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The effect of die spacer on retention and fitting of complete cast crowns

Mohammad Reza Hajimahmoudi [1], Somayyeh Niakan [1], Hossein Mohebbi [2*], Romina Sarooghi [3]

1. *Department of Prosthodontics, Dental School, Tehran University of Medical Sciences, Tehran, Iran.*

2. *Department of Prosthodontics, Tehran University of Medical Sciences, Tehran, Iran.*

3. *Dentist, Tehran University of Medical Sciences, Tehran, Iran.*

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**Corresponding author:*
Hossein Mohebbi

Department of Prosthodontics, Tehran University of Medical Sciences, Tehran, Iran.

Tel: +98-936-9767012
Fax: +98-21-84902473
Email: hossein_mohebbi74@Yahoo.com

ABSTRACT

Purpose: The aim of this study was to determine the influence of multiple layers of die relief agent and different cement thickness on the retention of cast restorations using two different cements.

Materials and Methods: 144 standard stainless steel dies were divided into two groups. Each of them includes 72 dies. These groups were divided into 12 equal subgroups as well. In both groups, die spacer was applied to dies in 0, 3, 4, 5, 6 and 7 layers (each layer=5μ). In the first group, crowns were cemented with Zinc Phosphate and in the second group, Polycarboxylate was used for cementing. After that, the strength required for separating the castings from the dies was measured.

Results: The difference among 12 subgroups analyzed by one-way ANOVA regarding Polycarboxylate cement did not reach statistical significance. (P=0.95). A similar result was obtained with zinc phosphate cement (P=0.616). Likewise, the two-way ANOVA was carried out between the zinc phosphate and polycarboxylate groups. There was a significant difference between the average of two groups (P<0.001).

Conclusion: Range of cement layer thickness that used in this study didn't statistically significantly affect the force required to remove cemented cast copings. Although the castings cemented with Zinc Phosphate needed higher force to be dislodged from dies.

Keywords: Cement space; Die spacer; Retention; Polycarboxylate cement; Zinc phosphate cement.

Introduction

The retention of cast restorations is influenced by several factors, including preparation design, casting accuracy, cement space and physical properties of cements. Traditionally, retention of cast restorations has been believed to be improved by a frictional fit between the casting and the tooth. However, Castings do not seat completely during cementation if the fit is too close, so it causes incomplete seating during cementation [1] venting of casting and internal relief in the casting have been used to solve the problem of incomplete seating of crowns. Venting significantly improves crown seating but rarely is used [2]. The most common methods of achieving internal relief are mechanical grinding of the inner side of casting, carving of the wax pattern, etching of casting, electrochemical milling, cutting an internal channel and die spacing [3]. Die spacing technique is done by painting the relief material on die before fabrication of wax pattern. This method can provide uniform space for luting agent which allows complete seating of the restoration during cementation [4]. Optimum cement film thickness for maximum shear resistance between teeth and restoration is 30μ and based on laboratory studies optimum range for internal relief of casting is 25–40μ [3]. By providing proper cement space, the retention of the cemented crown can be improved. Conversely, if the cement space is exceedingly wide, the probability of crown loosening during function would considerably increase [5].

Many studies have done about die spacing and retention. Eames et al 5 indicated that die spacing provides retention 25% better than when stress areas are not relieved. Gegauff and Rosenstiel 9 assessed crowns constructed on dies coated with zero to six layers of die spacer and found that the spaced crowns to be significantly less retentive than unspaced crowns. Hembree and Cooper 4 found no statistically significant difference in the retention of crowns constructed with and without four layers of Tru-fit die spacer. Because of their conflicting results, it seems that more studies are needed. Additionally, since experimental study about correlation between retention and cement film thickness is rare in dental literature, on the other hand, theoretically more retention achieved with recommended film thickness of them (25μ), 12, 13 because of better sitting of crowns so there is necessity for study to show correlation between this two parameters. In the present study, the influence of different cement thickenings and multiple layers of die relief agent on the retention of cast restorations using two different types of cement was evaluated.

Materials and Methods

144 Stainless steel dies machined by CNS lathe machine (Index GU800, index–werke ke hamen and tessy Esslingen N35172). These dies were used to minimize the effects of preparation variations. Their length and diameter were 40mm and 8mm, respectively. Prepared region had diameter of 7mm, length of 8mm, and wall inclination of 4˚ and finish line of 135˚ chamfer. Dies were ditched just below the finish line with a fissure bur (width of 2mm/angle of 140˚) to have an emergence profile like natural tooth. The occlusal surface of the dies notched (width and depth of 1mm, divergence of 5˚) as an anti-rotation. To demark the buccal and lingual surface, the notch was eccentric. A hole of 3mm was made within 10mm of the end of the dies to put them in universal testing machine (Instron/1195). Dies divided into two groups. One group was cemented with Zinc Phosphate (ZP) and the other group was cemented with Polycarboxylate (PC). Dies in each group were labeled and divided into 12 subgroups of 6 teeth each. Die spacing material (Tru-Fit, George Taub Products Co. Inc, Jersey City NJ) was used to coat the dies. In both group die spacer applied to dies in 0, 3, 4, 5, 6, 7 layers and thickness of each layer of die spacer (Tru-fit) was considered 5μ according to the manufacture recommendation (Table 1). The preparation surface of each die was coated to within 1mm of the preparation margin. At least one minute was allowed for drying between coats.

