The Effect of Selective Die Spacer Placement Techniques on the Seatability of Castings

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It has been reported in the literature that impingement of the casting at the axial-occlusal line angle of the tooth preparation may be a major cause of incomplete seating following cementation. It has been suggested that an additional coat of spacer applied to these areas on the laboratory die before the fabrication of the casting may alleviate this discrepancy. This study evaluated the effect of three die spacer placement techniques on the seatability of cemented castings. Results showed no statistical difference in seating between castings made with conventional relief and those made with additional relief at the axial-occlusal line angles. Castings relieved exclusively at the axial-occlusal line angles exhibited significant post-cementation marginal openings.

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INDEX WORDS: die spacer, castings, seating

INCOMPLETE seating of castings with the introduction of a luting agent has been shown by several authors.[1-4] This phenomenon has been proven microscopically by the presence of a postcementation margin gap.[1,4,5] It has been found that postcementation spaces, especially in the occlusal area, often greatly exceed the recommended film thickness for most cements.[2,3]

Resistance to seating can be attributed to several factors, such as the height or taper of a preparation, margin configuration, or the absence of internal relief within casting. The latter by far has been shown to be the most significant in terms of compensating for nonuniform casting distortion.[3]

Methods for creating a relief space for castings are either subtractive or additive.[6] Subtractive methods involve bulk reduction of metal from the internal surface of the casting by mechanical, chemical, or electrochemical means. Hollenback was the first to recognize the importance of providing a relief space for cement and introduced the technique of etching the internal surface of a casting with aqua regia (nitrohydrochloric acid).[7] Mechanical relief of the finished casting with burs or stones is undesirable and may produce unpredictable results. The additive method of applying a spacer directly onto the stone die is widely used today because of its convenience and relative predictability. An optimal die spacer thickness of 25 to 40 μm has been suggested by most authors.[8] The variability of die spacer film thicknesses, however, was shown by Gardner and Vermilyea.[9]

The role of die spacers is to provide for cement film thickness and to compensate for distortion during impression making and metal casting. Campbell consistently found smaller die spacer thicknesses at the axial-occlusal line angles as compared with other surfaces.[8] Campagni et al have postulated that spacer paint tends to flow away from sharp die angles as a result of increased surface tension.[10] The absence of adequate relief space in these areas may impede the flow of cement beyond the occlusal portion of the casting, which could result in incomplete seating because of hydraulic pressure. The purpose of this study was to compare the seatability of castings using various die spacer placement techniques.

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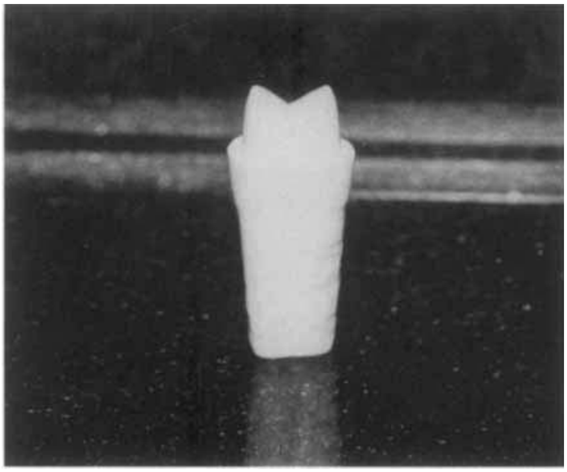

Figure 1. Maxillary second premolar master ivorine die.

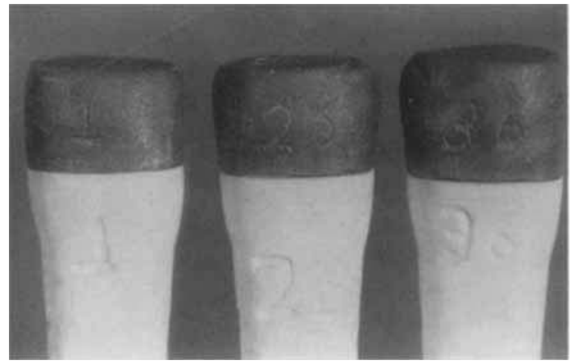

Figure 3. Precemented cast samples from each group seated onto their respective dies. Note the visible margin opening in the casting fabricated with no axial wall relief.

Materials and Methods

An ivorine maxillary first premolar tooth was prepared with a uniform 1-mm shoulder finish line and an axial wall taper of 9° (Fig 1). Sixty exact duplicates were fabricated from the master die (Viade Products, Inc, Camarillo, CA) to be used for three experimental groups. A circular benchmark scribed approximately 3 mm below the finish line of each die was used for measuring purposes.

