

INFLUENCE OF DIE SPACER APPLICATION ON MARGINAL ADAPTATION OF INDIRECT TEMPORARY CROWNS FABRICATED USING STONE AND SILICONE MODEL MATERIALS

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ABSTRACT

Purpose: Evaluate and compare the effect of using die spacer on marginal accuracy and fit of indirectly fabricated temporary restorations using silicone model material and stone dies.

Problem statement: Chairside temporary restorations fabricated by the direct method commonly show binding on seating, or short margins or premature contacts after temporary cementation. Temporary restorations are fabricated without spacer which may compromise the fit. Therefore it would be an advantage to provide adequate internal fitting space to optimize marginal adaptation.

Methodology: Master die was typodont .Maxillary first molar was manually prepared as in an actual clinical situation. A vacuu-pressed tooth index was made before preparation to standardize the dimension of the temporary restoration. A total of twenty temporary crowns were fabricated from autopolymerizing Bis-acryl resin material and divided into two groups according to the model material used (n=10) stone (Fuji rock; type IV die stone, GC & Modellsilikon, VOCO GmbH, Cuxhaven, Germany) poured from alginate impressions. Each group was subdivided into two subgroups according to spacer used; with and without spacer (n=5). Two coats (approximately 30 μ m) were painted on the dies. All the fabricated temporary restorations were visually examined internally and verified for complete seating on its corresponding die. Seating and fit of each crown were evaluated on the master die and were stored in distilled water overnight till testing took place. Margins were inspected and photographed under magnification of 45X using USB Digital microscope measurements. The generated data was statistically analyzed. The significance level was set at $P \leq 0.05$

Results: There was no statistically significant difference between vertical marginal gap distances in the two groups; (79.9 \pm 15.0 μ m) (66.4 \pm 10.0 μ m) without spacer and with spacer respectively at $P \leq 0.05$

Conclusion & Clinical implications: Despite that the resulted difference in gap is insignificant however painting spacer seems to provide better cement escape vent thus easing fit, also the use of silicone model material offers a practical, speedy and simplified method to conveniently fabricate a good fitting temporary restoration.

KEYWORDS: Temporary restorations, temporization, Silicone model material, Die spacer, marginal gap.

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INTRODUCTION

Temporary restorations, either tooth or implant supported, play an integral role in fixed prosthodontics; they form a critical treatment component ⁽¹⁾. A temporary restoration is routinely fabricated during fixed dental prosthesis (FDP) construction; mainly to protect abutments, maintain positional stability by means of occlusal stop and maintaining interproximal contact. Being properly constructed they promote development and maintain soft tissue contour around abutments, peri-implant periodontal tissues and pontics ⁽²⁻⁹⁾.

The intended service interval of a temporary restoration, being short or extended, is limited. Wassell et al ⁽⁹⁾ highlighted their importance and ensured that sufficient time should be devoted to producing good fit and contour. Unfortunately many practitioners undervalue temporary restorations; being regarded as transitory they are mostly constructed in very little time speedily and imprecisely.

Making temporary crowns and bridges is both interesting and challenging, available techniques and materials are successfully used in daily practices to make well-adapted and functional temporary restorations. The basic chairside techniques to fabricate temporary restorations are well described in dental literature; fabricated directly on prepared teeth, or indirectly from an impression taken off the prepared teeth, it is also possible to combine indirect-direct techniques (*hybrid*) ^(2,6,10)

Considering the direct and indirect-direct techniques; the direct technique offers an advantage of reduced chairside time ⁽¹⁾, although simple and practical it presents a disadvantage of resulting in relatively poor marginal integrity since the temporary restoration is directly separated off the tooth before setting ⁽¹¹⁻¹⁵⁾. The indirect-direct technique for the most part is made outside the mouth inlab as well as chairside, but it involves having many sets of models; one set to make the

silicone matrix, and another set to prepare under-reduced abutments, entailing additional time and additional laboratory fees ⁽²⁾.

