The Bond Strength of Panavia Ex to Air-Abraded Amalgam

The tensile bond strengths of a resin cement, Panavia Ex, to a spherical and an admixed amalgam were measured after surface treatment with different aluminum oxide abrasive spray procedures. The type of amalgam and the brand of aluminum oxide affected the bond strength of the resin to amalgam alloy. When the spherical alloy was air abraded using 60-μm aluminum oxide prior to cementation of a Rexillium rod using Panavia, the bond strength was not significantly different from the previously reported bond strengths of Panavia to etched enamel. Significantly lower bond strengths were obtained between Panavia and the admixed amalgam alloy. These results suggest that it may be possible to place a resin-bonded prosthesis on an abutment tooth that has been restored using a spherical amalgam alloy. Int J Prosthodont 1991;4:276-281.

Recently, resin systems that provide chemical adhesion to some treated metal surfaces have been developed. One such cement, Panavia Ex (J Morita, Tustin, California), has been shown to have an exceptional bond to metals containing tin. The presence of tin in amalgam alloy makes it reasonable to assume that a chemical bond to this commonly used restorative material would also be possible.

Since amalgam is so commonly used clinically, the ability to bond to this material would be of great value to the restorative dentist. Castings adhesively cemented could offer the benefits of a chemical bond as well as the frictional retention of conventional cements. Additionally, the use of resin-bonded restorations could be extended to situations where abutment teeth have been restored with amalgam. Previously, abutments restored with amalgam were considered a contraindication to placement of a resin-bonded restoration.2-5

Previous research has demonstrated that the bond strength of resin cements to an amalgam surface treated with 120-grit silicon carbide varied with the choice of amalgam alloy. However, the bond strength between amalgam and resin cement was significantly less than that of the cement to etched bovine enamel.6 The purpose of this study was to examine the bond strength of an adhesive resin to two types of amalgam (spherical and admixed) with different surface treatments.

Materials and Methods

Sample Preparation

Rexillium Rods. The hexagonal heads of nylon 1/4-20 bolts were removed, and the shank portion was used as a pattern to cut threaded rods of Rexillium III (Jeneric/Pentron, Wallingford, Connecticut). The castings were half threaded and half smooth-surfaced. The cylinders were approximately 25.4 mm in length and had a diameter of 6.35 mm. Aluminum rod (12.7-mm diameter) was cut into pieces 25.4 mm in length. On one flat end of the
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When assembled, the flat end of the Rexillium casting was milled to be normal to the long axis of the aluminum/Rexillium combination. The surface was then air abraded with 50-μm aluminum oxide.

Amalgam Alloy Specimens. Aluminum rods were prepared to receive amalgam alloy by drilling a recess in the end of the cylinders 1.6 mm deep and 6.35 mm in diameter and with a small circumferential undercut. A nylon cap (1.6 mm thick) was made to fit over the end of the prepared aluminum cylinder. A 6.35-mm-diameter hole was drilled through the nylon so that it was concentric with the recess in the aluminum cylinder, and amalgam alloy was condensed into the recess. The amalgam was allowed to harden for 30 minutes before the cap was removed. The amalgam materials tested represented two commonly used alloys: an admixed product (Dispersalloy, Johnson and Johnson Dental Products, East Windsor, New York) and an all-spherical amalgam (Tytin, Kerr Mfg Co, Romulus, Michigan). The amalgam alloy was allowed to set for 24 hours, after which the end was milled perpendicular to the long axis of the aluminum cylinder using 120-grit, followed by 400-grit, silicon carbide abrasive. The prepared amalgam specimens were rinsed ultrasonically in deionized distilled water and dried. Ten specimens of each alloy were treated by air abrasion with either 60-μm aluminum oxide (Ney-Brasive, JM Ney Co, Bloomfield, Connecticut) or 50-μm aluminum oxide (Comco Inc, Burbank, California) at 0.48 MPa (70 psi) air pressure using an intraoral microblaster (Microetcher, Model 300, Danville Engineering, Danville, California). The prepared surfaces were examined using scanning electron microscopy (SEM).

Joining Rexillium to Amalgam Alloy

The aluminum cylinder with the prepared amalgam surface was placed in the lower portion of the aligning apparatus. An aluminum cylinder having a properly prepared Rexillium rod was positioned vertically above the prepared amalgam specimen with two long axes concentric. The upper plate was parallel to the lower plate and could be moved vertically. To simulate clinical use, Panavia Ex was dispensed and mixed according to manufacturer’s recommendations. One scoop of fluffed powder and one drop of liquid were mixed for 1 minute and applied to the aluminum oxide air-abraded ends of the Rexillium rod. The two units were joined, the excess luting agent removed, and Oxyguard applied. The adhesive resin was allowed to polymerize for 10 minutes at room temperature under a load of 19.6 N (4.4 lb). The Oxyguard was then removed, and the assemblies were placed in water and stored at 37°C for 24 hours.

Bond Strength Testing

The joined rods were then placed in the holders of a universal testing machine (Model TTB, Instron Corp, Canton, Massachusetts). A tensile load was applied using a crosshead speed of 1.27 mm/min, and the tensile bond strength was recorded. The sequence of specimen testing was randomly arranged according to both amalgam type and abrasive size. In this manner, the effects of operator learning characteristics were minimized. Figure 1 illustrates the Rexillium-resin-amalgam alloy specimen configuration. The fractured specimens were examined using SEM to determine whether failure was adhesive or cohesive and to indicate the failure site (resin/resin, amalgam/resin, Rexillium/resin).