In the control group, 25 dies were coated in the conventional manner with two layers of Belle de St Claire blue die spacer to attain an approximate 25-μm film thickness (Belle de St Claire, Van Nuys, CA) (Fig 2). In group one, 10 dies were painted with two coats of spacer exclusively at the axial-occlusal line angles (Fig 2). Group two, containing the remaining 25 samples, received the conventional two layers with an additional coat at the axial-occlusal line angle (Fig 2). Wax patterns were fabricated directly on the ivorine dies and invested in a high-heat investment material (CB 30, CMP Industries Inc, Albany, NY). The manufacturer's guidelines for the use with base metal alloys were followed. The patterns were heat-eliminated, and Rexillium III alloy nickel-chrome (Jeneric/Pentron Inc, Wallingford, CT) was cast into the molds (Fig 3). The internal surfaces of the crowns were sandblasted with 50-μm aluminum oxide and then inspected for casting irregularities using a light microscope.

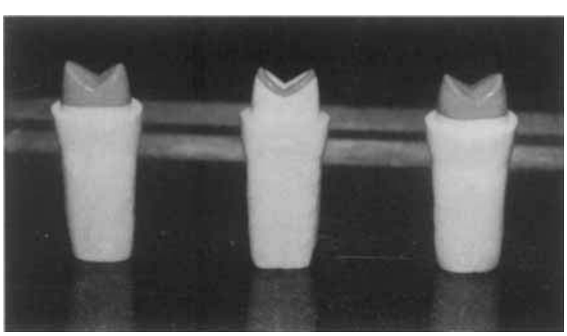

Figure 2. Test samples from the control, group one, and group two with paint-on spacer before wax pattern formation.

Figure 4. Measurements were made at a magnification of 50× using a measuring eyepiece.

Table 1. Data (in Increments) for Uncemented Castings

Group	*n*	$\bar{X}$	*SD*
Control	100	4.407	0.496
1	40	4.618	0.480
2	100	4.581	0.454

Minor casting irregularities were carefully removed with the use of a rotary instrument, and the surfaces were again sandblasted.

The paint-on spacer was removed with acetone, and the castings were seated onto their respective dies with a static load of 15 kg. A light microscope (Wild M5A, Wild Heerbrugg Ltd, Heerbrugg, Switzerland) with a filar eyepiece was used to measure the distance between the metal margin and the benchmark at the mid-facial, mesial, palatal, and distal areas on the die (Fig 4). A vertical reference line was scribed onto each surface to ensure precise relocation for postcementation evaluation. Castings were reseated using the same 15-kg load following the introduction of a luting agent (Ketac Cem, Espe, Seefeld/Oberbay, West Germany). Postcementation distances were compared statistically with the preliminary measurements, and differences among the three groups were calculated.

Results

Three one-way ANOVAs used to detect differences between sides (M D L F) showed no significance at the 0.05 level. The means and standard deviations of uncemented groups are shown in Table 1. Each increment equates to a distance of 280 μm (4.4 = 1,232 μm). The figures for the cemented groups are given in Table 2. Three separate independent student *t* tests were conducted, and the results are given in Table 3. The differences between the control and group two were not significant ($P = .14$). However, significance was detected between control and group one and between group one and group two ($P < .001$).

Discussion

A preliminary *t* test conducted on five samples each for the three experimental groups demonstrated significance only in group one, which accounts for its small sample size. In the current study, a mean discrepancy between uncemented and cemented crowns in group one was 116.5 μm (Figs 5, 6). This would seem to indicate that resistance to seating was not restricted entirely to interference at the occlusal line angles. In reality, binding occurred almost exclusively along the axial walls, which required some crowns to be relieved slightly to allow for adequate seating (Fig 7). No crowns in group one could be fully seated without gross modification of the internal surface of the casting. The mean discrepancies between uncemented and cemented crowns for the control and group two were 32.7 μm (Figs 8, 9) and 15.3 μm (Figs 10, 11), respectively. Although a general improvement was seen with dies receiving an additional coat of spacer at the axial-occlusal line angle, it was not found to be statistically significant.

