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INFLUENCE OF CASTING ON MARGINAL FIT OF METAL COPINGS FABRICATED FROM WAX OR LIGHT-CURED RESIN (IN VITRO STUDY)

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Abstract

Background: The marginal fit of dental casting is the major decisive factor in determining the success of restoration. Not only does the fit of casting depend on the method of fabrication, but also on the type of pattern material utilized, which is considered one of the essential variables.

Objectives: This study aimed at comparing the marginal fit of patterns fabricated from wax or light-cured resin on two bases: casting and after casting. It, furthermore, studied the change in the marginal gap between these two stages.

Material and methods: A total of 15 resin dies milled on computer-aided design and computer-aided manufacturing system were used to prepare 30 patterns, which were fabricated using wax or light-cured resin. The marginal gaps were measured with a light microscope in 12 marginal points for each pattern; castings were fabricated using the lost wax technique. The marginal gaps were measured in the same points for each metal coping and their average was recorded. Data were analyzed using t-Tests at a confidence level of $\alpha = 0.05$.

Results: No statistically significant difference in the marginal gap observed between wax and light-cured resin before casting (15.25±3.6, 13.83±2.85) or after casting (21.17±6.11, 19.25±3.95) respectively. The mean of marginal gap increased after casting in wax and light-cured resin groups, respectively. Its difference was statistically significant; still, the change in marginal gap was not statistically significant between the study groups.

Conclusions: Within the limitations of this in vitro study, it can be concluded that the marginal gap of patterns – copings fabricated from wax or light-cured resin – was within the range of clinical acceptability. Casting increased the marginal gap of copings fabricated from wax or light-cured resin although it was within the range of clinical acceptability. Using both of the materials to fabricate the patterns of cast coping gives approximate results in the marginal adaptation.

Keywords: *marginal fit, wax, light cured resin, casting.*

Introduction

The success of any restoration depends on its accurate fit on the dental structure with the least gap possible, which reduces the accumulation of bacterial plaque and diminishes the spread of dental caries or the incidence of periodontal diseases [*Bronson MR et al., 2005; Farid F et al., 2012*]

As the dental procedures performed by the dentist have a role in the marginal fit of crowns, so are the laboratory procedures [*Rahme HY*].

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Many laboratory errors eventually lead to the failure of crowns as a result of the failure of marginal fit. This is perhaps best exemplified by the damage of the margins of the restoration during trimming, the excessive thickness of the die spacer, the inaccurate fit of wax patterns, and the incorrect procedures of casting [*Akbar JH* et al., 2006].

The fit of cast restoration depends on the appropriate and fine details of patterns [*Northeast SE et al., 1992*]. In this regard, it is imperative to state that wax has been traditionally used to build crowns and bridges patterns. This is due to the positive properties of such a material, being common, easy to manipulate, and well produced for details. Above all, its principal advantage is represented by its rea-

sonable cost so that it can be seen as an always-available choice [*Mccabe JF, Walls AWG, 2009*]

Nevertheless, wax has a high tendency to distort or warp, and a high coefficient of thermal expansion. [*Ito M et al., 1996*]

The Marginal fit, on the other hand, depends not only on the method employed to yield it fabricated, but also on the materials used in it [*Morey EF, 1992*].

Henceforth, it was necessary to look for alternative materials to be used in building the patterns instead of wax [*Hunter AJ ana Hunter AR, 1990*].

Having mentioned that, it has been found in the dental literature that a considerable number of researchers resorted to the use of light-cured resin due to a host of factors. Some of the major factors are summarized in its ease of use, stability of its dimension after polymerization, and low polymerization shrinkage. These advantages are topped with its capability of providing sufficient working time in complex procedures [*Iglesias A et al., 1996; Whitworth J et al., 1999*]

However, the lost wax technique is the traditional technique in the fabrication of prosthodontics. It is seen in our field as a complex process involving many stages that increase the incidence of mistakes. [*Arora A et al., 2018; Jadhav V et al., 2018*]

Thus, comes the idea of research, where the accuracy of the marginal fit had to be investigated for patterns fabricated from wax or light-cured resin: before and after casting. This present research evaluated the change in the marginal gap between this two stages, namely before and after casting [*Waldmeier M, Grasso J., 1992*].

