

Cement Application Techniques in Luting Implant-Supported Crowns: A Quantitative and Qualitative Survey

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Purpose: To investigate different techniques used by dentists when luting an implant-supported crown and to evaluate the application of cement quantitatively and qualitatively. **Materials and Methods:** Participants were given a bag containing cement sachet, mixing pad, spatula, a variety of application instruments, and a polycarbonate crown form. The participants were instructed with a standardized audio-video presentation to proportion the cement, mix it, and apply it to the intaglio of the crown as they would if they were to cement it onto an implant abutment in a clinical situation. The crowns were weighed, first unfilled and then again once the applied cement had set. The mean weights of fully-loaded crowns ($n = 10$) were used as a control group. The patterns of cement loading were recorded. The weights of collected cement-loaded crowns were compared to those of the control group and analyzed statistically. **Results:** Four hundred and one dentists in several different geographic locations were surveyed. Three distinct cement loading patterns were observed: gross application (GA), brush-on application (BA), and margin application (MA). The mean weights for each cement loading pattern were 242.2 mg for the GA group, 59.9 mg for the BA group, and 59.0 mg for the MA group. The weight of cement in the GA group was significantly higher than that in the other groups. No statistically significant difference between groups BA and MA was seen. **Conclusions:** The diversity of the cement loading patterns disclosed in this study indicates that there is a lack of uniformity and precision in methods and a lack of consensus in the dental community regarding the appropriate quantity of cement and placement method for a cement-retained implant crown. INT J ORAL MAXILLOFAC IMPLANTS 2012;27:859–864.

Key words: cement-retained implant crown, cement volume, dental cement, luting cement application

The use of cementation as a means to secure restorations to an implant abutment is a well-established procedure with many documented advantages.^{1,2} The use of luting cements with implant restorations has been studied through surveys on material selection³ and laboratory studies on cement retentive values,^{4–6} radiopacity,⁷ seating discrepancies,⁸ and other physical and biologic properties. However, clinical problems associated with excess cement around implant restora-

tions have also been reported.^{9–12} A multicenter 3-year prospective study reported that the peri-implant soft tissues responded more favorably to screw-retained crowns than to cement-retained crowns.⁹ Case studies have indicated that excess cement can have a detrimental effect on peri-implant tissue health.^{10,11}

A recent prospective clinical study found a positive relationship between excess cement and peri-implant disease.¹² Restorations luted to titanium abutments with simulated margins have been shown to leave a surprising quantity of cement remnants.^{13,14} Reports that cement extruded into the peri-implant tissues may be problematic have led to the development of techniques to control cement excess.^{15–17}

When considering the quantity of cement within the crown and abutment system, an absolute space is provided for the cement—the cement lute space—which is commonly provided for by the use of a die spacer during crown fabrication. It is clear that any quantity of cement placed within the crown that exceeds the cement lute space must be extruded out of the crown and abutment for complete seating. On the other hand, if a quantity of cement less than that required for

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Fig 1 (Left) Image of an abutment that was shown to the participants during the survey. (Right) Image of the crown type that was provided to participants.



Fig 2 A control specimen filled flush to the rim represents 100% loaded.

the cement lute space is placed within the crown, then the cementation layer is inadequate to completely fill this space.

Few studies have evaluated cement application techniques in the intaglio of crowns with respect to tooth preparations¹⁸⁻²³ or implant abutments.⁵ These studies failed to adequately quantify the amount of cement employed as well as the placement technique employed. Translation of these data into clinical practice and determination of how the data may influence dentists have not been performed.

The purpose of this study was to investigate the cement loading patterns and the typical quantity of cement employed by practicing dentists when considering cementation of an implant-supported crown. The null hypothesis was that there were no differences in the quantity of cement used by practicing dentists when contemplating the cementation of a crown onto an implant abutment and that the quantity of cement applied would not vary by application technique.

MATERIALS AND METHODS

The participating dentists for this survey were attending continuing dental education lectures either given at a private study club or at academic institutions. Each participant was provided with a plastic bag that contained the following: a single-dose cement package (TempBond NE, Kerr); a polycarbonate crown (No. 52 Polycarbonate Crowns, Henry Schein); and application tools for cement loading, including a mixing pad (Kerr), mixing spatula (Mixing Sticks, Zirc), and a brush (Ultra Brush 2.0, Microbrush Intl) mounted in a handle with a flat plastic end (Brush Tip Handle, Henry Schein). The empty crowns were weighed and numbered individually with ultraviolet permanent ink (Dri Mark Security Marking System, Dri Mark Products), which was invisible under natural light.