The results of this study concur with the findings of Eames et al, who found that castings were elevated an additional 20 μm or more following cementation.[1] The greatest discrepancy was seen with crowns that were not relieved. It has been suggested that internal relief achieved either through subtractive or additive means will compensate for cement film thickness and thereby allow more complete seating of castings. However, it has been found in similar studies that increased marginal opening of a crown will invariably

Table 2. Data for Mean Differences After Cementing

Group	*n*	$\bar{X}$	*SD*
Control	100	.118	0.532
1	40	.417	0.517
2	100	0.55	0.389

Table 3. Differences Between Cemented Groups

Group	*Difference in Means: Cemented*
Control-2	.062 $P = .14$
1-2	.362 $P < .001$
1-Control	.299 $P < .001$

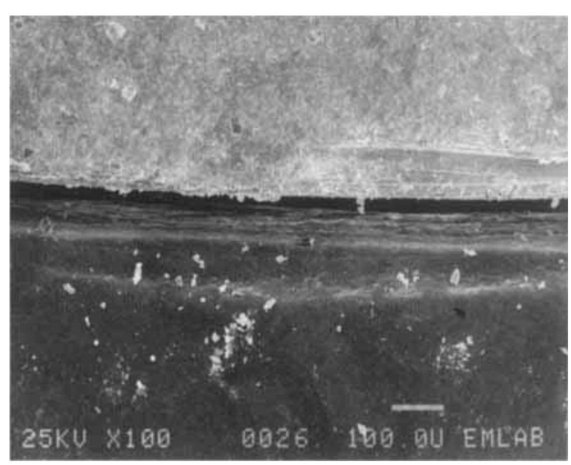

Figure 5. Precementation sample from group one.

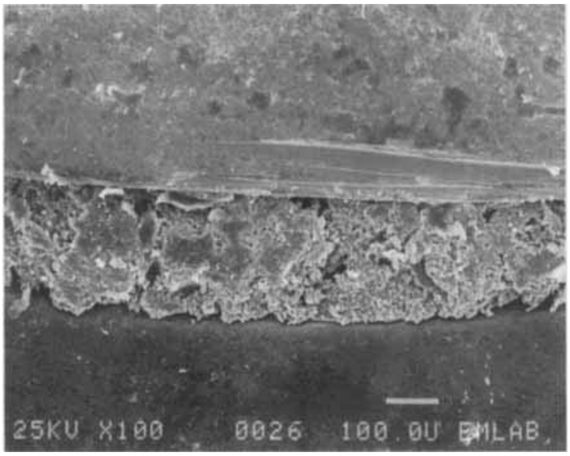

Figure 6. An increase margin opening of about 120 μm following cementation in the same sample from group one.

occur with the introduction of a luting agent regardless of the relief method used.[2,11] The assumption that a uniform thickness of die spacer could be attained was disputed by Gardner and Vermilyea.[9] Other variables, including impression making, pouring of stone dies, wax pattern formation, and casting procedures ultimately affect the fit of a crown.

It has been reported that nonuniform casting distortion accounts for the majority of incompletely seated castings.[6] This phenomenon was shown clearly in this experimental design where crowns were seated on the same die used to fabricate the wax pattern. Tight-fitting crowns as a result of casting shrinkage were consistent findings for all samples studied, especially for those in group one. Binding along the axial walls was much more frequent than in other areas. The degree of binding seemed to correlate

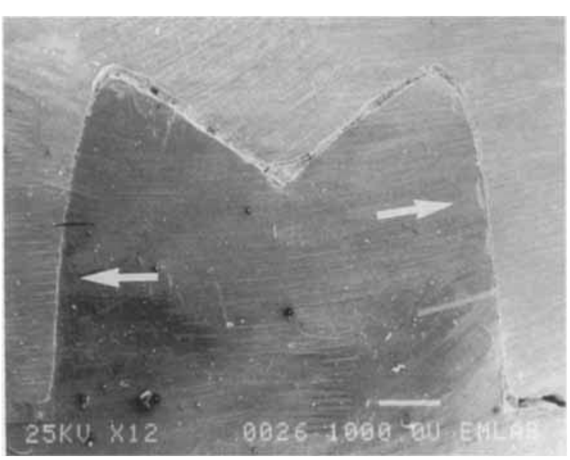

Figure 7. The arrows indicate the areas of most frequent binding during seating of castings.

