

Longitudinal Microleakage Evaluation of Super-EBA as a Root-End Sealing Material

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This study evaluated the sealing ability of fast and regular set Super-EBA with different powder-to-liquid ratios as a root-end filling material. Fifty extracted maxillary central incisors were uniformly cleaned and shaped using a crown-down technique with Gates-Glidden drills and Profile series 29 .04 taper rotary instruments. After root-end resection and ultrasonic preparation, 48 root sections were randomly assigned to 4 groups of 12 teeth each and filled with a thick or thin mix of fast or regular set Super-EBA. Fast and regular set Super-EBA were mixed to a thick (1 scoop powder:1 drop liquid) or a thin (1 scoop powder:2 drops liquid) consistency. Positive and negative controls were used. Microleakage was assessed at 24 h, 72 h, 1 wk, 2 wk, 4 wk, 6 wk, and 8 wk using a fluid filtration system. There were no significant differences in the microleakage measured for any group at any of the time points evaluated. These results suggest that either fast or regular set Super-EBA mixed to various consistencies may be acceptable for root-end filling.

Apical root resection, preparation, and root-end filling is an accepted method of sealing root canals when nonsurgical endodontic therapy is not practical or has failed. The quality of the apical seal is considered a critical factor in the success of periradicular surgery. Super-EBA (Harry J. Bosworth Co., Skokie, IL) has been evaluated as a root-end filling material in numerous studies. Microleakage results concerning Super-EBA have been favorable, with few exceptions (1, 2). Bondra et al. (3) and O'Connor et al. (4) found that Super-EBA exhibited significantly less leakage than amalgam with Copalite. King et al. (5) showed Super-EBA to produce a significantly better seal than Ketac-Silver. Bates et al. (6) demonstrated that Super-EBA and mineral trioxide aggregate provided comparable seals, both significantly better than amalgam. In a retrospective study on success and failure, Super-EBA had a success rate of 95% (7).

Previous studies have evaluated the effect that varying the powder-to-liquid ratio (P/L) has on the sealing ability of IRM

(L. D. Caulk, Inc., Dentsply International, Milford, DE) (8, 9). Like IRM, Super-EBA has powder and liquid components and various clinical applications dependent on the P/L ratio used. Super-EBA is available in a fast and regular set powder. The manufacturer's instructions describe the use of Super-EBA for final or temporary cementation, as a liner or base, and as a temporary restorative material. The clinical application of Super-EBA as a root-end filling material is not listed in the manufacturer's instructions; however, it has been used extensively for this purpose. A review of studies involving Super-EBA cement usually indicates that the material was mixed according to the manufacturer's instructions. When used as a base, a P/L of 1:1 is recommended. For crown cementation, a P/L of 1:2 is recommended. The manufacturer instructs that "thicker mixes result in stronger cement." Gartner and Dorn (10) recommend only fast set powder for use in surgical endodontics.

Super-EBA is generally accepted as an effective root-end filling material. However, it has not been determined if there is less microleakage (*in vitro*) with a thicker mix or with a less viscous mix, or if there is a difference in microleakage when using the fast set versus regular set material. The purpose of this study was to evaluate the longitudinal sealing ability of Super-EBA cement in root-end preparations filled with fast and regular set powder at different P/L ratios. An *in vitro* fluid flow technique, first developed by Pashley et al. (11) and later modified by Derkson et al. (12) was used to measure microleakage.

MATERIALS AND METHODS

Fifty extracted, human maxillary central incisors with straight, fully formed roots were used in this study. The teeth were fixed in 10% formalin and transferred to 0.9% saline, with 0.1% thymol (Sigma Chemical Co., St. Louis, MO) added for antibacterial activity at least 30 days before use. The crowns were removed at the level of the facial cemento-enamel junction with a low-speed diamond saw (Isomet; Buehler Ltd., Lake Bluff, IL). Pulp tissue was removed with barbed broaches. Working length was determined by placing a #10 K-file in the canal until it was visible at the apical foramen and subtracting 1 mm. All canals were instrumented with a crown-down technique using #2 to #5 Gates-Glidden drills (L. D. Caulk Division) and Profile series 29 .04 taper rotary instruments (Tulsa Dental Products, Inc., Tulsa, OK) with

TABLE 1. Mean microleakage measurements (in μl per min \cdot 20 psi \pm SD)

