### Effect on Indigenous Die Spacer Thickness at Varied Evaporation Times

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### Abstract

**Aim:** The present study was conducted to compare the effect of evaporation at different time intervals on film thickness at various applications of indigenous die spacer (S) Surana Enterprises, Mangalore Dental Corporation, India and TRUFIT GEO. TAUB PROD. & FUSION CO. INC. Jersey City, N.J Die spacer on ultrarock KALABHAI, Karsan, India die stone (DII) and Resin modified gypsum SynaRock XR, DFS GmbH, Germany die stone (DII). **Materials and Methods:** A total of 200 samples were prepared for study, and each sample was used for specific number of die spacer application (1, 2, 3, 4, or 5) after its evaporation at specific interval of time (0 h, 2 h, 4 h, 8 h, or 24 h). The specimens so obtained were then sectioned and die spacer thickness was measured using a stereo microscope. One-way analysis of variance was used for study parameters with 5% level of significance followed by Tukey’s HSD post hoc test. **Results:** The highest mean value of die spacer thickness of 32.85 ± 0.28 μm was for SynaRock die stone sample with 5 applications of TRU-FIT die spacer after 24 hours of evaporation and least of 13.80 ± 0.02 μm for ultrarock die stone sample with 1 application of Surana die spacer after 0 hour of evaporation. There is a significant difference in all subgroups at various evaporation time intervals. **Conclusions:** Evaporation of volatile substances at various time intervals varies the thickness of die spacer and thus affects the casting relief. The indigenous die spacer and die stone can also be used effectively.

**Keywords:** Casting relief, die spacer, die spacer thickness, die stone, evaporation

### Introduction

Fixed restorations are one of the finest services rendered for dental patients to improve their comfort and mastication, maintain the health and integrity of the dental arches, and, in many instances, elevate the patient’s self-image. The proper fit and cementation of cast restorations onto a prepared tooth using luting agent is crucial to both short- and long-term functions. Casting relief is required for proper seating of casting which allows space for luting agent thickness. Die spacer is a solution that is painted on the die before the fabrication of the pattern. The reported ideal die spacer thickness ranges from 25 to 40 μ. Studies have also shown that various commercially available die spacers varied in thickness per coat applied to the die along with the variation of the time intervals. Hence, the present study was aimed to compare the thickness of indigenous die spacer (S) from Surana Enterprises, Mangalore Dental Corporation, India and TRUFIT GEO. TAUB PROD. & FUSION CO. INC. Jersey City, N.J die spacer on die stone DI (ultrarock KALABHAI, Karsan, India die stone) and DII (Resin modified gypsum SynaRock XR, DFS GmbH, Germany die stone)

### Materials and Methods

Two-hundred die stone block samples were prepared using a stainless steel die with 10 grooves at 1 cm intervals of dimension measuring 10 cm × 1 cm × 0.5 cm. Impression of this stainless steel die was made using putty reline technique and then the die stone was poured. The models of the die stones were retrieved and sawed using a diamond disc into 1 cm × 1 cm × 0.5 cm dimension [Figure 1a-d]. The dimension was kept 1 cm × 1 cm × 0.5 cm, so that it would almost resemble that of a prepared posterior tooth and flat surface of die stone blocks was used to achieve the actual

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die spacer thickness on die stone. The die stone blocks were equally divided into DI (UltrarockKalabhai, Karsan, India) and DII (Synarock XR, DFS GmbH, Germany) on to which the die spacers S (Surana Enterprises, Mangalore Dental Corporation, India) and T (Trufit Geo Taub, Jersey City, USA) of two different colors silver and gold were alternatively applied after shaking the bottles for 30 s. Fifty samples from each group DI S, DI T, DII S, and DII T were sectioned after applying the respective die spacer to obtain 100 specimens in each group; these were further divided into five groups, each group consisting of 20 samples for 1, 2, 3, 4, and 5 layers of die spacer application left open at different intervals of time 0 h, 2 h, 4 h, 8 h, and 24 h as shown in flow chart below [Figure 2a].

The above samples were sectioned into two halves after application of S and T on above and below surface at various time intervals 0, 2, 4, 8, and 24 h to obtain again 100 samples in each group.

Each subgroup as shown in the flow chart of DI & DII samples [Figure 2b] were further divided with four specimens in each for 1, 2, 3, 4, and 5 layers of die spacer application (AP 1, Ap 2, Ap 3, Ap 4, and Ap 5) of die spacer.

