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ORIGINAL ARTICLE

A Comparative Evaluation of Application Techniques of a Paint-On Die Spacer in Grooves: An In Vitro Study

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Abstract The use of paint-on die spacer to improve the seating of casting has become quite popular in the recent years. The generally accepted range of paint-on die spacer is approximately 20–40 µm, which suggests a range of tolerance. The painting of the retentive grooves with die spacer has always been a subject of debate. The primary purpose of this study was to determine if there was a tendency for the paint-on die spacer to accumulate in grooves of tooth preparation in sufficient thickness to exceed this accepted range of tolerance when applied using two different techniques. Eight die stone blocks with three grooves each were prepared. Half the samples were painted in unidirectional method and the other halves were painted using the haphazard method of application. The thickness of the die spacer was measured at different positions using 200× magnification and the mean and standard deviations were calculated. On analysis it was seen that the thickness of the paint-on die spacer in grooves was in the range of 20–40 µm for unidirectional method of application, whereas in haphazard method of application the thickness of the paint-on die spacer was in the range of 28–132 µm. From the above study it was concluded that the method of application influenced the thickness of the paint-on die spacer. The recommended thickness of the die spacer was achieved on unidirectional method of application.

Keywords Paint-on die spacer · Internal relief · Axial grooves · Unidirectional brush stroke technique · Haphazard method of application

Introduction

One of the factors that affect the success of the cast crown is the accuracy of the fit [1].

Various concepts have been put forward to obtain accuracy of fit for cast crowns [1–3].One widely used method is the fabrication of internal casting relief so as to provide space for cement. It is believed that unless there is some degree of internal relief provided in castings they will fail to seat completely [4].

The application of paint-on die spacer to dies prior to the fabrication of the wax pattern to improve seating of castings is popular because it is simple to use, convenient and cost effective [5]·

The use of axial grooves as an aid to increase retention has gained popularity in recent years. To effectively utilize these grooves, it is important that their counterparts in the casting adapt accurately. The thickness of paint-on die spacer can influence this accuracy of fit [1, 6, 7]. Carreira et al. [6] reported that the cervical discrepancy with two layers of die spacer was less when compared to cervical discrepancies without any die spacer. Carter and Wilson [7] noted that there was an increase in post-cementation retention and decrease in crown elevation when multiple layers of die spacers were used. The optimum thickness of the paint-on die spacer has never been scientifically established. However, the generally accepted range is approximately 20–40 µm which suggests a *range of tolerance* [4, 8].

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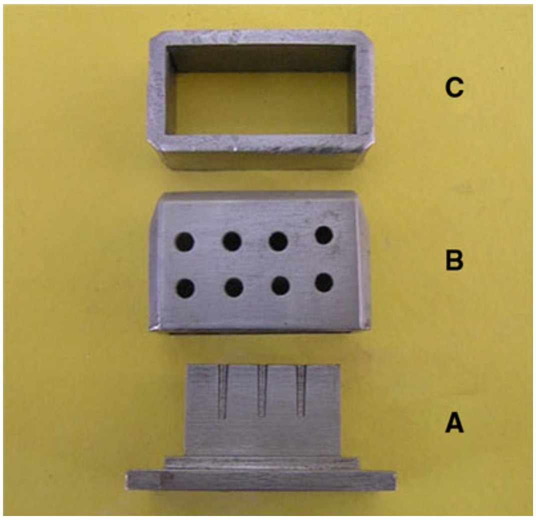

Fig. 1 **A** Metallic master model; **B** Perforated metallic tray; **C** Metallic rectangular tray

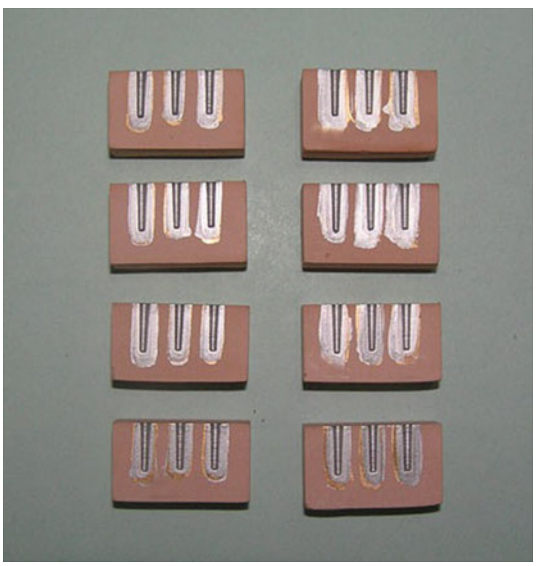

Fig. 2 Paint-on die spacer painted on the die stone blocks

This optimum tolerance of 20–40 µm is generally specified to facilitate complete seating of the casting and to allow for film thickness of the cement. Various thickness of paint-on die spacer has been reported depending on the material used, number of coats and location on the die [4, 8, 9]. Different application techniques also could have an effect on the thickness of the paint-on die spacer [9].