	24 h	72 h	1 wk	2 wk	4 wk	6 wk	8 wk	p Value
Fast/thin	0.035 \pm 0.029	0.045 \pm 0.038	0.044 \pm 0.032	0.044 \pm 0.034	0.040 \pm 0.039	0.041 \pm 0.029	0.025 \pm 0.019	0.758
Fast/thick	0.042 \pm 0.036	0.038 \pm 0.035	0.051 \pm 0.031	0.047 \pm 0.033	0.033 \pm 0.036	0.032 \pm 0.019	0.039 \pm 0.025	0.736
Regular/thin	0.032 \pm 0.014	0.026 \pm 0.018	0.028 \pm 0.016	0.044 \pm 0.021	0.028 \pm 0.016	0.037 \pm 0.014	0.044 \pm 0.020	0.502
Regular/thick	0.031 \pm 0.020	0.029 \pm 0.025	0.031 \pm 0.017	0.019 \pm 0.015	0.038 \pm 0.042	0.040 \pm 0.018	0.044 \pm 0.029	0.306
p value	0.710	0.393	0.110	0.067	0.831	0.686	0.198	

p values determined by one-way ANOVA.

5.25% NaOCl as an irrigant. Final preparation was to a #7 Profile (size .465).

The apical 3 mm of the roots was resected perpendicular to the long axis of the tooth with a #701 fissure bur in a high-speed handpiece with water spray. A resection angle of 90 degrees to the long axis of the root was used to minimize the possible leakage through exposed dentinal tubules (13). The apical end of the root was prepared with a Neosonic Piezo-Electric ultrasonic unit (Amadent Co., Cherry Hill, NJ) with a CT-5 retropreparation tip (Analytic Endodontics, Orange, CA) with water coolant. A circular preparation \sim 0.75 mm in diameter and 3 mm in depth was created. Preparations were checked to ensure that the microcondenser tip (MCBLS; Hu-Friedy, Chicago, IL) would fit to length. Canals were rinsed with saline and dried with paper points. A single fine-medium gutta-percha point (L. D. Caulk Division) was fit and trimmed to the depth of the 3 mm root-end preparation to support condensation of the root-end filling material.

One root was not prepared and coated with two layers of nail polish to serve as a negative control. The apical preparation in another root was left unfilled to serve as a positive control. The remaining 48 roots were randomly divided into 4 groups of 12 teeth each. The apical preparations were filled with Super-EBA as follows: *group A*—(fast/thin) fast set with P/L of 0.26 g of powder:0.06 g of liquid (1 scoop powder:2 drops liquid); *group B*—(fast/thick) fast set with P/L of 0.26 g of powder:0.03 g of liquid (1 scoop powder:1 drop liquid); and *group C*—(regular/thin) regular set with P/L of 1 scoop of powder:2 drops of liquid; and *group D*—(regular/thick) regular set with P/L of 1 scoop of powder:1 drop of liquid. The less viscous mixes of Super-EBA in groups A and C were placed with a C-R syringe (Centrix, Inc., Shelton, CT) and disposable fine tube. The thicker mixes of Super-EBA in groups B and D were rolled into small cones and placed with a condensing instrument. The Super-EBA for all groups was condensed with a microcondenser tip. After setting, the Super-EBA was finished with a #7904 finishing bur. All roots were radiographed to ensure adequacy of the root-end fillings.

Plexiglas platforms measuring 4 \times 4 cm were prepared with a hole drilled through the center to accept an 18-gauge stainless-steel tube (modified syringe needle). The stainless-steel tubes were positioned and cemented with cyanoacrylate (Zapit; Dental Ventures of America, Anaheim Hills, CA) so that 1.5 mm extended past the Plexiglas surface where the root was to be cemented. Two coats of nail polish were applied to the external surface of all roots except at the apical end. The gutta-percha points were removed from the coronal end of the roots. The coronal portion of the root was centered over the metal tube and cemented onto the Plexiglas platform with cyanoacrylate adhesive. The Super-EBA group for each tooth was recorded on the Plexiglas platform with an indelible marker. After the adhesive was dry, the platforms and teeth were stored in plastic tubs containing 0.09% saline with 0.01% thymol at 37°C for the remainder of the study.

The fluid filtration apparatus consisted of a pressurized tank of nitrogen gas, a pressurized fluid reservoir, polyethylene tubing containing a 5 μl micropipette, a tuberculin syringe assembly, and the root segment attached to the Plexiglas platform (14). Fluid flow was measured from the coronal aspect of the root toward the apical end. Microleakage measurements were made by delivering nitrogen gas at a constant pressure of 20 psi to the fluid reservoir, which contained a beaker of ultrafiltered distilled water with FD&C #40 dye (Adam's Extract, Austin, TX) added. The red dye was added to aid in the visualization of the air bubble and any leakage. Polyethylene tubing connected the pressurized dye solution to the micropipette, which was subsequently connected to the Plexiglas-root assembly. A 4-min pressurization preload of the system was completed before beginning any measurements. A small, 1 to 2 μl air bubble was introduced into the tubing with the tuberculin syringe and centered in the micropipette. Linear movement of the bubble was viewed with telescopic magnification against an endodontic ruler graduated in 0.5-mm increments. A digital electronic timing device was used for all readings.

