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THE EFFECT OF PATTERN MATERIALS ON THE MARGINAL GAP OF METAL COPINGS – AN IN-VITRO STUDY

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ABSTRACT

Introduction: Accurate marginal seating and internal fit of cast restorations are crucial to meet the biological, physical, and aesthetic requirements of a successful restoration. Considering these factors, the present study aimed to evaluate and compare the marginal adaptation of cast copings made using inlay wax, pattern resin, and autopolymerized pattern resin, each invested at different time intervals. **Objective:** The study aims at evaluating and assessing the marginal adaptation of three different pattern with the objective of determining the pattern material with less discrepancy. **Methodology:** A replica abutment resembling a prepared mandibular premolar was created. An impression of the prepared premolar was taken, and 30 type IV gypsum dies were produced. Patterns made of three different materials were fabricated and casting was done. The evaluation of marginal adaptation was conducted using stereo microscope. All collected data was statistically analyzed using one-way ANOVA test. **Result:** The findings indicated a significant statistical variance in the marginal adaptation among the three materials. Light-cured wax consistently demonstrated the highest accuracy, followed by thermoplastic resin and inlay casting wax. **Conclusion:** The marginal adaptation of the three materials tested showed marginal gap within the range of 25–70 µm which is in clinically acceptable span.

KEYWORDS: Marginal adaptation, inlay wax, light cure wax, autopolymerising resin, pattern-material.

INTRODUCTION

Metal ceramics are still the most widely used material for fabricating complete coverage crowns and fixed partial dentures.[1] The traditional technique for fabricating the metal substructure is the lost wax casting technique introduced by Taggart.[1,2] In recent years, additive manufacturing has become more attractive in which multiple layers of material are added one by one to fabricate the coping.

The marginal accuracy and internal fit of the restoration are the major determining factors for the success of restoration. Any discrepancy at the marginal or internal level occur due to cumulative results of many variables, as multiple steps in the production increase the number of variables that can cause misfit. Thus, the fabrication technique plays an important role in providing accuracy.

Conventionally, wax patterns were fabricated with wax and waxing instruments for example the popular PKT instruments. Wax is used to make the patterns because it can be conveniently manipulated, precisely shaped and can also be completely eliminated from the mold by heating.[3]

The fabrication of the wax pattern is the most critical and labor-intensive step in making the porcelain fused-metal crown. In this time-consuming task, the wax–up's quality is dependent on the skilled labor of the individual.[4] Zeltser et al.[5] found that the act of removing a wax pattern from a die with a shoulder margin causes an average of 35µm opening of the margin before investing. Because of the wax pattern's color and glossy surface, small defects can be difficult to identity.[3] Wax has several inherent limitations namely, delicacy, thermal sensitivity, elastic memory and a high coefficient of thermal expansion (CTE).[6]

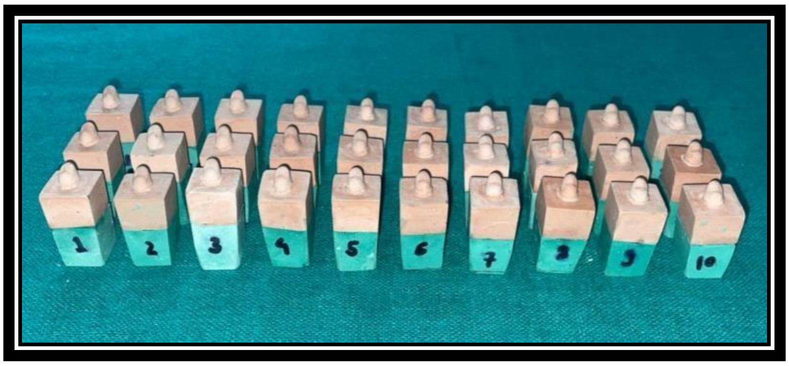
MATERIALS AND METHODS

Specimen Preparation

A zirconia abutment, simulating a prepared mandibular right first premolar, was milled. The abutment featured a height of 7 mm, and a consistent taper of 6°. A custom-made tray was fabricated and single step impression of the die was made. Dies were prepared and die hardener was applied. The die spacer was evenly coated on the axial surface within 0.5 mm above the margin. Each coat was allowed to dry before fabricating the wax pattern. Before making patterns, a thin layer of lubricant was applied to the gypsum dies, and the dies were allowed to dry.

i All the samples were distributed randomly into three groups.