On using the indirect technique the temporary restoration is, for the most part, made outside the mouth. The technique involves preparing a silicone matrix from the diagnostic wax-up or its stone cast duplicate, then tooth preparation is carried out, and an irreversible hydrocolloid impression is made off the prepared teeth. Traditionally this irreversible hydrocolloid impression is poured in fast setting plaster or stone. After setting the preparation, adjacent teeth and tissues on the produced model are coated in separating medium. The preformed silicone matrix is filled with the selected temporary restoration material and seated over the stone cast and allowed to set. The decreased strength of the dental plaster allows easy separation of the temporary restoration from the cast ^(2,16).

The *indirect technique* displays more benefit and versatility as the temporary restoration is mostly fabricated outside the mouth thus preventing exposure of tissue to possible exothermic reaction as well as chemical irritation of some temporary materials. Furthermore, instead of having to be removed while in its rubbery stage to perform pumping action the temporary restorations are left polymerize undisturbed on stone casts, which significantly promotes better marginal adaptation since the resin shrinkage is restricted by the plaster or stone dies during polymerization ^(2,6).

However, in the indirect technique the required plaster or stone necessitate a lot of equipment that can be annoying to both the patient and the operator. Even with fast setting varieties time and convenience can still be an issue. Also, the plaster or stone casts are most often damaged on removing the temporary restoration, therefore they cannot be maintained. The use of silicone model material for the chairside fabrication of temporary restorations has been reported in literature ⁽¹⁷⁻²¹⁾. Recently

they have been reintroduced and are employed to fabricate chairside composite inlays in a simple one visit procedure ⁽²²⁾.

Silicone model material overcome setbacks of using plaster or stone models; it display easy handling, rapid setting, enable easy establishment of proximal contacts, and permit uncomplicated retrieval of the temporary restorations since they are flexed off and out of any undercuts. Silicone models provide added value to operator in convenient restoration fabrication, maintaining the integrity of the produced model, as well as storage and reuse should a new temporary restoration be later required ^(20,21,23-27).

It is a common practice among dental technicians to use a die spacer to make room for the cement during waxing the final restorations ⁽²⁸⁾. Using die spacer is safe practice in preventing interference of the cement layer with the complete restoration seating by promoting internal relief, thus avoiding open margins^(2,29-37). The ideal cement space ranges from 20 – 40 microns for a cast crown ^(38,39). Literature has demonstrated that the cement spacer does not compromise the retention of a cemented restoration in fact it improves the fit of the seated restoration, and increases the retention 25% ^(40,41).

Most authors agree to that the clinically acceptable limit of marginal opening is less than 120 μm (34, 42-58). Temporary crowns should also have similar marginal gaps, irrespective of its fabrication technique. Providing a definitive marginal seal not only prevents pulpal sensitivity, bacterial ingress, microleakage and temporary cement dissolution which could result patient discomfort, but also supports the gingival architecture, and facilitates the impression and cementation procedures ^(49,50).

In their study Khng et al ⁽⁵¹⁾ investigated the marginal accuracy of two CAD/CAM temporary materials using two CAD/CAM units versus using two materials used to fabricate temporary crowns in the conventional manner. Each CAD/CAM unit

had a default internal spacer value to substitute for the die spacer. They showed that on using default values were low and impeded complete seating of the crowns on their respective dies, while on using higher setting values of internal spacer allowed successful seating without binding. This concludes that the die spacers allow more accurate and passive seating ^(9,32,33,52).

According to Kurtzman ⁽⁵³⁾ temporary restorations fabricated at chairside intraorally show a tighter fit than a final laboratory fabricated prosthesis. Intraoral fabrication of temporary restorations is done without using spacer material, therefore no space is available to accommodate the cement between the preparation and the temporary. Kurtzman advocates to paint only the internal margins with the temporary cement so that on seating the cement spreads over the axial walls, and not to fill the temporary with cement as this may prevent full seating and may require subsequent occlusal adjustments.

