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Adaptation of Complete Cast Crown Constructed with and without Die Spacer

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Abstract. This study evaluated the effect of die spacer on the fit and retention of complete cast crown restorations. Ten Typodont plastic premolar teeth were prepared to receive ceramometal crowns, the teeth were duplicated with silicone material and poured with die stone. The duplicated 20 crown preparations were divided into 4 groups. Two groups were painted with one layer of die spacer and the other two groups were untreated. Crowns were waxed and cast on the dies with two different alloys. The preparations were sectioned and examined under a photomicroscope to measure the gap between the die and casting. The result showed significant difference in the gap adaptation of the castings coated with die spacer and the non coated ones, the non-coated dies for either alloy showed a gap with acceptable dimensions for cement thickness. The adaptation of the non-coated dies was close to and in equivalence to the recommended ADA specification No. 8 for the maximum film thickness. The observation of the study shows that a die spacer may not be necessary for creating adequate cement space between the internal surfaces of the cast restoration and the prepared tooth surfaces. However, further studies are necessary to investigate the effect of die spacer on other aspects such as marginal adaptation and retention of the crown.

Introduction

The retention of cast restorations is improved by the 'frictional fit' between the casting and the tooth (Worley *et al.*, 1982). However, a tightly fitting crown and the viscosity of the cement may prevent the complete seating of the restoration (Campagni *et al.*, 1986; Petteno *et al.*, 2000; Cho *et al.*, 2006). Various methods of achieving internal relief are mechanical grinding, carving the wax pattern, etching with aqua regia, electrochemical milling, and die spacing (Carter and Wilson, 1997). Venting or perforating the crown occlusally has some disadvantages. An extra visit is necessary to fill the vent hole; the materials used to fill the vent hole may cause microleakage and/or discoloration; and, in the case of ceramometal restorations, occlusal venting may weaken the strength of the porcelain.

The complete seating during cementation is the prime benefit of die spacing. However, the fit of the casting is based on both retention and seating of the crown. The role of the die spacer on the retention of the castings is still controversial (Gegauff and Rosenstiel, 1989; Olivera and Saito, 2006). Studies have shown that the retention of the restoration can be improved with the use of an appropriate thickness of die spacer (Lee and Ibbetson, 2000). Many researchers have agreed that the use of die spacers during fabrication improves the fit of the casting at cementation and may improve retention (Marker *et al.*, 1987; Grajower *et al.*, 1989). Die spacers allow increased space for the cement between the tooth surface and the internal surface of the casting, reducing stress areas created during cementation, and thereby resulting in better fit and retention of the final restoration (Grajower *et al.*, 1989; Petteno *et al.*, 2000).

The ideal thickness of die spacer has not been scientifically established. The general accepted range is approximately 20-40 µm. According to ADA specification No. 8 for zinc phosphate cement Type 1, 25 µm is the maximum limit for the film thickness (Oliva *et al.*, 1988; Tuntiprawon and Wilson, 1995). The objective is to study the adaptation of complete crowns fabricated with and without die spacer by measuring the gap between the die and crown.

The hypothesis of this study is that a die spacer may be necessary for creating adequate cement space

between the internal surfaces of the cast restoration and the prepared tooth surfaces to improve the retention of the restoration.

Materials and Methods

Ten plastic teeth (maxillary first premolar) were selected for the study. Each tooth was prepared for a complete coverage cast restoration. Two impressions of each prepared tooth were made using a polyvinyl siloxane impression material (Aquasil Ultra, DENTSPLY Caulk, Milford, DE). The impressions were poured with die stone plaster Type III (CASTONE®DENTSPLY Trubyte, York, PA) resulting in 20 dies. Ten dies were painted with one layer of die spacer (Trufit Die Spacer; George Taub Products and Fusion Co., Inc., Jersey City, NJ). Manufacturer states that one layer is equivalent to 25 µm. The 20 dies (10 with die spacer and 10 without die spacer) were waxed for metal-ceramic crowns. The waxing (using Starwax®) was done by the same technician. The 10 dies with die spacer were divided into two. Half of them were cast with Titanium (Rematitan®) metal and the other 5 cast with a semiprecious alloy Artisan®. The remaining 10 dies without die spacer also divided to 2 groups. Five of them were cast with titanium and the remaining five with the semiprecious alloy.