GROUPS	SAMPLES	NO. OF SAMPLES
GROUP 1	Inlay wax	10
GROUP 2	Autopolymerising resin	10
GROUP 3	Light cure wax	10



Die stone samples

Fabrication of pattern - Inlay Pattern Wax (Group 1)

Inlay wax medium was melted using a wax heater and sculpted with a wax carver over the die. The molten wax was allowed to cool to room temperature. Once the wax cooled down, the margins were redefined, and any excess wax was carved away. The margins were refined as needed.

Thermoplastic resin pattern material (Group 2)

Autopolymerised pattern resin was dispensed into two separate plastic mixing cups (as instructed by the manufacturer). The patterns were fabricated through incremental buildup using the brush-on technique. Afterward, the patterns were separated from the die and examined for any defects.

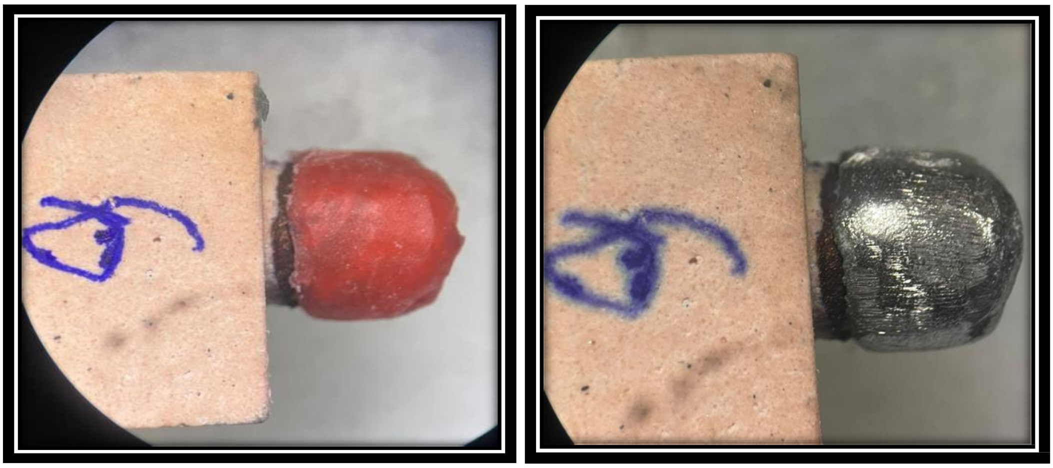
Light-cured pattern material (Group 3)

LiWa II light cure modeling paste was applied in layers and polymerized incrementally, ensuring that the length and width of the pattern were consistently maintained. Once solidified, the patterns were placed in a light-curing chamber for curing cycle (as instructed by manufacturer). They were then carefully removed with minimal distortion.

Investing and casting

Wax sprues were attached, and all thirty wax patterns were invested in a phosphate-bonded investment, at a 24ml/100g (water/powder) mixing ratio. After heating to 950˚C for wax elimination the copings were cast in Ni-Cr Alloy using a casting machine. The castings were removed from the investment and cleaned with 50µm aluminum oxide particles at a pressure of 0.3MPa.

The margins were examined under optical stereo zoom microscope (model – CD 500A) using Capture Pro 4.6 software at 10x magnification, and all measurements were conducted by the same operator to maintain consistency. The average marginal discrepancy in microns was calculated. The mean value of measurements on midpoint of buccal surface of finish line for each of these time intervals was utilized for statistical analysis.



PATTERN FABRICATION AND CAST COPING

RESULTS AND OBSERVATION

Descriptive statistical data of marginal adaptation of three different wax pattern of inlay wax, autopolymerising resin and light cure wax on stone dies were measured at three intervals of 1 hour, 6 hours and 24 hours.

Table 1: Comparison of study parameters between three study parameters respectively.

	Mean	SD	SE	Minimum	Maximum
GroupA (Inlay Wax)	58.35	1.15	0.36	56.60	59.90
Group B (Autopolymerising wax)	42.34	2.76	0.87	39.10	46.30
Group C (Light cure wax)	32.19	1.27	0.40	30.30	33.50

Table 2: Comparison of study parameters between three study parameters respectively using One way Anova F test.