Microleakage measurements were obtained at 24 h, 72 h, 1 wk, 2 wk, 4 wk, 6 wk, and 8 wk after placement of the root-end filling. Positive and negative controls were examined at the beginning of each measuring session. After a 4-min preload, the microleakage for each sample was measured for 1 min, four times in succession at each test period to the nearest 0.5 mm. The linear measurements were averaged and converted to microliters per minute at 20 psi.

After data collection was complete, microleakage data for each group at each measurement period were pooled. Data were analyzed using the Statistical Analysis System (SAS Institute, Cary, NC). ANOVA was used to determine if the groups were significantly different from each other.

RESULTS

The mean microleakage measurements and standard deviations in microliters per minute at 20 psi for each group at each time interval are summarized in Table 1. One-way ANOVA showed no statistically significant differences in microleakage between groups at any of the time intervals.

The positive control demonstrated extreme amounts of leakage at each time interval and was too rapid to permit measurement of bubble movement in the usual manner. Instead, the fluid was collected in a graduated cylinder for 1 min and converted to microliters per minute. Mean leakage for the positive control was observed to be 40,000 $\mu\text{l}/\text{min} \cdot 20$ psi. The negative control registered no detectable bubble movement over the 4-min observation time at each time interval. Three root samples were lost during the study due to root fractures.

DISCUSSION

The results of the present in vitro study showed no statistically significant difference in microleakage between thin or thick mixes of fast or regular set Super-EBA over a 2-month observation time. Very little leakage was observed at any time for any of the experimental groups. Clinically, Super-EBA can be frustrating to handle: mixing is difficult, it sticks to almost everything, and it may set up before being adequately condensed. There may be clinical application for the use of fast set Super-EBA mixed to a less viscous, injectable consistency. The C-R syringe fine tips were small enough to fit into apical preparations 0.75 mm or larger in diameter. Very few, if any, voids were detectable radiographically. In cases where multiple preparations are to be filled and more working time is desirable, the regular set Super-EBA mixed to a thicker consistency may be beneficial. When mixed to the thin consistency, the regular set Super-EBA may require excessive setting times. In vivo studies will need to be performed to determine if an injectable fast set mix or thick regular set mix is clinically practical.

Super-EBA cements were developed in the 1960's in an attempt to improve upon some properties of zinc oxide-eugenol cements. Various components were added to the zinc oxide-eugenol cement that resulted in an increase in strength and reduced the solubility and setting time. Staline Super-EBA cement, manufactured by Staines in England, was the original EBA cement. In the United States, Super-EBA is marketed by the Harry J. Bosworth Co. The liquid component of both consists of 62.5% *ortho*-ethoxy benzoic acid (EBA) and 37.5% eugenol. The Staine's powder contains 60% zinc oxide, 34% silicon dioxide, and 6% natural resin. The Bosworth Co. replaced the silicon dioxide with 34% alumina. In 1970, Super-EBA was advocated for root-end filling (15). Oynick and Oynick reported the use of Super-EBA in over 200 teeth in 1978 (16). Studies on tissue response after implantation and replantation have shown Super-EBA to be biocompatible (17, 18). Super-EBA has shown some degree of antibacterial activity due to its incorporation of eugenol (19). A recent in vivo study on dogs comparing various root-end filling materials (Super-EBA, two glass ionomer cements, amalgam with varnish, IRM, and a light-cured composite) and histological healing responses showed Super-EBA to be the best root-end material tested (20).

The quality of the apical seal is considered a critical factor in evaluating potential success of a root-end filling material. Microleakage, defined as the passage of bacteria, fluids, and chemical substances between the root structure and the filling material, can be evaluated in vitro by numerous techniques. The fluid filtration method described by Pashley and Derkson offers distinct advantages: it allows for evaluation of a material's resistance to microleakage when challenged with a fluid under pressure; it allows for quantitative and longitudinal analysis of leakage; and a smaller sample size is needed because the tooth samples are not destroyed after each evaluation.

In summary, the results of this in vitro microleakage study suggest that either fast or regular set Super-EBA mixed to various consistencies may be acceptable for root-end filling.

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