A comparative evaluation of the marginal adaptation of a thermoplastic resin, a light cured wax and an inlay casting wax on stone dies: An *in vitro* study

Reji P. Gopalan, Vivek V. Nair, K. Harshakumar, R. Ravichandran, S. Lylajam, Prasanth Viswambaran

Department of Prosthodontics, Government Dental College, Thiruvananthapuram, Kerala, India

Abstract

Background: Different pattern materials do not produce copings with satisfactory, marginal accuracy when used on stone dies at varying time intervals.

Purpose: The purpose of this study was to evaluate and compare the vertical marginal accuracy of patterns formed from three materials, namely, thermoplastic resin, light cured wax and inlay casting wax at three-time intervals of 1, 12, and 24 h.

Methodology: A master die (zirconia abutment mimicking a prepared permanent maxillary central incisor) and metal sleeve (direct metal laser sintering crown #11) were fabricated. A total of 30 stone dies were obtained from the master die. Ten patterns were made each from the three materials and stored off the die at room temperature. The vertical marginal gaps were measured using digital microscope at 1, 12, and 24 h after reseating with gentle finger pressure.

Results: The results revealed a significant statistical difference in the marginal adaptation of three materials at all the three-time intervals. Light cured wax was found to be most accurate at all time intervals, followed by thermoplastic resin and inlay casting wax. Furthermore, there was a significant difference between all pairs of materials. The change in vertical marginal gap from 1 to 24 h between thermoplastic resin and light cured wax was not statistically significant.

Conclusion: The marginal adaptation of all the three materials used, was well within the acceptable range of 25–70 μm. The resin pattern materials studied revealed significantly less dimensional change than inlay casting wax on storage at 1, 12, and 24 h time intervals. They may be employed in situations where high precision and delayed investing is expected.

Keywords: Dimensional accuracy, inlay casting wax, light cured wax, pattern distortion, thermoplastic resin

Address for correspondence: Dr. P. G. Reji, Department of Prosthodontics, Government Dental College, Thiruvananthapuram, Kerala, India.
E-mail: rejibabbadi@gmail.com
Received: 13th March, 2017, **Accepted:** 22nd September, 2017

INTRODUCTION

The replacement of missing structures of the stomatognathic system should be in such a way that they blend harmoniously with the oral environment. This has been a challenge and of utmost priority to the prosthodontist. Complete crowns are commonly used as

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/jips.jips_70_17

How to cite this article: Gopalan RP, Nair VV, Harshakumar K, Ravichandran R, Lylajam S, Viswambaran P. A comparative evaluation of the marginal adaptation of a thermoplastic resin, a light cured wax and an inlay casting wax on stone dies: An *in vitro* study. J Indian Prosthodont Soc 2018;18:3-9.

a part of fixed prosthodontic treatment for many years. The procedure for making cast restorations has been so perfected in recent years that casting failures must now be considered an exception rather than a rule. The success of any cast restoration depends on its fit onto the underlying tooth structure with minimal discrepancies.[1] The ability to produce routinely smooth, sound, and well-fitting castings require strict adherence to certain fundamentals. A deficient margin leads to plaque retention resulting in gingival inflammation and marginal leakage which can lead to secondary caries, sensitivity, gingival recession, cement dissolution, and debonding of the restoration.[2,3] The steps involved from the time the wax pattern is formed until the restoration is seated in the mouth has a definite effect on the ultimate clinical outcome.

The dimensional accuracy of the castings depends not only on the methods used but also on the various materials used in its fabrication.[4] Conventionally, patterns for dental castings have been constructed using inlay casting wax. These materials combine familiarity and ease of manipulation with good reproduction of details and are also cost-effective. However, waxes have two major defects: high coefficient of thermal expansion and a tendency to warp or distort on standing.[5] Wax patterns, regardless of the method of manipulation, develop a degree of internal strain during its preparation. This strain tends to be relieved over time, and thus the wax distorts. Distortion of wax is both time and temperature dependent, and ideally, wax patterns must be invested immediately after removal from the die or cast.[6]

Command curing materials are popular in dentistry and have superseded chemically activated materials in a variety of clinical and laboratory applications. They exhibit a number of benefits, including faster and more complete curing, reduced porosity as mixing is generally not required, almost instant finishing, adequate working time for complex procedures and material economy.[7] Light cured resins are seldom used for wax pattern fabrication. Limited available literature quotes that the advantages of these light curing resins have low polymerization shrinkage, good dimensional stability, ease of manipulation, reduced chair time, and absence of residue on burn-out.

