Effect of Selective Application of Die Spacer on Marginal Discrepancy of Post-Cementing Crown: An in Vitro Study

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ABSTRACT

Background: *Marginal adaptation is a critical determinant of the clinical success of full-coverage restorations. Adequate cement space is essential to allow complete seating of the crown and minimize marginal discrepancy after cementation. Die spacer application is the most commonly used method for providing cement space. This study aimed to evaluate the effect of selective die spacer application on post-cementation marginal discrepancy of full-coverage crowns.* ***Materials and Methods:*** *This cross-sectional laboratory study was conducted in the Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), with instrumental support from BCSIR. Forty stone dies fabricated from a preformed steel die were allocated into four groups (n=10): Group A (no die spacer), Group B (double layer of die spacer 0.5 mm short of the margin), Group C (Group B plus an additional layer on the occluso-axial line angles), and Group D (Group B plus an additional layer on the axial walls). Metal copings were fabricated and cemented with glass ionomer luting cement under a 10 kg static load. Post-cementation marginal discrepancy was measured at four points using an optical microscope. Data were analyzed using one-way ANOVA.* ***Results:*** *The post-cementing mean marginal discrepancy in the group A showed the highest (161.9 µm±9.216) and the group C showed the lowest (79.24 µm±3.647). A significant P value (.000) was found.* ***Conclusion:*** *Based on the result of the study, it can be concluded that selective application of die spacers significantly affects the post-cementing marginal discrepancy; additional relief in the occluso-axial line angles can markedly reduce the marginal opening after cementation.*

Keywords: Marginal Discrepancy, Post-Cementing Crown, Die Spacer, Wax pattern

How to cite this article: Anee NA, Ahmed AHHU, Faruk SMO, Akhter SM, Solaiman F, Rahman MM. Effect of Selective Application of Die Spacer on Marginal Discrepancy of Post-Cementing Crown: An in Vitro Study. Int J Drug Deliv Technol. 2026;16(71s): 1562-1568. DOI: 10.25258/ijddt.16.71s.182

INTRODUCTION

Once tooth structure (enamel, dentine) is lost due to caries, trauma, or wear, it must be restored by prosthetic intervention, as human dental tissues are devoid of regeneration properties. A fixed prosthesis is the most practical and well-liked treatment, and it is frequently utilized. A fixed dental prosthesis is any prosthesis that is securely fixed to a natural tooth or teeth or to one or more dental implants or implant abutments and cannot be removed by the patient [1]. Depending on the material used, fixed prostheses can be all metallic, all ceramic, metal ceramic, or all acrylic.

Whatever the material used, during restoring the tooth with fixed prosthesis, it is very crucial to achieve an ideal restoration, which means prosthesis with its original form and position. For an ideal restoration, a casting must be made such way so that it should fit with the prepared tooth intimately [2]. If the casting fits too closely with the prepared tooth, it is difficult to escape the cementing material between the casting and tooth surface, resulting in improper seating of the casting causing an open margin. Ultimately their premature occlusal contact, inappropriate proximal contacts, and a lack of comfort [3].

In fixed prosthodontics, when teeth are restored with full coverage restoration, it is very important to achieve marginal integrity. Furthermore, oral health and the longevity of restoration mostly depend on marginal integrity. Marginal opening of the crown after cementation causes secondary caries, plaque accumulation, and ultimately restoration failure [4].

When a crown is undergoing cementation, two phenomena occur. Firstly, there is frictional resistance occurs between the internal surface of the crown and the axial wall of the die during cementation. Second one, hydrodynamics occurs at the time of cementation may resulting in the crown's incomplete seating [5].

A margin greater than 50 µm is considered as an open margin [6]. According to marginal opening ranges from 50 µm to 120 µm are considered clinically acceptable.

There are many suggestive techniques to avoid this undesirable phenomenon, which can be categorized basically into two categories: one is venting of the casting and another is internal relief in the casting [7]. The improvement of the seating of a crown significantly by means of venting is already proven [3]. But its use is rare because another visit is required sealing the escape hole and the material which used to seal the escape hole may wear away. Occlusal venting in the metal ceramic crown may weaken the prosthesis [8].

On the other hand, to achieve internal relief in the casting, methods are available including:

- (a) mechanical grinding of the inner surface of the casting,
- (b) carving of the wax pattern,
- (c) electrochemical milling,
- (d) cutting an internal channel,
- (e) die spacing.