Hence this study was undertaken with an objective to determine whether there was any tendency of the paint-on die spacer to accumulate in the axial grooves in sufficient thickness to exceed this tolerance and also to compare the two different application techniques, namely unidirectional brush stroke and haphazard application .

Fig. 3 Embedded die stone blocks

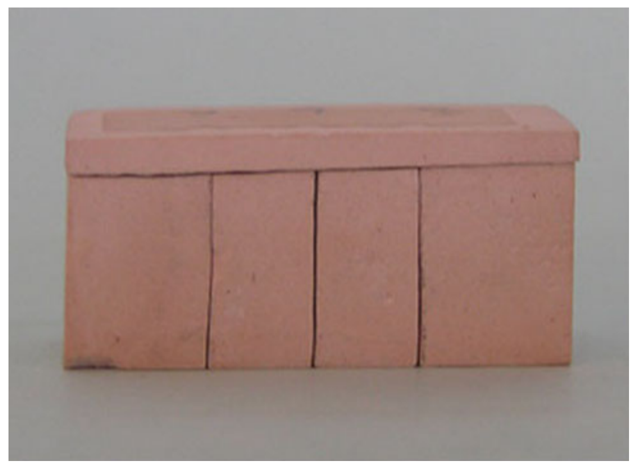

Fig. 4 Embedded die stone blocks sectioned horizontally and vertically

Methodology

A stainless steel metal master model of dimensions 25 × 9 × 15 mm with three grooves simulating the grooves formed by flat end taper fissure carbide bur no 171(Mani carbide bur, Prime dental products Pvt. Ltd. India) was fabricated by precision milling machine for the purpose of this study (Fig. 1). The dimension of the flat end taper bur were as follows, tip diameter-0.76 mm, base diameter-1.2 mm, cutting length-4.2 mm, inclination per side of 3 degrees. Impression of this metal block was made with addition polyvinyl siloxane impression material (Aquasil, Dentsply, Germany) with a metal perforated tray. This impression was poured with die stone type IV (Kalrock, Kalabhai Karson Pvt. Ltd. India). Total of eight blocks were made. These blocks were allowed to dry for at least 48 h. Four coats of Pico fit (Renfert, Germany) gold

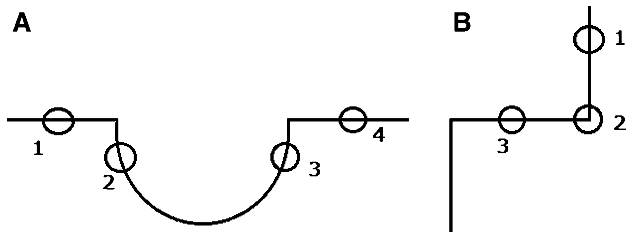

Fig. 5 Schematic representation of the grooves in *horizontal* (**A**) and *vertical* section (**B**) indicating points where the thickness of the paint-on die spacer was measured

and silver die spacers was applied with a camel hair brush no.0, in two different techniques (Fig. 2).

Group A

This group consisted of four blocks, with each block consisting of three grooves, so a total of 12 grooves were included in this group.

Four coats of die spacer were meticulously applied using unidirectional brush stroke technique (brush strokes in only one direction) on to each of these grooves.

Group B

Similarly total of 12 grooves were coated with four coats of die spacer which were applied using haphazard method of application (brush strokes in more than one direction).

These die stone blocks were then embedded in type IV die stone again and once set were sectioned in horizontal and vertical sections through the grooves (Figs. 3, 4). Each section was measured at 200× magnification with a metallurgical microscope with a filar eye piece. The thickness of the die spacer was measured at seven different positions (Fig. 5)

Mean and SD were calculated for film thickness in each of the locations measured for each group of materials. Because the recommended thickness of die spacer is a relatively broad range (20–40 μm) and the hand painting technique involves a high degree of variation in the film thickness, no statistical analyses were undertaken. The mean as a measure of central tendency will be reported in relation to clinical significance.

