A COMPARATIVE EVALUATION OF MARGINAL AND INTERNAL ADAPTATION OF COMPLETE CAST COPING FABRICATED USING DIFFERENT PATTERN MATERIALS –AN IN VITRO STUDY

Shaikh SA, [1] Chandra PK, [2] Lekha K, [3] Rao M, [4] Taneja P [5]

1. Associate Professor, Department of Prosthodontics, SDM College of Dental Sciences & Hospital, Dharwad, Karnatka
2. Post Graduate Student, Department of Prosthodontics, SDM College of Dental Sciences & Hospital, Dharwad, Karnatka
3. Professor & Head, Department of Prosthodontics, SDM College of Dental Sciences & Hospital, Dharwad, Karnatka
4. Post Graduate Student, Department of Prosthodontics, SDM College of Dental Sciences & Hospital, Dharwad, Karnatka
5. Post Graduate Student, Department of Prosthodontics, SDM College of Dental Sciences & Hospital, Dharwad, Karnatka

ABSTRACT

Objective: The present laboratory study was carried out to compare and evaluate the marginal fit and internal adaptation accuracy for the complete cast crowns fabricated using Inlay wax, light cured wax and pattern resin.

Materials and Method: The pattern materials compared in the present study were conventional Inlay wax, Light Curing and Pattern resin. The castings were fabricated using the lost wax technique. The marginal fit and internal adaptation of uncemented complete cast crowns were assessed with the help of a stereo microscope and then subjected to image analysis. The scanned results were analyzed at five different points for each casting. Three readings at each point were taken and their average was recorded.

Results: The mean marginal and internal discrepancy of the castings fabricated using the Inlay wax was the least. The mean marginal and internal discrepancy of the castings fabricated using the Light Cured Wax was the highest. The castings fabricated using the Pattern Resin had better marginal and internal accuracy than the castings fabricated using Light Cured Wax. However, the castings fabricated using the Light-cured wax was inferior in terms of marginal and internal accuracy compared to the castings fabricated using the Inlay wax.

Conclusion: Considering the various aspects of the present study, it is concluded that with strict adherence to the principles of pattern fabrication, Inlay wax can still be the pattern material of choice to produce a casting with minimal marginal and internal discrepancy which is user friendly and cost effective.

KEY WORDS: Internal adaptation, Light – Cure Wax, Marginal fit, Pattern-resin.

Introduction

Precise marginal seating is more important in dental restoration to fulfill biological, physical and cosmetic requirement.[1] Many factors affects the fit of dental castings e.g. tooth preparation, impression materials, pattern wax, die stone, investment, casting procedure, luting cement etc. The marginal fit of a dental prosthesis is essential for optimum function, esthetics and long-term success in oral cavity.[2] The fit and detail of the cast restoration will depend to a great extent on the accuracy and fine detail of the wax pattern.[3] Traditionally, patterns for dental Castings have been formed from inlay casting wax. Controlled manipulation and understanding of the dimensional changes of wax may lead to an acceptable pattern, but distortions caused by prolonged storage, high thermal expansion and contraction (infact the highest of all dental materials), their visco-elastic behavior under load has been shown to affect marginal integrity.[4]

Now many newer materials are been evolved with additional advantages of easy manipulation better accuracy of details good adaptation and minimal distortion less time consuming procedures. Different pattern waxes are available commercially in the market as of today, no study has been conducted to evaluate and compare the effect of different materials used to fabricate patterns on the marginal fit and internal adaptation.

The purpose of this in-vitro study is to evaluate the marginal accuracy & internal adaptation of castings fabricated by using three different patterns at a conventional burn out temperature and casting procedures.

Materials and Method

Cast coping were divided into 3 group based on pattern materials used for their fabrication into:

GROUP I (n=12): Cast coping fabricated by using BEGO Inlay wax patterns.

GROUP II (n=12): Cast coping fabricated by using W/P LIWA wax patterns.

GROUP III (n=12): Cast coping fabricated by using GC Pattern resin patterns.