MATERIAL AND METHODS

Two pattern materials were used in making the patterns: light-cured build-up resin (YETI, Germany) and inlay wax (YETI, Germany).

The research sample consisted of 15 resin abutments that were milled on computer-aided design and computer-aided manufacturing (CAD/CAM) according to the principles of dental preparation, [*Shillinburg H et al., 2013*] with 0.5 *mm* chamfer finish line and 6° opposing axial surfaces taper from each side [*De Almeide J et al., 2019*] and an anatomical shape similar to a prepared upper premolar. Likewise, Self-resin bases were poured into each abutment to facilitate the work and were numbered from 1 to 15.

Three layers of die spacer (YETI, Germany) were successively applied – according to the manufacturer's recommendations – to the entire abutment. This was performed except for the last 0.5 mm of axial surface above the finish line; the first single gold layer was applied. After that, a single red layer was applied, followed by the application of a second gold layer. Each layer was allowed to dry for two minutes before the application of another layer, followed by application of lubricant die (YETI, Germany).

The pattern materials were applied using incremental technique. At first, the dipping wax (Renfert, Germany) was melted in a wax dipping pot to 95°C. The first layer of wax pattern was built, then the entire pattern was constructed by adding inlay wax; besides, wax margins were melted and rebuilt before evaluation. In the next phase, the abutments were reused to apply light-cured resin after the wax patterns were removed, while keeping the layers of die spacer. The light-cured substance was applied and polymerized in layers; each layer was less than 2 *mm* and was cured for 20 seconds (Fig.1)

The layers of die spacer were removed using the nail polish remover (Acetone). Then, the patterns were returned to their abutments for measurement. Wax patterns were numbered from W1 to W15, and light-cured resin patterns are numbered from L1 to L15.

The measured marginal gap was the vertical marginal misfit from the casting margin to the cavosurface angle of the abutment. [*Holmes JR et al., 1989*]

Marginal gaps of patterns were measured directly under the microscope with a 10-*micron* micro ruler at 12 identified marginal points; these points were distributed uniformly onto the circumference of the pattern (Fig. 2).

Directly after that, all patterns were invested after measurement, using phosphate bonded investment material (Ivoclar Vivadent, Germany). Later, the casting process was done according to the recommendations using Ni-Cr alloy (Kera NH, Germany).

To overcome it is possible, due to the uniting the knowledge and will of all doctors in the world

The marginal gaps of metal copings fabricated from wax or light-cured resin were measured at the same predetermined points and in the same previous method (Fig. 3)

Statistical calculations of the data obtained in the venue of this research were conducted via SPSS. The means and standard deviations were calculated; the data were analyzed using the standardized t-Test at a confidence level of $\alpha = 0.05$.

Figure 1. *The first layer of wax pattern was built* ***(a)****, then and in the next phase, the abutments were reused to apply light-cured resin after the wax patterns were removed, while keeping the layers of die spacer* ***(b)****.*

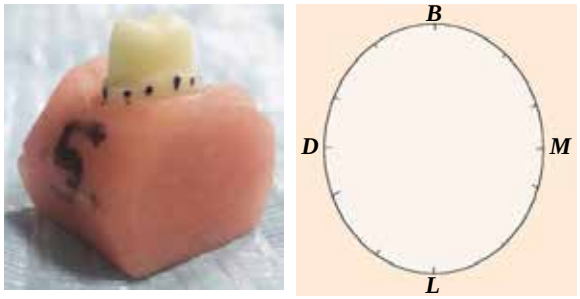

Figure 2. *Marginal gaps of patterns at 12 identified marginal points* ***(a)*** *and these points were distributed uniformly onto the circumference of the pattern* ***(b)***

