In vitro fracture resistance of root-filled teeth using new-generation dentine bonding adhesives

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Abstract

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Aim To compare the fracture resistance of root-filled premolar teeth restored with new-generation dentine bonding adhesives.

Methodology Sixty extracted single-rooted human maxillary premolar teeth were used. Access cavities were prepared, and the roots were instrumented with K-files to an apical size 50 using a step-back technique. Root fillings were accomplished using gutta percha (Sure-Endo, Seoul, Korea) and AH Plus root canal sealer (Dentsply DeTrey, Konstanz, Germany) using the lateral condensation technique. The teeth were then randomly divided into six groups of 10 teeth each. A mesiodistocclusal (MOD) cavity was prepared in the teeth to the level of the canal orifices so that the thickness of the buccal wall of the teeth measured 2 mm at the occlusal surface and 3 mm at the cemento-enamel junction. Preparations were restored using the following adhesive systems: Etch & Prime 3.0 (Degussa AG, Hanau, Germany), Clearfil SE Bond (Kuraray, Osaka, Japan), Prompt L-Pop (ESPE, Seefeld, Germany), Panavia F (Kuraray, Osaka, Japan), Optibond Plus (Kerr, Orange, CA, USA) and Admira Bond (Voco, Cuxhaven, Germany); all preparations except those of the Panavia F and Admira Bond groups were further restored with resin composites. The Panavia F group was restored with amalgam and the Admira Bond group with Ormocer (Voco, Cuxhaven, Germany). The teeth were mounted in a Universal Testing Machine (Hounsfield, Surrey, UK), and the buccal walls were subjected to a slowly increasing compressive force until fracture occurred. The force of fracture of the walls of each tooth was recorded and the results in the various groups were compared. Statistical analysis of the data was accomplished using one-way ANOVA.

Results There was no significant difference in the fracture resistance of any of the test groups.

Conclusions In this laboratory study, the type of dentine bonding agents had no influence in the fracture resistance of teeth.

Keywords: dentine bonding, fracture resistance, root-filled teeth.

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Introduction

Compared to teeth with healthy pulps, root-filled teeth are considered more susceptible to fracture as they possess reduced dentinal toughness, lower water content and deeper cavities (Madison & Wilcox 1988).

In particular, occlusal forces may result in cuspal fractures in root-filled posterior teeth (Eissman & Radke 1984). Thus, root-canal treatment should not be considered complete until the coronal restoration has been placed (Wagnild & Mueller 2002).

An optimal final restoration for a root-filled tooth maintains aesthetics and function, preserves remaining tooth structure and prevents microleakage. Today, intracoronal reinforcement of teeth is a significant process in preventing root-filled teeth from fracturing (de Oliveira *et al.* 1987, Kanca 1988).

Various studies have reported a significant increase in the fracture resistance of root-filled teeth when restored with a resin composite material intracoronally with routine acid-etch and bonding procedures (Trope *et al.* 1986, de Oliveira *et al.* 1987, Hernandez *et al.* 1994).

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In recent years, numerous new bonding adhesives with new mechanical and physical properties have appeared. The purpose of this study was to compare the fracture resistance of root-filled premolar teeth restored with new-generation dentine bonding adhesives.

Materials and methods

Sixty freshly extracted human mature maxillary premolar teeth without caries, abrasion cavities, injury from forceps or fractures were used. The mesiodistal and buccolingual dimension of the crowns and the cervico-apical length of the roots of the teeth were similar. All teeth were radiographed in a buccal and proximal direction to check for a single root and single canal. The teeth were cleaned of debris and soft tissue remnants, and were stored in physiological saline at +4 °C until required.

Endodontic access cavities were prepared and canals were instrumented with K-files to an apical size 50 using a step-back technique (Kfir *et al.* 2003). The canals were irrigated with 3 mL of 2.5% NaOCl solution using a 27-gauge endodontic needle after the use of each instrument. Following biomechanical preparation, the canals were irrigated with 3 mL of 15% EDTA (Pulpdent, Watertown, USA) solution for 30 s to remove smear layer. Final canal irrigation was accomplished with 5 mL of 2.5% NaOCl solution. Canals were dried with absorbent paper points. Root fillings were completed using gutta percha (Sure-Endo, Seoul, Korea) and AH Plus root canal sealer (Dentsply DeTrey, Konstanz, Germany), using a lateral condensation technique. The teeth were then randomly divided into six groups of 10 teeth each.