According to literature ⁽¹³⁻¹⁵⁾ most of the available materials used to fabricate temporary restorations undergo some shrinkage and marginal discrepancy. Tight fitting temporary restorations are commonly observed with the direct technique; presented as binding on seating, or short margins or patient experiences premature contacts after temporary cementation. Lack of space between temporary restoration and the preparation is an issue during temporary cementation. Tight fit mandates fitting surface relief which might jeopardize the fit of the temporary restoration all together. Therefore on fabricating temporary restoration it would be an advantage to provide adequate internal room as an escape vent to optimize marginal adaptation.

The aim of the present study is to evaluate the effect of providing space with die spacer on marginal accuracy and fit of indirectly fabricated temporary restorations using two different die materials; stone and Silicone model material. The hypothesis is that marginal fit will show difference.

Methodology

This power analysis is for a 2 x 2 fixed effects analysis of variance; the first factor (Spacer) includes 2 levels and the second factor (Die material) includes 2 levels. Based upon the results of Chiramana et al (2014)⁽⁵⁴⁾; using alpha (α) level of (5%) and Beta (β) level of (20%) i.e. power = 80%; the minimum estimated sample size was 5 specimens per cell giving a total of 20 specimens. Sample size calculation was performed using IBM® SPSS® Sample Power® Release 3.0.1

Maxillary first molar typodont was selected for this study (Elbanna, Egypt) to be prepared as the master die. A vacuu-pressed tooth index was made off the typodont before tooth preparation to standardize the dimension of the temporary restoration.

A total of twenty temporary crowns were fabricated from autopolymerizing Bis-acryl resin material (Alpha-crown; Dental technologies, USA), then they were divided into two groups according to the model material used (n=10); stone (Fuji rock; type IV die stone, GC & Modellsilikon, VOCO GmbH, Cuxhaven, Germany), each group was subdivided into two subgroups according to spacer use; with and without spacer (n=5) . The

materials, manufacturers, composition are listed in Table 1

Master Die

Preparation was carried out according to the preparation guidelines for traditional metal ceramic restorations. The molar was manually prepared in accordance to an actual clinical situation ⁽⁵⁵⁾. The preparation design was a 1mm deep chamfer, 6mm ($\pm 0.02\mu\text{m}$) in height, planar occlusal table of 1.5-2 mm reduction, convergence angle/taper was between 10-15°, all line angles were rounded off. A magnifying lens was used to inspect evenness and absence of undercuts.

Model Preparation (fig. 2)

Twenty alginate impressions were made (Orthoprint; Zhermach, Italy) for the typodont model including the prepared tooth and two neighboring teeth. Ten of these impression were poured by injecting model silicone (Modellsilikon, VOCO GmbH, Cuxhaven, Germany), and the other ten were poured in stone (Fuji rock; type IV die stone, GC). After setting each group of models, stone and silicone, were removed from their impressions, inspected for bubbles or defects on the finish line and the preparation, defected models were discarded and remade. Both stone and silicone models were

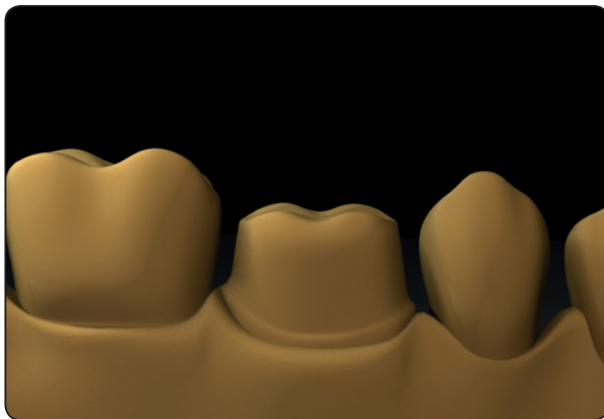


Fig (1): Diagrammatic model of the preparation.



Fig. (2) Model material used without and with spacer painted; (A) die stone, (B) model silicone.

