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The Effects of Custom Tray Material on the Accuracy of Master Casts

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Aim: In addition to the impression material, the type of impression tray influences the accurate dimensional transfer of the size and position of the teeth to the master cast. The aim of this study was to determine the accuracy of master casts produced from an alginate impression material using a visible-light-curing resin and autopolymerizing polymethyl methacrylate resin custom tray materials.

Methods and Materials: Two types of custom trays were fabricated from a stainless steel master model with three index studs. Twenty-two irreversible hydrocolloid impressions were made of the master model and then poured with a Type III dental stone. The distances between the reproduced index studs were measured to +/- 0.01 mm with a digital caliper. A one-way analysis of variance (ANOVA) and T-test were used for data analysis.

Results: There were no significant differences between the two tray materials for any of the three distances. There were no statistical differences between the master model and the casts made from the two tray materials in the length dimension, but there were significant differences in the vertical dimension. In terms of the width dimension there was a significant difference only between the cold curing group and the master model.

Conclusion: Within the limitations of this study, the dimensions of stone casts poured from an impression made using a light-cured tray did not differ significantly from those created from impressions made using autopolymerizing acrylic trays. However, working dies from the light-curing tray impressions were more accurate buccolingually than those from the autopolymerizing acrylic trays.

Clinical Significance: The accuracy of master cast reproduction using visible-light-curing resin or an autopolymerizing polymethyl methacrylate resin custom tray material is acceptable. Although autopolymerizing resin materials require less equipment and are relatively more inexpensive, light-cure tray materials may be the material of choice for custom tray fabrication due to greater accuracy in the buccolingual dimension.

Keywords: Impressions, impression trays, impression technique, dimensional accuracy

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Introduction

Accuracy and dimensional stability of an impression material are paramount to the overall accuracy of an impression and the cast made from it.[1] Distortion of a master cast is a three-dimensional problem related to impression accuracy which can be influenced by several factors such as the type and viscosity of impression material, the type of impression tray, model location, impression technique, time of pouring, and the repetition of pouring that can be analyzed.[2-5] Errors in dental impressions may be caused by the clinician,[6] impression material,[7] or by the impression technique[8] and are due to shrinkage during the polymerization reaction,[9] the building up of internal stress,[10] as well as deformation of the impression tray.[11-13] Most acceptable limits for accuracy are from 0.1% to 0.27%.[14,15] Other researchers claim a value of 50 μm is the maximum acceptable dimensional discrepancy between a master model and a poured impression made from that model.[16] There are numerous investigations to determine which dental materials should be used to create the most accurate dental cast.[17-20] Most of these studies are about impression materials and their dimensional accuracy[1-3,5,8-9] or the differences between impressions that are made using different tray designs.[7,12-13,17,21-28] However, there are only a few investigations that focused on custom tray materials and their effects on the accuracy of resultant master casts. Clinically, there are many kinds of custom impression materials available for dental use. The most popular materials are autopolymerizing polymethyl methacrylate and visible-light-curing resins. Martinez et al.[29] examined the accuracy of master cast production using a polyvinylsiloxane impression material in conjunction with two visible-light-cured resin custom trays and an autopolymerizing polymethyl methacrylate resin custom tray. They stated all three tray materials produced acceptable casts, and the small measured differences in cast dimensions may not have clinical significance.

The aim of this study was to examine the accuracy of master cast production using an alginate impression material along with a visible-light-curing resin custom tray and an autopolymerizing polymethyl methacrylate resin custom tray because of the importance of an accurate model in the fabrication of a dental prosthesis.[30-32]

Methods and Materials

The Master Die

The method used in this study was the same as the study by Tan et al.[33] and Jagger et al.[34] A stainless steel die was made to simulate the shape of a maxillary arch (Figure 1).

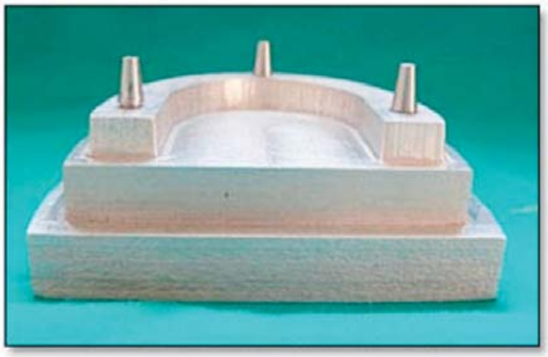


Figure 1. Stainless steel die simulating the shape of a maxillary arch.

