

Effect of Venting and Seating Techniques on the Cementation of Complete Coverage Restorations

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Clinical Relevance

The best seating of complete crowns during cementation can be achieved by venting the crown and using a tapping cementation technique. When the crown is not vented, a dynamic seating method provides the best seating.

SUMMARY

Statement of Problem. The incomplete seating of crowns resulting from cementation phenomena is a universal problem for clinicians. This seating error may lead to disturbances in the occlusion, proximal contacts, reduced retention and open margins. Various cementation protocols are practiced, with no established standard that maximizes crown seating and marginal fit.

Purpose. This study investigated the effect of various combinations of venting and cementation seating techniques with the routine use of die relief on the seating of complete gold crowns.

Material and Methods. Fifty human molars were prepared with a mounted handpiece for

complete coverage crowns with a featheredge finish line and six degrees of taper, according to Tylman.³⁹ Impressions were made, stone dies fabricated, die spacer was applied and the crowns were waxed and cast in type III gold. The respective crowns were placed on the teeth and preloaded. The distance between reference marks on the tooth and crown were measured at four points around each tooth. Zinc phosphate cement was mixed and the crowns were cemented in the following groups: 1) vented, tapping the crown into place with a mallet, 2) non-vented, tapping the crown into place, 3) vented static seating with a 25 kg load, 4) non-vented dynamic seating, 5) non-vented static loading with a 25 kg load. A 25 kg load was then maintained on the crowns during the cement setting time. Distances between reference marks were then measured and the change in post-cementation distances calculated.

Results. ANOVA ($F=14.995$, $p<.0001$) and multiple range tests revealed significant differences between the groups. The mean increased post-cementation distances for the seating groups were (μm): 1) 132 ± 20 , 2) 372 ± 26 , 3) 367 ± 59 , 4) 239 ± 35 , 5) 537 ± 45 .

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Conclusions. The vented tapping technique produced the best seating. The non-vented tapping seating group produced seating not significantly different from the vented static method. The non-vented static group had the worst seating, with a gap four times greater than the vented tapping group.

INTRODUCTION

Failure to attain a completely seated crown during cementation may lead to disturbances in the occlusion, interproximal contacts, decreased retention, open margins and, consequently, cement wash-out possibly leading to recurrent caries.¹⁻² There is general agreement in the literature regarding the virtues of venting, die spacing and dynamic seating as it relates to improved crown seating, but virtually no consensus on the optimal combination to use.³⁻⁹ This study investigated the effect of the routine use of die spacing with various combinations of non-static seating (tapping), static seating and dynamic seating techniques with vented and non-vented complete coverage restorations.

METHODS AND MATERIALS

Fifty molars were prepared with a high-speed hand-piece and water spray mounted on a milling machine for complete gold crowns. An 860-014 bur (Brasseler USA, Savannah, GA, USA) was used to prepare a featheredge finish line and 6 degrees of taper according to Tylman and Malone.¹⁰ Impressions of the tooth preparations were immediately poured with 25 grams of Indec Stone (Modern Materials, South Bend, IN, USA), which was pre-measured and mixed with 5.5cc of distilled water and mixed under vacuum. All stone casts were placed in a chamber with 100% relative humidity to maximize the physical properties of the stone during setting. The dies were prepared with two coats of die spacer (Belle de St Claire, Encino, CA, USA), measuring ~22-26 μm on the axial walls to within 1 mm of the margin and three coats on the occlusal surface, measuring ~33-39 μm .¹¹ Waxing and casting procedures were followed according to Tucker¹² to compensate for inherent expansion and shrinkage properties of the materials used in attaining precision castings, as described by Asgar and Clark.¹³ The 50 teeth with their respective crowns were randomly divided into five cementation seating groups of 10, as shown in Table 1.

