the Journal of CONTEMPORARY DENTAL PRACTICE at www.thejcdp.com
Volume 5 Number 3 August 15, 2004 Summer Issue

Resistance of Bonded Composite Restorations to Fracture of Endodontically Treated Teeth

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Abstract

The aim of this *in vitro* study was performed to evaluate the effect of dentin bonding agents and glass ionomer cement beneath composite restorations and its resistance to fracture of endodontically treated teeth. Fifty sound extracted maxillary teeth were selected; ten of them for controls and the remainder were modified with root canal treatment and a mesial occlusal distal (MOD) cavity preparation. The modified teeth were then divided into five groups:

1. Sound teeth
2. Prepared without restorations for control
3. Prepared and restored with Vitrebond (3M, USA), Singlebond (3M, USA), and Z100 (3M, USA) resin composite
4. Prepared and restored with Concise enamel bonding agent (3M, USA) and Z100 resin composite
5. Prepared and restored using Singlebond and Z100 composite resin

The modified specimens were subjected to compressive load by an Instron machine until fracture occurred. Group 1 showed the highest resistance to compressive force followed by Groups 5, 3, 4, and 2, respectively. Statistical analysis using analysis of variance (ANOVA) and a t-test indicated significant difference between all groups. Use of a dentin bonding agent and composite resin increased the resistance of endodontically treated teeth to fracture.

Keywords: Tooth fracture resistance, dentin bonding agent, glass ionomer cement, compressive strength

Citation: Daneshkazemi AR. Resistance of Bonded Composite Restorations to Fracture of Endodontically Treated Teeth. J Contemp Dent Pract 2004 August;(5)3:051-058.

Introduction

Restoration of the pulpless tooth is a critical final step in the success of endodontic therapy[1] because such a tooth is susceptible to fracture.[2]

Traditionally, most endodontically treated teeth have been restored in conjunction with a retentive post in the belief the teeth were reinforced, but there is evidence that posts may weaken the teeth rather than strengthen them.[1]

Another point of emphasis, proposed for the first time by Denehy and Tornay[3], is the use of adhesive materials can reinforce weakened teeth and support undermined enamel. Hernandez[1], DeFreitas[4], and Ausiello[5] showed the use of dentin bonding agents and composites can strengthen the tooth, as well as produce leak-free restorations. In addition, combined glass ionomer bases and composite restorations can reinforce the tooth.[5,6]

This study was performed to evaluate the effect of enamel and dentin bonding agents and glass ionomer cements beneath composite restorations. These agents were compared to control groups and resistance to fracture in endodontically treated teeth was assessed.

Materials and Methods

Unrestored, maxillary premolars without caries that had been extracted as part of orthodontic treatment were collected and kept moist in normal saline. Twenty-four hours before use all of the teeth were immersed in 10% formalin for infection control and then examined using the transillumination technique. Teeth found to have pre-existing cracks were discarded. The teeth used had been extracted from one week to two months prior to the study. The crowns of the teeth were measured to establish the size: Faciolingual 8-9 mm and mesiodistal 6-7 mm.

Fifty teeth were selected and mounted separately in an autopolymerizing resin block with the cementum enamel junction (CEJ) located 3 mm above the surface of acrylic resin and two cusp tips in horizontal plane. The specimens were immediately placed in cool water. Except for the ten controls, obturation of the teeth was accomplished using No. 35 size gutta percha points and mesial occlusal distal (MOD) cavity preparations were done. A width of two thirds of the intercuspal distance was chosen for the occlusal portion of the preparation and two thirds of the total facial-lingual distance was used for the width of proximal boxes. Each box extended to within 0.5 mm of the CEJ (Figure 1).

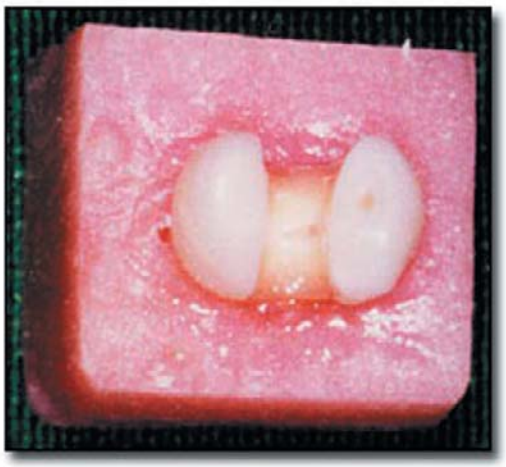

Figure 1. Photograph of a prepared premolar mounted in autopolymerizing resin block.

