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Effect of a new desensitizing material on human dentin permeability☆

Richard P. Rusin[a,*], Kelli Agee[b], Michael Suchko[b], David H. Pashley[b]

[a] 3M ESPE Dental Products, Saint Paul, MN, USA
[b] Medical College of Georgia, Augusta, GA, USA

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ABSTRACT

Objectives. Resin-modified glass ionomers (RMGI) have demonstrated clinical success providing immediate and long-term relief from root sensitivity. RMGIs have been recently introduced as paste-liquid systems for convenience of clinical usage. The objective of this study was to measure the ability of a new paste-liquid RMGI to reduce fluid flow through human dentin, compared to an established single-bottle nanofilled total etch resin adhesive indicated for root desensitization.

Methods. Dentin permeability was measured on human crown sections on etched dentin, presenting a model for the exposed tubules typical of root sensitivity, and permitting measurement of the maximum permeability. In the first two groups, the etched dentin was coated with either the RMGI or adhesive, and permeability measured on the coated dentin. In a third group, a smear layer was created on the dentin with sandpaper, then the specimens were coated with the RMGI; permeability was measured on the smeared and coated dentin. Specimens from each group were sectioned and examined via scanning electron microscopy (SEM).

Results. Both the resin adhesive and the new paste-liquid RMGI protective material significantly reduced fluid flow through dentin, and exhibited excellent seal on dentin with either open tubules or smear-layer occluded tubules. The RMGI infiltrated the smear layer with resin during placement, penetrated dentin tubules, and formed resin tags.

Significance. The RMGI was equivalent to the adhesive in its ability to reduce fluid flow and seal dentin. It is therefore concluded that the new RMGI and the adhesive show the potential to offer excellent sensitivity relief on exposed root dentin.

1. Introduction

Dentin sensitivity from exposed roots afflicts many people [1–4]. As the gingiva recedes, the cementum initially covers and protects the tubules, but is gradually removed by toothbrushing, acid erosion, etc., leaving tubules open and exposed. Because these fluid-filled tubules are in direct contact with pulpal nerve endings, exogenous stimuli are quickly transmitted and nerve depolarization occurs, leading to the sensation of sharp, well-localized pain [5,6]. This phenomenon is referred to as hydrodynamic conductance or the hydrody-

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* *Corresponding author at*: 3M ESPE Dental Products Laboratory, 3M Center 260-5S-12, Maplewood, MN 55144, USA. Tel.: +1 651 733 0127; fax: +1 651 575 0692.
E-mail address: rprusin@mmm.com (R.P. Rusin).

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namic theory. The theory was first reported by Gysi in 1900 [7], studied heavily and corroborated in the 1950s and 1960s by Bränström [8,9] and remains the most widely accepted theory of tooth sensitivity to date [10,11].

Occluding or sealing the exposed dentin tubules provides relief from root sensitivity [11,12] by preventing intratubular fluid shifts. There are a variety of strategies for this, including via precipitation of poorly soluble salts, or plasma proteins within dentinal fluid, and coating and sealing with either rosins or polymerizable materials [13]. Glass ionomers have demonstrated clinical success providing immediate and long-term relief from root sensitivity [14–16]; in addition, they offer protection of the adjacent tooth structure [17–23] and fluoride release [24,25]. To date, however, the clinical use of glass ionomers for root desensitization has been limited, perhaps because the prevalent powder-liquid format is less convenient than alternative liquid materials. The recent availability of glass ionomer materials in paste-liquid or paste–paste formats might encourage the wider use of these materials; however, little information is available in the literature regarding their performance.