Results

The measurements of the paint-on die spacer are shown in Tables 1, 2, and 3.

In group A at position 1 the range of film thickness of the die spacer was 20–36 μm, in position 2 the range was 22–40 μm; in position 3 the range was 24–40 μm, in position 4 the range was 20–40 μm. In group B at position 1 the range of film thickness of the die spacer was 32–70 μm, in position 2 the range was 34–62 μm; in

Table 1 Range of the thickness of the paint-on die spacer at different positions in μm in the horizontal sections in the two techniques

Group	N	Minimum	Maximum	Mean	SD
A					
Position 1	12	20.00	36.00	25.7500	6.12710
Position 2	12	22.00	40.00	34.0000	6.01513
Position 3	12	24.00	40.00	33.1667	6.68558
Position 4	12	20.00	40.00	28.0000	8.14000
B					
Position 1	12	32.00	70.00	49.3333	11.51547
Position 2	12	34.00	62.00	47.5000	8.74383
Position 3	12	48.00	60.00	55.0000	4.86172
Position 4	12	44.00	74.00	53.8333	8.06602

Table 2 Range of the thickness of the paint-on die spacer at different positions in μm in the vertical sections in the two techniques

Group	N	Minimum	Maximum	Mean	SD
A					
Position 1	12	22.00	34.00	29.8333	4.04145
Position 2	12	28.00	40.00	37.5000	3.31662
Position 3	12	20.00	34.00	29.3333	4.37624
B					
Position 1	12	28.00	80.00	56.0000	13.34848
Position 2	12	62.00	132.00	100.6667	24.55914
Position 3	12	30.00	68.00	45.5000	10.27353

Table 3 Range of the thickness of the paint-on die spacer in the two techniques

Group	*N*	Range (µm)
A	12	20–40
B	12	28–132

Group A-unidirectional brush stroke technique; Group B-haphazard method of application; *N* number of samples

position 3 the range was 48–60 µm, in position 4 the range was 44–74 µm (Table 1).

In group A at position 1 the range of film thickness of the die spacer was 22–34 µm, in position 2 the range was 28–40 µm in position 3 the range was 20–34 µm. In group B at position 1 the range of film thickness of the die spacer was 28–80 µm in position 2 the range was 62–132 µm, in position 3 the range was 30–68 µm (Table 2).

In group A the minimum thickness was 20 µm and the maximum thickness was 40 µm. In group B the minimum thickness was 28 µm and the maximum thickness was 132 µm (Table 3).

Discussion

Die spacing involves the application of a material to a die in multiple coats within 0.5–1 mm of the margins which results in production of an over sized die for wax pattern construction [8]. An optimum thickness of 20–40 µm is generally specified to facilitate complete seating of the casting and to allow for the film thickness of the cement [2, 10].

From the observations of this study it was seen that there was a significant difference in the thickness of the paint-on die spacer between technique A and B in horizontal and vertical section as shown in Table 3 (Figs. 6, 7). This indicates that thickness of the die spacer varies with the application technique. The increase in thickness may be attributed to the overlapping of the layers of the die spacer. This observation is similar to the observation of Oliva and Lowe [1].

The thickness of paint-on die spacer in all the 3 positions in vertical sections in technique A was within the range of tolerance i.e. 20–40 µm as shown in Table 2.

In vertical sections in technique B the thickness was above the range of tolerance, with increased thickness at position 2 (base of the groove) as shown in Table 2 (Fig. 7B), which was due to pooling of the material at the base of the groove. Similar observations were also made by Donovan [4].

It was also observed that the thickness of the paint on die spacer in technique A was not found to be uniform throughout the horizontal section (Fig. 6A) but the thickness was within the range of tolerance as shown in Table 1. In technique B too the thickness was not found to be uniform throughout the horizontal section (Fig. 7A) and the thickness was above the range of tolerance as shown in Table 1. This may be due to the overlapping of the coats of the die spacer, absorption of the first layer by the die stone, merging of the layers, and surface roughness of the die stone.