An ADA specified full crown die is fabricated using stainless steel with specific dimension which is machined milled to obtain mater stainless steel full crown die. To form a mold space a cylindrical stainless steel is fabricated which is made hollow from inside to get a uniform dimension and specific taper. Figure 1(a)
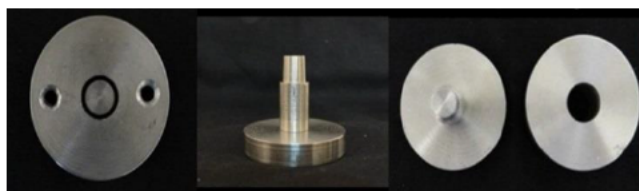

A) ADA Specified Stainless Steel Die

Specifications for full crown die are as follows: Length of die 26.194 mm, Diameter at the base 12.70 mm, Crown height 9.271mm, Diameter of crown 9.22mm, Width of shoulder margin 1.74 mm, Taper 2 ½ degree. Silicone putty index of this master die were made to replicate 36 times so that all the sample size has same dimension and degrees

taper as that of master die. Impression of metallic die was made using a custom made metal ring lined with three layer modeling wax to the inner wall of the metal ring to reduce the excessive thickness of the impression materials which may leads to distortion.

Elastomeric impression material (Aquasil, soft putty, Dentsply) is mix and placed inside the metal ring and cellophane sheet adapted to the metallic die and placed in to the metal ring containing silicone putty material. Figure 1(b).
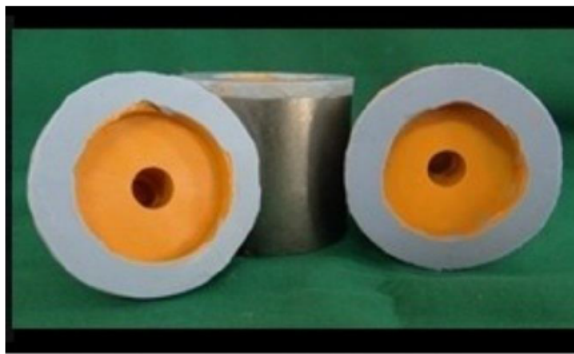

B) Impression of Die

After putty material set metallic die is removed from the metal ring and cellophane sheet removed. A light body impression material (Reprosil, light body, Dentsply) is place inside putty material and metallic die introduced into the metal ring and impression is made. After light body impression material get set metallic die is removed. This impression was poured with die stone to get a full crown die. Figure 2(a).


A) Die Stone Specimens

Impression was poured after 1 hour with type IV dental stone (Elite stone, Zhermack technical). Water /powder ratio was 23 ml: 100grams. It was mechanically mixed using vacuum mixer and poured into impression using vibrator. After final set, dies were recovered. Die hardener (Plastodur , DFS , Germany) was applied to die with the help of sable brush. Die spacer (Plastodur , DFS , Germany) were applied to axial surface within 0.5mm above margin. First single layer of silver layer of die spacer was applied and allowed to dry. After that, single layer gold layer was