Thermoplastic resin is considered to be a cheap, easily manipulated, elastic material and as accurate and dimensionally stable as the cold cure resin pattern.[8] Furthermore, the time needed for its cooling and solidifying is 1 min which is much less than the time needed for the polymerization of cold cure resin or incremental building of the inlay pattern wax.[9] Good flow of this material in molten state leaves the pattern free from voids that may affect the accuracy of the investing procedures. The resin used in the present study is a type of hot melt adhesive (HMA), which is supplied in solid cylindrical sticks of various diameters. These sticks are melted using a hot glue gun. The gun uses a continuous duty heating element to melt the resin by trigger mechanism. These materials have very little or no volatile organic compounds and also the drying and curing step is eliminated.

Marginal openings of 25–70 μm are generally considered clinically acceptable for complete coverage restorations on natural teeth.[10,11] Nevertheless, *in vitro* studies have demonstrated that marginal openings of metal-ceramic crowns cemented on metal implant abutments are between 11 and 67.4 μm, while the marginal discrepancies of ceramic crowns cemented on implant abutments range from 65.9 to 168 μm.[12-14] Earlier studies have shown that inlay wax and light cured wax produced acceptable crowns in terms of marginal openings. Till date, no studies have been done to test the efficacy of thermoplastic resin as a pattern material. Hence, this study is aimed at to evaluate the marginal accuracy of a thermoplastic resin, a light cure wax and an inlay casting wax on stone dies at varying time intervals of 1, 12, and 24 h.

METHODOLOGY

A zirconia abutment mimicking a prepared maxillary right central incisor was milled with a mesiodistal dimension of 7 mm and faciolingual dimension of 6 mm at the finish line. The abutment had a facial height of 7 mm, mesial and distal height of 6 mm, a palatal height of 4 mm, and a uniform taper of 12°. A 3.5 mm platform implant analog (Adin Dental Implant System Ltd., Afula, Israel) was placed vertically in an autopolymerizing polymethyl methacrylate resin (DPI-RR Cold Cure, DPI, Mumbai) block of dimensions 35 mm × 25 mm × 10 mm. Milled zirconia abutment was fastened on the implant analog. Four markings were made on the milled zirconia abutment on the base of the die, separated by 90° (mid-facial, mid-lingual, mid-distal, and mid-mesial), each serving as standard reference points for measurement of the vertical marginal discrepancy of all patterns [Figure 1]. A full metal crown resembling a permanent maxillary right central incisor was fabricated using direct metal laser sintering technique. This served as a standardized sleeve for wax pattern fabrication [Figure 2].

The impression of the metal master die was made in polyvinyl siloxane impression material (Express, 3M ESPE) in a custom tray made of auto polymerizing polymethyl

Figure 1: Zirconia master die

Figure 2: Master die with metal sleeve

methacrylate resin. Type IV die stone (Ultrarock, Kalabhai, Mumbai, Maharashtra, India) was vacuum mixed and poured into this mold to obtain a stone die for preparation of wax pattern. Thirty impressions were made using the same technique and 30 individual stone dies were fabricated. Two coatings of die spacer (Giroform Die Link, Amann Girrbach, Germany) were applied on each of these dies 1 mm short of the margin on all the dies.

The specimens were divided into three groups of 10 each:

- Group 1: Ten patterns fabricated using thermoplastic resin (Trigger Feed, Glue Gun, China) on stone dies
- Group 2: Ten patterns fabricated using light-cured resin (Metacon Light Cured Wax, Primotec, USA) on stone dies
- Group 3: Ten patterns fabricated using inlay casting wax (Bego Crown Wax, Bego Bremer, Germany) on stone dies.

Thermoplastic resin pattern material

Two layers of die spacer were applied onto the gypsum dies, and thereafter the dies were allowed to dry. The sleeve was then lubricated with petroleum jelly (Nice chemicals Pvt. Ltd, Cochin). The thermoplastic resin (Trigger Feed, Glue Gun, China) was loaded onto a hot melt gun and plugged on. After attaining the sufficient temperature, the material was dispensed into the metal sleeve by the hot melt extrusion technique. The die and waxing sleeve was assembled and allowed to cool to room temperature. The excess material was carved away, and margins were redefined.

