Original Article

EFFECT OF IMPRESSION MATERIAL, TRAY SPACE AND ATTACHMENT ON CAST ACCURACY

Ayodeji Idowu,* BDS, MS
H. Mohammed-Al Tahawi,* DDS, MScD, PhD
Yousef F. Talk,* BDS, MSc
Bassem F. ElMallakM BDS, MSc, PhD

تمت هذه الدراسة في جامعة الملك سعود – كلية طب الأسنان أخذت طبعات نهائية لأطقم جزئية باستعمال مادة المطاط المتعدد الكبريت الألجينات السريعة التصلب وذات التصلب العادي وكان الطابع الإفرادي المستعمل ذات فراغ واحد أو فراغين • استخدمت طريقتين لالتحام مادة الطبعة بالطابع وذلك باستعمال مادة لاصقة أو بطريقة التثقيب • استخدم مثال لطقم جزئي الصنف الثالث لكندي ذو فراغين • أخذت ثلاث نقاط للقياس أ ، ب ، ج على المثال الرئيسي من كل الطبعات ، كانت مجموع القراءات ٤٨٠ قراءة (٨٠ مثال x ٣ أبعاد x ٢ قراءتين) تم التحليل إحصائياً بطريقتي أنوفا وتيكي •
لم توجد فر وقات إحصائية هامة بين أبعاد أ ب ، أ ج ، ب ج وبين المثال الرئيسي • وجدت فروقات إحصائية هامة بين المثال المصنوع من طبعات الألجينات والمأخوذة بطابع إفرادي ذات الفراغ الواحد وذلك المصنوع من الألجينات السريعة التصلب ا في المثال المصنع من الطابع ذات الفراغين •
من الدراسة تبين أن جودة التحام مادة الطبعة على الطابع وصب المثال الرئيسي في خلال(٥دقائق) هي السبب الرئيسي في دقة المثال وليست مادة الطبع سواء كانت الجينات أو مطاط متعدد الكبريت •

At King Saud University's College of Dentistry, final impressions for removable partial dentures are made using polysulfide rubber, fast-set and regular set irreversible hydrocolloid impression materials. Custom trays used are either single-spaced or double spaced. Further, impression material attachment to the tray could be through tray perforations or the use of adhesives. Literature to support each one of these methods separately to obtain an "accurate impression" is available. There is, however, a dearth on literature reporting on the influence of these combined variables. The purpose of this investigation was to simultaneously study the influence of impression material type, tray space and method of tray attachment on the accuracy of the resulting cast dimensions. A factorial experimental design was used. One master model representing a Kennedy Class 111 Modification 2 partial edentulous arch was used. Three reference points A, B, and C were placed on the master cast and reproduced on all experimental casts. Ten combined variables of tray space (2), impression material (3), and method of tray attachment (2) were used. Eight casts were made utilizing each of the combined variables resulting in 80 experimental casts. The dimensions AB, AC and BC were accurately measured (+10 jL/m) on the master model and all experimental casts. Each measurement was repeated twice and averaged resulting in 480 experimental measurements (80 casts x 3 dimensions x 2 readings). One way analysis of variance (ANOVA) was utilized to discern differences between the dimensions of the master model and those of casts produced by each of the combined variables including the effect of the impression material. Tukey's standardized range test was used to discern accuracy differences among the combined variables. Statistical analyses revealed no significant differences for the dimensions A-B, A-C, or B-C between the master model and those produced by the ten combined variables. Nonetheless, the mean B-C dimensions on casts produced by the ten combined variables tended to be smaller (though not significantly) than for the master model. Further, while there were no significant differences for the dimensions A-B and A-C among casts produced by the ten combined variables, significant differences were detected for the B-C dimension. Casts poured in regular set alginate impressions in single spaced perforated trays showed significantly larger B-C dimension than those derived from fast-set alginate impressions in double spaced perforated trays ($P<0.05$). Provided that impressions are well attached to their trays and poured immediately (within 5 minutes), tray conditions tested in this study had no effect on accuracy of casts poured from either polysulfide or either of the irreversible hydrocolloid impression materials.

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"Lecturer, Department of Prosthetic Dental Sciences, College of Dentistry, King Saud University
^Professor of Biomaterials, Dept. of Restorative Dental Sciences, College of Dentistry, King Saud University
• Associate Professor and Chairman, Dept of Prosthetic Dental Sciences, College of Dentistry, King Saud University
• Previously Associate Professor of Biomaterials, Dept. of Prosthetic Dental Sciences, College of Dentistry, King Saud University
Address reprint requests to: Dr. Ayodeji Idowu, College of Dentistry, King Saud University, PO Box 60169, Riyadh 11545, K.S.A.

Introduction

The accuracy and dimensional stability of impression materials as well as the effectiveness of impression tray space and mode of attachment have continued to generate much interest.