Specimen Number and Statistical Analysis

Ten specimens were prepared for each bonding condition, and the mean tensile strength was determined. A one-way analysis of variance was used to determine the presence of significant differences in bond strengths among the different testing schemes. Tukey’s hsd test was used to determine significant differences between specific pairs of group means at the 95% confidence level.

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Fig 1  | Tensile testing apparatus, Rexillium-resin-amalgam.
Results

Figure 2 shows the mean bond strengths and standard deviations for each testing combination. When both amalgam alloys were abrasive sprayed with 60-μm aluminum oxide, they had a higher mean bond strength than when abraded with 50-μm abrasive; however, these differences were not significant ($P > .05$). Panavia bonded to 60-μm air-abraded Tytin had the highest tensile strength (14 MPa) and was significantly different ($P < .05$) from Dispersalloy air-abraded with 50- or 60-μm aluminum oxide. With Tytin, there was no significant difference between bond strengths of specimens sprayed with 50- or 60-μm abrasive. The bond strength of Panavia to Tytin treated with 50-μm abrasive was superior to all Panavia-Dispersalloy bond strengths, but the difference was not significant ($P > .05$).

Analysis of the fractured samples using SEM revealed that failure occurred both cohesively and adhesively at the amalgam/cement (Figs 3a and 3b) and Rexillium/cement interfaces (Figs 4a and 4b). In these figures, the dark material is polymerized resin and the lighter images the metal surface. While this pattern was a common failure mode for all samples, there were differences noted between the Dispersalloy and Tytin samples. Voids within Panavia were present at the fracture surface of all the samples, but these voids were much larger when Panavia was bonded to Dispersalloy samples (Figs 4a and 4b).

Discussion

The effects of thermocycling and long-term water storage on the Panavia-amalgam bond were not examined in this study. However, previous investigations have found that thermocycling had no effect on the tensile strength of samples bonded with Panavia and that storing bonded samples in water for up to 6 months did not significantly lower the tensile bond strength.

The 60-μm prepared amalgam surface produced a superior bonding strength compared to the 50-μm air-abraded surfaces on both types of amalgams tested. It is unlikely that this difference is related solely to the aluminum oxide particle size, but may be a result of differences in the manufacturer's aluminum oxide formulation. Aluminum oxide abrasives contain a range of particles of varying hardnesses, and a difference in the proportions of...
these particles could affect their abrasive action on the prepared alloy surfaces. Additional investigations are being conducted to determine differences between the two aluminum oxides.

Panavia bonded better to Tytin than to Dispersalloy regardless of the surface treatment of the alloy. This variation in bonding could be attributed to differences in the prepared amalgam surface topography, differences in surface wettability, or to the quantity and distribution of tin within the amalgam.

The SEM evaluation of the prebonded air-abraded amalgam surfaces revealed no differences in topology between any of the sample groups (Figs 5a to 5d). However, SEM evaluation of the fractured
specimens showed that there were large voids in the resin within the fracture plane of the Dispersalloy samples (Fig 4a). There were also resin voids present in the fracture plane of the Tytin-Panavia samples, but these areas were both smaller in size and fewer in number (Fig 4b). This difference in number and size of the voids observed at the alloy-Panavia fracture site suggests that Panavia did not wet the surface of Dispersalloy as well as it did the surface of Tytin.

Differences in the formulation between the two amalgam types may also account for the variation in their bonding potential to Panavia. The alloy portion of Dispersalloy is an admixture of particles with two thirds lathe cut and one third spherical configuration. Tin is found only in the lathe-cut phase and accounts for 18% of the alloy by weight. Tin accounts for 27% of Tytin by weight and is distributed throughout the spherical alloy. The higher concentration of tin found in Tytin and its more homogeneous distribution may be the primary reason for Panavia's superior bond to Tytin.

The bond strength of Panavia to Tytin air abraded with Ney’s 60-μm aluminum oxide is equal to the bond strength of composite resin to etched enamel obtained under similar conditions in the authors' earlier study* (Fig 2). These results suggest that adhesive prosthodontics may be extended to include teeth that have been restored with amalgam. However, additional research is needed to understand the mechanisms of this bond and its longevity following fatigue and thermocycling.
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Conclusions

1. The tensile bond strength of Panavia Ex to air-abraded amalgam is influenced both by the choice of abrasive and the type of amalgam alloy selected.
2. For a given type of amalgam alloy, mean tensile bond strength values were greater when using the 60-μm Ney aluminum oxide than the 50-μm Comco aluminum oxide.
3. The spherical amalgam alloy demonstrated higher mean tensile bond strength values to Panavia than did the admixed product, regardless of the surface preparations.
4. The combination of the spherical amalgam alloy and air abrasion with the 60-μm product provided tensile bond strengths to Panavia that were equivalent to that of Panavia to etched bovine enamel.

References


Literature Abstract

Crown Margin Design: A Dental School Survey

Citing the wealth of dental literature concerning metal ceramic restoration margin design as an indication of the controversy surrounding this subject, a survey of all dental schools in the United States and Puerto Rico was conducted to determine which margin designs are currently being taught. Of the 59 dental schools surveyed, 51 responded. There appears to be no consensus on which designs are appropriate in any particular clinical situation, with at least seven designs (flat shoulder, chamfer, deep chamfer with bevel, 125° shoulder, 45° shoulder, 70° to 75° bevel shoulder, and knife-edge or shoulderless margin) currently being taught. The flat shoulder and 45° bevel shoulder margin designs are most popular for maxillary and mandibular anterior and maxillary posterior teeth. Of the margins listed, the 45° bevel shoulder and the chamfer are most frequently taught. With the exception of the knife-edge margin, all can be supported by the dental literature.

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