Three tapering cylindrical studs were pressed into the top surface of the simulated ridge, one at the anterior midline and two at the molar areas, to serve as landmark reference points. All horizontal surfaces were precisely machined and smoothly finished to make them parallel to each other. The opposing vertical surfaces had a 10° convergence to facilitate the separation of the impression from the die. The sharp line angles were rounded off to avoid tearing the impression material during manipulation.

Custom Tray Fabrication

The die was covered evenly with two layers of baseplate wax (Dentsply, Dentsply Co., London, England) and duplicate casts were made of the relieved die. Custom trays were made using a visible-light-curing resin (Tray material UV, Bredent medical GmbH & Co. KG, Senden, Germany) and an autopolymerizing polymethyl methacrylate resin (Meliodent, Heraeus-kulzer GmbH, Wehrheim, Germany) from the duplicate casts according to manufacturers' instructions (Figure 2).

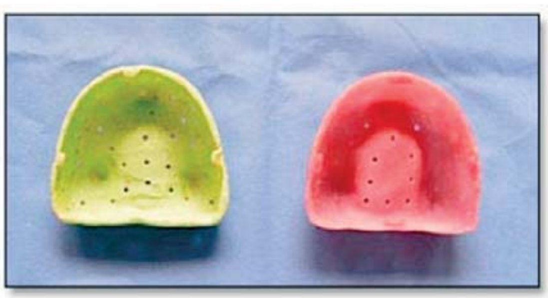


Figure 2. Custom trays.

A light curing unit (Polylux, Bredent medical GmbH & Co.KG, Senden, Germany) was used for 10 minutes for curing each visible light-cured resin tray. Four steps (keys) were placed along the border of the tray to ensure the trays could be seated in a reproducible position in relation to the die during impression making. The time interval between tray construction and impression making was 24 hours to compensate for autopolymerizing resin shrinkage.

Identical retention holes (1.5 mm diameter and 5 mm distance from each other) were prepared manually in all custom trays to provide mechanical retention of the impression material.

Impression Making

Irreversible hydrocolloid impression material was used in this study because of its accuracy and handling characteristics, making it suitable for both diagnostic and final impressions in the fabrication of removable partial dentures. This material is easy to use and relatively inexpensive.[35]

The impression material (Alginoplast, Heraeus Kulzer, Hanau, Germany) was mixed, a small amount of the alginate was applied around the three studs on the metal die, then a custom tray loaded with alginate was seated onto the die to make the impression. The setting time was doubled to insure sufficient polymerization of the material because of a 23°C room temperature. Upon removal all impressions were rinsed for 10 seconds under cold tap water to simulate clinical conditions. Excess water was shaken off by hand from the impressions. The impression trays were then removed, and the resulting impression was examined macroscopically for the absence of air bubbles.

Cast Fabrication

The impressions were poured with a Type III dental stone (Mold stone, Pars dandan Co., Tehran, Iran) which was mixed properly under vacuum and handled according to the manufacturer instructions. All impressions were allowed to sit for 1 hour before removal of the casts. Upon removal the casts were again checked macroscopically for the absence of air bubbles. Any discrepancy found between stud surfaces and a glass slab provided evidence the gypsum cast was distorted. As a result, three casts were excluded from the statistical analysis.

Finally, eleven impressions were taken for each type of tray. The stone casts were left to bench dry for 24 hours then measurements of the metal master die and stone casts were recorded using an electronic digital caliper to the nearest 0.01 mm (Electronic Digital Caliper, Minova Co., Osaka, Japan).

The distances between the studs were measured to +/- 0.01 mm in three dimensions as follows:

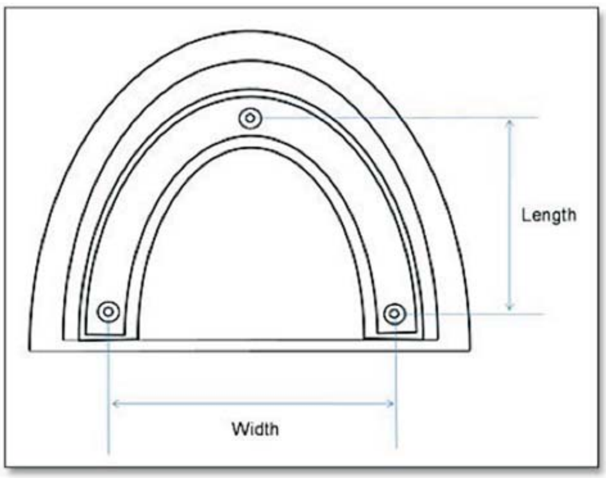


Figure 3. Diagram of measurements made on the X-Y plane.