Two reference points (midline) were marked on the mesial and distal surface of all the cast copings, the reference points were connected occlusally and used for the sectioning. The 20 cast crowns were removed from their dies and were sectioned from mesial to distal by carborandum cutting disk. The buccal halves were replaced on the dies free of die spacer and were stabilized externally by wax to have flat surface with the edges of the crown. The uncovered part of the die was trimmed with die trimmer and air blasted to get rid of any stone particles. Then the dies were inspected under Wild photomicroscope® (Wild Leitz Ltd., Heerbrugg, Germany) at 125x magnification power to measure the gap in micrometers (µm) between the surface of the die and the internal surface of the metal using stage graticules for microscopy. All measurements were recorded tabulated and analyzed statistically to determine the difference in the gap between the groups.

Statistical analysis

The mean and standard deviations were calculated for each group. Comparison of the different groups was done using ANOVA. Tukey-Kramer Multiple Comparisons post hoc test was used to compare the results. The pooled data was analyzed using unpaired t test.

Results

The mean gaps measured at three surfaces, i.e. occlusal, buccal and lingual are depicted in Table 1 and Fig. 1. The mean gap for the sample fabricated with a die spacer was 41.33±7.17 µm and 46.73±18.33 µm respectively for the titanium and semiprecious alloys. The values were significantly higher than the group of samples fabricated without die spaces in both metals with a value of 15.47±4.66 µm and 18.33±5.18 µm respectively ($p<0.001$). The difference in spacing observed between the precious and non-precious metal was not statistically significant ($P>0.05$). The spacing was found to be more in the buccal surface in the titanium alloy compared to the occlusal and lingual surfaces. In semiprecious alloy maximum spacing was observed in the occlusal surface.

Discussion

Complete crowns frequently do not seat with minimal marginal discrepancy following cementation (Pilo *et al.*, 1988). Various strategies have been developed to overcome this problem. These strategies include provision of cement space (Eames *et al.*, 1978; Grajower *et al.*, 1989), cement escape channels, (Webb *et al.*, 1983) venting, (Van Nortwick and Gettleman, 1981) seating-aid procedures such as vibratory techniques, dynamic loading (Gegauff and Rosenstiel, 1989) and limiting the amount and site of cement placement (Ishikiriama *et al.*, 1981).

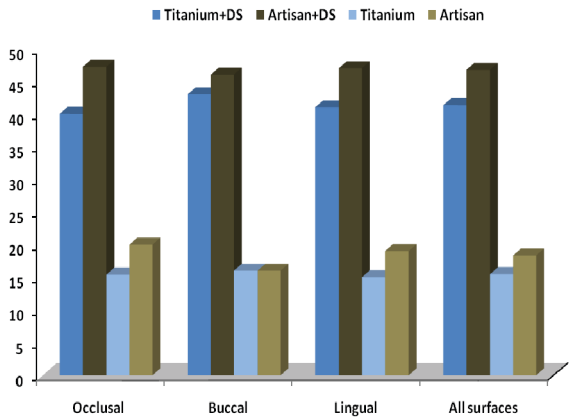

Fig. 1. The mean gaps measured at three surfaces (occlusal, buccal and lingual) with and without die spacer in both titanium and semiprecious metals.

Table 1. The mean gaps measured at three surfaces (occlusal, buccal and lingual) with and without die spacer in both titanium and semiprecious metals

Material	occlusal (µm)		buccal (µm)		lingual (µm)		All surfaces (µm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Titanium+DS	40.00	6.54	43.00	7.74	41.00	7.24	41.33	7.17
Artisan+DS	47.20	9.20	46.00	7.18	47.00	6.47	46.73	7.62
With Die Spacer	**43.60**	**7.87**	**44.50**	**7.46**	**44.00**	**6.86**	**44.03**	**7.40**
Titanium	17.40	4.64	16.00	4.48	15.00	4.87	15.47	4.66
Artisan	20.00	6.12	16.00	5.24	19.00	4.18	18.33	5.18
without die spacer	**18.70**	**5.38**	**16.00**	**4.86**	**17.00**	**4.53**	**16.90**	**4.92**

Die-spacing is a technique commonly used to provide space for the cement. The popularity of this technique has been attributed to its simplicity, convenience and cost-effectiveness (Passon *et al.*, 1992). The provision of a cement space between the internal surface of the crown and the prepared tooth surface may affect the important clinical factors of crown seating and retention.

The observations of the present study shows that the groups of samples without die spacer showed a gap that may be adequate for the cement placement. The results were consistent for both precious and semiprecious metals. However, the samples which used die spacer showed significantly higher spacing at the interface between the crown and the tooth preparation which might lead to poor retention and marginal sealing. The values were much higher than the optimal recommended values. Moreover the gap was not uniform in all surfaces resulting in higher values at the occlusal surface.