TABLE (1) Materials, Manufacturers, Composition

Materials	Manufacturers	Composition
Alpha-crown; temporary crown & bridge material	Dental technologies, USA	autopolymerizing Bis-acryl resin material
Die stone; Fuji rock	Fuji, Japan	type IV die stone
Die silicone/ Modellsilikon	VOCO GmbH, Cuxhaven, Germany	addition silicone
Picosep; separating medium	Renfert, Germany	
Die spacer; Gold	Renfert, Germany	Metal oxide in organic solvent

inspected and verified for complete and easy seating into the vacuum-pressed preoperative index.

Construction of the temporary crowns was carried out immediately after model construction. Temporary crowns were fabricated on stone and Silicone model material without die spacer and with die spacer (n=10; five for each of model silicone and stone). First the model were painted with separating medium (Picosep; Renfert) using a soft brush, then autopolymerizing resin material was injected into the preoperative matrix and immediately fully seated over the model, firmly held in place by hand till the temporary resin completely polymerized. The preoperative index was separated, and the temporary crown was removed off the model. Finishing and polishing was carried out in the usual chairside manner; excess material was trimmed away, sharp edges and irregularities were removed, contacts were adjusted, and finally the restorations were polished. Each temporary crown was visually examined internally and verified for complete seating on its corresponding die. Seating and fit of each crown were evaluated on the master die.

Construction of temporary crowns with die spacer (n=10; five for each of model silicone and stone) the prepared models were painted with two coats of die spacer (Renfert; gold.). 1 mm away from the finish line, using a clean unclogged brush before then the temporary crowns were fabricated in the same described. According to the manufacturer each layer of spacer is equal to thickness 12-15µm,

therefore two coats would approximately equal 30 µm. All the fabricated temporary restorations (without and with spacer) were stored in distilled water overnight for 24 hours till testing took place.

Marginal gap Assessment:

The temporary restorations of both groups (with and without die spacer) were seated on the master die. Each restoration was firmly secured on the master die, With the aid of a custom-made holding device (fig. 3), care was taken to place a soft sponge between the restoration and the device to avoid fracturing the restoration or the master die. Margins of each specimen were inspected and photographed under a fixed magnification of 45X using USB Digital microscope (Scope Capture Digital Microscope, Guangdong, China) with a built-in camera connected to an IBM compatible personal

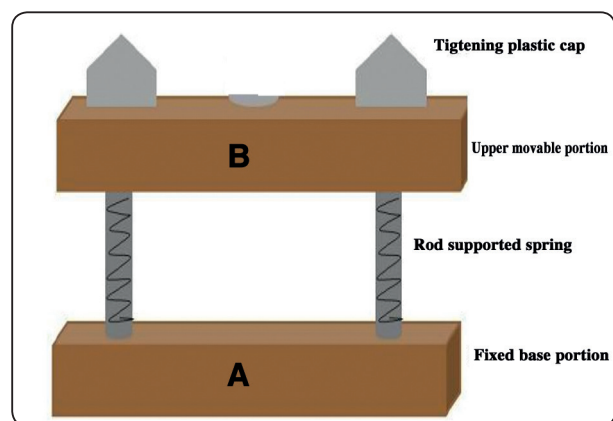


Fig. (3) Holding device: base, top and the assembly frame. Base is fixed and held the master die.

computer. A digital image analysis system (Image J 1.43U, National Institute of Health, USA) was used to measure and qualitatively evaluate the gap width. Within the Image J software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the Image J software. The margins of each specimen were photographed at the four aspects; mesial, buccal distal, and lingual. Then morphometric measurements were done for each photograph where four equidistant landmarks were marked and measured for each aspect. . Measurement at each point was repeated five times, and the generated data was tabulated and statistically analyzed.

Statistical Analysis

Numerical data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed non-parametric distribution. Data were represented by mean, standard deviation (SD), median, range and 95% Confidence Interval (95% CI) values. Mann-Whitney U test was used to compare between the two die materials as well as vertical marginal gap without and with spacer.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM (IBM

Corporation, NY, USA.) SPSS (® SPSS, Inc., an IBM Company) Statistics Version 20 for Windows.

