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An Analysis of the Effect of a Vent Hole on Excess Cement Expressed at the Crown–Abutment Margin for Cement-Retained Implant Crowns

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Abstract

Purpose: The labial margins of anterior implant-retained crowns are often positioned subgingivally for a superior esthetic appearance. One of the consequences of subgingival margins is the increased risk of leaving excess cement behind following cementation. This can lead to potential problems, including peri-implant inflammation, soft tissue swelling, soreness, bleeding or suppuration on probing, and bone loss. The purpose of this laboratory study was to investigate the effect of placement, location, and diameter of a vent hole on the amount of cement being expressed at the margin of an anterior implant abutment-retained crown.
Materials and Methods: Three implant crown copings were fabricated to fit on the same custom abutment. Three vent diameters (0.75, 1.25, and 1.65 mm) and three locations on the palatal surface of the coping (cervico-palatally, mid-palatally, inciso-palatally) were chosen for vent hole placement. For each test, the coping was cemented onto the abutment under standardized conditions. A preweighed thin coating of cement was applied to the fit surface of the coping. The amount of cement expressed at the margin and vent hole was measured by weight and calculated as a proportion of the amount of cement placed in the coping before seating. The procedure was completed 15 times for each variable. The results were statistically analyzed using univariate ANOVA with post hoc Bonferroni-adjusted independent samples *t*-tests.
Results: The presence of a vent hole influenced the proportion of cement expressed at the coping margin ($p < 0.05$). The location of a vent hole influenced the proportion of cement expressed at the coping margin ($p < 0.05$), with the exception of the mid-palatal and inciso-palatal positioning where there was no significant difference ($p = 0.61$) between groups. The diameter of the vent hole did not significantly influence the proportion of cement expressed at the coping margin ($p = 0.096$).
Conclusions: When using anterior cement-retained implant crowns, the use of a 0.75-mm mid-palatal or inciso-palatal vent hole to minimize the amount of cement expressed at the margin during cementation should be considered.

It has long been recognized that cast restorations do not seat completely when cemented. The more accurately the crown fits the prepared tooth, the more difficult it is for the cement trapped between the crown and the occlusal surface of the tooth to escape.[1]

Over the years, there has been much research directed toward improving the seating and marginal fit of crowns on natural teeth. Various methods, including conventional venting, internal venting, die spacing, and vibration, have been advocated to improve seating. In addition, several authors have advocated the placement of supragingival crown margins wherever possible to reduce the level of irritation of the periodontal tissues and to allow better access for oral hygiene techniques.[2–4] However, there are occasions when the subgingival placement of some margins is necessary; for instance, the labial margins of anterior crowns are often made subgingivally to obtain a superior esthetic appearance.

One of the consequences of subgingival margins is the increased risk of leaving cement behind following cementation; with tooth-supported crowns, caries and periodontal disease have been shown to be potential sequelae associated with excess cement. Although these disadvantages are of no relevance to implant-retained crowns, other disadvantages have been reported in the literature. These include peri-implant inflammation, soft tissue swelling, soreness, bleeding or suppuration on probing, and radiographic bone loss of the peri-implant bone.[5,6]

Several authors have demonstrated that the placement of a vent hole in tooth-supported crowns will improve the marginal fit;[5,7,8] however, there are few studies specifically addressing its effect on the amount of cement expressed at the margin. In addition, few studies specifically examine the effect of vent hole placement in cemented implant-retained crowns on the amount of cement expressed at the crown–abutment margin.

The null hypothesis of this study was that the placement, location, and diameter of a vent hole have no significant influence on the amount of cement expressed at the margin of an anterior implant crown cemented to a cast custom abutment.

Materials and methods

An upper anterior preformed plastic anatomical abutment was selected from the Neoss (Neoss Ltd., Harrogate, UK) implant system. The marginal contour of the abutment was modified to follow a classic gingival contour, and a labial shoulder and palatal chamfer were produced. A parallel-sided jackscrew corresponding in size to the diameter of the screw access channel was chosen to tap the internal surface of the screw access hole. This was screwed in an incisal direction from the "implant end" until it was visible at the "incisal end" of the screw access hole (Fig 1). The screw was then unscrewed, and the resulting thread produced on the internal walls of the access hole was visually verified. Several spherical retentive features were placed at the base of the pattern using wax (Fig 1), and the wax pattern was cast in type III gold alloy (Degussa-Dental, Hanau, Germany). The jackscrew used to tap the access hole prior to casting was

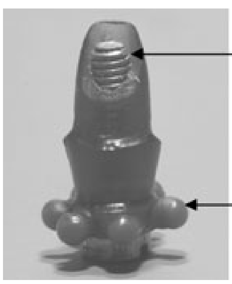

Figure 1 The plastic abutment with a corresponding jackscrew within the screw access channel.