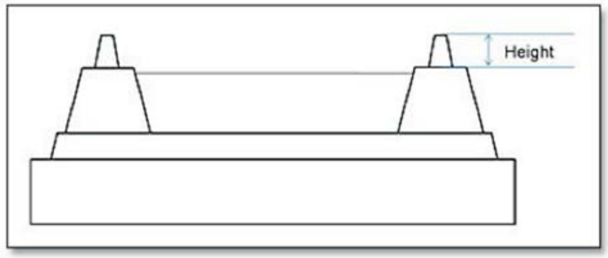


Figure 4. Diagram of measurement made on the vertical plane.

- **Length:** The distance between the center of anterior and posterior left studs.
- **Width:** The distance between the centers of two posterior studs (Figure 3).
- **Height:** The distance between the top of the posterior left stud and the flat portion of the highest metal arch (Figure 4).

Each measurement was repeated three times, and the mean measurement was calculated for each dimension. Data were analyzed by use of a one-way analysis of variance (ANOVA) and a T-test at the 95% confidence level.

Results

The mean difference between casts produced from the two tray materials and the master model were determined for each of the distances between the three measuring points. The mean buccolingual, mesiodistal, and occlusogingival dimensions of the stainless steel model and the working dies are given in Table 1.

Table 1. Means and standard deviations of dimensions of casts poured from two tray materials.

	Group	N	Mean	Std. Deviation
Vertical	Cold cure	11	8.2564	.08535
	Light cure	11	8.2836	.07672
Buccolingual	Cold cure	11	48.8027	.10845
	Light cure	11	48.7136	.16317
Mesiodistal	Cold cure	11	46.2800	.11480
	Light cure	11	46.3164	.33140
Master model dimensions: Vertical: 8.19, Buccolingual: 48.78, Mesiodistal: 46.18				

Table 2. ANOVA table for measurements of each dimension.

		Sum of Squares	df	Mean Square	F	Sig.
Vertical	Between Groups	.004	1	.004	.621	.440
	Within Groups	.132	20	.007		
	Total	.136	21			
Buccolingual	Between Groups	.044	1	.044	2.274	.147
	Within Groups	.384	20	.019		
	Total	.428	21			
Mesiodistal	Between Groups	.007	1	.007	.118	.735
	Within Groups	1.230	20	.062		
	Total	1.237	21			

Table 3. One sample T test, mean values, and statistical differences between master model and study samples.

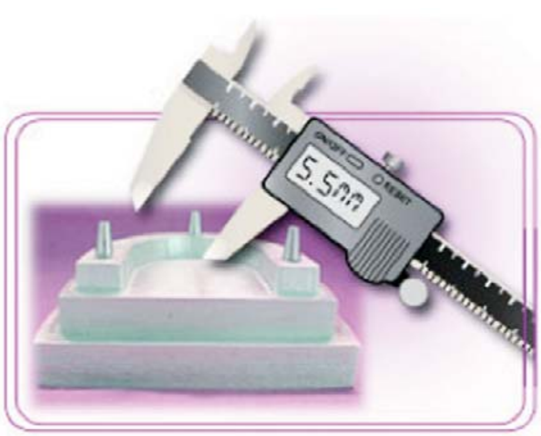
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Vertical	Cold Cure	2.579	10	.027*	.0664	.0090	.1237
	Light Cure	4.048	10	.002*	.0936	.0421	.1452
Bucco-lingual	Cold Cure	.695	10	.503	.0227	-.0501	.0956
	Light Cure	-1.349	10	.207	-.0664	-.1760	.0433
Mesio-distal	Cold Cure	2.889	10	.016*	.1000	.0229	.1771
	Light Cure	1.365	10	.202	.1364	-.0863	.3590

Statistical analysis with one-way ANOVA showed there were no significant differences between any of the tray materials for any of the three distances ($P > 0.05$) (Table 2).

When the results from the two tray materials were compared with the master model, there were no statistical differences between the master model and the casts from the two tray materials in a mesiodistal dimension (arch length). But in the vertical or occlusogingival dimension (stud height) there were significant differences between the two tray groups and the master model. In buccolingual dimension (arch width) there was a significant difference between the cold-cured tray group and the master model, but there was no significant difference between the light-cured tray group and the master model (Table 3).