RESULTS

Descriptive statistics

Effect of die material

Results obtained for vertical marginal gap without spacer model silicone showed mean $[79.9 \pm 15.0 \mu\text{m}]$ and stone die showed $[124.2 \pm 27.7 \mu\text{m}]$. There was statistically significant difference.

Results obtained for vertical marginal gap with spacer model silicone showed mean $[66.4 \pm 10 \mu\text{m}]$ and stone die showed $[57.6 \pm 27.7 \mu\text{m}]$. There was no statistically significant difference.

Effect of spacer

Results obtained for vertical marginal gap using model silicone showed mean $[79.9 \pm 15.0 \mu\text{m}]$ and $[66.4 \pm 10 \mu\text{m}]$ without spacer and with spacer respectively. There was no statistically significant difference.

Results obtained for vertical marginal gap using stone dies material showed mean of $[124.2 \pm 27.7 \mu\text{m}]$ and $57.6 \pm 27.7 \mu\text{m}]$ without spacer and with spacer respectively. There was statistically significantly lower mean vertical marginal gap than without spacer.

TABLE (2): Descriptive Statistics of Vertical Marginal Gap Values (μm)

<i>Die material</i>	<i>Spacer</i>	Mean	SD	Median	Minimum	Maximum	95% CI	
							Lower bound	Upper bound
<i>Flex die</i>	<i>No spacer</i>	79.9	15.0	77.9	67.8	105.0	61.3	98.5
	<i>Spacer</i>	66.4	10.0	62.7	55.0	77.6	54.0	78.8
<i>Stone die</i>	<i>No spacer</i>	124.2	27.7	120.2	95.0	159.0	89.8	158.6
	<i>Spacer</i>	57.6	27.8	40.2	36.0	98.8	23.0	92.2

TABLE (3) Mean, standard deviation (SD) values and results of Mann-Whitney U test for comparison between die materials

Spacer	Model silicone		Stone die		P-value
	Mean	SD	Mean	SD	
No spacer	79.9	15.0	124.2	27.7	0.028*
Spacer	66.4	10.0	57.6	27.8	0.347

*: Significant at $P \leq 0.05$

TABLE (4) Mean, standard deviation (SD) values and results of Mann-Whitney U test for comparison between vertical marginal gap without and with spacer

Spacer	No spacer		Spacer		P-value
	Mean	SD	Mean	SD	
Model silicone	79.9	15.0	66.4	10.0	0.076
Stone die	124.2	27.7	57.6	27.8	0.016*

*: Significant at $P \leq 0.05$

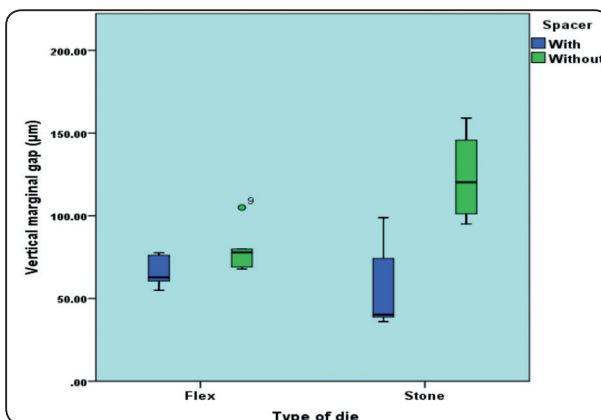


Fig. (4) Box plot representing median and range values of vertical marginal gap in the different groups (Circle represents an outlier)

DISCUSSION

Poor marginal fit creates a potential source of restoration failure. Gap margin discrepancy measurement is usually selected. Evaluation of vertical marginal discrepancy was used in this study ⁽⁵⁶⁾, based on literature margin gaps till 120 µm are considered clinically acceptable ^(33,42), accordingly to that the results of this study demonstrated clinically acceptable range of marginal adaptation in general.