During the survey, participating dentists were instructed by prerecorded audio and video footage to proportion, mix, and load the cement into the intaglio of the crown. The instructions included a description of the bag's contents and directions on disbursement and mixing the cement and indicated that the dentists might use any instrument included in the bag to load the crown. No actual implant abutment was provided; instead, the participants were shown an image (Fig 1) of the proposed implant abutment as well as the actual crown form they were given. The dentists were then instructed to consider that they were about to cement the crown form onto the implant abutment in a manner consistent with that used in their clinics. After the cement was loaded onto the crown, the cement-loaded crowns were placed in a clip vertically to prevent cement flowout and allowed to set for 1 hour. The crowns were collected, placed in a sealed plastic bag, and labeled according to the city of origin. The cement-loaded crowns were identified by their ultraviolet marking and weighed again 24 hours after collection. The weights of cement were thus calculated for each specimen. The pattern of cement application was also observed and recorded.

A control group of 10 crowns was established. These crowns were weighed empty and subsequently loaded with TempBond NE cement so that the cement was flush with the margins of the crown form circumferentially (Fig 2). They were manipulated in the same manner as the survey specimens with respect to individual identifiers, time of setting, sealing within a plastic bag, and a 24-hour waiting period prior to reweighing. The mean weight of the cement-filled control group was considered 100% cement fill. A second calculation was made to determine the absolute quantity of cement required for an ideal cement lute space according to the dimensions of the polycarbonate crown provided and assuming a standard lute space thickness. The calculation was

Table 1 Distribution of Samples by Location, Cement Application Technique, and Range of Weight of Cement

Sampling location	n	Application technique			Cement loaded (range, in mg)	% range compared to control*
		GA	BA	MA		
Bothell, WA	13	4	8	1	12.6–406.8	3.0–97.6
Tacoma, WA	14	1	12	1	16.0–396.0	3.8–95.4
Bozeman, MT	19	5	13	1	22.2–481.5	5.3–115.9
St Louis, MO	74	49	19	4	13.1–506.4	3.1–121.9
Vancouver, BC, Canada	19	7	7	5	11.5–230.5	2.8–55.5
Everett, WA	22	2	18	4	3.3–438.4	0.8–105.6
Hong Kong, Taiwan	39	19	3	27	17.7–397.3	4.3–95.7
Bellevue, WA	7	0	7	0	14.1–167.7	3.4–40.4
Tri-Cities, WA	17	6	9	2	22.7–382.4	5.5–92.1
Seattle, WA	12	0	8	4	8.3–141.0	2.0–33.9
University of Washington, WA	28	2	15	11	12.6–338.0	3.0–81.4
Honolulu, HI	36	15	16	5	10.9–402.0	2.6–96.8
Portland, OR	81	27	45	9	3.2–469.1	0.8–112.9
Omaha, NE	19	6	10	3	15.7–361.5	3.8–87.0

*Ranges given in weight of cement and percentage compared to control fill (415.3 mg).

made by measuring the internal dimensions of the crown and assuming a 40- μ m gap available for the cement lute space.²⁴ This allowed the volume of the ideal cement lute space to be calculated, assuming that the cement-filled control weight equaled 100% volume.

A one-way analysis of variance (ANOVA) was used to compare the weights of different pattern groups at $\alpha = .05$. The Tukey honestly significant difference multiple-comparisons test was used to conduct post hoc comparisons.

RESULTS

All specimens were analyzed collectively since the sample sizes varied within each region. Four hundred and one specimens from 14 locations were sampled (Table 1). The cement application pattern produced three distinct groups. The gross application (GA) group consisted of crowns loaded using the spatula or flat plastic instruments, which resulted in gross pooling of cement in the intaglio of the crown (Fig 3). In the brush-on application (BA) group, the specimens were loaded by brushing cement into the intaglio surfaces, including the occlusal surface (Fig 4). In the margin application (MA) group, the crown specimens had the cement loaded preferentially around the 1- to 3-mm

intaglio margin of the crown (Fig 5). The distributions of samples and cement application techniques are summarized in Table 1. Practicing dentists used the BA approach in 54.7% of cases, the GA technique in 28.4% of cases, and the MA method in 16.9% of cases.

The weight of the cement used in each group was recorded. The cement used by the GA group weighed, on average, 242.4 mg (range, 75.5 to 506.4 mg). The BA group cement had a mean weight of 59.9 mg (range, 3.2 to 252.2 mg), and the MA group average cement weight was 59.0 mg (range, 7.3 to 174.2 mg).