Light-cured wax pattern material

The adaptation of light-curing wax (Metacon Light Cured Wax, Primotec, USA) onto the gypsum stone dies followed the application of a double layer of die spacer on the dies. The sleeve was lubricated with petroleum jelly (Nice chemicals Pvt. Ltd, Cochin). The low viscosity material was adapted onto the margin of the die. Curing light of recommended wavelength was applied onto the die for 90 s. The materials were added incrementally confining to the borders of the metal sleeve. After the final increment, the pattern was cured for about 90 s.

Inlay casting wax pattern material

Inlay wax (Bego Crown Wax, Bego Bremer, Germany) was melted in an electrically controlled water bath (Denstar Co, Korea) at the recommended temperature. The stone dies and the metal sleeve were lubricated and the sleeve was fitted on the stone die. Molten wax was poured into the metal sleeve and the sleeve was fastened. After the molten wax was allowed to cool down to room temperature, the excess wax was carved, and margins were redefined if necessary.

All the thirty patterns were visually inspected with a magnifying lens to ensure proper marginal adaptation. The patterns were then separated from their dies and stored in a container at room temperature at intervals of 1, 12, and 24 h. Later, the patterns were reseated on to their respective dies, using gentle finger pressure. The margins were observed under the digital measurement microscope (Keyence Digital Microscope, Keyence America, USA) and the image was captured using Moticam 325 at ×100 magnification. The marginal gaps were measured at all three-time intervals at the four predetermined points on each die using Motic Image Plus 2.0 software(MOTIC,MOTIC ASIA PACIFIC, HONG KONG). All 120 measurements (3 waxes × 10 specimens × 4 points on each specimen) were performed by the same operator to ensure consistency. The average was calculated and shown as marginal discrepancy in microns. Mean value of measurements at the gingival margin at each of these time intervals was used for the statistical analysis.

RESULTS

Repeated measure analysis of variance (ANOVA) and one-way ANOVA were used. Data were analyzed using computer software, Statistical presentation system software, SPSS INC. 1999,NEW YORK Data were expressed in its mean and standard deviation. A repeated measure ANOVA by Greenhouse–Geisser method [Table 1] was carried out to test the significance in the difference of marginal gaps among the three pattern materials at all the three-time intervals. The ANOVA [Table 2] reveals that there is a significant difference between marginal gaps of the three materials at the three-time intervals (1, 12, and 24 h). A multiple comparison using Bonferroni's test [Table 3] was carried out to verify the significance of the difference in marginal gaps between any pair of pattern materials. The test revealed that there was statistically significant difference between all the pairs of pattern materials employed in the study.

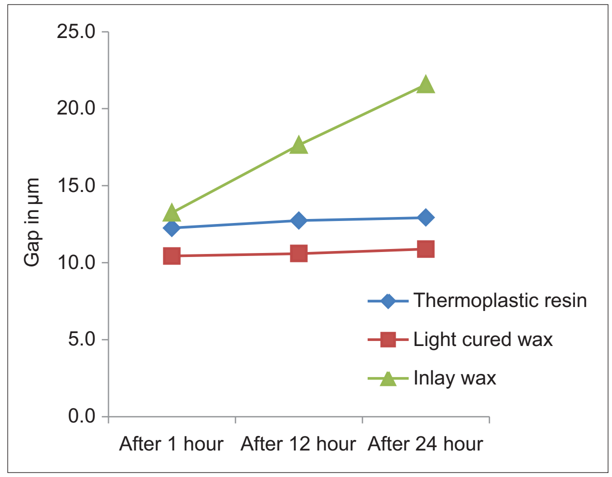

Figure 3: Line diagram showing mean marginal gap in microns at three-time intervals

Table 1: Test of within-subjects effects

Source	TEST	Type III sum of squares	df	Mean square	*F*	*P*
Time	Greenhouse–Geisser	149.062	1.489	100.114	246.438	<0.001
Time×group	Greenhouse–Geisser	201.666	2.978	67.722	166.703	<0.001
Error (time)	Greenhouse–Geisser	16.331	40.201	0.406		

Change in marginal gap overtime was statistically significant as $P<0.001$. This change is significant in each group also (change is not similar in every group)