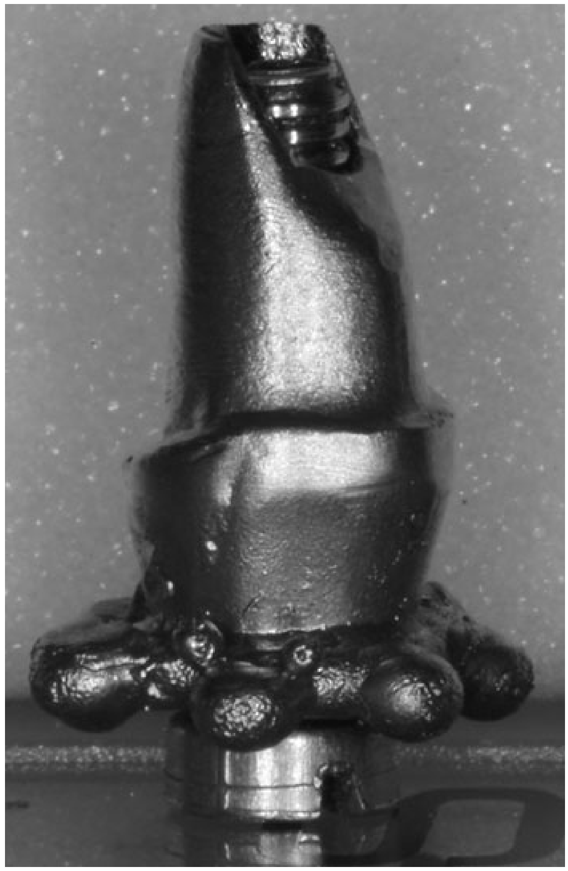

Figure 2 The cast abutment with the brass jackscrew screwed in the access channel.

tried-in to ensure that it could be screwed in and out effectively and easily (Fig 2). A gold inlay was fabricated to sit in the screw access channel above the jackscrew. The jackscrew was used to remove the cemented casting after each experiment, allowing the casting to be removed without the risk of damaging it.

Following construction, the abutment was secured in an acrylic resin cylinder such that access to the jackscrew was permitted.

The external surface of the implant abutment with the corresponding inlay in place was coated with three thin layers of die spacer and abutment copings constructed from gold–platinum bonding alloy (Degudent U, Degussa-Dental). In total, ten abutments were constructed; one was an unmodified control, and the others constituted three vent hole diameters on the palatal surface of the coping: 0.75 mm, 1.25 mm, and 1.65 mm, at three locations: cervico-palatally (CP) (located close to the crown margin), mid-palatally (MP) (located just above the cingulum), and inciso-palatally (IP) (located close to the incisal edge) (Fig 3, Table 1).

Tempbond (Kerr USA, Romulus, MI) temporary cement was used in accordance with manufacturer's instructions. A volume of 0.5 ml of base and accelerator was dispensed from separate preloaded 1.0-ml plastic syringes onto a mixing pad. The base, accelerator, and the mixing spatula were weighed using digital weighing scales (Precisa 120A, Pag Oerlikon AG, Zurich,

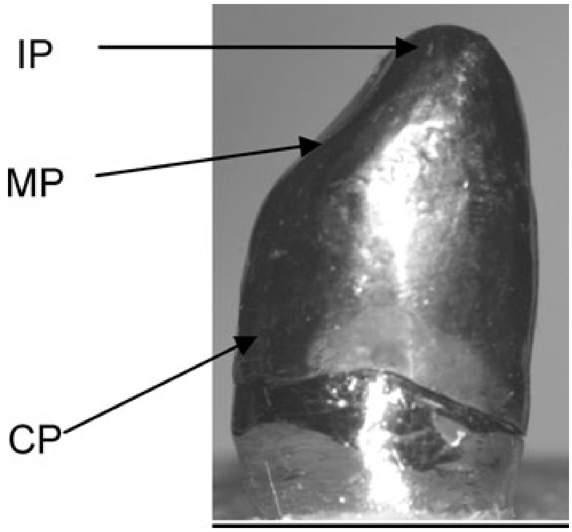

Figure 3 Locations of the vent holes in the implant crown coping.