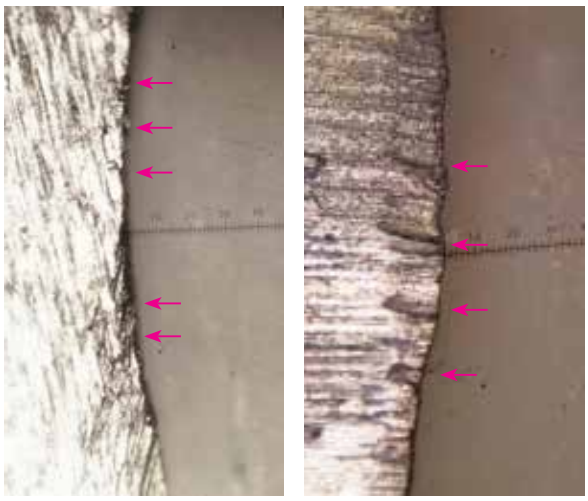

Figure 3. *The marginal gaps of metal copings fabricated from wax* ***(a)*** *or light-cured resin were measured at the same predetermined points in the same previous method* ***(b).***

Results

Table 1 illustrates the mean and standard deviation for each group. The t-Test yielded no statistically significant differences in the gap observed between the two study groups, wax or light-cured resin, before casting (p=0.243) or after casting (p=0.316). The p-value registered a number more than the hypothesized alpha, $p > 0.05$.

In addition, the mean marginal gap increased after casting to be in the level of 5.92 and 5.42 μm in the wax and light-cured resin groups, respectively the t-Test demonstrated statistically significant difference, The p-value registered a number less than the hypothesized alpha, specifically (p=0.001,0.000 in the wax and light-cured resin groups, respectively < 0.05). Although, the change in marginal gap was not statistically significant between both of the study groups p=0.745.

Discussion

Most fixed prosthodontics have the problem of misfit metal copings after casting, although they fit well during the pattern-fabricating phase. Likewise, the pattern fabricating material is one of the most important variables in the casting process, which can affect the accuracy of marginal fit [*Nawafleh N et al., 2013*].

This research was conducted to assess the effect of pattern material on the amount of marginal gap of patterns, metal copings. As a matter of fact, a diminutive number of studies have been found in the literature on the topic to study this link; this research, further, aimed to study the change in the amount of marginal gap between the two phases studied, before and after casting. To the humblest knowledge of the researchers, no previous study was found to address this area of interest.

Table 1.

Mean and standard deviation (SD) of study groups before and after casting

	Light cured resin		Wax	
	Mean	SD	Mean	SD
Before casting	13.83	2.85	15.25	3.6
After casting	19.25	3.95	21.17	6.11

On the one hand, two materials were used to fabricate the patterns. The first of which is wax, which is the traditional material and the most invasive to be used in this regard. However, the distortion of wax pattern, resulting from thermal changes and release of internal stresses, led to search for an alternative material. The choice was directed towards resins, including the light-cured resin, which was the second material in this study. On the other hand, the research sample consisted of 30 samples divided into two groups. The sample size was calculated according to the G-power program and previous similar studies.

Die spacer was applied to compensate for shrinkage of metal resulting from casting process. The number of die spacer layers was determined based on the results of our pilot study, which was conducted prior to this current study.

Moreover, wax patterns were built first to preserve layers of die spacer because the application of light-cured resin led to dissolution of some its layers in some samples. It was one of the hardships that confronted our study. Later, layers of die spacer were removed before measurement, allowing the metal crowns to be placed well on their abutment.

The marginal gap was measured directly on the resin abutment; therefore, the measured gap did not involve the dimensional change resulting from the polymerization shrinkage of the impression materials and the setting expansion of the stone materials.

Only 12 marginal measurement points per sample were adopted in this study, which reduced the accuracy of its results. This subdues itself to the fact that the increase in the number of measurement points makes the results more reliable.