In the control group, the mean weight of the 10 crown samples filled level to the margins was considered 100% crown volume and corresponded to 415.3 mg. The ideal cement lute space weight, corresponding to 3% volume, was calculated to be 13.6 mg. The quantity of cement loaded (Fig 6) was calculated for each application technique and compared to the control group, as well as to the ideal cement lute space required.

The one-way ANOVA comparing the mean weights of different groups revealed significant differences between the groups ($P < .001$) (Table 2). The Tukey post hoc evaluation showed significant differences between the BA and GA groups ($P < .01$) and the GA and MA groups ($P < .01$). No statistically significant differences between groups BA and MA were found ($P > .05$).



Fig 3 Gross application (GA) crown.



Fig 4 Brush-on application (BA) crown.



Fig 5 Margin application (MA) crown.

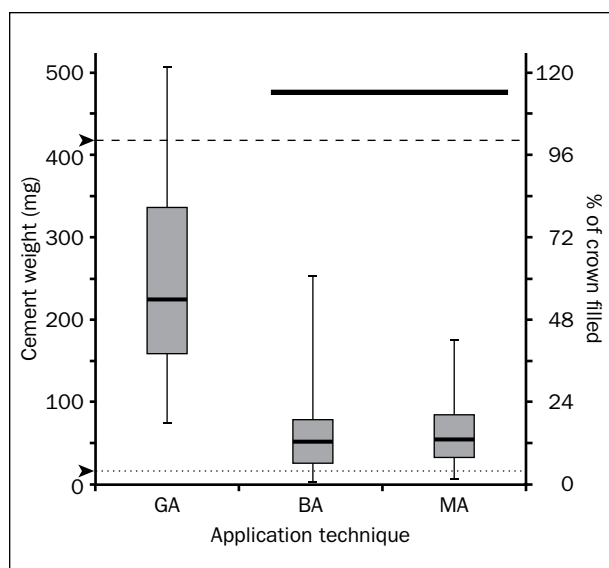


Fig 6 Box plots of the application techniques and quantity of cement loaded. The median, 25th percentile, 75th percentile, highest, and lowest values are shown. The horizontal line above the box plots indicates no statistically significant differences ($P > .05$). The lower arrowhead and dotted line indicate the 13.6-mg “ideal” cement lute quantity required with a 40 μ m coating. The upper arrowhead and dashed line indicate the 415.3-mg maximum intaglio cement fill, as a control.

Table 2 Results of One-Way ANOVA

Source	Sum of squares	df	Mean square	F	P
Treatment (between groups)	2,727,107.4	2	1,363,553.7	314.54	< .0001
Error	1,729,683.3	399	4,335.0		
Total	4,456,790.7	401			

df = degrees of freedom.

DISCUSSION

Crowns cemented to implant abutments are fabricated to fit together congruently, with the space between components filled with luting cement. If an inadequate quantity of cement is used, the space may not be completely filled. If too much cement is used, the excess must be extruded out of the system for the independent units to fit in the intended manner. Clinically,

too little cement translates into the potential for leakage and loss of retention. Too much cement may have the effect of occlusal alteration, increased difficulty in cleanup, and the possibility of detrimental effects to tissue health around implants such as peri-implant disease.^{6,10–14}

Few studies have reported on the method and quantity of cement that is required when cementing a crown restoration on either teeth or implants.

Subjective descriptions have been used, such as “the luting cement was mixed according to the manufacturers’ instructions and placed in each casting with a plastic instrument,⁸” the clinicians “brushed the cement into the crown in a uniform thin layer,²³” “the inferior aspect of each abutment was coated with luting agent and placed in a fixture filled with the same luting agent,⁴” and “a thin layer was spread into the crown’s inner surface with a brush.”²² The lack of objectivity in these studies renders their results subject to variation, reduces the value of the data obtained, and may not be clinically appropriate.

This study was designed to evaluate the process of cement application within a crown qualitatively as well as to give an estimate of the quantity of cement that is typically used. Of particular interest was to observe loading patterns to determine whether differences existed, both between the quantity used and within each application pattern group. Another feature of the study was to determine whether the practicing dentists had an understanding of the appropriate quantity required, for example, how many would overfill or underfill compared to the control maximal and minimal cement lute space.

It is understood that a relationship exists between the quantity of cement placed within the crown, the cement lute space provided, and whether any interim method of cement extrusion is employed prior to seating, such as a copy abutment.^{15,16} It is not common practice with traditional tooth-form dentistry to use a copy abutment to control cement volumes used prior to seating, and to date no surveys have been found to corroborate the use of such devices in clinical implant practice.