Switzerland). The cement was mixed by hand using a plastic mixing tool as consistently as possible before being loaded into the implant crown coping. During each cementation, the internal walls of the implant crown coping were lightly coated using the mixing tool as consistently as possible. The cementation procedure was carried out under controlled laboratory conditions at 21°C. After the implant crown coping was loaded with cement, it was seated onto the abutment with gentle finger pressure and subsequently loaded under the pressure of a 1 kg weight for 5 minutes using a static loading rig (this had been deemed appropriate from a pilot study). The mixing sheet and spatula were reweighed, allowing the exact amount loaded to be calculated.

After setting, all excess cement expressed at the margin of the implant crown coping was removed with a scalpel blade. The excess cement was weighed and calculated as a proportion of the amount of cement loaded into the coping before seating. The procedure was completed 15 times for all the variables of vent hole diameter and location. Abutments were completely cleaned of all residual lute by soaking in temporary cement remover (Premier Dental Products Co., Plymouth Meeting, PA) for 20 minutes in an ultrasonic bath and subsequent steam cleaning. Examination under magnification (×12) was done to confirm the complete removal of all temporary cement.

Table 1 Diameter and location of the vent holes in each test group

Test group	Vent hole	
	Diameter (mm)	Location
Control (0)	None	None
1	0.75	Cervico-palatally (CP)
2	1.25	CP
3	1.65	CP
4	0.75	Mid-palatally (MP)
5	1.25	MP
6	1.65	MP
7	0.75	Inciso-palatally (IP)
8	1.25	IP
9	1.65	IP

Table 2 Group statistics for the proportion of cement expressed at the margin in vented and nonvented crowns

Presence of a vent hole	Number	Mean
No	15	0.3943
Yes	135	0.0983

The protocol was repeated for all variables of vent hole diameter and location.

An independent samples *t*-test was used to determine whether there was a difference in the proportion of cement expressed at the margin between vented and nonvented implant crowns. Univariate ANOVA was used to compare whether there was a difference in the proportion of cement expressed at the margin for implant crowns when varying the diameter and location of the vent hole. A conservative post hoc test correction was applied (Bonferroni multiple test comparison) to pairwise comparisons of the means of subgroups.

Results

The amount of excess cement expressed at the margin was described as a proportion of the cement loaded into the coping before seating. Figure 4 shows a general overview of the proportion of cement expressed at the margin for each of the test groups in the study. Figure 5 shows a general overview of the estimated marginal means of the proportion of cement expressed for each test group with vent holes.

Table 2 shows that 15 test runs were carried out with nonvented implant crown copings with a mean proportion of excess cement expressed at the margin of 0.3943, that is, a mean of 39.43% of the cement placed in the copings before loading was actually expressed at the margin. In comparison, 135 test runs were carried out with vented implant crown copings with a mean proportion of excess cement expressed at the margin of 0.0983, that is, a mean of 9.83% of the cement put in the copings before loading was actually expressed at the margin.

Results of the independent samples *t*-test (Table 3) reveal significant differences ($p < 0.001$) as a function of the proportion of cement expressed at the margin between vented and nonvented crowns.

Results of the univariate ANOVA (Table 4) reveal significant differences in the proportion of cement expressed at the margin with the position of vent hole ($p < 0.001$) but not with the size of the vent hole ($p = 0.096$).

Multiple pairwise comparisons using the Bonferroni adjustment for multiple testing revealed significant differences between the proportion of cement expressed at the margin with cervico-palatal vent holes compared to those with mid-palatal or inciso-palatal vent holes ($p < 0.001$); however, there is no statistically significant difference between the proportion of cement expressed at the margin when comparing implant crowns