The variables were restricted in this study starting with mill abutments with uniform dimensions, number of die spacer layers, investing and casting procedures.

One clinician was relied upon to perform laboratory procedures, but no technique was used to adjust the thickness of patterns, although the clinician tried to build them with a uniform method.

The finishing of metal copings was limited to the sandblasting process, which aimed to remove the residues of investment without affecting the internal surface of metal copings. This was operated to eliminate any effect of finishing factors on the value of marginal gap.

The values obtained in this study came in accordance with the range of values mentioned in previous studied. They were even one of the best – 15.25 and 13.83 μm before casting; 21.17 and 19.25 μm after casting – in both the wax and light-cured resin groups, respectively. Thanks to the pilot study that was conducted prior to initiating this study, the procedures to be followed were determined to obtain an acceptable marginal gap.

The difference in the values of the marginal gap between the current study and previous studies may be due to the difference in the definition of marginal fit, varying from one study to another. Each study based its conclusion upon the definition it adopted; this made it difficult to compare them. There are also a plethora of factors that played a decisive role in that difference, such as the design of study, sample size, finish line type, number of die spacer layers, number of measure sites, and measurement method. [*Nawafleh N et al., 2013; Contrepois M et al., 2013*]

Before casting, there was no statistically significant differences in the value of the marginal gap between wax and light-cured resin groups. Both materials gave similar results within the range of clinical acceptable values. However, our results differed from those of [*Iglesias A et al., 1996*] in that they concluded that the accuracy of marginal fit was better in the light-cured resin group than the wax group. This can be ascribed to the fact that the margins in our study were rebuilt before measurement, while this process was limited to the light-cured resin group in the aforementioned study.

The results of the current study also differed from several previous study, [*Rajagobal P et al., 2012; Gopalan RP et al., 2018; Megashyam P et al., 2018*] which concluded that light-cured resin was the best material to achieve the marginal fit compared to wax,. This may be due to the differences in the procedural methods.

After casting, there was no statistically significant differences in the value of the marginal gap between metal copings fabricated from wax and light-cured resin. All the values were within the range of clinical acceptance. Our results differed from several previous studies [*Shaikh SA et al., 2014; Sushma K et al., 2014; Karrunakaran B et al., 2018]* which concluded that wax achieved less marginal gap for metal copings compared to light-

cured resin. This difference can be ascribed to the fact that in the previous studies the process of investing was performed immediately after building the patterns. In the current study, however, this process was delayed in order to measure the marginal gap of patterns. It is well established that wax patterns are exposed to distortion and change of dimensions when the investing is delayed.

Our study postulated that the value of standard deviation of metal copings fabricated from wax was twice as its value in metal copings fabricated from light-cured resin. Nonetheless, the two values were close before casting, even when the standard deviation is a measure of variance. The values of the marginal gaps of metal copings fabricated from light-cured resin were more consistent and less dispersive than the values of marginal gaps of metal copings fabricated from wax. This gives more prominence for future selection and preference to be directed to the light-cured resin.

The value of marginal gap increased after casting in both the study groups. Even though the increase was statistically significant, the values remained within a clinically acceptable range. This increase may be due to shrinkage of metal during casting, which led to reluctance of axial walls of the metal coping to come down completely. It shows that the casting process has an effect on the fit of metal copings built from wax or light-cured resin. Nevertheless, there was no difference in the amount of increase in the marginal gap between both of the study groups; actually, there was found no previous study on this topic to compare it with the current study.

Conclusion

Within the limitations of this in vitro study, it can be concluded that the marginal gap of patterns – copings fabricated from wax or light-cured resin – was within the range of clinical acceptance. Casting increased the marginal gap of copings fabricated from wax or light-cured resin, although it was within the range of clinically acceptable values. Utilizing both of the aforementioned materials to fabricate the patterns of cast coping can yield approximate results in the margins.

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