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Cuspal reinforcement in primary teeth: an in vitro comparison of three restorative materials

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Abstract

The purpose of this study was to evaluate cuspal flexure in posterior primary teeth following restoration with three different materials. Twelve primary second molars were obtained. A precision strain gage was attached to the buccal surface of each tooth and balanced at zero. The teeth were mounted and then loaded with a 10 kg force; the strain appearing on the strain gage indicator was recorded. A mesiocclusodistal preparation was placed, and then each tooth was restored using amalgam, posterior composite resin, and glass ionomer silver. Following restoration placement, the tooth again was loaded with the 10-kg force. Each tooth was restored using all three materials. Results demonstrated that composite resin restorations recovered an average stiffness of 75% of the original intact tooth, glass ionomer silver recovered 52% of the original tooth stiffness, and amalgam recovered 34% of the uncut tooth stiffness. The analysis of variance demonstrated that significant differences in external cuspal deflection stress were associated with the different restorative materials. Scheffe's test demonstrated that loading a tooth restored with composite resin created significantly less strain than restoring the tooth with glass ionomer silver or amalgam. Loading a tooth restored with glass ionomer silver created significantly less strain than restoring the tooth with amalgam ($P < 0.001$).

During the past 10 years, many advances have occurred in pediatric operative dentistry. More recently, glass ionomer silver has become available for use as a posterior restorative material. The advantages of glass ionomer silver include: (1) the continual release of fluoride ions; (2) ability to chemically bond to tooth structure; (3) a coefficient of thermal expansion near that of tooth structure; (4) radiopacity; (5) the capacity to be etched for the mechanical bond of composite resin; and (6) resistance to abrasion with the addition of silver particles to the glass ionomer.[1]

The ability of glass ionomer to bond to tooth structure may add to increased tooth fracture resistance, due to increased cuspal reinforcement, and promote conservation of tooth structure in cavity preparation. Traditionally, the restoration of interproximal carious lesions, that extended even slightly beyond ideal limits of cavity preparation resulted in full coverage with stainless steel crowns.

More contemporary materials, with the potential to bond tooth structure, may offer a more conservative approach during the restoration of the primary dentition (Croll and Phillips 1986). Morin et al. (1984) showed acid-etch composite resin restorative procedures to have significantly higher cuspal reinforcement than nonbonding restorative procedures. McCullock and Smith (1986b) found composite resin and glass ionomer restorative materials to increase the fracture resistance of teeth, while amalgam produced no increase in fracture resistance. These same authors found less internal cuspal deflection when restoring teeth with glass ionomer cement, compared to the deflection forces produced by polymerization contraction of composite resin (1986a).

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Materials and Methods

Twelve primary molars were obtained from patients treated in the University of Texas Dental Branch Clinics. None of these teeth were affected by caries or had previous restorations placed; each had been extracted prior to orthodontic treatment. The teeth were placed in 10% formalin[a] solution immediately after extraction and retained in this preservative until the study was initiated.

One at a time, each tooth was taken from the preservative solution, rinsed with distilled water, and air

[1] McComb et al. 1984; Smith 1985; McLean et al. 1985.

[a] Formaldehyde solution — Fisher Scientific; Fair Lawn, NJ.

dried. A precision strain gage[b] was attached to the buccal surface of each tooth with an epoxy adhesive.[c] The tooth was situated in a l-inch retention tube, the tooth roots being retained within the tube by acrylic,[d] leaving the crown and strain gage exposed. The mounted tooth had two stabilized leads from the strain gage connected to the digital strain gage indicator.[e]

A 10-kg load, generating a force comparable to the mean chewing force for children ages 6-12 years (Fields et al. 1986), was applied to each tooth. The force was exerted approximately parallel to the long axis of the tooth. The load was applied to the tooth by bringing a sphere, attached to the upper member of the testing instrument, into contact with both the buccal and lingual cusps (Figure). The points of contact placed lateral deflecting forces on the tooth, situated so the sphere did not touch the occlusal table. The strain appearing on the strain gage indicator, after loading the intact tooth, was recorded.

A mesiocclusodistal preparation was placed in the tooth, the isthmus being approximately one-half of the intercuspal width. The standardized preparation was essentially the same as that used for conventional amalgam preparations in primary molars (McDonald and Avery 1983). Each tooth then was restored using three different techniques described as follows:

Technique 1: An amalgam[f] restoration was placed.

Technique 2: Polyacrylic acid was placed on all exposed dentin for 10 sec and rinsed. A glass ionomer silver[g] restoration was placed as recommended by the manufacturer.

Technique 3: A 45°, 0.5-mm bevel was placed on all enamel margins. The enamel margins were etched with 37% phosphoric acid[h] for 60 sec. Unfilled resin[i] was applied to the etched surface, followed by a buccolingual incremental placement of posterior composite resin[j] presented previously (Donly and Jensen 1986).

Each tooth was restored using all three techniques. After one technique was completed, and the strain appearing on the strain gage indicator recorded, the restoration was cut from the preparation and the next technique initiated. Four teeth were started with each technique to randomize the order of restoration placement.