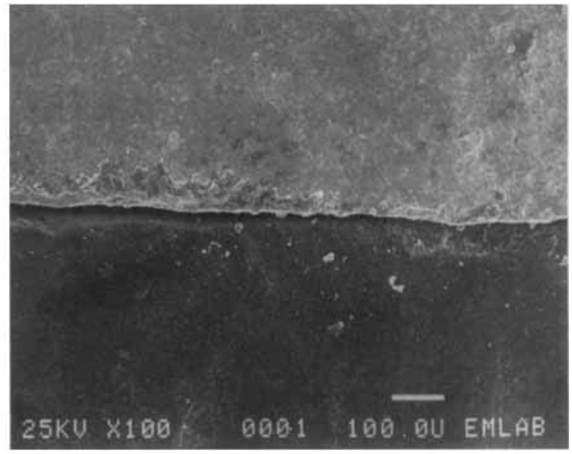

Figure 8. Scanning electron photomicrograph of precementation control sample at magnification of 100×.

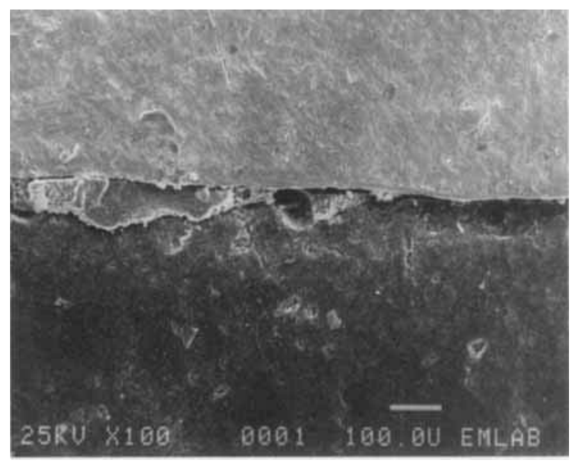

Figure 9. Postcementation control sample showing an increased margin opening of approximately 30 μm.

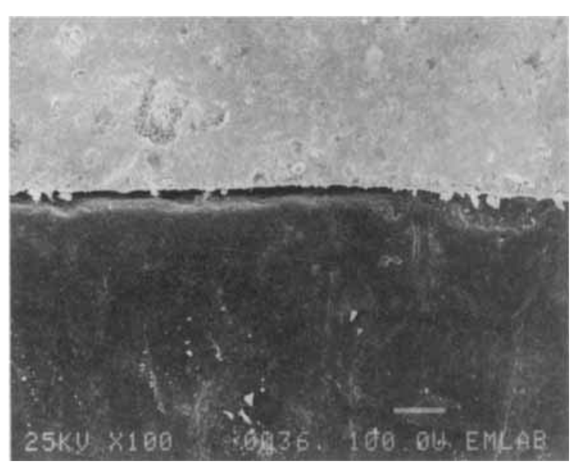

Figure 10. Precementation sample from group two.

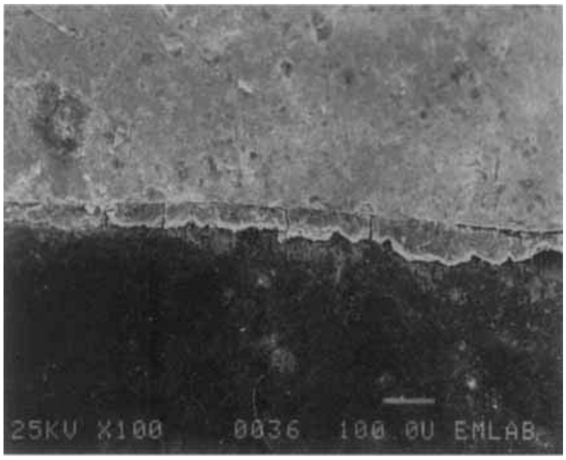

Figure 11. Postcementation sample from group two showing an increased margin opening of approximately 20 μm.

directly to the magnitude of post-cementation margin opening. However, this may not be true in actual clinical situations where a loss of accuracy can be expected during the impression and die making stages.

The results of this study pointed out the need for providing additional relief, especially at the axial walls when casting base metal alloys. It was found that two coats of spacer applied to these areas did not provide sufficient protection against binding. An additional coat would be required for this purpose. Although impingement at the axial:occlusal line angles was not significant in this study, it was found that castings relieved in this area exhibited improved seating. This may have a greater significance clinically in compensating for the impression material's inability to accurately record sharp angles on tooth preparations.

Conclusion

The assumption that castings contact predominantly at the sharp axial:occlusal line angles was not observed in this study. When compared with the conventional spacing technique, there was no significant improvement in casting seatability when an additional coat of spacer was applied to these areas. Crowns relieved exclusively at the axial:occlusal line angles consistently showed poor seating caused by binding along the axial walls of the die.

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