It was observed that the thickness of the die spacer was erratic in vertical section in both technique A and technique B as shown in Table 2 (Figs. 6B, 7B). This indicates that the die spacer has a tendency to accumulate in the grooves which is due to the pooling of the die spacer and merging of the layers. Similar observation is also made by studies done by Oliva [4]. So from the above observations it is clear that it would be exceedingly difficult to achieve a consistent amount of cement space if die is relieved with technique B.

From this study it was noted that in technique A there was no tendency for the paint-on die spacer to accumulate beyond the range of tolerance. This is probably due to the extreme care taken in application. This may well improve the hydrodynamics of the cementation procedure and allow

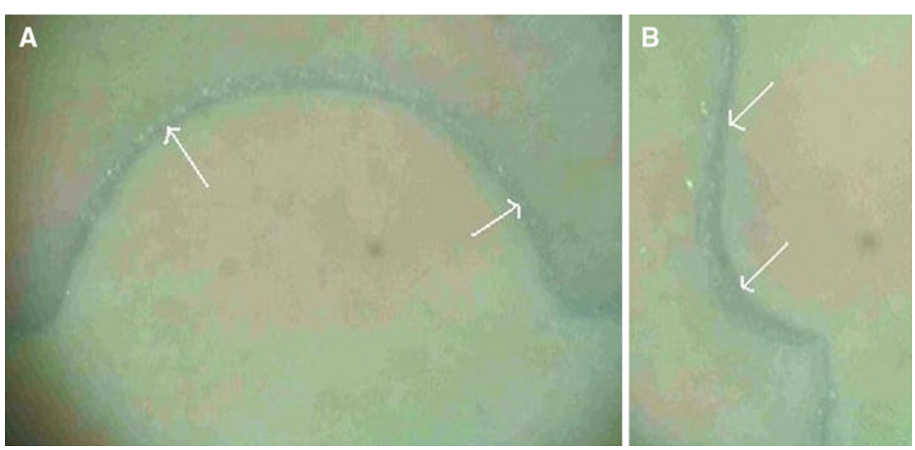

Fig. 6 Microscopic picture of the paint-on die spacer in *horizontal section* (**A**) and *vertical section* (**B**) in technique A at ×70 magnification

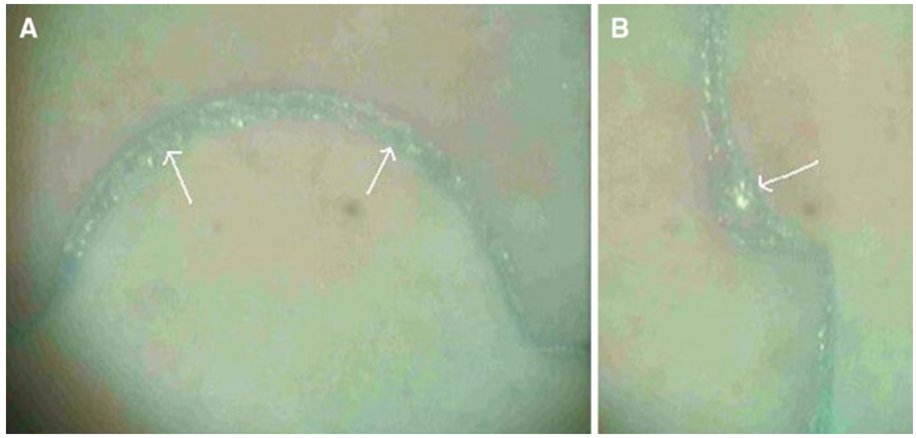

Fig. 7 Microscopic picture of the paint-on die spacer in *horizontal section* (**A**) and *vertical sect*ion (**B**) in technique B at ×70 magnification

more complete seating of the casting. Whereas with technique B the die spacer showed a tendency to accumulate beyond the range of tolerance which could adversely affect the function for which it was designed for.

Conclusion

From the results of this study the following conclusions were drawn.

1. The technique used to apply the die spacer can affect the film thickness produced.
2. The thickness of the paint-on die spacer in grooves at different points in both the horizontal and vertical section in group A (unidirectional brush stroke technique) were within the range of tolerance, where as in group B (haphazard method of application) exceeded the range of tolerance.
3. Careful application of Pico-fit die spacer will not result in significant accumulation of the die spacer in the grooves.
4. Pico-fit die spacer generally produced erratic film thickness on haphazard application and demonstrated a potentially significant amount of pooling in the groove.

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