Lubricated dies waxed up using sheet wax method to equalize wax thickness. All coping design had a lingual gingival collar of 3mm. then a wax loop with diameter of 3mm and length of 20mm was affixed to the occlusal of the pattern to serve as a handle for coping removal. The wax patterns were sprued. An identifying mark was marked in the sprue to determine the number of layer of die spacer. Then wax patterns invested and casted with a base metal alloy (Vera band, albadent, cordelia, CA. 94534 USA). All castings were sand-blasted with a 50μm alumina oxide. The dies were cleaned with the solvent of die spacer, and then adaptation of castings was examined with fit checker. The copings and dies were cleaned by alcohol. Then copings were cemented using Zinc Phosphate (Harvard Dental GmbH, Berlin) and Polycarboxylate (Harvard Dental GmbH, Berlin). Each Cement mixed following the manufacturer instructions. After cementation a static 5 kg load was applied to the coping and dies along the long axis of the tooth during the first 10 minutes of cement setting. Excess cement was carefully wiped from the casting margins. The cemented copings were stored in a moist environment at 37˚C for 48-72 hours. Coping removal and force measurement were performed by an Instron universal testing machine with a 1000 Kg tensile load cell at a crosshead speed of 0.5mm/min. The mean force required to remove the cemented copings for each test group was measured and recorded by computer. One way ANOVA was used to compare subgroups of each cement and for comparison between two cements two ways ANOVA was used.

Results

Mean values of the forces required to dislodge the castings cemented with Zinc Phosphate are shown in table 2. Analysis of the data using one way ANOVA revealed no significant differences in retention of cast copings relating to die space layer. (P=0.095). The mean retention values of casting cemented with Polycarboxylate are shown in table 3. Statistical analysis using one way ANOVA indicated no significant difference between the groups. (P=0.616). Using two ways ANOVA, the mean force required to remove the cemented copings between the copings cemented with Polycarboxylate and the copings cemented with Zinc Phosphate showed significant difference. (P<0.001) The copings cemented with Zinc Phosphate needed higher force to remove.

Table 1. Die groups and coats of die spacer.

Cement	*Zinc Phosphate*						*Polycarboxylate*					
Group	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Number of coats	*0*	*3*	*4*	*5*	*6*	*7*	*0*	*3*	*4*	*5*	*6*	*7*
N	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*

Table 2. The mean force (N) required to remove castings cemented with Zinc Phosphate.

Group	*Number of coats*	*N*	*Mean*	*SD*	*P value*
1	*0*	*12*	*1128.75*	*319.59*	*0.616*
2	*3*	*12*	*1137.50*	*326.13*	
3	*4*	*12*	*1039.16*	*408.91*	
4	*5*	*12*	*938.33*	*446.00*	
5	*6*	*12*	*936.25*	*270.31*	
6	*7*	*12*	*1038.33*	*357.23*	
Total	*-*	*72*	*1036.38*	*355.83*	

Discussion

The result of current in vitro study showed that the retention of the copings did not influenced by thickness of die spacer. A cement space of 20–40µm is suggested to be optimum for full seating of a conventional crown [6]. In this study we used 0 to 7 layer of die space material to produce 0-35µm cement space. Studies on die spacer produce conflicting results. Hassan L [7] found same result about crowns that manufactured with digital workflow. Though in that study the cement space was 70, 80 and 110µm. on the other side, Gultekin et al [8] showed that Increasing the gap size from 20 to 40 µm improved retention significantly for implant high strength cements. In the other study by Taha et al [9], crowns with 80µm space showed more retention than crowns with 100 and 120µm. Increasing cement space from 100µm to 120µm did not yield a significantly lower retention value. All the crowns were cemented with resine adhesive cement.

Significant differences in experimental design would be expected to account for some of this variation. Difference in cement space, tooth preparation, Cement type, manufacturing process like investing and casting procedure may be the reason [1,3]. In addition, Gegauff and Rosenstiel [10] found the spaced crowns to be significantly less retentive than the unspaced crowns. In their study the castings did not seat fully initially and the application of a dynamic seating force causes the crowns to be forced further onto the tooth. It may be possible that dynamics loading result in increased frictional fit between the tooth surface and the fitting surface of the restoration and that may account for the increased retention recorded for the unspaced crowns. There are many type of die spacer available. Each requires a different application technique to produce ideal desired thickness. However material age, method application, and environmental factors can also affect the final thickness [1].

In our study, comparison of mean force values indicated that castings cemented with Zinc Phosphate cement required more force for removal than those cemented with Polycarboxylate cement. Although the difference among different subgroups for each cement was not significant. Both zinc phosphate and polycarboxylate cements are non adhesive cement with limited mechanical properties, but it presents reliable clinical results [11]. Olivera et al [1] showed that resin cement exhibits the highest tensile strength when compared with resin modified glass ionomer cement and zinc phosphate cement. Though their study was based on area of cement space instead of thickness. Mehl et al [12] conducted a study using three cements (Glass ionomer, polycarboxylate and resin cements) and 4 cement spaces (15, 50, 80, or 110µm). In contrast to our results, crown retention For all cements decreased significantly between a cement film thickness of 15 and 50 µm. The resin cement was significantly more retentive than polycarboxylate and glass ionomer cements at 15 µm. Further research is needed using wide range of cement space, other luting and adhesive cements.

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1. Increasing the thickness of die spacer didn't statistically significantly affect the force required to remove cemented cast copings.

2. Different cement thickness had no effect on crown retention.

3. The mean force to dislodge cemented castings was higher in castings cemented with Zinc Phosphate than those cemented with Polycarboxylate.

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Conflict of Interest

There is no conflict of interest to declare.

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