DISCUSSION

One of the important variables in the casting process is the type of pattern material used. In general, waxes and resins are used. Although inlay waxes possess desirable properties such as ease of manipulation, predictable coefficient of thermal expansion, and absence of residue on burnout, their thermoplastic characteristics can lead to distortion resulting from thermal changes and release of internal stresses.[6] The amount of contraction which inlay waxes undergo is the most important factor to be noted when the direct technique is used for wax pattern fabrication. Phillips and Biggs[15] found that most of the distortion occurred during the first 2–3 h of storage off the preparation and in some patterns in the first 30 min. Distortion was more pronounced as the storage temperature was increased and also in patterns which had been formed from molded wax at nonuniform temperatures and which had been subjected to patching and pooling during formation.[16]

A number of methods exist for wax pattern fabrication, and till date, no one method is found to be foolproof. It has been advocated that molten wax be poured into the mold and allowed to solidify without pressure. The poured wax patterns (molten wax) showed less distortion than molded patterns and that the higher the temperature at which the wax is manipulated, the fewer are the internal strains developed and the less is the resulting distortion upon storage. Fusayama[17] observed that the wax molded into the cavity exhibited both shrinkage during solidification and cooling. In the present study, the wax patterns were fabricated by pouring molten inlay casting wax into a warm die and waxing sleeve assembly.

Resins are the alternative materials used as the pattern materials for the fabrication of the castings. Light-curing materials are popular in dentistry and have superseded chemically activated materials in a variety of clinical and laboratory applications. They exhibit many benefits, including faster and more complete curing and reduced porosity as mixing is generally not required; almost instant finishing; adequate working time for complex procedures; and material economy (Whitworth *et al.*).[18] Thermoplastic resin is a cheap, low-cost, easily manipulated, elastic material and as accurate and dimensionally stable as the rigid cold cure resin pattern. Furthermore, the time needed for its cooling and solidifying is 1 min which is much less than the time needed for polymerization of cold cure resin or incremental building of the inlay pattern wax.[9] Meiners and Kunzemann,[19] and Jörgensen and Ono[6] concluded that because of the inherent property of distortion, inlay wax was an inadequate material for pattern production in techniques requiring high precision. Hence in the present study, thermoplastic resin and light cured wax

Table 2: Descriptive statistics (marginal gaps of patterns on storage)

	Gap in μm, mean±SD	95% CI for mean		Minimum	Maximum
		Lower bound	Upper bound		
After 1 h					
Thermoplastic resin	12.25±0.81	11.67	12.83	10.75	13.43
Light cured wax	10.43±0.85	9.82	11.04	9.23	12.12
Inlay wax	13.23±1.11	12.44	14.02	11.82	15.42
After 12 h					
Thermoplastic resin	12.73±0.84	12.13	13.34	11.12	14.12
Light cured wax	10.59±0.85	9.99	11.20	9.41	12.28
Inlay wax	17.63±1.79	16.35	18.90	14.31	20.45
After 24 h					
Thermoplastic resin	12.92±0.86	12.30	13.54	11.31	14.47
Light cured wax	10.88±0.86	10.27	11.50	9.51	12.35
Inlay wax	21.56±0.88	20.93	22.18	20.32	23.68
Difference					
Thermoplastic resin	0.67±0.24	0.49	0.84	0.24	1.04
Light cured wax	0.45±0.41	0.16	0.75	0.20	1.56
Inlay wax	8.33±0.99	7.62	9.04	5.95	9.24

SD: Standard deviation, CI: Confidence interval

Table 3: To find out level of significance between patterns fabricated from three materials over time using multiple comparison (Bonferroni's test)

Group (I)	Group (J)	Mean difference (I−J)	SE	*P*
Thermoplastic resin	Light cured wax	2.001*	0.412	<0.001
Thermoplastic resin	Inlay wax	−4.834*	0.412	<0.001
Light cured wax	Inlay wax	−6.834*	0.412	<0.001

$P<0.001$ indicates that there is a significant difference in vertical marginal gaps among the three materials over time. Marginal gap increases in the order light cure wax < thermoplastic resin < inlay casting wax over time. SE: Standard error, I-J is positive here because light cure wax (J) exhibit less dimensional change than thermoplastic resin (I)

were evaluated as pattern material and compared with inlay wax.