Reference markings were made at the buccal, lingual, mesial and distal aspects approximately 1 mm from the margins on both the tooth and castings. Each crown was placed under a static load of 11.3 kg (25 lbs) for 15 seconds prior to pre-cementation measurements (Figure 1) made with a measuring microscope (Nikon, Tokyo, Japan). Three measurements were made at each

Group	Venting	Seating Technique
1	Vented	Tapping with mallet ¹
2	Non-vented	Tapping with mallet ¹
3	Vented	Static
4	Non-vented	Static
5	Non-vented	Dynamic—rocking with stick ²

¹ Tucker
² Rosenstiel and Gegauff⁴



Figure 1. Pre-cementation loading.

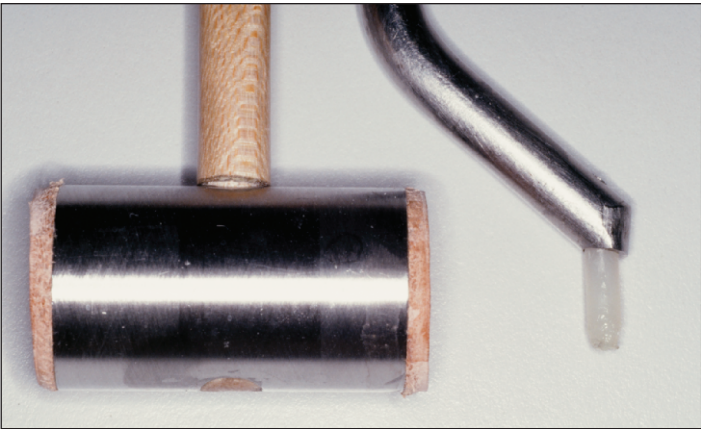


Figure 2. Mallet and Suter seating instrument (contra-angle).

of four points around the crown. Zinc phosphate cement (Flecks, Keystone, Cherry Hill, NJ, USA) was mixed in a standardized manner on a glass slab and applied to the casting with a cement spatula by filling approximately half way. The mallet and seater (Suter Dental, Chico, CA, USA) (Figure 2) were used to tap the crowns into place in the first two groups by applying the mal-

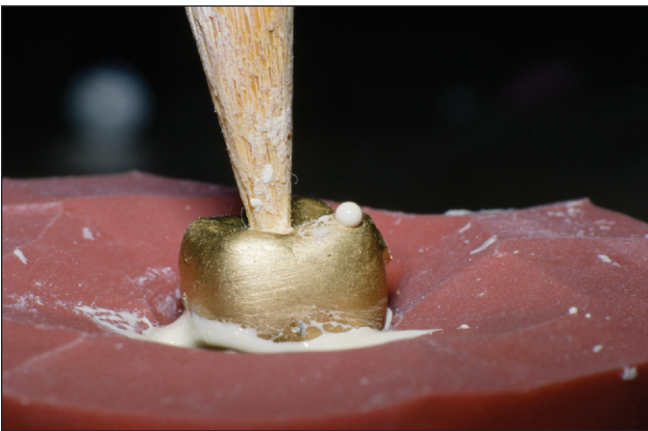


Figure 3. Extrusion of cement through vent hole (tapping).

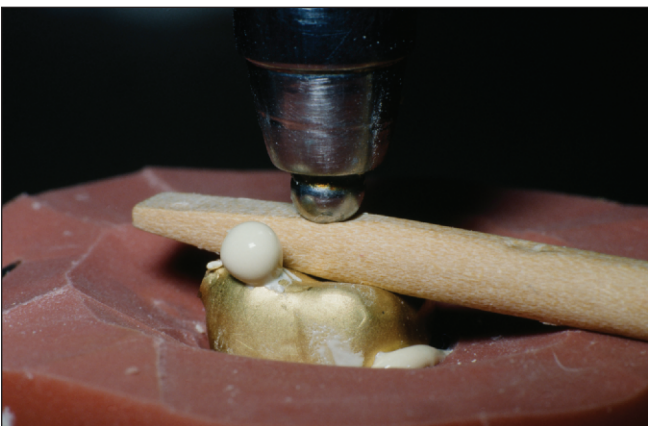


Figure 4. Extrusion of cement via dynamic seating.

