtek Z250 restorative systems.

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Resin cement properties and stress effects with different polymerization methods

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Objectives: This study evaluated how time elapsed between mixing and polymerization affects mechanical properties, post-gel shrinkage, and residual stresses for different resin cements.

Materials and methods: Nine resin cements: RelyX ARC (ARC); RelyX Unicem (UNI); sET (SET); GCem (GCE); Enforce (ENF); All Cem (ALL); ClearFil SA (CLE); Dual Cement (DUA); Mono Cem (MON) were polymerized using 3 methods: M0 – immediately after mixing; M3 – polymerized 3-min after mixing; M5 – polymerized 5-min after mixing. Post-gel shrinkage (Shr) was measured using strain-gauges ($n = 10$). Knoop indentation ($n = 5$) was used to determine hardness (KNH) and elastic modulus (E). The post-gel shrinkage and elastic modulus values were applied in two-dimensional finite element models of a maxillary premolar with a ceramic inlay. The stresses generated for each material and polymerization method were recorded as modified Von Mises equivalent stresses (Str). The Shr-, KNH-, E-values were statistically analyzed using two-way ANOVA and Tukey test ($p = .05$).

Results: The table shows the mean KNH (kg/mm^2)/E (GPa)/Shr (vol%). KNH and E were not significantly affected by polymerization method. However, Shr and Str were significantly higher for M0 compared to M3 and M5, except in CLE.

Conclusions: The Str was modulated by Shr and also E with different behavior regarding resin cement. Except for CLE, waiting for 3 or 5 min before polymerizing the resin cements reduced post-gel shrinkage and residual shrinkage stress levels significantly.

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Effect of aging on the bond strength of anatomic posts

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Objective: To evaluate the bond strength of glass fiber posts relined (anatomic posts) after aging by thermo-mechanical cycling.

Materials and methods: Twenty bovine incisors were selected to assess post retention; after endodontic treatment, the canals were flared with diamonds burs. Post spaces were prepared in lengths of 5 mm; fiber posts were relined with composite resin and luted with RelyX Unicem. Ten samples were subjected to cycling with 1,200,000 mechanical cycles at a load of 88.4 N and a frequency of 4 Hz and 3200 thermal cycles at to 5° and 55° for 30 s. Specimens were then subjected to a pull-out bond strength test in a universal testing machine; the results (N) were submitted to one-way analysis of variance and Tukey post hoc test ($\alpha = 0.05$).

Results:

Groups	Mean (kg f) and Standard Deviation
Control	31.09 (±7.84) A
Thermo-mechanical cycling	22.77 (±5.91) B

One-way ANOVA demonstrated a significant difference ($p < 0.02$) between the bond strength values of the control and the cycled specimens.

Conclusion: Aging through thermo-mechanical cycling decreased the bond strength values of glass fiber posts relined with composite resin (anatomic posts).

Method	ARC	UNII	SET	GCE	ENF	ALL	CLE	DUA	MON
M0	48/12/ 0.97^A	49/15/ 0.91^A	47/9/ 0.78^A	44/14/ 0.61^A	49/18/ 0.74^A	53/12/ 0.90^A	23/5/ 0.18^A	45/9/ 1.07^A	32/9/ 0.91^A
M3	47/13/ 0.73^B	50/15/ 0.73^B	46/10/ 0.66^B	46/14/ 0.52^B	50/18/ 0.60^B	51/12/ 0.78^B	23/5/ 0.18^A	44/9/ 0.86^B	30/9/ 0.83^B
M5	46/13/ 0.64^C	51/15/ 0.64^C	48/10/ 0.54^C	42/13/ 0.33^C	49/18/ 0.41^C	51/12/ 0.68^C	25/6/ 0.18^A	45/9/ 0.78^C	31/9/ 0.71^C

Different letters indicate significantly different Shr-results between methods.