Mechanical grinding of castings and curving of wax patterns are rejected earlier because of their inaccuracy and inconsistency. During the procedure of electrochemical milling, potassium cyanide is required, which is hazardous [9].

Internal relief by cutting internal channels either from prepared tooth or from the internal surface of the crown before cementation has reduced the mean marginal discrepancy, but their loss of fit between the tooth and casting in the areas in which channels were prepared [10,11].

Another technique for internal relief in the casting is aqua regia etching. Aqua regia etching was considered as an effective one but it produced uneven relief from the casting [12].

Among all, the die spacing by using die spacer is mostly used technique to provide space for cementing materials because of its simplicity, ease of handling, and reliability. It gives a uniform space for cementing material [8].

The composition of the die spacer is metallic oxide powders, adhesives, and organic liquid (ketone) as a solvent particle. It is usually painted on the die stone before the wax pattern.

Fusayama and his co-authors used manicure liquid as a spacer on the die for the first time and gave a positive result to the profession, but the limitation of the study was that they did not measure the thickness of the manicure liquid what they were used [13].

Van Nortwick and his co-authors produced internal relief by adding three layers of die spacer to the die prior to wax pattern construction, but there was no recorded measurement of die spacer thickness [14].

Measured the die spacer thickness and found that two coats of aeroplane drops were each 10 µm thick and two coats of a proprietary cement spacer were 23 µm thick [9]. They also reported that the estimated die spacer thickness was 20.84 µm to 39.12 µm[9].

The optimum range of die spacing from 25 µm to 40 µm was suggested by most authors and was based mainly on vitro studies [8].

Normally, die spacer material is applied evenly in all areas of the die except 0.5–1 mm away from the die margin, which is left uncovered, so that in that area there is a closed adaptation between tooth and crown to prevent dissolution of luting cement [15].

The die spacer tends to flow away from the sharp line angles like occluso-axial line angle and cusp tip due to surface tension [9]. Lack of adequate relief in these areas hamper the flow of luting agents beyond the occlusal surface of the casting prevents the complete seating of the casting due to hydrostatic pressure [16].

So, it is very important to come to a point about the proper area of the die, where the die spacer is painted, and the proper thickness of the die spacer. The focus of the current research is to assess the impact of the selective application of die-spacer on the marginal integrity of the post-cementing crown in vitro environment.

MATERIALS AND METHODS

Type of study: This study was a cross sectional study.

Place of study: This study was carried out in the laboratory of the department of prosthodontics at BSMMU and instrumental support from BCSIR.

Study duration: The study period was from January 2021 to September 2023.

Study population: Duplicated stone dies from a prefabricated steel die.

Study sample: Duplicated stone dies by fulfilling the inclusion and exclusion criteria.

Sampling technique: Purposive sampling technique was used to select the sample for this study. All the available samples were picked up that was meet the preset criteria for this study till the desire sample size was reached.

Sample size: The sample size was forty (40) in number.

Selection criteria:

The study featured stone dies that were devoid of nodules and voids on the prepared surface and possessed a complete finish line. Coping mechanisms for a solitary nodule measuring under 0.5 mm in diameter were also considered. Stone dies featuring slight imperfections were omitted from the research. Copings showing several nodules, nodules larger than 0.5 mm in diameter, or a noticeable short margin prior to cementation were also omitted.

Research tool:

Data collection sheet: An open data collection sheet was developed for recording data.

Study procedure:

Armamentarium:

The tools employed in this research comprised a pre-made steel die, duplicating silicone, Type III die stone (DENTAMERICA, USA), a rubber bowl and spatula for handling the stone, Durolan die spacer (DFS, Germany), inlay casting wax (MAARC, India), nickel-chromium alloy (VeraBond, USA), a 4× magnifying loupe (LACTONA, USA), glass ionomer luting cement (GC Fuji I, Japan), an optical microscope, and a Universal Testing Machine for assessing the test samples.

Procedure:

Preparation of the specimen and application of die spacer

A steel die was prepared to resemble a prepared lower first molar tooth for a crown with 6□ tapering and a 1 mm shoulder finish line. Then forty stone dies were duplicated from this preformed steel die using type III die stone and picked up by fulfilling the inclusion criteria. Forty stone dies divided into four groups. Sample size was 10 in number in each group.