To differentiate between the thickness for 2, 3, 4, and 5 applications, alternating layers of gold and silvercolored die spacer were considered [Figure 3]. Three readings from above and below surface of each sample were taken, and a mean of these six readings was recorded as the die spacer thickness for that particular sample as shown in Figure 4. The samples were sectioned in the middle to avoid both over pooling of die spacer at the edges where the application of die spacer was started and thinning at the opposite edge just before lifting the brush away from it, thus ensuring thorough application in the middle surface. The die spacer thickness was measured using a stereo microscope (Olympus corporation, US) and Prog Res® CT3 microscope camera SPECTRA services, US [Figure 5 and Table 1].

Areas of irregularly thick layer of die spacer were not included to exempt the probability of porosities on the surface of sample. Onto the sectioned die sample, three widely placed die spacer thickness readings on top and below surface at various time intervals 0, 2, 4, 8, and 24 h were noted. So on the whole 12 readings were obtained from each sample. Die spacer thickness values in micrometer (μm) was recorded. The mean, standard deviation was calculated for the same. Analysis of variance (one-way ANOVA) was used to find the significance of study parameters between different

![Figure 1: Stainless steel die (a), elastomeric impression of stainless steel die (b), die stone block retrieved from impression (c), die stone samples used in the study (d)](image)

![Figure 2a: Flow chart of the samples](image)

![Figure 2b: Flow chart of the DI and DII samples](image)
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The maximum mean thickness of 32.85 ± 0.28 μm for DIIT 24 h 5 applications and least of 13.80 ± 0.02 μm for DI S 0 h 1 application resulted, and also there is significant difference between various evaporation time intervals. Pair-wise comparison by Tukey’s HSD post hoc test for die spacer thickness, after different applications at various evaporation time intervals on die stone, indicates that evaporation of volatile substances from die spacer affects the thickness of die spacer when applied on die stones [Tables 2-6].

Die spacer left open for 2, 4, 8, and 24 h as compared with bottles open for 0 h affected the die spacer thickness and consistently increased by 104% 2 h for DIS, to 154% 24 h for DIIT [Table 7]. The mean die spacer thickness ranged from 16.64 ± 2.28 μm for DIS at 0 h to 28.74 ± 3.18 μm for DII, irrespective of number of applications [Table 8 and Graph 1]. Die spacer thickness per brush application ranged from 7.06 μm per layer to 12.38 μm per layer. There is significant variation in per-layer thickness of die spacer at various time intervals. Null hypothesis is true as there is no statistical difference between DI and DII die stones when S and T were applied at various time intervals.

DiscussIon

Paint on die spacer for internal relief provides a space for the luting agent between the casting and prepared tooth; this space is dependent on the type of technique used for cementation.[2,6] Application of die spacer result in reduced elevation of cemented complete crowns on prepared tooth compared with un spaced crowns.[7-9] It also allow improved out flow of excess cement without crown deformation.[10]

The effect of evaporation on die spacer applied on glass slide and profilometer was used to measure die spacer thickness which had no direct clinical implications also the thickness of die spacer on the die resembling the prepared tooth could vary on all surfaces as it includes inclined surfaces.[8,11,12]

Die stone blocks used in the present study had both added advantage of flat surface and also painting of die spacer directly on die stone for better comparison. Special care was taken while measuring thickness in stereomicroscope, not to in include abruptly thick layer to eliminate the possibility of surface porosity on die stone blocks. To achieve optimal thickness, all components of die

Table 1: List of materials used and their brand name

| List of materials | Material brand name |
|-------------------|--------------------|
| Die stones        | DI (UltrarockKalabhai, Karsan, India) DII (Synarock XR, DFS GmbH, Germany) |
| Die spacers       | S (indigenous die spacer Surana enterprises, Mangalore Dental Corporation, India) T (Tru-fit Geo Taub, Jersey City, USA die spacer) |
| Elastomeric impression material | Putty material (Aquasil soft putty, DENTSPLY, USA) Light body (Reprosil hydrophilic vinyl polysiloxane DENTSPLY, USA) |
| Stereomicroscope and microscope camera | Olympus corporation, US Prog Res® CT3 microscope camera (Spectra services, US) |

Figure 3: Stereo microscope image of die stone sample showing alternating layers of gold and silver die spacer thickness

Figure 4: Readings recorded for image of DI T 2 h 5 application

Figure 5: Stereo microscope with microscope camera

die materials applied with different die spacers at various evaporation time intervals at 5% level of significance. Pair-wise comparison by Tukey’s HSD post hoc test was carried out.