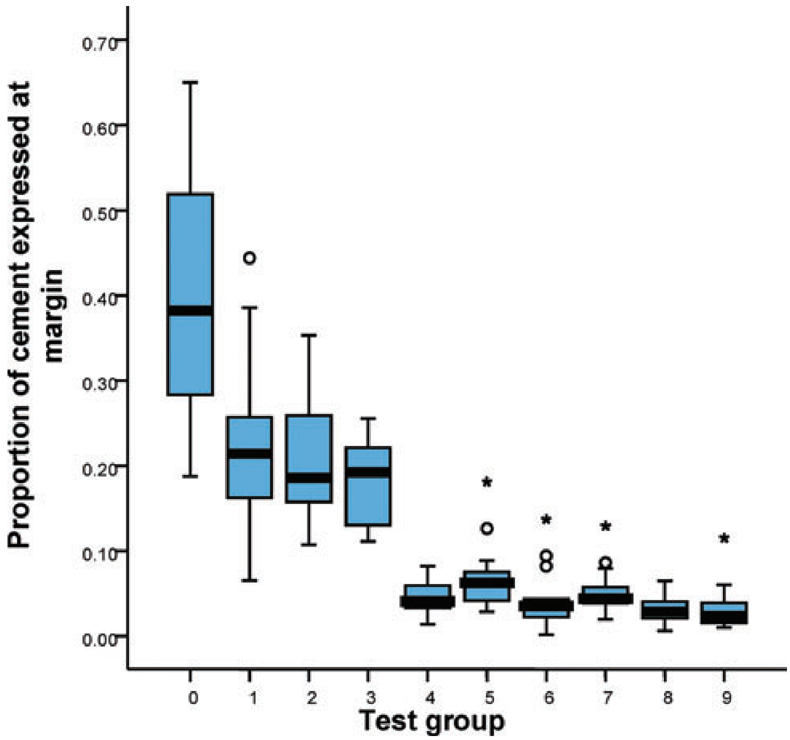

Figure 4 A box plot showing the proportion of cement expressed at the margin for each test group. Test groups are the same as described in Table 1. Outliers are indicated by stars and circles.

with mid-palatal and inciso-palatal vent holes ($p = 0.613$) or with vent holes of varying diameter ($p > 0.05$).

Discussion

The null hypothesis of this study stating that the placement, location, and diameter of a vent hole will have no significant influence on the amount of cement expressed at the margin of an anterior implant abutment crown was rejected. A significantly greater proportion of cement was expressed at the margin of nonvented implant crowns. These findings are similar to those found in the literature investigating the effects of vent hole placement on tooth-supported crowns. All show that venting significantly reduced the degree of seating of crowns;[1,7,9-16] however, none have correlated it to the amount of cement expressed at the margin.

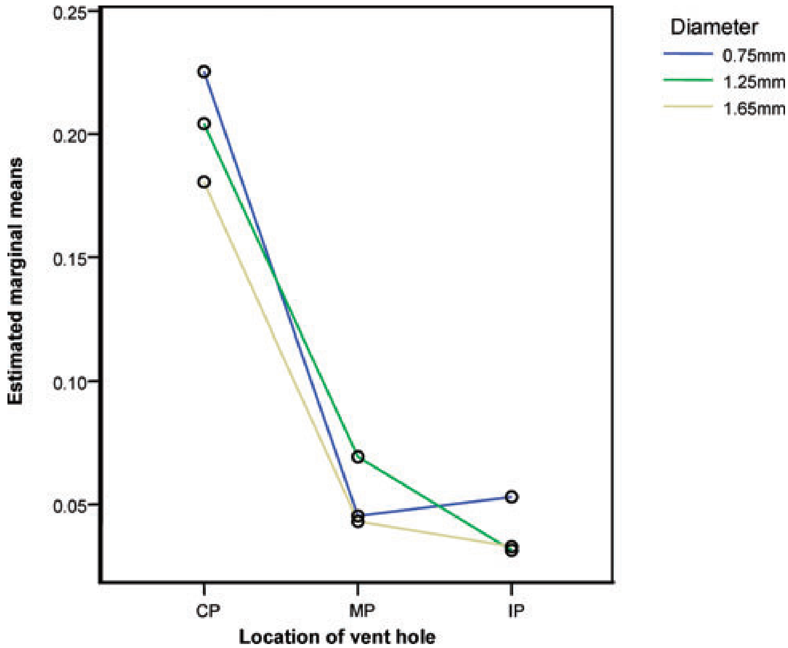

Figure 5 Estimated means of the proportion of cement expressed at the implant crown coping margin.