applied to get an thickness of 14 to 20 μm. For standardization, die spacer was applied with manufacturer brush with strokes in one direction each coat is allowed to dry for at least 2min before the application of another coat. Stone die applied with die spacer and die lubricant (Wax separator, HAN DAE CHEMICAL CO.LTD) were applied. To the inner surface cylindrical stainless steel die lubricant is applied. Cylindrical stain steel mold is placed on the die to create a mold space. To this mold space Inlay pattern wax (Bego, Germany) is melted in electrical bath and poured in to the mold space. After pattern wax solidifies cylindrical stain lees mold is removed, excess materials removed from the pattern and margins are redefined. Figure 2(b).
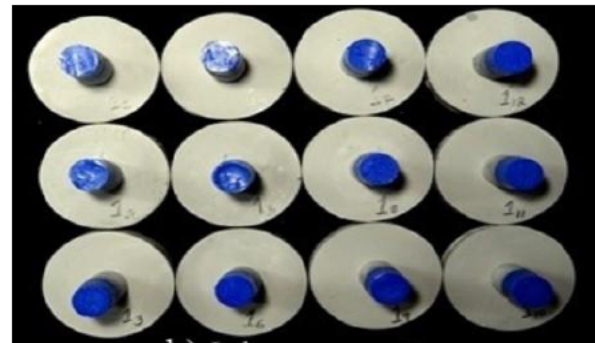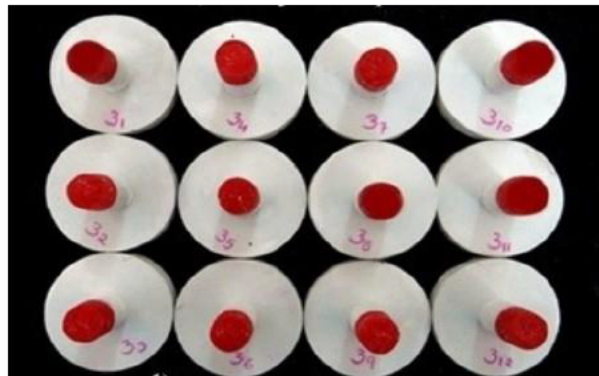

B) Inlay Wax Pattern

Stone dies are applied with Liwa step 1 and step 2 on the die. To the inner surface cylindrical stainless steel die lubricant is applied. Cylindrical stain steel mold is placed on the die to create a mold space. By using Liwa light curing modeling paste (LiWa, Wilmann & Pien Gmbh) which is hand adapted on to the die layer by layer to gain the desire shape of the mold and finally cylindrical stainless steel mold is placed on the die and to finish vacant space paste is followed in to mold by using electric PKT to gain mold dimension. After solidification of the Liwa wax. die and stainless steel mold is kept in the light curing chamber for 6 min curing cycle. After one curing cycle cylindrical mold is removed and die with Liwa wax pattern cured for 6 min of second curing cycle. Figure 2(c).
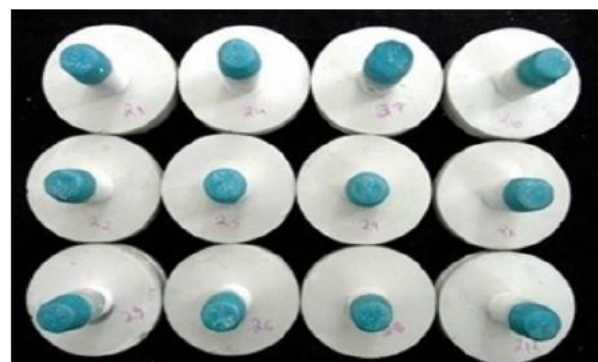
C) Liwa Wax Pattern

Pattern is checked for margin adaptation after completion of curing. Stone die applied with die spacer and die lubricant were applied. To the inner surface cylindrical stainless steel die lubricant is applied. Cylindrical stain steel mold is placed on the die to create a mold space. The pattern resin (GC Corporation, Tokyo, Japan) was applied by wetting a fine brush with monomer and dipping it in the powder to produce a bead of acrylic material and thus applied layer by layer constantly maintaining the length and width of the die. After polymerization of resin pattern it is removed from the pressure pot. The pattern resin pattern was trimmed carefully using the hand piece to exact dimensions. Resin patterns are examined for void and marginal adaptation. Figure 2(d).