Table 2: Mean ΔH (μm)	
Group	Distance (SD)
Vented, Tapping	132 (20)
Non-vented, Dynamic	239 (35)
Vented, Static	367 (58)
Non-vented Tapping	372 (28)
Non-vented, Static	537 (45)
ANOVA: $F=14.995$, $p<.0001$	

let force in various directions to assure full seating of the casting. This was continued with a moderate and clinically relevant force until no more cement extruded through the vent hole (Figure 3), and the crown was held with 11.3 kg of static pressure until complete cement cure. No vent pin was applied to the casting, as is customary in the clinical setting,⁷ due to the *in vitro* nature of the study. Groups 3 and 4 were seated with a static load of 11.3 kg after cement application as previously described, while Group 5 was dynamically seated as described by Rosensteil and Gegauff.¹⁴

All crowns were placed under a static load of 11.3 kg until completion of the cement cure (Figure 4), then

placed in 100% humidity at 37C° for 10 minutes prior to placement in a water bath. Post-cementation measurements were again made three times at each of four points on each crown with a measuring microscope at 100x magnification.

The mean pre- and post-cementation distances between the four reference marks were calculated for each crown. The mean change in height post-cementation was then calculated for each crown and the mean change in height was calculated for the five-cementation seating groups.

RESULTS

ANOVA ($F=14.995$, $p<.0001$) and multiple range tests revealed significant differences between the groups (Table 2). The non-vented tapping seated group produced seating not significantly different from the vented static method. The vented tapping technique produced significantly better seating than the other methods tested, while the non-vented static method produced the greatest seating discrepancy.

DISCUSSION

Often, the clinician works with focused diligence to prepare the tooth without causing pain to the patient, takes an accurate impression and finally fabricates the casting with precision only to give minimal consideration to the cementation procedure. Typically, the patient bites on a cotton roll or an orangewood stick while the cement cures, then the excess cement is removed. The literature suggests that this is the least desirable protocol to use when optimizing the seating of complete-coverage crowns.¹⁴⁻¹⁵ The consequences have been previously mentioned. There is general agreement that open margins pose a risk factor for secondary decay; however, the occlusal considerations are often accepted as a clinical reality or overlooked altogether. It appears that gnathologic adjustment of extensive cases in fine-tuning the occlusion after remount procedures may be moot if there is a cementation error of higher magnitude.

In appreciating the significance of the cementation error, if one bites on a piece of articulating paper or a human hair (40-70 microns), its presence is perceived (Table 3). Therefore, it could be said that 100 microns is of clinical significance. In fact, there is a body of evidence to suggest that the human dentition is exquisitely sensitive to much finer tolerances and may accordingly alter gnathologic function.¹⁶⁻¹⁷

Although novel luting agents abound in the market place today and, as such, are more popular in use, zinc phosphate cement has been the standard in the profession and the only luting agent to receive a specification (No 8) from the National Bureau of Standards and the American Dental Association. It is specifically

Table 3: Comparative Measurement (μm)

Material	Thickness (μm)
Mylar	12.5
.0005 Plastic shim stock paper	12.7
.001 inch tin foil	25.4
Cigarette pack cellophane	25.4
Human hair diameter	40-70
Scotch magic tape	63
X-ray packet tin foil	75
Articulating papers/ribbons	62-100
Bond typing paper	112

“designed for the accurate seating of precision appliances...”²⁰ The ADA specification for film thickness of type I zinc phosphate cement is 25 microns.²⁰ As Pilo and others point out in their literature review on cementation, most investigations have found film thickness on cemented crowns to range from 60-435 microns; the reason for such a wide range is manifold.²¹ Eames states that we must face the fact that, under average conditions, our castings will be elevated 200 microns on the prepared tooth.¹ So, what is the correct cementation protocol to follow to predictably achieve an optimally seated full crown and mitigate the consequences? A systematic approach to reviewing the major considerations may prove useful.

