Microleakage around zirconia crowns after ultrasonic scaling around their margin

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Abstract

Problem: Ultrasonic cleaning of teeth that have been restored with full-coverage crowns may cause mechanical disruption of the cement bond leading to microleakage under the crown.

Goal: Determine the microleakage under zirconia crowns that have been cemented with resin or resin modified glass ionomer (RMGI) cement following ultrasonic scaling.

Expected outcome: There will be more microleakage under the crowns after ultrasonic scaling. Additionally, we expect that RMGI cement will be more affected by ultrasonic scaling than resin cement. Also, we would like to test if a new experimental resin cement from Danville will have less microleakage than a commonly used self-adhesive resin cement.

Impact: If ultrasonic scaling causes microleakage under crowns cemented with RMGI or resin cements, dentists and dental hygienist should be cautioned against cleaning the cervical areas of fixed dental prostheses with an ultrasonic scaler. If a new resin cement causes less microleakage, this may prolong the lifetime of dental crowns.

Introduction

Microleakage at marginal interfaces of restorations causes treatment failure. This is due to the dynamic passage of bacteria, oral fluids, molecules and ions between the interface of the restoration and tooth, causing secondary caries and discoloration of margins as well as tooth hypersensitivity. Cemented crowns are at a higher risk for marginal leakage due to polymerization shrinkage of the cement. Furthermore, the cement experiences mechanical and thermal contractions within the oral cavity. Sometimes, crown margins extend below the cementoenamel junction (CEJ). A problem arising from this situation is that bonding to cementum is different from enamel in that cementum contains higher organic and water content as well as tubular structures and fluidity not present in enamel. Its low surface energy causes difficulty in wetting the surface with dental bonding agents and thus lower bond strengths.
A problem that arises during dental hygiene procedures is mechanical stimulation of the restorative margins. Mechanical stimulation ultrasonic scalers may cause microleakage due to disruption of restorative bonding at the restorative margins. Also, instrumentation may cause roughening of the marginal interface or increase in marginal gaps which may lead to plaque accumulation and secondary decay.¹ ² Sonic and ultrasonic scalers are often the common tools used for removing plaque and calculus from tooth and root surface.¹ They can be categorized and differentiated based on its tip vibration frequency. Ultrasonic scalers are divided into two common units: magnetorestrictive (elliptical vibration pattern active on all sides of the tip) and piezoelectric (linear vibration pattern with only two active sides of the tip). Sonic scalers vibrate between 3,000 to 8,000 cycles per second (Cps) whereas magnetorestrictive and piezoelectric units vibrate between 18,000 to 45,000 Cps and 25,000 to 50,000 Cps respectively.¹ An in vitro study found more adverse effects on surface roughness of resin-based restorative materials using magnetorestrictive ultrasonic scalers than sonic scalers.³ Another study found no statistical difference in microleakage using a magnetorestrictive ultrasonic cleaning device (Cavitron 660, Dentsply, Milford, DE).⁴ Piezoelectric ultrasonic scalers are clinically favorable due to its quieter operation, smaller tips and handpieces, and ease of use.⁵

We have completed a previous study which demonstrated that ultrasonic scaling Class V restorations with a piezoelectric unit caused microleakage at the cementum margin.¹ It follows that ultrasonic scaling margins of a crown will cause disruption of the cement bond leading to microleakage. Based on a review of Pubmed and I/AADR abstracts, this study will be the first to examine microleakage under crowns following ultrasonic scaling. This testing methodology is based on existing protocol for testing microleakage between resin-based materials and tooth structure.¹

**Materials and Methods**
Following IRB non-human research subjects approval, thirty human molars were collected from the UAB Oral and Maxillofacial Surgery department. All teeth were examined under 20X magnification (VHX 600, Keyence, Osaka, Japan) for any cracks. Teeth were notched at the roots and embedded into an acrylic resin base. Crowns were prepared in a standardized crown preparation device (Figure 1) with all walls and occlusal table in dentin. The finish line will be placed within 0.5mm apical of the CEJ. The finish line will be designed as a 1mm chamfer.