	Mean	SD	One-way Anova F test	P value, Significance
Group A (Inlay Wax)	58.35	1.15	F = 492.523	p<0.001**
Group B (Autopolymerisingwax)	42.34	2.76		
Group C (Light cure wax)	32.19	1.27		

Table 3: Pairwise comparison of study parameters between three study parameters respectively using Tukey's post hoc test.

Group	Comparison Group	Mean Difference	P value, Significance
Group A (Inlay Wax) vs	Group B (Autopolymerising wax)	16.01	p<0.001**
	Group C (Light cure wax)	26.16	p<0.001**
Group B (Autopolymerising wax) vs	Group C (Light cure wax)	10.15	p<0.001**

DISCUSSION

The precision of a cast restoration's fit and details is heavily reliant on the accuracy of the fabricated pattern.[7] This investigation aimed to evaluate and contrast the marginal adaption of patterns made from three different materials: thermoplastic resin, light-cured modeling paste, and inlay casting wax, at three different time interval: 1, 6 & 24 hours.

The composition of inlay wax is composed of 60% mineral paraffin, 25% plant carnauba, 10% mineral ceresin, and 5% animal beeswax.[8] Autopolymerising resin composed of methylmethacrylate polymer powder that makes up the powder, and ethyl methacrylate (5%–10%), ethylene dimethacrylate (2%–5%), and methylmethacrylate monomer (80–90%) makes up the liquid.[7] Light-activated pattern material description of direct pattern manufacturing was first published by Cohen et al. in 1991. In order to achieve a favourable colour contrast with die materials, UDMA resins were developed, impregnated with blue dyes. The structural integrity of the material is enhanced by the addition of natural, non-glassy additives that burn out of the investment mould without leaving behind residue.[9]

While the comparision was made between inlay wax and autopolymersing resin & light cure wax and inlay wax under stereomicroscope, it was observed that inlay wax had a highly significant difference with light cure wax as compared to autopoymerising resin at 1 hour. There could be a number of causes for the variations in the marginal adaption of inlay wax pattern. The two main flaws with waxes are their high coefficient of heat expansion and their propensity to twist or deform when left to stand.[7] The high coefficient of thermal expansion of inlay wax was one of their most noticeable thermal properties. Phillips and Biggs have demonstrated that distortion becomes noticeable within just 30 minutes after the wax pattern was prepared. Therefore, it was recommended to store the wax patterns at low temperatures to decrease the extent of distortion, or alternatively, invest the patterns promptly to minimize distortion.[11]

The high coefficient of thermal expansion of inlay wax was one of their most noticeable thermal properties. Wax may expand by up to 0.7% when the temperature rises by 20˚C (36˚F), while it may shrink by up to 0.35% when the temperature drops from 37˚ to 25˚C (99˚ to 77˚F). Within this temperature spectrum, the linear coefficient of thermal expansion is around 350 × 10−6/˚C on average.[12]

Autopolymerizing resins provide strength, rigidity, and dimensional stability. Nevertheless, this material's propensity for polymerization shrinkage is a disadvantage.[13] In a study conducted by Shillingberg, it was revealed that autopolymerizing resin pattern material experiences a polymerization shrinkage ranging from 1% to 7% when stored for 24 hours.[11] hence the marginal discrepancy of resin was noted. Autopolymerizing pattern resin showed a considerably reduced marginal discrepancy than wax and VLC triad resin, according to a study by Komajian and Holmes.[14]

Light penetration of a high enough intensity to start polymerization is necessary for the formation of light-cured materials. The light's intensity is important at the material specimen's surface, but beyond that, it is attenuated by absorption and scattering, which limits the depths of cure that may be reached. For light-activated pattern materials, thorough polymerization is essential because the presence of unpolymerized or partially polymerized inclusions may cause plastic distortion of the pattern during handling, compromising the fit of the ensuing casting.[7]

The crown pattern fabrication materials available do not meet all the requirements, as each has its own advantages and disadvantages; however, they remain popular choices. Both the approach and the operator's skill level have a major impact on the application's success.

CONCLUSION

Within the limitation of this study, following conclusions were made.

1. All the pattern materials exhibited marginal discrepancies at 1 hour, 6 hours, and 24 hours.
2. Patterns created with light-cured modelling material had the least mean marginal adaption discrepancy.
3. For patterns created using inlay wax, the mean marginal adaption discrepancy was the highest.
4. Statistically significant difference was found in determining the marginal adaptation amongs all determined groups that is.

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