The objective of this study was to measure the ability of a new paste-liquid resin-modified glass ionomer (3M™ ESPE™ Vanish™ XT Extended Contact Varnish, VXT) to reduce fluid flow through exposed human dentin, compared to an established resin adhesive (3M™ ESPE™ Adper™ Single Bond Plus Dental Adhesive, SBP). VXT and SBP are both indicated for the treatment of root sensitivity. SBP is a single-bottle total etch resin adhesive with a silica nanofiller. VXT is based on the methacrylate-modified polyalkenoic acid technology first commercialized in 3M™ ESPE™ Vitrebond™ Glass Ionomer Liner/Base, as well as other 3M ESPE dental materials; it is applied directly to dentin without etching or surface conditioning in a thin layer (up to approximately 0.5 mm). The liquid component consists of methacrylate-modified polyalkenoic, 2-hydroxyethylmethacrylate (HEMA), water, initiators (including camphorquinone), and calcium glycerophosphate. The paste is a combination of HEMA, 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy)phenyl]propane, water, initiators and fluoroaluminosilicate glass. Calcium glycerophosphate, whose benefit in oral care has been demonstrated [26–30], was also added to provide bioavailable calcium and phosphate to the oral cavity [23].

The direct measurement of fluid flow through dentin, or dentin permeability, has been used to evaluate desensitization materials [31–33], and has been correlated with various stimuli that induce pain in root dentin [34]. While post-treatment reduction of dentin permeability compared to pre-treatment is accepted as a good measure of the ability of a material to occlude tubules [13,35,36], and the incidence of pain with respect to dentinal fluid flow has been investigated [37], the precise correlation between permeability reduction and desensitization is not established [11]. In these models, open tubules obtained by etching or polishing the dentin surface represent one extreme of the clinical condition where the cementum layer has been completely removed by, for example, acid erosion, abrasion from toothbrushing or food, while dentin with an abrasive-applied smear layer represents the condition where only partially exposed tubules exist, such as in the early stages of root exposure. In this study, the permeability reduction was measured for VXT applied to phosphoric acid-etched dentin, and for dentin covered with an abrasive-created smear layer, in order to characterize its behavior on each of these surfaces; for comparison, permeability reduction was also measured for SBP.

2. Materials and methods

2.1. Tooth preparation

Unerupted, unidentifiable extracted human third molars were screened to determine if they were permeable enough to be used in this study. The teeth were mounted enamel side down on cylindrical aluminum stubs using extra fast set epoxy cement (Hardman, Belleville, NJ, USA). Two sections were made using a slow-speed diamond saw under water lubrication (Isomet: Buehler Ltd., Lake Bluff, IL, USA). The first section, made 90° to the long axis of the tooth, removed the roots approximately 3 mm below the cementum–enamel junction. The second section, made in the same plane, was made 2–3 mm below the deepest occlusal pit or central groove to expose middle to deep coronal dentin. This removed all occlusal enamel and superficial dentin, creating a crown segment with a remaining dentin thickness between the highest pulp horn and the exposed dentin surface of between 0.6 and 1.2 mm, as measured with a digital pincer micrometer (Renfert GmbH, Hilzingen, Germany). This dentin thickness is permeable enough for screening desensitizing agents via this *in vitro* model [31,38].

The pulpal soft tissue was removed taking care not to touch the soft surface lining of the pulp chamber. The crown segment was then mounted to 2 cm × 2 cm × 0.5 cm squares of acrylic with a viscous cyanoacrylate adhesive (Zapit™ Glue, Dental Ventures of American, Corona, CA, USA). The center of the acrylic square was penetrated by a 1.5 cm length of 18 gauge stainless tubing, permitting the pulp chamber to be filled with fluid. A 0.02% sodium azide aqueous solution was used as the liquid medium to prevent microbial growth. All air bubbles were removed from the pulp chamber using a 23 gauge needle and syringe filled with the azide solution.

2.2. Fluid flow (permeability) measurements

The rate of fluid flow through a dentin specimen was measured using the Flodec device (DeMarco Engineering, Geneva, Switzerland) illustrated in Fig. 1, which follows the movement of a tiny air bubble as it passes down a 0.6 mm diameter glass capillary located between a water reservoir under 140 cm (2 psi) of water pressure and the dentin specimens [31]. An infrared light source passes through the capillary and is detected by a diode, allowing the unit to follow the progress of the air bubble along the length of the capillary. Linear displacement is automatically converted to volume displacement per unit time, from which the instantaneous volumetric flow rate is calculated and logged into a spreadsheet. Flow was measured until a steady-state was reached, typically 0–3 min; then the flow was measured for at least 2 min; since one datum was taken every second, this resulted in at least 100 readings for