Jorgensen and Esbensen (1968) in a study designed to investigate the relationship between film thickness of cement and crown retention found that there was a statistically insignificant trend for increasing film thicknesses to cause a decreased retention for the cemented crowns. Hembree and Cooper (1979) in a study to investigate the effect of die relief on the retention of cast crowns and inlays found no statistically significant difference in the retention values of crowns constructed with and without four layers of Tru-fit die-spacer after cementation with three different cements. Vermilyea *et al.* (1983) investigated the effect of die relief on the retention of full coverage gold copings cemented to prepared, extracted human molars. A 32% decrease in the retention of gold copings, constructed on dies coated with two 20-25 µm layers of Trufit® die-spacer was found in this study over copings constructed on unspaced dies after cementation with zinc phosphate cement. Retention values for the other two cements tested in this study did not differ significantly for the spaced and unspaced copings. Carter and Wilson (1996) investigated the effect of die-spacing on crown retention using natural teeth prepared to a standardized full crown preparation by a high speed handpiece attached to a dental surveyor. They applied paint-on die spacer in zero, two, four, six or eight coats to the dies for complete occlusal and axial coverage and used a 25 N seating force. Mean post-cementation retention, in this study, increased from 250 N (zero coats of spacer) to 375 N (eight coats of spacer).

In this experimental study casting without die spacers proved to give better adaptation with sufficient film thickness for cement in the two materials that had been used in casting. The result of this study agree with report of Hager *et al.* (1993) who found that post cementation spaces, especially in occlusal area, often greatly exceeds the recommended film thickness for most cements, which corresponds for low level of adaptation, micro leakage and high occlusal contact where all these factors highly suggest failure. Vermilyea *et al.* (1983) found that the mean force required to dislodge unspaced casting was more. Also, Gegauff and Rosenstiel (1989) observed that retention without spacer was greater. Marker *et al.* (1987) found that die spacing has positive benefit when properly used. However, Passon *et al.* (1992) found that die spacer did not affect the retention of cemented cast copings even after increasing the application up to 16 coats (151 micrometers).

Conclusion

Crown retention is a complex phenomenon related to a number of factors including: preparation variables, surface finish of the preparation and of the casting, use of preparation sealing agents and

additional retentive features and cementation variables. The observation of the study shows that a die spacer may not be necessary for creating adequate cement space between the internal surfaces of the cast restoration and the prepared tooth surfaces. Further research is required to establish the role of die spacer in the retention of cast crowns.

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تهيئة التاج المصبوب بالكامل المصمم بفاصل المثال الجبسي الإفرادي أو بدونه

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ملخص البحث. تقيم هذه الدراسة تأثير فاصل المثال الجبسي الإفرادي على انطباق التاج المصبوب بالكامل وثباته. تم تحضير ١٠ ضواحك بلاستيكية لاستقبال تيجان خزفية معدنية، وتم نسخ هذه الأسنان بمادة السيليكون وصبها بالجبس. وتم تقسيم التيجان المحضرة المنسوخة العشرون إلى أربع مجموعات. وقد تم طلاء مجموعتين بطبقة واحدة من فاصل المثال الجبسي الإفرادي، بينما لم يتم طلاء المجموعتين الأخريين. ثم بعد ذلك تم تشميع وصب المثال الجبسي الإفرادي بنوعين مختلفين من السبائك المعدنية. وأخيراً تم تقطيع التحضيرات وفحصها بواسطة مجهر photomicroscope وذلك لقياس الفراغ بين المثال الجبسي الإفرادي والصبة المعدنية. وأظهرت النتيجة فارقاً ملحوظاً في الفجوة في الصبات المغلفة في المثال الجبسي الإفرادي مع المثال الجبسي الإفرادي غير المغلف. أظهر المثال الجبسي الإفرادي غير المغلف لكلا السبيكتين تكيفاً مقبولاً في الأبعاد لسماكة الإسمنت. وكان التكييف في المثال الجبسي الإفرادي غير المغلف قريباً ومعادلاً لمواصفات الجمعية الأمريكية لطب الأسنان رقم ٨ الخاصة بالحد الأعلى لسماكة الإسمنت. تظهر مراقبة الدراسة أن فاصل المثال الجبسي الإفرادي قد لا يكون ضرورياً لخلق مساحة كافية للإسمنت بين السطوح الداخلية للصبة المعدنية وسطح الأسنان المحضرة. ومع ذلك، فمن الضروري إجراء المزيد من الدراسات للتحقق من تأثير فاصل المثال الجبسي الإفرادي على جوانب أخرى مثل تكيف الحواف وثبات التاج.