A mesiodistocclusal (MOD) cavity was prepared in the teeth to the level of the canal orifices so that the thickness of the buccal wall of the teeth measured 2 mm at the occlusal surface and 3 mm at the cemento-enamel junction (Trope *et al.* 1986, Hernandez *et al.* 1994). These measurements were confirmed with preadjusted measuring gauges. Throughout the experimental procedures, in order to avoid dehydratation, the teeth were stored in a sealed container containing 0.9% saline, incubated at 37 °C and maintained at 100% humidity.

The test specimens were restored in the following manner:

- Group 1: Etch & Prime 3.0 (Degussa AG, Hanau, Germany) was applied on the cavity surface in accordance with the manufacturer's mixing instructions. The bonding agent was gently dried with an air syringe, followed by light curing for 10 s. A resin composite material, Charisma (Heraeus Kulzer, Dormagen, Germany), was added into cavities in four increments, each approximately 2 mm thick, and each increment was cured for 40 s.
- Group 2: Clearfil SE Bond (Kuraray, Osaka, Japan) was applied on the cavity surface and thinned with a jet of compressed air, followed by light curing for 10 s. Charisma was then added incrementally and light-cured as in group 1.
- Group 3: Panavia F Primer (Kuraray) was applied on the cavity and dried gently with an air syringe. Then agents A and B were mixed and applied. The teeth were then restored with amalgam ANA 2000 (Nordiska Dental AB, Angelholm, Sweden) and contoured to their final shape, after which photopolymerization for 20 s was performed.
- Group 4: The cavities were total-etched for 15 s, rinsed and air dried with a brief jet of compressed air, leaving the surface moist. Optibond Plus (Kerr, Orange, CA, USA) was applied on the cavity and light-cured for 20 s. Charisma was used to restore the cavities and was applied as in groups 1 and 2.
- Group 5: Prompt L-Pop (ESPE, Seefeld, Germany) was applied on the cavities as per the manufacturer's instructions and light-cured for 20 s. Again, Charisma was added and light-cured incrementally as in groups 1, 2 and 4.
- Group 6: The cavities were total-etched with phosphoric acid (Voco, Cuxhaven, Germany) for 20 s, rinsed and briefly air-dried, leaving the surface visibly moist. Admira Bond (Voco) was applied on the cavity, air-thinned and light-cured for 20 s. Restoration of the teeth was accomplished using the manufacturer's recommended restorative material, Admira (Voco).

The restored teeth were stored in an incubator at 37 °C in 100% humidity for 48 h. Copper rings, 25 mm in length and 10 mm in diameter, were filled with a self-curing polymethylmethacrylate resin (Vertex, Dentimex Dental, Zeist, Netherlands), and the teeth were placed into the resin to the level of the cemento-enamel junction. The copper rings with the teeth were placed into a Universal Testing Machine (Hounsfield, Surrey, UK). The buccal walls of the teeth were then subjected to a slowly increasing force (1 mm min^{-1}) at the junction of the buccal cusp and the filling material. The force was applied at the middle mesiodistal width of the buccal cusp and at a 150° angle to the long axis of the teeth. The force necessary to fracture each tooth was recorded. The data were subjected to one-way ANOVA for the six experimental groups after the logarithmic conversion of the fracture values.

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Table 1 Fracture resistance of root-filled premolars after different methods of restoration

Groups	Mean ($log_{resistance}$)	SD
Etch & Prime 3.0	2.50	0.09
Clearfil SE Bond	2.52	0.08
Panavia F	2.41	0.10
Optibond Plus	2.47	0.13
Prompt L-Pop	2.46	0.05
Admira Bond	2.45	0.09

Mean values expressed in Newtons.

Results

The mean force of fracture and standard deviation for the six groups are presented in Table 1.

Statistical analysis of the data showed no significant difference between the experimental groups ($F = 1.52$; $P = 0.19$).

Discussion

Healthy single-rooted human maxillary premolar teeth were chosen for this study. The mesiodistal and buccolingual size of the crown and the cervico-apical length of the roots of the teeth were similar, but some discrepancies in tooth size occurred. To compensate for the differences, the buccal walls of the teeth were prepared in a uniform manner.