Results

The maximum mean thickness of 32.85 ± 0.28 μm for DIIT 24 h 5 applications and least of 13.80 ± 0.02 μm for DI S 0 h 1 application resulted, and also there is significant difference between various evaporation time intervals. Pair-wise comparison by Tukey’s HSD post hoc test for die spacer thickness, after different applications at various evaporation time intervals on die stone, indicates that evaporation of volatile substances from die spacer affects the thickness of die spacer when applied on die stones [Tables 2-6].
spacer liquid must be properly dispersed and the composition held constant for optimal clinical effectiveness. Maximum die spacer film thickness with increased open bottle time probably is caused by subsequent high concentration of metallic oxide particles due to evaporation of volatile solvents in the die spacer solution, resulting in more metal oxides being applied per brush stroke. Shaking the bottle after they are left open for different time intervals, followed by vibrating homogenize the solution, else particles tend to remain near the bottom of the bottle. This possibly congregates resulting in insufficient number of the particles captured by brush to obtain full thickness of die space.\[13\] In the present study, die spacer bottles were hand shaken vigorously for several minutes for thorough mixing all components.

There is a variation in thickness between different commercially available die spacers.\[14\] The American Dental Association

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**Table 2: Die spacer thickness, after one application at various evaporation time intervals**

|       | 0 h   | 2 h   | 4 h   | 8 h   | 24 h  |
|-------|-------|-------|-------|-------|-------|
| DI S  | 13.80±0.02 | 14.32±0.13 | 16.13±0.74 | 19.57±0.63 | 21.84±0.72 |
| DI T  | 15.48±0.35 | 16.73±0.25 | 18.79±0.27 | 21.89±0.38 | 23.46±0.29 |
| DII S | 14.62±0.25 | 15.68±0.40 | 17.72±0.27 | 20.74±0.42 | 22.33±0.41 |
| DII T | 16.72±0.22 | 17.82±0.18 | 19.28±0.26 | 22.54±0.13 | 24.82±0.16 |

*Tukey’s HSD post hoc test. HSD: Honestly significant difference

**Table 3: Die spacer thickness, after two applications at various evaporation time intervals**

|       | 0 h   | 2 h   | 4 h   | 8 h   | 24 h  |
|-------|-------|-------|-------|-------|-------|
| DI S  | 15.28±0.06 | 15.96±0.83 | 17.38±0.44 | 21.33±0.60 | 23.59±0.30 |
| DI T  | 16.94±0.25 | 18.10±0.36 | 19.94±0.44 | 23.72±0.16 | 25.93±0.23 |
| DII S | 15.89±0.35 | 17.03±0.33 | 18.88±0.31 | 22.58±0.20 | 24.84±0.47 |
| DII T | 17.98±0.19 | 19.23±0.25 | 20.10±0.58 | 24.93±0.19 | 26.53±0.21 |

*Tukey’s HSD post hoc test. HSD: Honestly significant difference

**Table 4: Die spacer thickness, after three applications at various evaporation time intervals**

|       | 0 h   | 2 h   | 4 h   | 8 h   | 24 h  |
|-------|-------|-------|-------|-------|-------|
| DI S  | 16.49±0.22 | 17.18±0.30 | 18.27±0.20 | 23.27±0.25 | 25.63±0.36 |
| DI T  | 18.44±0.29 | 19.53±0.31 | 20.86±0.44 | 25.69±0.39 | 27.85±0.26 |
| DII S | 17.22±0.21 | 18.49±0.26 | 19.78±0.34 | 24.49±0.20 | 26.78±0.31 |
| DII T | 19.57±0.27 | 20.64±0.14 | 21.25±0.27 | 26.75±0.21 | 28.91±0.22 |