The tooth preparations were captured with an intraoral scanner (True Definition Scanner, 3M). The .stl files were exported to a commercial laboratory (Custom Milling Center) which were used to fabricate zirconia (Bruxzir Glidewell) crowns. The crowns were fabricated with a 0.6mm wall thickness and a 100µm cement gap.

The crowns were luted with either a self-adhesive resin cement (RelyX Unicem, 3M) or a resin-modified glass ionomer cement (RelyX Luting Plus, 3M). Prior to cement application, the zirconia crowns were airborne particle abraded with 50µm alumina at 2 bar pressure. No restoration or tooth primers were applied when using RelyX Luting Plus or Unicem 2. An adhesive (Prelude One, Danville) was applied to both the crown and tooth when using the Danville experimental cement. The adhesive applied to the tooth was light cured. The crowns were seated with a 2kg lead weight and allowed to self-polymerize for 6 minutes. The Danville experimental cement was additionally light cured for 20 seconds per surface at its crown margins. Specimens were stored in water at 37°C for 24 hours before testing.

Ultrasonic scaling with a piezoelectric device (Varios 750, NSK-Nakanishi Inc, Kanuma, Japan) with a scaling tip (model G1, NSK-Nakanishi Inc) was used at full power with distilled water. The lateral side of the tip was used to trace the crown-cementum interface for 60 seconds (n=8) or 120 seconds (n=2) under moderate hand pressure on one side of the crown.

Specimens underwent 10,000 cycles of 5°C and 55°C thermocycling in water baths with a 15-second dwell time. After thermocycling, specimens were immersed in 5wt% solution of Fuchsine solution (Fischer Scientific Company, Fairlawn, NJ, USA) for 24 hours. All specimens
were sectioned buccal-lingually through the center of the crown with a dental sectioning disc (Abrasive Discs, ZirMet) and examined under light microscopy (VHX 600, Keyence) at 30X magnification. Distance (µm) of dye penetration from the external crown surface to the point where no dye could be seen was measured with the built-in image analysis software. Percentage microleakage was measured by dividing the linear distance of dye penetration by the linear distance from the external margin to the axial-occlusal line angle (Figure 2).

Teeth were mounted in acrylic

Standardized crown preparations were performed
Preparations were scanned with a True Definition Scanner

Zirconia copings were milled from Custom Milling Center
The copings were cemented to the preparations.

Excess cement was cleaned from the crowns.
Crowns were allowed to set for 6 minutes

After 24 hours of storage the copings were ultrasonic scaled for 60 sec or 120 sec and then thermocycled
The copings were then soaked in fuschine blue dye for 24 hours

The copings were sectioned
The sectioned copings were examined by microscopy to determine the amount of microleakage.

Diagram of method to measure microleakage

Results
Images of cross sections of crowns (note: margin on left was control and margin on right was scaled)

RelyX Luting Plus 60 sec Scaling

Control    Scaled
RelyX Luting Plus 120 sec Scaling

Control    Scaled (open margin)

Control    Scaled
RelyX Unicem 2 60 sec Scaling

Control    Scaled

Control    Scaled

Control    Scaled

Control    Scaled (open margin)

Control    Scaled
RelyX Unicem 2 120 sec Scaling

Control       Scaled

Control       Scaled
Danville experimental material 60 sec

Control    Scaled

Control    Scaled

Control    Scaled

Control    Scaled

Control    Scaled
Danville experimental material 120 sec Scaling

Control  Scaled

Control  Scaled
Conclusion

For Danville experimental cement and Unicem 2, neither 60s or 120s of scaling caused increased microleakage. For Rely X Luting Plus, 60s of sonic scaling did not increase microleakage. For Rely X Luting Plus, 120s of sonic scaling caused significantly more microleakage for 1 out of 2 specimens tested. The specimen with high amount of microleakage demonstrated an open margin at the area where microleakage occurred.

In general, sonic scaling did not produce increased levels of microleakage in this study. The RMGI cement led to slightly more microleakage regardless of sonic scaling. The Danville experimental cement led to less microleakage than Unicem 2 resin cement. The crowns with open margins demonstrated increased microleakage.

Bibliography