In Group A, there was no die spacer applied. In group B, double layer of die spacer was applied to all surfaces 0.5 mm away from the margin. In group C, double layer of die-spacer was applied to all surfaces 0.5 mm away from the margin, with an additional single layer on the occluso-axial line angles. In group D, double layer of die-spacer was applied to all surfaces 0.5 mm short of the margin, with an additional single layer on the axial surfaces not involving the occluso-axial line angles.

The thickness of single layer of die spacer (Durolan, DFS, Germany) is 13 µm, hence three layers 39 µm, which was under the acceptable optimum thickness of 25–40 µm.

Description of various Groups:

- **Group A:** No die spacer used
- **Group B:** Double layer of die-spacer all over 0.5 mm away from the margin.
- **Group C:** Double layer of die spacer all over 0.5 mm away from the margin with additional single layer on the occluso-axial line angles.
- **Group D:** Double layer of die-spacer all over and 0.5 mm away from the margin with additional single layer on the axial surfaces but not involving the occluso-axial line angles.

During the application of the die spacer paint, the unidirectional method followed, avoiding as much overlapping of strokes as possible. Waited for a minute in between two layers. The applicator brush was cleaned frequently with thinner.

Wax pattern: Wax patterns were done by inlay casting wax. The patterns were marked according to the groups they belong to.

Casting and Sandblasting: After the wax pattern, forty copings were fabricated by using Ni-Cr alloy, cleaning them with ultrasonic cleaner, and being carefully sandblasted by 50 µm aluminium oxide particle under 30 psi pressure from an approximate 5 cm distance.

Inspection of coping: Copings were inspected with a magnifying loupe cautiously to see any nodules present or not, and if present, they were removed carefully by rotary instrument with smaller diameter round bur to prevent additional grinding of internal surface of copings. Any other adjustment on the internal surface was avoided as there might be increased adaptation of the casting that may lead to variables in the result.

Cementation of crown: All the copings were cemented on the same die using type-1 glass ionomer cement under a 10 kg static load by a universal testing machine. Hold it for 5 minutes for the final setting of cement.

Post-cementing measurements: Measurements were taken using an optical microscope at four points, which were 90□ apart from each other.

Statistical analysis: Data were analyzed statistically, and ANOVA was used for data comparison. The data were expressed as the mean and standard deviation. Appropriate tests were performed as applicable. A P value <0.05 was considered statistically significant.

Ethical considerations: Ethical clearance for the study was obtained from the institutional review board (IRB) of BSMMU, Registration No: 3851, Date: 25-05-2022, prior to precede the study. Before the research protocol was approved by the board, permission for the study was obtained from the department of prosthodontics at BSMMU. Standard laboratory procedure was done at BCSIR. Laboratory ethics were followed accordingly. Proper collection, handling, and labeling of samples were done by maintaining as many laboratory rules as possible. Care was also taken in handling laboratory records, instruments, and other facilities.

RESULTS

Table 1 shows marginal discrepancy of crown after cementation in different groups of selective application of die spacer. The no die spacer group (group A) shows highest value of marginal discrepancy, the mean ± SD is 161.9±9.216 µm. Double layer of die spacer all over 0.5 mm away

from the margin with additional single layer on the occluso-axial line angles group (group C) shows lowest value, mean ± SD is 79.242±3.647 µm. The mean ± SD for double layer of die spacer all over 0.5 mm away from margin group (group B) and double layer of die spacer all over 0.5 mm away from the margin with additional single layer on the axial surfaces not involving the occluso-axial line angles group (group D) are 96.429±8.365 µm and 91.296±5.797 µm respectively.

Table 1: Descriptive statistics of marginal discrepancy (µm) after cementation in different groups (n=10 in each group)

Groups	Minimum	Maximum	Mean	Std. Deviation
Group A	149.40	173.53	161.9000	9.21623
Group B	83.87	110.23	96.4290	8.36528
Group C	72.98	85.68	79.2420	3.64744
Group D	81.35	97.45	91.2960	5.79717

- **Group A:** No die spacer used
- **Group B:** Double layer of die spacer all over 0.5 mm away from the margin.
- **Group C:** Double layer of die spacer all over 0.5 mm away from the margin with additional single layer on the occluso-axial line angles.
- **Group D:** Double layer of die spacer all over 0.5 mm away from the margin with additional single layer on the axial surfaces not involving the occluso-axial line angles.