Table 3 Independent samples *t*-test used to test the null hypothesis (there is no difference in the proportion of cement expressed at the margin between vented and nonvented implant crowns)

t-test for equality of means						
					95% confidence interval of the difference	
t	df	*p*-value	Mean difference	Standard error of the difference	Lower	Upper
7.23	15.06	<0.001	0.30	0.04	0.21	0.38

Table 4 Univariate ANOVA showing tests of between-subjects effects

Source	Type III sum of squares	Degrees of freedom	Mean square	*F*	Significance
Corrected model	0.76	8	0.10	38.44	<0.001
Intercept	1.30	1	1.30	517.60	<0.001
Position of the vent hole	0.75	2	0.38	148.63	<0.001
Diameter of the vent hole	0.01	2	0.006	2.38	0.096
Interaction between the position and diameter of the vent hole	0.01	4	0.003	1.37	0.247
Error	0.32	126	0.003		
Total	2.40	135			
Corrected total	1.09	134			

It would seem that the presence of a vent hole, regardless of location or diameter, provides a path for the escape of excess cement to not only enable a greater degree of seating, but also to reduce the amount of cement actually being expressed at the margin.

The results of this study showed that the diameter of the vent hole did not have any effect on the proportion of cement expressed at the implant crown margin. This could be explained by the fact that the corresponding rate of flow of cement compensates for the change in vent hole diameter. The diameter of the proposed vent holes was determined using the existing literature.[8,10,11,13,15,17] There does not seem to be any consensus as to which diameter vent hole is the most effective or why a particular diameter was chosen. Consequently, in this study, three diameters were used that reflected the range of diameters previously used.

The results obtained in this study infer that a vent hole as small as 0.75 mm is sufficient.

This study showed that the location of the vent hole does have an effect on the proportion of cement expressed at the margin. There was a statistically significant difference in the proportion of cement expressed at the margin when comparing cervico-palatal vent holes to both mid-palatal and inciso-palatal vent holes. There was no statistical difference in the proportion of cement expressed at the margin for mid-palatal and inciso-palatal vent holes. Previous studies using vent holes have predominantly used occlusal vent holes. It would appear that on seating, hydraulic pressure builds up as the cement travels in an occlusal direction and accumulates at the occlusal surface under the coping. The cement in the nonvented coping has nowhere to go but to travel to the margin to escape. Cement under copings with cervico-palatal vent holes still seems to preferentially travel to the margin to escape, the vent hole having minimal effect. Cement under copings with mid-palatal and inciso-palatal vent holes appears to preferentially travel to the vent hole to escape. It is interesting to note that there is no statistically significant difference in the proportion of cement expressed at the margin between mid-palatal and inciso-palatal vent holes, suggesting that as long as the vent hole is above the cingulum, its desired effect will occur.

The placement of a mid-palatal vent hole is just as effective as an inciso-palatal vent hole, but from a clinical perspective, a mid-palatal vent hole may interfere least with the strength and function of the crown. However, since the issue of removal of excess cement from the subgingival margin still remains, it is suggested that postoperative follow-up after cementation be carried out to detect any early changes or reactions of the peri-implant tissues as recommended by Pauletto et al.[6]

The potential adverse effects of incomplete removal of cement lute from the subgingival implant-crown margin include peri-implant inflammation associated with swelling, soreness, deeper probing depths, bleeding and/or suppuration on probing, and peri-implant bone loss.[5,6] There are inherent practical difficulties with trying to remove all excess subgingival cement effectively without damaging the implant abutment or crown.[18,19]

This study suggests that in clinical situations where anterior cement-retained implant crowns are indicated, consideration should be given to the benefits of venting.

Minimal loading of cement, by applying a thin layer of cement to the fit surface of the crown to reduce the amount of cement expressed at the margin, has been advocated by several authors.[5,12,20,21] A limitation of this method is that it is difficult to determine the exact amount of cement required, too little and complete cementation may not be achieved, too much and gross extrusion beyond the margin will occur. The provision of a vent hole would allow the crown to be loaded with an adequate amount of cement for retention while allowing the excess to escape through the vent, minimizing the amount expressed at the margin.

Since it is a frequent clinical scenario, labial shoulder and palatal chamfer margins were chosen. Gavelis et al[22] and McLean and Wilson[23] found that although the use of shoulder margins led to an improved degree of seating than with other margin types, it was due to the fact that the inferior marginal seal facilitated the cement to escape. This reinforces the benefits of the use of vent holes to allow an escape channel for excess cement, away from the gingival margin where it could potentially end up subgingivally.