The amalgam was allowed to set for 1 hr, the composite was allowed to set for 30 min, and the glass ionomer silver was allowed to set for 5 min. Again, the loading force was applied to the internal cuspal inclines, the sphere not coming into contact with the restoration, the force causing outward deformation. To ensure that dehydration had minimal effects, the tooth was exposed to water spray throughout the experimental procedures. Restorations were cut from the teeth and the strain gage indicator allowed to balance before proceeding; the recording returning to the original set (± 2 strain gage units) eliminated the concern of plastic deformation.

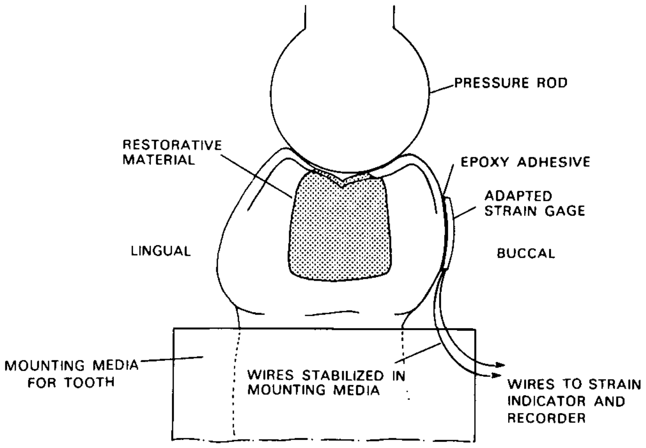

FIGURE. Schematic diagram of a mounted primary tooth with a pressure rod in place for applying an axial loading force to measure lateral deflecting force (cuspal stiffness) with a strain gage.

Results

The microstrain data in Table 1 is presented in the form of the mean relative deformation (RD) and the mean relative stiffness (RS), the intact tooth being given the value of one. The definition and calculation of RS and RD is explained by Morin et al. (1984). Composite resin restorations recovered an average stiffness of 75%

TABLE 1. Deformation and Stiffness of the Loaded Primary Molar Cusps with Different Restorations Relative to the Sound Tooth

	Mean Relative Deformation	*Mean Relative Stiffness*	*Standard Deviation of Relative Stiffness*
Sound tooth no treatment	1.0	1.0	—
Composite resin glass ionomer	1.33	0.75	0.24
Silver	1.93	0.52	0.12
Amalgam	2.95	0.34	0.09

[b] CEA-09-032UW-/20 precision strain gages — Measurement Group Inc; Raleigh, NC.
[c] Devcon epoxy adhesive — Devcon Corp; Danvers, MA.
[d] Fastray — Harry J Bosworth Co; Skokie, IL.
[e] V/E - 20A strain gage indicator — Measurements Group Inc, Raleigh, NC.
[f] Premalloy — ESPE-Premier Sales Corp; Norristown, PA.
[g] Ketac® Silver — ESPE-Premier Sales Corp; Norristown,PA.
[h] Etching gel — 3M Dental Products; St Paul, MN.
[i] Scotchbond® — 3M Dental Products; St Paul, MN.
[j] P-30® — 3M Dental Products; St Paul, MN.

of the original intact tooth. Glass ionomer silver recovered 52% of the original tooth stiffness and amalgam recovered 34% of the uncut tooth stiffness.

A randomized block design was the format used for data evaluation. The analysis of variance (ANOVA) presented in Table 2 demonstrated that significant differences in external cuspal deflection stress were associated with different restorative materials ($P < 0.001$). The Scheffe's test demonstrated that loading a tooth restored with composite resin created significantly less strain than restoring the tooth with glass ionomer silver or amalgam. Loading a tooth restored with glass ionomer silver created significantly less stress than restoring the tooth with amalgam ($P < 0.001$).

Discussion

The results demonstrated that the restorative material and technique which allowed the least amount of external strain upon loading was the placement of posterior composite resin. The dentin bonding agent and acid-etched enamel would aid in cuspal reinforcement.

Placement of glass ionomer silver restorative material allowed more cuspal deflection upon loading than composite resin, but less than amalgam. The potential for glass ionomer to adhere to tooth structure aids in cuspal reinforcement, compared to amalgam which has no dentin adhesive properties.

Current problems in operative dentistry include the weakening of tooth structure following cavity preparation. Due to the frequency of amalgam or tooth fracture following interproximal restoration placement, stainless steel crowns often were indicated for restoring interproximal decay.

Cuspal reinforcement provided with composite resin restorations should be considered when treatment planning interproximal restorations.

Perhaps in certain situations, glass ionomer silver cermet would be considered the restoration of choice. The fluoride release and bonding properties may offer practical consideration in clinical applications of glass ionomer silver restorative material.

Additional in vitro and in vivo investigations are recommended to evaluate the potential clinical uses of posterior composite resin and glass ionomer silver.

Conclusions

A comparison of cuspal reinforcement following restoration with three different materials led to the following conclusions:

1. Buccolingual incremental placement and polymerization of posterior composite resin created significantly more cuspal reinforcement than glass ionomer silver and amalgam restorations.
2. Glass ionomer silver created significantly more cuspal reinforcement than amalgam restoration.

TABLE 2. Analysis of Variance Table for Cuspal Deflection Created During Loading

Source	*SS*	*DF*	*MS*	*F*
B (restoration)	373.06	k − 1 = 3	124.35	153.53*
S (teeth)	294.73	n − 1 = 11	26.79	33.07
Residual	26.69	(k − 1)(n − 1) = 33	0.81	
Total	694.48	N − 1 = 47		

$P < 0.001$, 6.89 critical value.

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