Table 2 shows comparison between four groups of marginal discrepancy of crown after cementation by One-way ANOVA. The obtained F value is 273.678 which is statistically significant (P value 0.000). Thus, marginal discrepancy is significantly difference between groups of selective application of die spacer.

Table 2: Comparison of marginal discrepancy (µm) after cementation in different groups (n=10 in each group) by One-way ANOVA

Group	Mean ± SD	F-value	P-value
Group A	161.9±9.216	273.678	.000* (<0.05)
Group B	96.429±8.365		
Group C	79.242±3.647		
Group D	91.296±5.797		

**P value is significant*

Table 3 shows comparison of marginal discrepancy after cementation of crown in each other group by Tukey Post Hoc test. Each pair group shows significant difference (P value <0.05) in marginal discrepancy except in between group B and group D.

Table 3: Comparison of marginal discrepancy (µm) after cementation in groups with each other (n=10 in each group) by Tukey Post Hoc test

Comparison groups	Mean Difference	P-value
Group A and group B	65.471	.000*
Group A and group C	82.658	.000*
Group A and group D	70.604	.000*
Group B and group C	17.187	.000*
Group B and group D	5.133	.383
Group C and group D	-12.054	.003*

**P values are significant*

DISCUSSION

This current study was carried out with the purpose of evaluating the impact of selective application of a die spacer on marginal discrepancy after cementation of a crown. Post-cementation marginal opening is a common phenomenon in daily clinical practice. Many factors are responsible for this from both the clinical and the laboratory sides. After desirable clinical work, this marginal opening might be happening just because of laboratory work, like a lack of cement space before wax pattern. Sometimes this thing is unacknowledged or missed by lab technicians as well as clinicians. This study focused on the laboratory part of how the post-cementing vertical marginal gap decreased by giving cement space through the thorough application of a die spacer and tried to come to a conclusion that can play an important role in fixed prosthodontics.

In this study, the post-cementing marginal discrepancy of the crown in different groups of selective application of die spacer. The no die spacer group (group A) shows the highest mean marginal discrepancy is 161.9±9.216 µm. Group with double layer of die spacer all over 0.5 mm away from the margin with an additional single layer on the occluso-axial line angles (group C) shows the lowest value, which is 79.242±3.647 µm. Double layer of die spacer all over 0.5mm away from margin (group B) and double layer of die spacer all over 0.5mm away from margin with additional single layer on the axial surfaces but not involving the occluso-axial line angles group (group D) are 96.429±8.365 µm and 91.296±5.797 µm respectively.

This result is closely in accordance, but not completely, with previous study,which also evaluated the effect of different layers of die spacer on vertical marginal discrepancy after cementing the crown. They reported that the maximum post-cementing mean marginal discrepancy was found in

the group where no die spacer was applied, which was 124.8 µm±49.06, and the minimum in the group where a double layer of die spacer was applied all over with an addition layer on the occluso-axial line angle was 55.55 µm±8.28. This numerical variation may be due to differences in magnification when seen under microscope or to the use of different methodologies [5].

Previous studies have demonstrated that post-cementing marginal discrepancy in groups comprised of no die spacer (A)=144.4 µm, single layer die spacer (B)=117 µm, and double layer of die spacer (C)=69.80 µm finding supports the findings of the current study. Though the results demonstrated that the die spacer did not significantly interfere with the material used, they clearly showed that the die spacer was a key variation factor for reducing the marginal opening [16].

Previous studies have reported that the post-cementing marginal opening was in a group having a double layer of die spacer (25 dies) of approximately 30 µm, another group where 25 dies were painted with a double layer of die spacer with an additional single layer on occluso-axial line angle of approximately 20 µm. Here, a 15Kg static load was applied during cementation. They concluded that die relief only relieving the occluso-axial line angle without relieving the axial wall showed poor seating. On the other hand, a double layer with additional relief on occluso-axial line angle provides better seatability. The conclusions of this study correspond to those of the present study, but findings differ numerically, which may be due to a difference in load used during cementation [15].

Previous studies have concluded that casting cemented with glass ionomer cement provided the best marginal adaptation when the die spacer covered all the preparation 0.5mm short of the margin. The concept of the result is very similar to that of the current study [17].