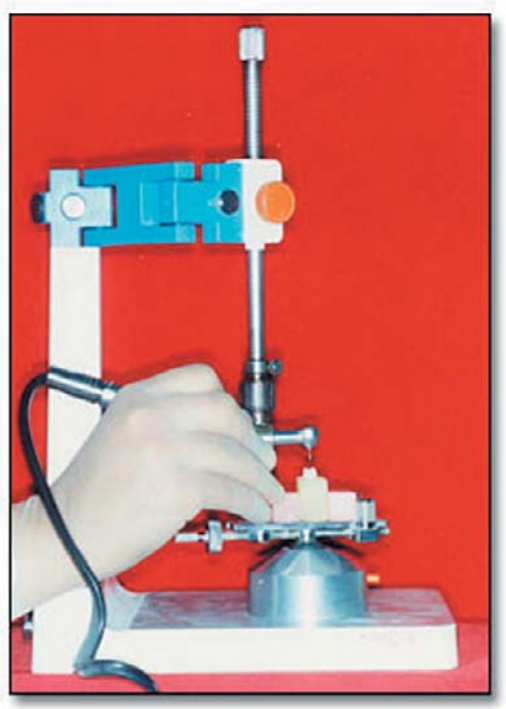

Figure 2. The highspeed handpiece mounted in a surveyor.

Cavity preparations were performed using a No. 245 bur and highspeed handpiece, mounted in a surveyor to ensure all of the cavity walls had the same angle, and there was no undermined enamel (Figure 2). Except at the gingival margin, a 0.5 mm bevel was placed on the cavosurface margin of all specimens.

The teeth were randomly divided into five groups:

- **Group 1:** Intact Teeth/Control Group (tested without preparations)
- **Group 2:** Preparation Only (tested without restoration)
- **Group 3:** Type 4 Glass Ionomer (tested with preparation, type 4 glass ionomer, dentin bonding agent, resin composite)
- **Group 4:** Enamel Bonding Agent (tested with preparation, enamel bonding agent, resin composite)
- **Group 5:** Dentin Bonding Agent (tested with preparation, dentin bonding agent, resin composite); all restorative materials were used in accordance with the manufacturers' recommendations, as detailed below

In Group 3 the cavities were cleaned and dried. After applying Vitrebond (3M Dental products, USA) with the recommended powder to liquid ratio as a base for superseding the dentin, it was cured for 30 seconds using a Coltulux 2.5 light curing unit (Coltene, USA); 3M Etchant (35% phosphoric acid gel) was then applied to the enamel and exposed dentin. After waiting 15 seconds, it was rinsed for 10 seconds and then air dried for 2 seconds. At this point, Singlebond (3M Dental products, USA) was applied to the cavity walls and glass ionomer in two consecutive layers. After application of the second layer, the adhesives were dried gently for 20 seconds and were light cured for 10 seconds. Z100 resin composite (3M Dental products, USA) with A2 shade was then added incrementally and cured.

In Groups 4 and 5 all of the processes were identical to Group 3, except that in Group 4 only a Concise enamel bonding agent (3M Dental products USA) and a composite resin were used. In Group 5, Singlebond and composite resin were used. Restorations were completed with finishing burs and fine finishing diamonds. Restored specimens were placed in a 37 degrees centigrade humidity chamber for 72 hours. The samples were thermocycled for 2500 cycles at a temperature of 5 degrees centigrade and 55 degrees centigrade. Before testing in the Universal Instron Testing Machine (Instron Model 8502, Instron Corporation, USA), a steel rod with 5 mm diameter and 10 mm length was used to contact the buccal and lingual cusp slopes, the compressive load was applied at 5 mm/minute, and the compressive load at fracture was recorded. Analysis of variance (ANOVA) was used for statistical analysis.

Results

The preparation only group (Group 2) and the preparation and restoration groups (Groups 2, 4, and 5) required significantly less force to fracture than the control group (Group 1). The group with enamel bonding and composite resin restorations (Group 4) showed significantly more fracture resistance compared to the preparation only group (Group 2).

The mean values for the force of fracture and the standard deviation for each of the five experimental conditions are presented in Table 1 and Figure 3. The ANOVA showed a statistically significant difference between all groups ($P<0.05$).

Table 1. Fracture resistance in the experimental groups (Kgf.)