Polymeric adhesives for bonding to dentine are used in dentistry for a wide range of purposes. Applying most adhesive systems involves removing or modifying the smear layer and demineralizing the dentine surface. Current methods of dentine bonding use acids to demineralize the surface followed by the use of hydrophilic, low-molecular weight primers to penetrate the remaining collagen network with the application of adhesive; a resin-impregnated dentine hybrid layer results, and a micromechanical bond is formed with the dentine surface (Duke 1993, Inokoshi *et al.* 1993).

Two types of self-etching adhesives were used in this study: one was a one-step system that combined the conditioner, primer and adhesive resin for a single application (Prompt L-Pop and Etch & Prime 3.0); the other was a two-step system that combined conditioning and priming into one bottle, but had a separate adhesive resin that was applied to complete the bonding procedure (Clearfil SE Bond and Panavia F). An acidic monomer in the primer of these systems demineralized the smear layer and underlying dentine, resulting in mild etching of the cavity surface. The final system used in this study was a so-called 'one-bottle' system, which combines both priming and bonding into a one-step system (Optibond Plus and Ormocer based single bond). In this system, phosphoric acid is used to etch the smear layer, and following rinsing, a moist surface is required to maintain a noncollapsed demineralized collagen network of etched dentine that is mediated by water (Gwinnett 1992, Kanca 1992). Usually, these one-bottle adhesive systems contain ethanol or acetone as a solvent, which assists with their application to the moist dentine substrate.

Previous research has indicated that the resistance to fractures of composite-restored teeth that utilized enamel-dentine etching and bonding was approximately equal to that of unaltered teeth (Gelb *et al.* 1986, Trope *et al.* 1986). Additionally, dentine bonding agents splint the cusps and reduce cuspal flexure, which reduces stresses that generate on tooth crowns (Salis *et al.* 1987). Several previous studies have shown that restoration with resin composite provided substantial recovery of tooth stiffness, especially when coupled with dentine etching (Trope *et al.* 1986, Hernandez *et al.* 1994). Etching both enamel and dentine provided additional mechanical retention and additional surface area for the dentine bonding adhesive, enhancing stiffness recovery (Munechika *et al.* 1984, McCabe & Rusby 1992). These reports are in accord with the results of this study. In the present study, no significant difference was found between the test groups. It is difficult to compare these findings with those of other studies on the restoration of root-filled teeth using different materials. The variations in the type and size of teeth used, the materials examined, the loading speed and the direction of the force do not allow direct comparisons. However, the results of this study are similar to those found by researchers who used the same methodology in their work (Trope *et al.* 1986, Hernandez *et al.* 1994).

de Oliveira *et al.* (1987) removed an extensive mass of dentine to simulate overpreparation of the access cavity. When such teeth were restored with amalgam, the reported fracture resistance was substantially lower than in those restored with an acid-etch/bond technique. Thus, their findings corroborate previous reports favouring the use of bonding techniques so as to provide support to reinforce natural tooth tissue.

Bakke *et al.* (1985) found a significant decrease in fractural strength when they tested unrestored prepared teeth compared with unprepared teeth. In the same study, they reported that restoration with amalgam did not increase the fracture strength of the prepared teeth, whereas restoration with posterior

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composite reinforced the tooth structure. The type of cavity preparation used in their study was different from that used in the present one; however, the methodologies were similar.

In an *in vitro* study, Hernandez *et al.* (1994) compared the resistance to fracture of endodontically treated premolar teeth restored with either new-generation dentine bonding adhesives or with acid-etch and chemically cured dentine bonding adhesives. The teeth restored with new-generation bonding adhesives showed more resistance to fracture. The preparations used by Hernandez *et al.* (1994) were similar to those used in the present study. Micromechanical retention is considered the most important mechanism for bonding to dentine, and adhesive restorations better transmit and distribute functional stresses across the bonding interface to the tooth, with the potential to reinforce weakened tooth structures (Hansen 1988). In the present study, the bond strengths of new-generation bonding adhesives (six experimental groups) were related to the product's ability to produce intimate micromechanical adhesions (McCabe & Rusby 1992).

Conclusion

There was no difference in the fracture resistance of root-filled teeth following restoration with a range of dentine bonding agents.

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