

Factors affecting contraction gap formation during cementation of ceramic inlays in dentin cavities

Gaps are formed under ceramic inlays due to contracting resin cement, and such gaps may explain a relatively high incidence of postoperative sensitivity

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A unique phenomenon occurs when resin composites are used in thin films as cements. Upon polymerization the flow in these thin films is hindered by the bonding to opposing walls causing the polymerization contraction to be directed almost entirely perpendicular to the walls. This inordinate stress causes disruption of the weakest bond most often located at the dentin-cement interface, resulting in contraction gaps with potential clinical consequences including postcementation sensitivity, recurrent caries and microleakage.

The purpose of this research was to study the factors affecting contraction gap formation during resin cementation of ceramic inlays in dentin cavities. A dental model was developed using standardized cylindrical dentin cavities with internal shoulders to create desired film thicknesses for support of cemented cylindrical ceramic inlays (Fig. 1). Embedding and cross-sectioning facilitated microscopic measurement at 800X magnification of interfacial contraction gaps of the inlay cavity floor and margins. To provide quantitative comparison of the variables, the gap size was divided by the measured film thickness to calculate the % wall-to-wall (WTW) contraction. Seven studies were performed to elucidate the variables involved in contraction gap formation during resin cementation of ceramic inlays in dentin cavities.

1. Cementation of ceramic inlays with one of 12 commercially available resin cements resulted in contraction gaps occurring at the dentin-cement interface of substantial size (1-7 μm). One cement showed a % WTW contraction of about 3.6. No gaps were detected at the inlay cavity margin.

2. Cylindrical ceramic inlays were cemented with one of six commercially-available resin composite cements and then the same cements were placed in identical inlay cavities as direct fillings. The % WTW contraction was 6-15 times greater when the resin composite was used for luting versus for direct filling in 4.5 mm butt-joint cavities. This despite the fact that

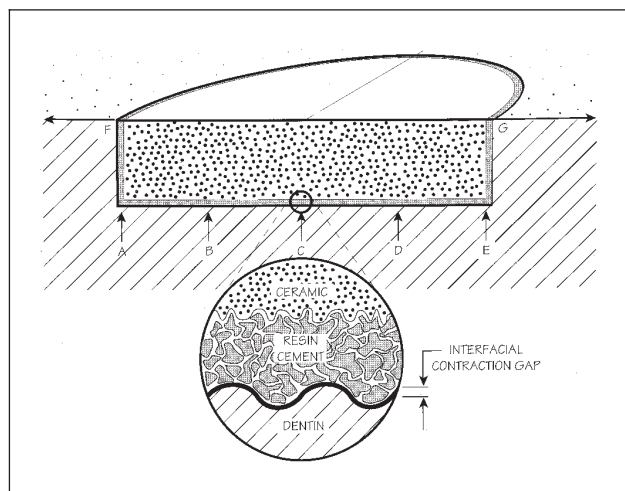


Fig. 1. View of cross-sectioned specimen used for measurement. A-G designate locations where gap size and film thickness were measured.

the volume ratio of resin composite in the cement film compared to the volume of the cavity filling was about 1:5. This demonstrated that the gap formation depends on the ratio of bonded to unbonded surfaces of polymerizing composite.

3. By altering the height of the internal shoulder in the cavity, another study determined the relationship between resin cement film thickness and the width of the contraction gap at the dentin-cement interface of cemented ceramic inlays. A power regression graph revealed a high correlation between film thickness and gap width ($r = 0.94$ and 0.96) for two cements evaluated. The % WTW contraction for the cements was approximately three times greater when measured with a 50 μm film thickness than with a 750 μm film thickness. This study suggested an inverse relationship between resin cement film thickness and the % WTW contraction.

4. The velocity and extent of ceramic inlay movement during polymerization of resin cements was measured without support for the inlay, that is without internal shoulders in the cavities. Inlays were cemented with one of four cements using an initial film thickness of 200 μm and the movement during setting was measured with a dial gauge. The velocity of the inlay movement decreased exponentially with time and with a velocity constant of 0.09 min^{-1} . The majority of the movement occurred within the first 12 minutes after photoinitiation and the movement continued probably for several days reaching for one of the cements an estimated value of 5.8 μm . By comparing the result with that obtained with cavities containing internal shoulders it was estimated that for unsupported cavities 2/3 of the resin cement contraction resulted in movement of the inlay and about 1/3 resulted in gap formation at the cavity floor.

5. Dentin cavities with internal shoulders were pretreated with one of 12 dentin bonding agents (DBA) before luting ceramic inlays with a dual curing resin cement (3.6% WTW contraction). Mean gap widths were reduced between 21 and 80% compared to control specimens prepared without a DBA.

6. The effect of combining various DBA with resin cements of varying % WTW contraction was also studied. Mean gap widths were reduced between 46 to 93% compared to control specimens prepared without a DBA. However, none of the dentin bonding agents tested were able to completely eliminate development of interfacial contraction gaps.

7. Methods for guiding the polymerization shrinkage of resin cements in order to avoid disruption of the bond to tooth structure were tested. Etched ceramic inlays were treated with a variety of conditions or with resins containing polymerization inhibitors or no initiators. Dentin cavities were pretreated with various dentin bonding agents and chemical- or light-cured resins. It was demonstrated that the pattern of polymerization shrinkage of thin film resin cements could be directed in such a way as to favour the weaker dentin bond over the stronger bond to etched ceramic. The application of a chemical curable resin over a DBA and placement of a resin containing no initiator on the etched ceramic, resulted in a reduction of gap size of 46 to 64% (dependent on type of DBA) compared to results obtained with the use of a light-curable resin at both locations. Also, the application of a resin containing 100 ppm BHT (a polymerization inhibitor) on the ceramic side reduced the contraction gap size by about 88% for a given DBA. Both approaches reduced the interfacial contraction gap size to well under half a micrometer. Whether these proce-

dures reduce the contraction gap size to a level that is clinically insignificant can only be proven by clinical trials.

Conclusions

Gaps are formed under ceramic inlays between the resin cement and dentin. In cavities without hindrance for inlay movement under seating, a situation not very common in clinical practice, 2/3 of the contraction of a cement results in movement of the inlay, with a velocity constant of 0.09 min^{-1} , and 1/3 results in gap formation.

For ceramic inlays cemented in dentin cavities with hindered movement for the inlay, the % WTW contraction of the resin cement, calculated as the gap in % of the film thickness, is much higher than the % WTW contraction of the resin filling.

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3. Sorensen JA, Munksgaard EC. Effect of resin cement film thickness on interfacial contraction gap size. *Dent Mater* (in press).
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