Group 1:	149.4 with Standard Deviation	14.9
Group 2:	23.2	5.6
Group 3:	51.4	14.7
Group 4:	37.6	12.1
Group 5:	85.1	25.5

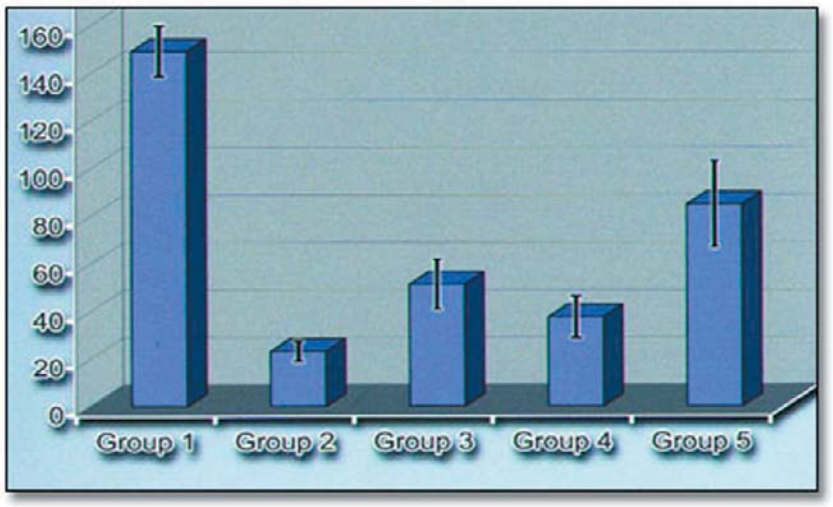

Figure 3. Force (Kgf.) to fracture teeth (n=10) in experimental groups with error bars Identifying standard deviations.

Discussion

In the present study the strength of unrestored teeth (Group 2) was about 15.5% of intact teeth (Group 1). Reel et al.[7] reported unrestored MOD preparations 3 mm deep at the occlusal isthmus with the faciolingual dimensions of proximal boxes at one half of the intercuspal distance were only 25% as strong as intact teeth. In a study conducted by Jagadish[6] the resistance of unrestored teeth was about 43% of intact teeth.

Reel et al.[7] and the present investigation agree maxillary premolars with enamel bonded composite restorations (Group 4 in this study) were approximately 100% stronger than unrestored premolars, but Joynt et al.8 reported a 23% increase in strength.[8]

In the present study, the fracture strength of the teeth restored with enamel bonded composite (Group 4) were 34.5% of intact teeth (Group 1). This strength was less than most other studies where the range of strength was 51% to 70% of the intact tooth strength.[8]

Simonsen[9] and present study agree there were significant differences between fracture resistance of dentin bonded and enamel bonded composite restorations (Group 5 and Group 4). Reel[7] reported there were no significant differences between enamel and dentin bonded composite restorations, but in this study a dentinal bonding agent was applied in two layers and separately cured.

The result of Group 3 indicates a sandwich of glass ionomer, dentin bonding agent, and composite resin was significantly stronger than Group 4 (unrestored and enamel bonded group) and significantly weaker than Group 1 (intact teeth) and Group 5 (dentin bonding agent-composite).

Studies by Ausiello[5] and Jagadish[6] have shown a sandwich of glass ionomer cement, dentin bonding agent, resin composite, as well as a dentin bonding agent-composite resin group were significantly weaker than intact teeth.

In this study the dentin bonded composite resin (Group 5) proved to be the most effective in offering fracture resistance of restored teeth. Studies done by Ausiello[5] and Jagadish[6] also have shown improved fracture resistance to teeth restored with dentin bonding agent and composite.

Ausiello[5] and this study showed intact teeth (Group1) produced better fracture resistance values than other groups. DeFreitas[4] has found there was no statistically significant difference between intact teeth and those groups restored with dentin bonding agent-composite resin.

In the present study the strength of prepared specimens (Group 2) was diminished by a combination of deep and extensive occlusal preparation and proximal boxes. Similarly, Macpherson[10] reported the mean force to fracture teeth decreases with cusp width.

Conclusion

A deep and extensive MOD cavity, with proximal boxes, appears to weaken teeth more than previously studied preparations. The two dentinal bonded composite resin restorations were significantly stronger than enamel bonded composite resin and a sandwich of glass ionomer cement, dentin bonding agent, and composite resin restorations.

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