Venting

The objection to venting techniques is unfortunately without basis. In fact, the importance of venting as described in the literature is significant. Cooper and others found that the venting of castings reduced the mean marginal opening by 45 microns,²² as did Van Nortwick and Gettleman, where the seating of crowns improved by 290 microns with venting.⁶ Kaufman and others showed a retention increase between 19% and 32%, while improving seating by 175 microns.²³ The use of venting and die spacing allows for optimal compensation of the hydrodynamic phenomena, while assuring a uniform distribution of the luting agent. As Dimashkieh and others found, the time of final seating with venting was reduced from 60 seconds to 15 seconds, thus preventing the restriction of cement flow due to curing viscosity.²⁴ Van Nortwick and Gettleman found that the combination of venting and internal relief seated full crowns more accurately than with either alone.⁶ Jorgensen considered the hydrodynamic condition created during cementation as the primary consideration to overcome in obtaining the thinnest cement film thickness.²⁵ Hoard and others describe venting as working, because it affects the flow, limits stacking of the particles and relieves residual intra-coronal pressure.³ Therefore, with these findings, why is venting not routinely used? Some possible explanations include the notion that venting requires an extra

visit to fill the vent hole or that the vent hole may display marginal microleakage resulting from the vent opening.¹¹ Bassett previously described a technique that requires a little more than 90 seconds of additional labor.⁷ The amount of time required to adjust the occlusion properly due to seating errors may run an order of magnitude greater if venting is not used, while still having a compromised margin seal. Plastic analog pins are sprued and cast out of a type 4 gold. After the cement has been vented, the pin is placed in the vent hole, malleted into place, then cut with a diamond disc or round bur. The remaining pin tag is removed and polished with traditional finishing discs. The vent hole is sealed and is not evident to the naked eye. One last compelling reason to routinely use venting was theorized by Bergenholtz and Nyman.²⁶ The hydrodynamic pressure that deforms the crown may also act on the pulp through the porous dentin, which, in turn, may transport some cement constituents into contact with vital tissue. This effect may have adverse consequences on the pulp, ranging from transient pulpal inflammation to pulpal necrosis. In the aforementioned study, it was found that, over a mean observation period of eight years, 9% of teeth receiving crown restorations required root canal therapy with no obvious cause. This incidence of approximately 1% of crowned teeth requiring root canal therapy per year has been confirmed in other studies and may be a delayed consequence of pulp damage from intra-cementation pressure generation.²⁶⁻²⁸

Seating Techniques

Jorgenson discussed the phenomena of obliquity, stating that it was impossible to seat a full casting without some degree of obliquity or tilt even when vented²⁵ (Figure 5). Bassett recommended a combination of internal relief and venting of the test die in an attempt to overcome the oblique seating problem, but he was still unable to cement a crown without some tipping of the casting on the die.⁷ Van Nortwick and Gettleman found that closer seating corresponded to less tilting.⁶

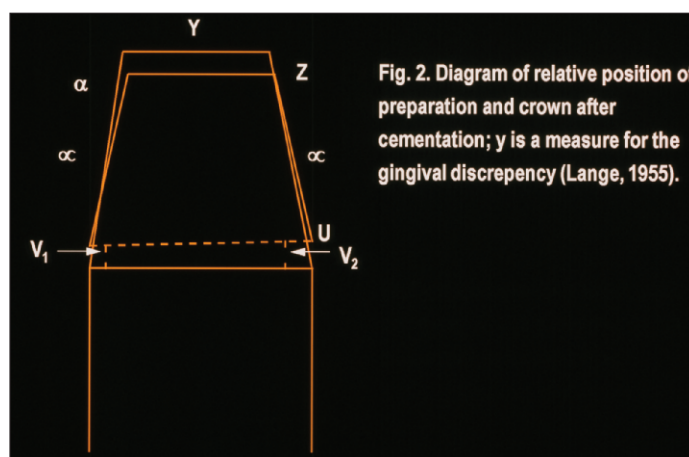


Fig. 2. Diagram of relative position of preparation and crown after cementation; y is a measure for the gingival discrepancy (Lange, 1955).