D) Pattern Resin Pattern

All patterns were invested immediately after fabrication. Preformed crucible former was used Sprue former – prefabricated made up of inlay wax (Bego, Germany). Thickness – 2.5 and 3.5 mm Sprue was attached at the thickest portion of the copings. Sprue was attached with 45 degree to patterns when pattern was on the respective die. These patterns were attached to runner bar which in turn joined with crucible former 6mm clearance was maintained between top of casting ring and pattern. A total 6 pattern were invested at a time. Positions of all patterns were numbered with helped to seat castings in their respective dies. Surfactant (Waxit, Deugdent, Germany) was sprayed on wax patterns and blow dried to decrease surface tension and increase wetting by investment material to form complete and smooth casting. Casting ring was lined with non-overlapping layer of moistened cellulose ring liner. This lined ring was soaked in water for minimum of 1 min and then excess water was shaken off. Investing (Bellavest, Bego) was done following manufacturer's instruction for Bella vest powder: liquid ratio is 160grams of investment: 40 ml of liquid (90% Begosol +10% distilled water), Investing was accomplished at constant room temperature of 28-30° C. liquid was poured into clean mixing bowl and powder added. It was hand spatulated for 15 seconds until investment is uniformly moist and has no lumps. Then it was vacuum mixed for 60 second in vacuum mixer. Mixed investment was poured into the ring with mild vibration on investment vibrator excess vibration was avoided. The mold was kept for 60 minutes for bench set. Invested molds

were kept in preheating furnace. The temperature of preheating furnace was gradually increased from room temperature of 26° C to 250° C in 15 - 20 minutes. Once the preheating furnace reached the temperature of 250° c, the molds were transferred from preheating furnace to main heating furnace which had the same temperature as preheating furnace i.e. 250° C. Temperature was increased by 8° C (15° F)/min to 430° C (800° F) for 30 minutes. After that, it was further increased by 14° C (25° F)/min to 950-1050° C (1740-1920° F) for 30-60 minutes. All castings were done in induction casting machine. Ni-Cr base metal alloy was used for casting which was molten by preheating alloy in ceramic crucible at 950° C. At casting temperature of 1380° C, casting was triggered when the cast solid component has submerged in the melt. Casting molds were allowed to cool down until they were warm to touch. Investment at button end of ring was trimmed to expose liner and investment was pushed out of ring. Pneumatic power chisel was used to remove gross investment. Investment that was tenacious and difficult to remove was removed by using 50 μm alumina particles in sandblaster at 30 psi pressure from approximately 5 cm distance. Sprues were cut with separating disk and castings were seated on respective dies. The intaglio surfaces of all castings were examined under magnifying lens and all apparent nodules were removed with a No.½ or No. 1 round carbide bur on high speed hand piece. A total 5 castings were rejected because of casting defects and procedure was repeated for the same. Finally all castings were seated on respective dies and fit was checked by using explore after that casting were ultrasonically cleaned in distilled water for 15 minutes , rinsed and dried.

To evaluate and compare dimension between the die and coping, the marginal fit and internal adaptation were measured by sectioning the coping along with their respective dies.After examining the coping for nodules and ultrasonically cleaned coping is placed on their respective dies, all the 36 coping and die were sectioned along the long axis at the middle of the coping using carborandom disc (1mm thick). Figure 3(a).

Group I   **Group II**

Group III

A) Sectioned Specimens

Groups	Occlusal		Marginal 1		Margin 2		Axial 1		Axial 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	179.20	72.78	89	58.56	72.36	34.73	157.98	45.51	144.05	45.41
2	83.01	18.16	62.75	30.22	66.38	39.80	120.59	41.26	138.31	58.01
3	88.93	50.98	59.27	17.98	88.31	61.34	154.25	45.83	144.3	23.19

[values in microns (μ)]

Table 1: Descripitve Statics of Mean and Standard Devations for All Expermental Groups

To achieve two half of coping this is then subject to microscopic examination by using stereo microscope.

All the sectioned coping with their respective die were subjected into stereo microscopic examination. Figure 3(b).