Previous studies have demonstrated that whatever the preparation, with or without grooves, die relief significantly improved the seating of the crown and thus decreased the vertical marginal discrepancy. They also stated that partial internal relief was better than no relief [9].

In this study, the marginal discrepancy has been significantly different for each group of selective application of die spacer, as the obtained F value is 273.678, which is statistically significant. The findings of the present study are consistent with previous reports, which also demonstrated a highly statistically significant difference among the study groups (F = 7.51), supporting the influence of die spacer application on marginal adaptation [5]. Another study conducted by Previous study showed a difference between the absence and presence of the die spacer layer, which was statistically significant. This result also supports the results of the current study [16].

In this current study, there is a comparison of post-cementing marginal discrepancies with each other. Group having no die spacer (Group A) had a higher marginal opening after cementation than other groups; that means group with double layer of die spacer all over 0.05mm away from margin (Group B), group with double layer of die spacer all over 0.5mm away from margin with additional single layer on occluso-axial line angle (Group C), group with a double layer of die spacer all over 0.5mm short of margin with additional single layer on axial surface but not involving occluso-axial line angle (Group D), respectively. P value 0.000 which was statistically significant.

The post-cementing discrepancy of Group B is lower than that of Group A but higher than that of Group C and Group D. The mean difference between B and C was statistically significant ($P<0.05$) but between Group B and Group D, the mean difference was statistically insignificant ($P>0.05$). Group C had a lower marginal discrepancy than all the other groups. The mean difference between C and A, B, D is also statistically significant ($P<0.05$). Group D had a lower post-cementing marginal discrepancy than Group A and Group B but a higher one than Group C, which was also statistically significant. This intra-group comparison reveals that group A had a greater post-cementing marginal discrepancy and group C had a lower one.

This result agrees with the findings of the study conducted by previous study that reported that an intra-group comparison in which the marginal discrepancy after cementation had a statistically significant mean difference [5]. Another study supports the result of the current study, as they found a statistically significant difference between the group with no die spacer and the group with double layer of die spacer [16]. The findings of the current study concur with those of previous study [15]. In an intra-group comparison, the post-cementing marginal discrepancy between the control group (double layer of die spacer) and Group 2 (double layer with additional single layer on occluso-axial line angle) was statistically insignificant (P value 0.14) but when these two groups compared with another group having a double layer of die spacer exclusively on occluso-axial line angle, which was statistically significant.

The result of the current study supports the hypotheses of previous researchers that there is a significant effect of selective application of die spacers on the marginal discrepancy of a post-cementing crown.

Meanwhile, while previous studies have focused on other options available to decrease the post-cementing marginal opening, like venting, internal relief in casting either additive method or subtractive method, this study focused on the additive method, which uses a die spacer to create cement space.

CONCLUSION

According to the results of the current study, it can be concluded that the selective application of die spacer can significantly reduce the marginal discrepancy of the post-cementing crown. Least marginal discrepancy after cementation found in double layer of die spacer all over 0.5mm away from margin with additional single layer on occluso-axial line angles in compared to no die spacer, double layer of die spacer all over 0.5mm away from the margin and double layer of die spacer all over 0.5 mm away from the margin with additional single layer on the axial surfaces not involving the occluso-axial line angles.

ACKNOWLEDGEMENT

We gratefully acknowledge all the patients and their attendances participated in this study. We would also like to acknowledge the Department of Prosthodontics, BSMMU where the study was carried out.

AUTHORS CONTRIBUTIONS

Nahida Akter Anee managed the patients, conceptualized the work, initiated the study with fabrication of prostheses and analyzed the data and formulated results Abu Hena Helal Uddin Ahmed designed the study and developed the data collection tools and initiated the manuscript writing. SM Omar Faruk designed the study and developed the data collection tools and initiated the manuscript writing. Syeda Mahmuda Akhter managed the patients of this study, collected data, arranged them in data sheet and finalized the manuscript writing. Faisal Solaiman designed the study and developed the data collection tools and initiated the manuscript writing. Muhammad Mahfuzur Rahman contributed in methodology, interpreted the results, reviewed the literatures and finally revised the manuscript critically.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

FUNDING

This research received no external funding and was conducted on authors' own expenses.

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