In this study, the overall range of cement weight used was 3.2 to 506.4 mg. If this truly reflects the quantities used by dentists in their offices, this suggests that some crowns would be underfilled and some would be overfilled beyond the crown margin. The quantity of cement that is actually required can be calculated by knowing the crown’s total volume and the desired cement lute space. The fabrication process of the crown usually allows for cement lute space, which is commonly attained by using some form of internal relief such as a die spacer. The ideal cement lute space has not been studied with respect to implant abutments, so a standard value recommended for tooth restorations was used.²⁴

The volume of cement lute necessary, assuming a 40- μ m space, was calculated by considering the premolar crown form to be approximately ovoid-shaped in cross section and cylindric in form. The estimated ideal cement lute volume was calculated to be 3% of the total crown volume, which equates to 13.6 mg of cement. Any quantity greater than 3% would result in

the extrusion of excess cement through the crown/abutment margin for complete seating of components to occur. Any volume below the ideal 3% of total intaglio volume would be inadequate to completely fill the lute space. Incomplete filling of the available space may cause issues, such as a discontinuous cement layer with void formation and the potential for leakage (which may not be problematic with implant restorations) or loss of retention. Although this was not seen to affect retention in one study,⁵ in another, investigators showed that retention was dependent on the amount of cement trapped in the areas that were affected by shear forces.¹⁸ The same study also suggested that cement should be placed on the axial walls of the preparation (abutment), rather than within the crown. The design of the present survey did not allow for this variation in cement application. However, similar issues with cement quantities and distribution would likely occur. This application technique may warrant further evaluation. The current survey provides information that may also be useful in that it used weight as an outcome measure; this may be used to design subsequent studies that involve cement luting of implant restorations, as no protocols exist for the quantity of cement required or technique of placement. Studies performed to date have used nonstandardized cement loading protocols with techniques that apply either arbitrary quantities or preweighed quantities but without specifying the cement placement pattern. These studies may not be clinically relevant, as it can be seen from the results of this survey that a variety of cement loading techniques and quantities is used by clinicians.

It is clear from these data that the application technique has a relationship to the quantity of cement applied. This relationship appears to differ between GA and MA and between GA and BA, with a similar range of cement application when the MA and BA approaches are used. What was of interest was that, even within each application technique group (GA, MA, BA), the weight of cement applied in some instances was far in excess of the proposed ideal quantity, while the MA and BA groups sometimes produced potentially inadequate quantities of cement. It should also be understood that the 3% ideal luting quantity would require that the cement be applied over the intaglio to a uniform thickness of 40 μ m. Because this is an impossible feat when the cement is loaded with a plastic instrument or even brushed on, a system should be adopted that provides greater accuracy and precision for the ideal quantity of cement placed, as well as a technique that allows liberal and uniform luting where possible. This may not be easily attainable given that the geometry of the intaglio of a crown can be complex. In some cases, the cement flow patterns are not uniform because of inclines and angles that necessitate

cement flow between parallel and nonparallel surfaces as the units travel relative to each other. Further evaluation with flow pattern analysis may help in cement placement. Other factors play a role in the cement lute space fill, such as flow properties, viscosity of the cement, dimensional stability, and the wetting ability of the involved surfaces.

The present investigation used a prerecorded auditory and visual instructional component to standardize the survey. The auditory instructions were designed to omit the use of directional wording such as “fill,” and no direction was given as to which instruments should be used. Generic terms were used where possible and the surveyed groups were not assisted in any other way. The collections were made en masse, allowing blinding of the investigators to the individuals surveyed.

One limitation of this study is the fact that the surveyed dentists may not in fact load cement into implant crowns in clinical practice; an assistant might carry out this procedure under the direction of the attending clinician. Alternative cement-loading instruments may also be chosen, as the supplied brush, flat plastic applicator, and spatula may not be the usual instruments used. No means were provided to remove excess cement, such as a copy abutment, which may be used clinically; if used, this would alter the results, and further study may be warranted. No abutment was provided in the bag of tools, as this may have affected the thought process of the dentists surveyed as well as resulted in survey bias, such as source population selection, voluntary response bias, and observational error bias.

CONCLUSIONS

The survey identified three distinct fill patterns of cement loading, each with their own degree of variation in the quantity of cement used. The most popular forms of application, in order, were brush application (BA), gross application (GA), and margin application (MA). The null hypothesis was rejected since a significant difference was observed in the quantity of cement used in the GA samples compared to the BA and MA samples. The mean weight of cement in groups BA and MA was closer to the calculated ideal, with no significant difference in the quantity of cement used in either group. The large variability in cement quantities used indicates a lack of uniformity and precision in cement application techniques. No consensus exists in the dental community as to the appropriate quantity of cement and placement method for an implant crown form.

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