Figure 5. Diagram of obliquity as described by Jorgensen.²⁵

The current investigation suggests that an alternative seating technique, such as mallet tapping in combination with venting and die relief, will predictably overcome the obliquity phenomena. Mallet tapping allows for uniform seating by directing the seating force at various angles to the long axis of the tooth, thus overcoming the tendency of the crown to hang up on any particular preparation wall.

Regarding the use of other non-static seating techniques, Koyano and others found that vibration during cementation produced a thinner cement film at the margins of the restorations than static pressure alone.⁵ Oliveira and others found that vibration improved the adaptation of MOD inlays.²⁴ Ishikiriama and others found that the mechanical vibration of crowns at cementation promotes a better fit.⁴

Axial Fit

Since 1932, more than a dozen gold casting procedures and techniques have been introduced to the dental profession.³ The main motive for developing and introducing these techniques is to produce a metallic replacement for missing tooth structure as accurately and easily as possible. An exact tolerance for acceptance or rejection of any dental casting has not been determined.¹³ In fact, in the literature relating to die relief, venting, cements and cementation techniques, it is assumed that the castings fit the die and/or tooth accurately and, as such, are subjective.^{13,30-31} It is apparent that a wide spectrum exists as to the amount of compensation that is taken in making the castings fit on dies, which obviously should affect our comparisons from one study to the next. It seems that the lack of consistency in the literature in accounting for the inaccuracies inherent with the lost wax technique allows for flawed comparison from one study to the next when evaluating film thickness/margin closure. In his study, Byrne discussed looking at the influence of finish-line form on crown cementation, the subject of internal or axial fit of castings as not having received much attention in the literature.⁹ He further mentions the difficulty in defining satisfactory casting adaptation for laboratory and clinical purposes. "In general, studies of cemented casting adaptation have only examined occlusal and marginal displacement, while ignoring axial wall adaptation." Fusayama and others found that the thickness of zinc phosphate cement for optimum shear strength was 31-38 microns.³²⁻³³ Vermilyea and others found that the advantage of high shear strength provided by zinc phosphate cement is compromised by cementing oversized full coverage castings.¹⁴ Thus, the use of zinc phosphate for "precision" castings, as indicated by ADA specification number 8,²⁰ diminishes if the casting is not precise and perhaps would be better off with one of the newer cements whose

microleakage and bonding properties are proven to be superior.

In summary, the routine use of die spacing with venting and mallet tapping affords the best opportunity to attain optimal margin closure. By understanding and following a strict laboratory protocol in compensating for the inaccuracies of the lost wax casting technique, one is able to concurrently achieve maximal retention via 1) primary retention at the margin through frictional accuracy of the casting and 2) secondary retention via cohesive friction along the axial wall from the cement.

The proven long-term history and superior shear strength of zinc phosphate is optimized due to the accuracy of the axial fit, further enhancing retention. All of this combines for predictable longevity and occlusal harmony. Although the 3 degree taper per side used in this study was maximal, as described by Tylman,¹⁰ its clinical relevance is questionable. In fact, in the clinical situation where less taper is applied to the preparation technique, the cementation error is significantly minimized without compromising axial fit or retention, and one should expect significantly lower margin discrepancy numbers than was reported in the current study. When using the hygroscopic expansion casting technique, the decreased taper allows for a more favorable water/powder ratio in attaining accurate expansion of the wax pattern invested and, as such, fits the tooth more accurately.¹² The cementation technique described must be used, however, to attain the most favorable result. Further investigation is necessary to determine the amount of achievable taper in a clinical setting without compromising the desired result.

CONCLUSIONS

1. The use of venting and tapping resulted in the best marginal closure compared to the other groups.
2. The non-vented static group resulted in the least desirable margin closure.
3. There was no statistically significant difference between the non-vented tapping group and the static vented group.

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