A – Margin
B – Axial
C – Center
D – Axial
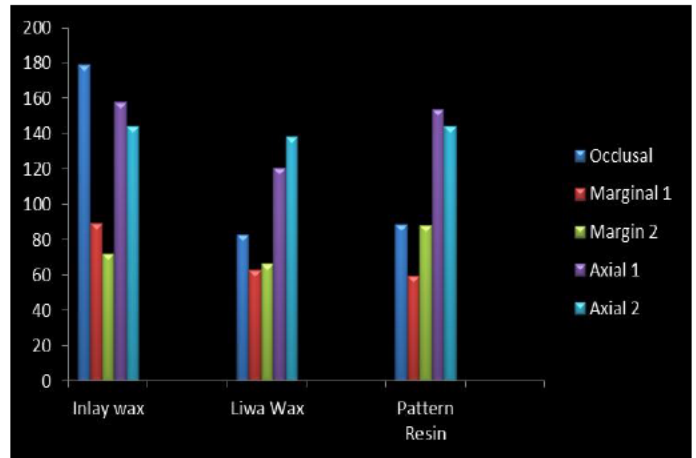E – Margin

B) Measurements Recorded

Figure 3A: -

Measurements are recorded at:

   A) At the centre of occlusal surface
   B) At the centre of axial wall
   C) At the shoulder margins

Total of 5 recording were recorded of the sectioned copings. At the cervical limit, it was important to define exact location of measurement in order to allow comparisons. It was taken perpendicular through the joint and gave information about vertical adaptation. For internal adaptation axial and occlusal vertical measurements are recorded

Results

The table 1 and graph 1 shows the mean measurement of the distance between metal and stone obtained for each group. For one specimen, measurement from all 5 areas was averaged. After that, mean was determined for a group by calculating averaging for 12 specimen in a group.

Graph 1: Mean for all experimental groups

In all group the mean was lowest at the margin region followed axial surface and occlusal surface.

The table 2 describes the comparing the mean value of three pattern materials i.e. inlay wax, Liwa wax and pattern resin. There was very high statistically significant difference seen with respect to discrepancy between the metal and stone st the center of the occlusal surface between the three pattern materials ($p < 0.0001$).

Therefore to find out which pattern was performing better in respect to adaptation and fit between three pattern materials, Tukey's HSD Post Hoc test was conducted.

The above table 3 describes the Comparing the distance between the metal and stone of three pattern materials at the center of the occlusal surface. When Inlay wax compared against the Liwa wax , there was very high significant difference seen ($p < 0.0001$)

Similarly when inlay wax is compared against the pattern resin test showed high significant difference ($p = 0.001$)

Whereas there was no statistically significant difference observed between Liwa wax and pattern resin ($p = 0.96$)

Discussion

Quality control is extremely important in fixed prosthetics.[5] The marginal fit of prosthetic crowns has always been a concern for clinicians. The dimensional accuracy of the casting depends not only on the method employed but also on the various materials involved in its fabrication.[6]

Pattern Materials	Sum of Squares	Df	Mean Square	F Value	P Value
Occlusal	69768.667	2	34884.333	12.683	<0.0001
Margin 1	6367.722	2	3183.861	2.048	0.145
Margin 2	3117.556	2	1558.778	0.714	0.497
Axial 1	10182.722	2	5091.361	2.594	0.090
Axial 2	276.500	2	138.250	0.069	0.933

(Df-Difference, F-frequency value, P-prevalence value)

Table 2: Anova Test Comparing Mean Values of Three Pattern Resin

Pattern Materials		Mean Difference	S E	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Inlay	Liwa	96.167	21.41	< 0.0001	43.63	148.70
Inlay	Pattern Resin	90.33	21.41	0.001	37.80	142.87
Liwa	Pattern Resin	5.83	21.41	0.960	58.37	46.70

Table 3: Comparing distance betweenn metal and stone interface of three parttern materials at the cemtr of occlusal surface Tukey HSD Post Hoc Test

One of the important variables in the casting process is the type of pattern material used. Generally these are waxes and resins. Waxes show not only a high co-efficient of thermal expansion, but also a tendency to warp or distort when allowed to stand unrestrained.[3]

Phillips and biggs[7] have shown that this distortion is evident just 30 minutes after the preparation of wax pattern, and hence should be stored at low temperatures to reduce the degree of distortion, or the patterns should be invested immediately to minimize the distortion.