*Tukey’s HSD post hoc test. HSD: Honestly significant difference
Specification No. 8 has established a maximum film thickness of 25 μm for dental cement. Donovan et al. and Campbell stated that the optimum thickness of a die spacer has never been scientifically established. However, the generally accepted range is approximately 20–40 μm. Hembree and Cooper used four layers of Tru-Fit die spacer; Eames et al. also used four layers of Tru-Fit die spacer to achieve 25 μm thickness; and Campagni et al. applied die spacer to stone dies and measured the actual thickness of the spacing materials. They found that two layers were 26.55 μm, four layers 58.87 μm, six layers were 77.7 μm thick. Rieger et al. showed that the thickness of the Tru-Fit spacer was approximately 6–7 μm/coat depending on the sequence of application and whether the silver- or gold-colored die spacer was measured. The mean thickness of a layer of silver-colored die spacer was 6.95 ± 1.14 μm and for gold colored was 6.03 ± 1.14 μm. Suggesting consistency within gold- and silver-colored die spacer of Tru-Fit die spacer is excellent. Rafael Grajower reported new and old spacer suspensions. The average thickness of one-layer new spacer was 23 μm for the silver and 15 μm for the gold-colored die spacer. He calculated that the average thickness of layers of Tru Fit die spacer was 19 μm in new suspension and the thickness increased to 32 μm when the container was periodically opened in routine use for 6 months. He recommended application of spacer to the shoulder margins.
of dies to decrease in elevation of crown after cementation. The thickness of die spacer in his study did not affect the elevation, but increased the cement thickness at the axial walls.[9]

In the present study, alternating layers of gold and silver die spacer were used. In the present study the DII T had mean thickness of 19.72 ± 0.25 μm for 4 coats of TruFit die spacer at 0 h. As the time interval of bottles left open increases, the number of applications has to be decreased to reach the optimal thickness, as the evaporation affects the thickness of die spacer.

The 147% of die spacer thickness increase at 24 h for DII T is not similar Psillakis et al study, in which 329% increase was found at the end of 24 h when compared with 0 h.[10] A similar study by Ishikiriama et al showed that 140% increase in thickness for TruFit bottles of 6monthold compared to new bottle. When the die spacer bottles were periodically opened in routine use for 6 months, the thickness increased to 32 μm from 19 μm(average thickness of layers of the new Tru-Fit die spacer).[11] In the present study, the mean die spacer thickness ranged from 16.64 ± 2.28 μm to 28.74 ± 3.18 μm, irrespective of number of applications and at various time intervals. It is possible that such large increases in die spacer thickness with open bottles at various times are clinically significant.

If it is assumed that bottle is left open for several minutes per application on to a clinical die, clinically significant increase may occur after painting on die. The clinical consequence of large die spacer thickness found with open bottle time may be excessive cement film thickness, with all the other variables held constant, and excessive luting agent thickness may lead to lower restoration retention and higher luting agent solubility at the margins.[12] Conflicting experimental results exist for crown retention versus cement thickness, possible because of the multitude of experimental and clinical variables as well as difference in experimental design.[3,4,8,9,16,17,19,21] Variation in applied die spacer thickness per brush application in literature is quite large 6.0–19.8 μm/layer and is probably due to variation in clinical and experimental techniques, composition, brushes, and subtract.[10,11,15,22]

The results of this study for die spacer thickness per brush application ranged from 7.06 to 12.38 μm/layer within the range mentioned in literature. Based on the results of this study, it can be suggested that there is a significant increase in the thickness per coat of applied die spacer with the increase evaporation times for both the die spacers, but when the thickness values of both the die spacers were compared, there is slight increase in thickness for Tru-Fit die spacer compared to Surana die spacer though statistically insignificant.

In this study, more emphasis was made for analyzing the actual thickness of die spacer on the flat surfaces, rather than on prepared tooth die, which has various surfaces, corners, and slopes leading to pooling of the die spacer at some areas and thinning at other.

This study limits to evaluate the effect of thickness of die spacer at different evaporation times and number of applications. A similar study using prepared tooth die can be done to calculate the thickness on different surfaces, inclines, and corners and its effect on the cement layer.

**Conclusions**

Application of die spacer for casting relief is essential for effective cementation of fixed prosthesis. As time of the die spacer bottles left open increases as a result of excess evaporation the die spacer thickness will also eventually increase, necessitating addition of thinner or reducing the number of applications. Following conclusions can be drawn from this study:

- The calculated values obtained in the present study are highest for the 24 h duration for each application of the die spacer applied on the die stone observed
- The values obtained for 0 h for each application of the die spacer to die stone was least
- Single application of die spacer was noticed with least value and fifth application was highest for each group
- Both die spacers showed a significant increase in film thickness when they were left open at various time intervals, though not significant TruFit die spacer has shown slight increase at various time intervals
- Four coats of TruFit die spacer applied on Synarock die stone block and five coats for other variables resulted in
optimal thickness for freshly opened bottles.

- Number of coats must be reduced for bottles open at various time intervals
- The indigenous die spacer and die stone used in the study gave statistically acceptable results compared to common die spacer and die stone.

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**Conflicts of interest**
There are no conflicts of interest.

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