Patterns fabricated using a light cured resin pattern material (Metacon, Primotec USA) has a unique chemical composition of cracked carbon chains (acrylic) with photoinitiators attached to both ends of the carbon chain. The light-cured materials rely on the entry of light of sufficient intensity to initiate polymerization. Light intensity is significant at the surface of a material specimen, but at deeper levels, it is attenuated by absorption and scatter, which limits the depths of cure that can be achieved. Complete polymerization is important for light-activated pattern materials since the presence of unpolymerized or partially polymerized inclusions may allow plastic deformation of the pattern as it is handled, resulting in impaired fit of the subsequent casting.[20] Rueggeberg *et al*.[21] found that important limiting factors in photopolymerization include the intensity of the incident light, the duration of exposure, material color, and the nature and volume of filler. The light-cured wax has a composition that ideally combines waxes, acrylics, and photopolymerizing elements. It also contained organic fillers and pigments (blue). Resin pattern materials, irrespective of their mode of activation show some degree of polymerization shrinkage which could lead to a compromise in the dimensional stability of patterns. Prolonged storage before investing has shown to affect marginal integrity due to distortion of patterns.[22] The study conducted by Whitworth *et al*.[18] revealed that the light-cured resin pattern materials cure in a manner similar to composite resins. The light cured resin patterns employed in the present study were fabricated in increments not more than 2 mm thick. Each increment was cured for 30 s in a light curing unit. After the final finishing and polishing it was cured again for 90 s and then stored off the die at room temperature.

The thermoplastic resin (Trigger Feed, Glue Gun, China) employed in this study is basically an HMA with reduced volatile organic compounds. For the pattern fabrication, the thermoplastic resin was first softened using electrical gun and then forced into the mold space of the sleeve using the gun. The advantages of using thermoplastic resin were first noted by Rosenstiel *et al*.[8] in their study of postfabrication. The main advantage of the thermoplastic system is its low cost. They concluded that the amount of time needed for cooling and solidifying the thermoplastic resin is approximately 1 min, which is much less than the time needed for polymerization of autopolymerizing resins and also the material flows well in its molten state, which leaves the surface of the postpattern free from voids that may affect the accuracy of investing procedures. Abdul-Hameed[9] studied the properties of thermoplastic resin in terms of dimensional accuracy surface detail reproduction and burnout residue. He compared the resin with polyether rubber base material and Duralay acrylic resin and found that dimensional change values ranged from −0.22% to −0.26% for all the materials used, and the percentage of solid residue left after burning out of thermoplastic resin was 0.079 ± 0.004, and that of cold cure resin was 0.082 ± 0.002. The study concluded that the surface detail reproduction of all these materials was comparable.

The present study evaluated the marginal fit of patterns fabricated from an inlay wax, thermoplastic resin and a light-cured wax on storage off the die for varying time intervals. Care was taken to maintain the uniformity at each step in the fabrication of the wax pattern. To simulate a situation warranting delayed investment after direct pattern fabrication, the patterns were stored off the metal dies at room temperature. The vertical marginal accuracy of the patterns at 1, 12, and 24 h were assessed with the help of a digital microscope and subjected to image analysis for the readings. The study revealed that inlay wax showed the maximum marginal discrepancy at 1 h followed by thermoplastic resin and light cured wax. Light cured wax showed the least marginal discrepancy at all time intervals followed by thermoplastic resin and inlay casting wax. The marginal discrepancy of patterns fabricated from the thermoplastic resin was more than that of light cured wax at all three-time intervals, but it was less than that of inlay casting wax. Furthermore, the change in dimensions from 1 to 24 h was statistically significant, and it was comparable to that of light cured wax. Inlay wax exhibited the maximum distortion when stored off the die for a period of 24 h. The light cured wax exhibited the least marginal gap at all time intervals of 1, 12 and 24 h) followed by thermoplastic resin and light cured wax. There was a statistically significant difference between all patterns and between each pattern at all time intervals. The study concluded that both material and time significantly affect marginal accuracy of wax patterns [Figure 3].

The factors that affect the vertical marginal discrepancy of the cast dental restorations include wax properties (flow, residual stress, and coefficient of thermal expansion), investment properties and investing procedures, alloy, casting, and finishing procedures. The marginal accuracy of the final castings was not considered in the present study, and only the marginal accuracy of the patterns was taken into consideration. The method of fabrication of thermoplastic resin by hot melt extrusion technique and its tackiness may be of concern to the dental technician as it sticks to the carving instruments. Furthermore, the manipulation of light cured wax employed in the study seems to be more technique sensitive and dexterity is required on the part of the operator during its manipulation as it is bound to set if not handled properly. All the above facts discussed are of prime concern and should be considered in future studies so that the selection of pattern material will become less challenging and foolproof.

CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

Light cured wax exhibited the least marginal discrepancy at all time intervals followed by thermoplastic resin. Inlay wax was found to have the greatest discrepancy at all time intervals. There is a significant relation between storage time and marginal adaptation: as the storage time increases marginal adaptation decreases. Light cured wax showed the least change in marginal adaption when stored off the die, after a 24 h period, followed by thermoplastic resin and inlay wax. Similarly, the difference between the light cured wax, and thermoplastic resin was not found to be statistically significant. The mean marginal gaps ranged from 10.43 to 21.56 μm. The range is well below the 25–70 μm marginal opening considered acceptable for a cast restoration. The observations made from the study showed that the resin pattern materials, namely, thermoplastic resin and light cured wax underwent a significantly less dimensional change than the inlay wax on prolonged storage. Hence, it is advisable to use them in preference to inlay wax in situations requiring high precision or when delayed investment (>1 h) of patterns can be expected. Thermoplastic resin proved to be a cheaper alternative to inlay wax for pattern fabrication.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Bronson MR, Lindquist TJ, Dawson DV. Clinical acceptability of crown margins versus marginal gaps as determined by pre-doctoral students and prosthodontists. J Prosthodont 2005;14:226-32.
2. Boeckler AF, Stadler A, Setz JM. The significance of marginal gap and overextension measurement in the evaluation of the fit of complete crowns. J Contemp Dent Pract 2005;6:26-37.
3. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent 1989;62:405-8.
4. Hunter AJ, Hunter AR. Gingival margins for crowns: A review and discussion. Part II: Discrepancies and configurations. J Prosthet Dent 1990;64:636-42.
5. Morey EF. Dimensional accuracy of small gold alloy castings. Part 4. The casting ring and ring liners. Aust Dent J 1992;37:91-7.
6. Jörgensen KD, Ono T. Distortion of wax crowns. Scand J Dent Res 1984;92:253-6.
7. Peyton FA. Evaluation of materials used for indirect technics. Dent

Clin North Am 1965;23:213-23.
8. Rosenstiel SF, Land MF, Holloway JA. Custom-cast post fabrication with a thermoplastic material. J Prosthet Dent 1997;77:209-11.
9. Abdul-Hameed N. Evaluation of thermoplastic resin as a new pattern material for posts: Dimensional accuracy and detail reproduction. J Dent Heal Oral Disord Ther 2014;1:1-5.
10. Wilson PR. Effect of increasing cement space on cementation of artificial crowns. J Prosthet Dent 1994;71:560-4.
11. Emtiaz S, Goldstein G. Effect of die spacers on precementation space of complete-coverage restorations. Int J Prosthodont 1997;10:131-5.
12. Keith SE, Miller BH, Woody RD, Higginbottom FL. Marginal discrepancy of screw-retained and cemented metal-ceramic crowns on implants abutments. Int J Oral Maxillofac Implants 1999;14:369-78.
13. Kersten S, Tiedemann C. Strength and marginal fit of full and partial porcelain crowns on Brånemark implants. Clin Oral Implants Res 2000;11:59-65.
14. Sutherland JK, Loney RW, Syed S. Marginal discrepancy of all-ceramic crowns cemented on implant abutments. J Prosthodont 1995;4:173-7.
15. Phillips RW, Biggs DH. Distortion of wax patterns as influenced by storage time, storage temperature, and temperature of wax manipulation. J Am Dent Assoc 1950;41:28-37.
16. Lasater RL. Control of wax distortion by manipulation. J Am Dent Assoc 1937;27:518-24.
17. Fusayama T. Factors and technique of precision casting Part I. J Prosthet Dent 1959;9:468-85.
18. Whitworth JM, Makhani SH, McCabe JF. Cure behaviour of visible light-activated pattern materials. Int Endod J 1999;32:191-6.
19. Meiners H, Kunzemann T. Wax relaxation in the making of cast crowns. Dtsch Zahnarztl Z 1983;38:18-20.
20. Cahi E, Rosen M, Becker PJ. A comparison of the dimensional stability of three inlay pattern materials. J Dent Assoc S Afr 1996;51:337-42.
21. Rueggeberg FA, Caughman WF, Curtis JW Jr., Davis HC. Factors affecting cure at depths within light-activated resin composites. Am J Dent 1993;6:91-5.
22. Iglesias A, Powers JM, Pierpont HP. Accuracy of wax, autopolymerized, and light-polymerized resin pattern materials. J Prosthodont 1996;5:201-5.