Hollenback and Roads[8] investigated the behavior of inlay wax patterns and concluded that if the wax is properly manipulated, the resulting pattern shows less distortion. They stated that the wax patterns had been wrongly accused of being a major cause of dimensional error and that inlay waxes were comparatively stable materials if not mistreated during pattern formation or storage. This was in direct contradiction to most of the results published previously, like the studies done by Van Horn[9] where he stated that the wax patterns were not constant in their dimensions. Under varying thermal conditions. Fusayama[10] observed that the wax molded into the cavity exhibited both shrinkage during solidification and cooling.

The present study was carried out to compare and evaluate the effect of different pattern materials on the marginal fit and internal adaptation of complete cast crowns. The pattern materials compared in the present study were conventional inlay wax, light cured wax and pattern resin. The castings were done using the lost wax technique. Care was taken to maintain the uniformity at each step in the fabrication of the castings, like preparation of patterns,

thickness of the patterns, location of the sprue, length and thickness of the sprue, type of the investment, powder: liquid ratio of the investment, burn-out temperature and the casting procedure. The vertical marginal accuracy of uncemented complete cast crowns were assessed with the help of a stereo microscope and then subjected to image analysis for the readings.

The results of the present study showed that the highest mean gap was noticed in the castings fabricated using pattern resin followed by the castings fabricated using light-curing modeling material and the least mean gap was observed in the castings fabricated using inlay wax. The difference in mean gap of the castings fabricated using inlay wax, and the rest of the pattern materials (pattern resin, light-cured wax) were found to be significant. However, the mean gap between the castings fabricated using pattern resin and light-cured was not significant. Among the castings fabricated using 3 types of pattern materials the castings fabricated using inlay wax had the least mean gap.

In a study conducted by Allan iglesium,[11] the marginal fit of mod inlay and full-crown patterns was compared. The patterns were fabricated from inlay wax, auto- polymerized pattern resin, and light-curing diacrylate resin pattern materials. It was found that the polymerization shrinkage for inlay wax was least and maximum for auto-polymerized pattern resin. The results obtained in the present study can be co-related to the results of the above mentioned study although; the results of the present study could have been affected by various steps involved in investing and casting procedures also.

A study conducted by Danesh G et al[12] on the various polymerization properties of the light-curing and auto-polymerized pattern resins reflected that the volumetric shrinkage of the light-curing resins are similar to the auto-polymerized pattern resin, which may be co-related to the results of the present study.

A probable explanation that can be given for the better marginal accuracy of the castings using the inlay wax (400ppm / k) is its higher coefficient of thermal expansion compared to the resin (81ppm / k),[13] which will provide bigger mold-space due to more expansion of wax during the setting of the investment and hence, slightly bigger castings are obtained with better adaptation. Light-curing modeling materials on the other hand, rely on the entry of light of sufficient intensity to initiate polymerization. Light intensity is great at the surface of a material specimen, but at deeper levels it is attenuated by absorption and scatter, which limit the depths of cure that can be achieved.[14]

The results obtained in this study can be related to the different types of pattern materials used in the study and also the various factors involved in the casting procedure itself, like the distortion of the patterns during their removal from the die, expansion of the patterns during the setting of the investment, expansion of the investment. Retrieval of the patterns from the die could also have affected the final result. Further, the marginal accuracy of the patterns on the dies was not taken into consideration and only the marginal accuracy of the final castings was considered in the present study. Considering the various aspects of the present study, it is concluded that with strict adherence to the principles of pattern fabrication, inlay wax can still be the pattern material of choice to produce a casting with minimal marginal and internal discrepancy, which is user friendly and cost effective.

Conclusion

Within the limitations of the present study, it was concluded that with strict adherence to the principles of pattern fabrication, Inlay wax can still be the pattern material of choice to produce a casting with minimal marginal discrepancy.

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Corresponding Author

Dr. Pradeep Chandra K.
Flat No. 002, Kalpatharu Royal Adobe,
Chikkalsandra Main Road,
New Hanumagiri Nagara,
Bangalore – 560061.
Email Id: - drdeepuchandra@yahoo.in