The indirect technique was selected as it is mostly fabricated outside the mouth thus preventing exposure of tissue to possible exothermic reaction as well as chemical irritation of some temporary materials. It also allows leaving the temporary restorations to polymerize undisturbed on models instead of having to interrupt its setting to perform pumping action while in its rubbery stage, owing to restricting any possible resin shrinkage by the underlying dies during polymerization ^(2,6).

Elastomeric model material (Modellsilikon, VOCO GmbH, Germany, Cuxhaven) is addition silicone and supplied by the manufacturer in cartridges designed for automixing in a dispensing gun. It shows convenience in handling, allowing easy removal of the temporary restoration without damaging either model or restoration, it also proved to be an efficient method to generate a chairside model. Using alternative materials to produce models for temporary restorations has been documented in literature ⁽⁵⁷⁾.

As to the effect of the material regarding using model silicone, the resultant gap is significantly smaller than that obtained on using stone dies without using die spacer coat. On using a die spacer coat there was no significant difference of gap for both model silicone and stone die material

To standardize the testing conditions separate alginate impression were made off the master preparation, each temporary crown was constructed on its own die, one vacuum-pressed matrix was made and ensured to seat freely on each die, also all temporaries were constructed on the same day.

The hypothesis is that marginal fit and adaptation will show difference between temporary restorations fabricated with and without die spacer was rejected, as No significant difference of gap distance was noted between temporary restorations produced from silicone model material and conventional die stone painted with die spacer however on using die spacer on stone dies yielded a significant difference.

The most important factor in reducing the marginal discrepancy of final restorations remains to be providing cement space^(58,59). Occlusal interferences, discrepancy of marginal fit are manifestations of poor seating⁽⁶⁰⁾. Lack of cement space leads to development of hydraulic under the restoration which continues to increase to match the seating force eventually impeding the restoration to completely seat⁽⁶¹⁾.

The results of the present study lie in support of using die spacer in fabricating temporary restorations as the presence of die spacer did benefit the seating of the restorations as validated by the gap measurements

Our results are also in agreement with the results of Chiramana et al⁽⁵⁴⁾ and Soriani et al⁽⁶²⁾ who clearly showed in their study that less marginal discrepancy resulted with two die spacer layers. The results of the present study also match those of Cherkasski et al⁽³⁴⁾ and Passon et al⁽⁴¹⁾ who highlighted the importance of using this laboratory resource to ensure a lower discrepancy of prosthetic castings

Die spacing is an additive method⁽⁶³⁾ of providing space relief by painting die spacer on stone dies before wax pattern fabrication⁽⁴⁵⁾ Die spacers consists of metal-oxide powders and adhesives dispensed in an organic liquid such as ketone^(64, 65).

According to literature⁽⁶⁶⁻⁶⁸⁾, difficulty in standardizing the thickness of the spacer may present variations in fit or restorations - this may have affected the results of our study in the same manner. Also the time of testing may have had an effect⁽⁶⁹⁾.

In this study the temporary crowns were allowed to completely polymerize over its respective die. This is similar to the method suggested by Kaiser⁽⁷⁰⁾. It is assumed that the frictional resistance of the die would inhibit polymerization shrinkage of the material

Ramesh& Shetty⁽⁶⁹⁾ linked marginal discrepancy of temporary crowns made from autopolymerizing resins to polymerization shrinkage, removal before complete polymerization and water sorption, Removal of the temporary crowns from the prepared tooth before complete polymerization is claimed to cause the most distortions.

Future studies are recommended to be carried out to evaluate effect of different storage times on marginal gap, and to evaluate varying thicknesses of paint-on die spacer to determine optimal amount to be used, and the feasibility of constructing multiple unit restoration as regards fit and seating .

CONCLUSION

1. Application of spacer on silicone die material and stone die material produced temporary restorations with comparable marginal fit.
2. Fabricating temporary restorations on model silicone material without spacer have produced superior marginal fit than those fabricated on stone die material without spacer.
3. Silicone model material is more versatile option, less time consuming and less messy, and offers longer storage

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