Discussion

When fabricating an indirect restoration, the accuracy of the impression tray may be one of several factors affecting the fitness of the final restoration.[5,13,17,22] Dental impression tray materials have been evaluated through an analysis of the resulting dental casts. These dental casts have been fabricated from a master die in either a linear or arch-form configuration.[13,17,26] Linear dental casts are not similar in shape to the dental arch and, therefore, it would seem a dental cast with an arch form configuration would be more clinically relevant in the evaluation of the impression material.[17] The machined stainless steel standard used in this investigation provided certain advantages in obtaining the measurements over a prepared plastic typodont tooth. The well-defined line angles and walls of this model could reduce measurement error.[5]



Both measuring microscopes and calipers have been used in the evaluation of dental casts.[5,16-17,21-24,29,32] Calipers are easy to use, provide quick results, and are readily available, but they are time-consuming, permit error due to operator fatigue, and make linear measurements only between two points. Measuring microscopes are more precise but they are expensive to purchase and maintain and may need special software to analyze the data.[5,17] In the present study three aspects of each cast were measured (buccolingual, mesiodistal, and occlusogingival) with an electronic digital caliper so a three-dimensional representation of accuracy could be assessed.[5]

Martinez[29] studied the effects of three custom tray materials on the accuracy of resultant casts and concluded all three tray materials produced acceptable casts, and the small measured differences in cast dimensions may not have clinical significance. In 2002, two studies[17,36] evaluated the effect of tray type selection on accuracy of resultant casts. Results obtained indicated the impression tray type did not affect the accuracy of final casts. In a study by Thongthammachat et al.[21] two types of stock trays (plastic and perforated metal) and four types of custom tray materials (autopolymerizing acrylic resin, thermoplastic resin, and two types of light-polymerized acrylic resins) were used with two types of impression materials (addition polymerizing silicone and polyether) to make impressions of a metal master model. They concluded accurate casts can be made with either stock trays or custom trays. Ceyhan et al.[5] stated different trays and impression materials may yield different results. They concluded clinically acceptable impressions can be made when plastic or metal trays are used with either a monophase or rigid impression material. In the present study the dimensions of stone casts from a light-curing tray impression did not differ significantly from those created with autopolymerizing acrylic trays. But after measuring casts produced from models of the upper and lower jaws another study[7] reported the type of the used impression tray influences the accurate dimensional transfer of the teeth position to the master cast in addition to the impression material.

Although all casts were larger in mesiodistal dimension (arch length) than the original model, there were no statistical differences in this dimension between the master model and the casts from the two tray materials in the present study. This may be due to shrinkage of impression material toward the center of mass during the polymerization reaction and the distance between two dies becomes larger. However, the use of a tray adhesive would redirect this shrinkage toward the impression tray walls. In the absence of a tray adhesive there is unrestricted polymerization shrinkage of the impression material.[5] Tray adhesive was not used in this study because both tray types had mechanically retentive features, and the aim of the study was to compare the dimensional accuracy of tray materials by indirect means. In the study by Ceyhan et al.[5] there was a significant interaction of tray type with impression material viscosity in the mesiodistal dimension.

There was a significant difference between the cold-cure group and the master model in the buccolingual dimension (arch width), but there was no significant difference between the light cure group and the master model. Although impression material shrinkage was still present in this dimension, the effects of a higher polymerization shrinkage of autopolymerizing resins cannot be overlooked.[7] However, some authors have suggested variations in the type of trays used have no effect on the accuracy of impressions.[9,21,22,24,29] The buccolingual dimension of the autopolymerizing tray group was larger than the master model but smaller in the light-cure group (Table 1).

The constriction area of the impression material varied in different parts of the impression, however, this phenomenon is complicated and difficult to explain.[30] Ceyhan et al.[5] revealed each die was larger in a buccolingual direction and narrower in a mesiodistal direction in their study. This may explain the increase in the mesiodistal distance and the decrease the buccolingual distance between the dies.

The vertical dimension (stud height) was significantly larger than the master model in both groups. According to Ceyhan et al.[5] the occlusogingival dimension of the gypsum dies generated from the two impression materials were larger than the master dies. But they stated although statistically significant differences were found, the magnitude of these differences was clinically insignificant. The difference between that study and the present study may be due to a difference in impression materials used.

Conclusion

Within the limitations of this study, the dimensions of stone casts from a light-cure tray impression did not differ significantly from those created with autopolymerizing acrylic trays. However, working dies from a light-cured tray impression were more accurate buccolingually than those from autopolymerizing acrylic trays.

Clinical Significance

The accuracy of master cast reproduction using visible-light-curing resin or an autopolymerizing polymethyl methacrylate resin custom tray material is acceptable. Although autopolymerizing resin materials require less equipment and are relatively more inexpensive, light-cured tray materials may be the material of choice for custom tray fabrication due to greater accuracy in the buccolingual dimension.

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