Conclusions

Within the limitations of this study, the following conclusions can be drawn:

(1) There is a difference in the proportion of cement expressed at the margin between vented and nonvented anterior implant crowns such that significantly more material is expressed at the margin of nonvented crowns.
(2) There is no difference in the proportion of cement expressed at the margin for anterior implant crowns when varying the diameter of the vent hole.
(3) There is a difference in the proportion of cement expressed at the margin for anterior implant crowns when varying the location of the vent hole; however, no statistically significant differences were seen when comparing mid-palatal and inciso-palatal vent holes. The choice of position for the placement of the vent hole may therefore be made on the basis of other clinically desirable features, provided that the hole is placed above the cingulum.

References

1. Jones MD, Dykema RW, Klein AI: Television micromeasurement of vented and non-vented cast crown marginal adaptation. Dent Clin North Am 1971; 15:663-677
2. Becker CM, Kaldahl WB: Current theories of crown contour, margin placement and pontic design. J Prosthet Dent 1981;45:268-277
3. Than A, Duguid R, McKendick AJW: Relationship between restorations and the level of the periodontal attachment. J Clin Periodontol 1982;9:193-202
4. Renggli HH, Regolati B: Gingival inflammation and plaque accumulation by well adapted supragingival and subgingival proximal restorations. Helv Odontol Acta 1972; 16:99-101
5. Dumbrigue HB, Abanomi AA, Cheng LL: Techniques to minimise excess luting agent in cement-retained implant restorations. J Prosthet Dent 2002;87:112-114
6. Pauletto N, Lahiffe BJ, Walton JN: Complications associated with excess cement around crowns on osseointegrated implants: a clinical report. Int J Oral Maxillofac Implants 1999;14:865-868
7. Cooper TM, Christensen GJ, Laswell HR, et al: Effect of venting on cast gold full crowns. J Prosthet Dent 1971;26:621-625
8. VanNortwick WT, Gettleman L: Effect of internal relief, vibration, and venting on the vertical seating of cemented crowns. J Prosthet Dent 1981;45:395-399
9. Jorgensen KD: Structure of the film of zinc phosphate cements. Acta Odontol Scand 1960;18:491
10. Bassett RW: Solving the problems of cementing the full veneer cast gold crown. J Prosthet Dent 1966;16:740-747
11. Eames WB, O'Neal SJ, Monteiro J, et al: Techniques to improve the seating of castings. J Am Dent Assoc 1978;96:432-437
12. Ishikiriama A, Oliveira JF, Vieira DF, et al: Influence of some factors on the fit of cemented crowns. J Prosthet Dent 1981;45:400-404
13. Darveniza M, Stevens L, Adkins B: Luting of vented and etched crowns. Aust Dent J 1983;28:233-238
14. Suthers MD, Wise MD: Influence of cementing medium on the accuracy of the remount procedure. J Prosthet Dent 1982;47:377-383
15. Clark MT, Richards MW, Meiers JC: Seating accuracy and fracture strength of vented and non-vented ceramic crowns luted with three cements. J Prosthet Dent 1995;74:18-23
16. Yeun TWH, Wilson PR: The effect of venting on pulpward pressure transmission and seating on crown cementation: a laboratory study. J Oral Rehabil 2000;27:958-966
17. Wilson PR: Deformation of vented crowns with fluids of differing viscosities. Aust Dent J 1993;38:97-101
18. Agar JR, Cameron SM, Hughbanks JC, et al: Cement removal from restorations luted to titanium abutments with simulated subgingival margins. J Prosthet Dent 1997;78:43-47
19. Dmytryk JJ, Fox SC, Moriarty JD: The effects of scaling titanium implant surfaces with metal and plastic instruments on cell attachment. J Periodontol 1990;61:491-496
20. Bassett RW. Solving the problems of cementing the full veneer cast gold crown. J Prosthet Dent 1966;16:740-747
21. Asif D, Rimer Y, Aviv I: The flow of zinc phosphate cement under a full-coverage restoration and its effect on marginal adaptation according to the location of cement application. Quintessence Int 1987;18:765-773
22. Gavelis JR, Morency JD, Riley JD, et al: The effect of various finishing line preparations on the marginal seal and occlusal seat of full crown preparations. J Prosthet Dent 1981;45:138-145
23. McLean JW, Wilson AD: Butt joint versus beveled gold margin in metal-ceramic crowns. J Biomed Mater Res 1980;14:239-250