Among the commonly used impression materials (hydrocolloids and elastomers), the elastomeric impression materials are more popular because of their proven accuracy and reliability.[1] In fact, delayed and repeated pouring of elastomers have not been found to diminish their accuracy.[2] The addition silicone impression materials (polyvinyl siloxane) are found to be the most accurate in dimensional stability and surface reproduction among the elastomers.[2-4] They have the least polymerization shrinkage and produce no reaction by-products.[5-6]

Although irreversible hydrocolloids are the least popularly used impression materials in fixed prosthodontics, the reverse is the case in removable prosthodontics.[7] Most often full arch impressions are recommended in removable prosthodontics. When a full arch impression is indicated the stiffness and the cost of the material are of prime consideration because of undercuts encountered and the bulk of material needed, respectively. While stiffness could be a desirable attribute of an impression material as it prevents permanent deformation on removal from slightly undercut areas, it could also constitute an undesirable resistance to removal from significantly undercut areas.

Irreversible hydrocolloid impression materials have been demonstrated to produce accurate casts especially when poured immediately[8] and their accuracy was found to be comparable to elastomeric impression materials.[9] One study found reversible hydrocolloid to be more accurate than condensation silicone when used in a stock tray[3] as opposed to an earlier observation.[10] The irreversible hydrocolloids introduced specifically for crown and bridge impressions have been demonstrated to have comparable dimensional accuracy with silicone impression materials.[11] Among all impression materials, the hydrocolloid impression materials have been found to exhibit the lowest contact angles with saliva.[12] It is easier and less time consuming to repeat an unacceptable irreversible hydrocolloid impression with less cost than to repeat an elastomeric impression.

Of all impression tray design factors evaluated, rigidity of the tray has been consistently demonstrated to be a prerequisite for an accurate impression.[13,15] Although custom acrylic resin trays with tissue stops are recommended,[16] no statistically significant differences were found among dimensional accuracies of impressions made with stock trays or with custom trays.[17,18]

Although rubber base impressions are reported to be most stable when an even thickness of 2-4 mm is present within the tray,[5,16-19] tray space has not been found to affect the accuracy of dies produced from polyvinyl siloxane impression materials.[18-20]

While Tjan and Whang (1987)[21] found no difference in the accuracy of material whether trays were perforated or unperforated so long as an adhesive had been applied, Bonberg et al. (1988)[22] found that impressions were more accurate when taken in trays with perforations.

There is, however, paucity of information on the effect of the combination of tray design factors and type of impression material on the dimensional accuracy of impressions. The purpose of this study was to evaluate the effect of tray space and the mode of impression attachment on the accuracy of casts produced from impressions made in two types of irreversible hydrocolloids and one elastomeric (polysulfide) impression materials commonly used in removable prosthodontics.

Materials and Methods

The master model used in this study was a maxillary manikin model that simulates Kennedy Class III modification 2 partial edentulous arch (Fig. 1). The missing teeth were #s 11, 12, 21, 22, 24, and 25 as well as the third molars which were not taken into consideration in the classification.

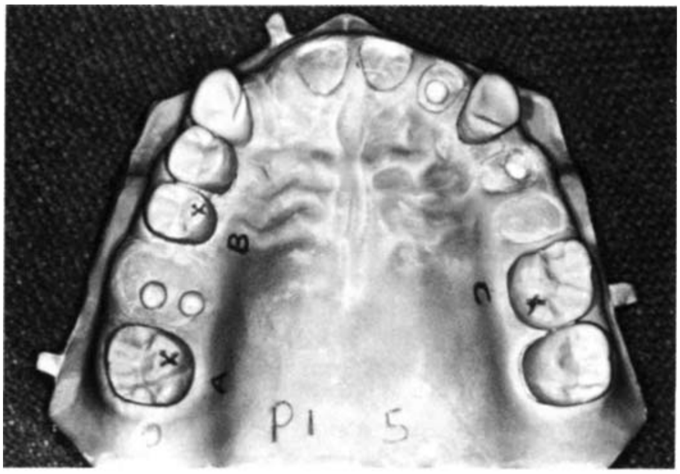

Figure 1. Master model used.

Kennedy.Class 111 and Class IV removable partial dentures are regarded to be more complex geometrically and found to fit less accurately than Kennedy Class I and Class II removable partial dentures.[23] The selection of this master model of the Kennedy Class III type is with the assumption that its reproduction by various impression materials will be more discriminatory than using a master model of posterior shortened dental arch type.

Ten (10) custom trays with tissue stops and horizontal handles were constructed from self-curing acrylic resin material. Five trays were adapted on a single thickness base-plate wax spacer (2 mm). A double thickness baseplate wax spacer (4 mm) was used for the other five trays. To standardize the size and critical spatial dimensions of the trays, each size of tray was adapted on a primary cast of the master model. To avoid later contami-nation of the tray with the wax spacer and avoid interference of the wax contaminants with the tray adhesive placement, all wax spacers were covered with a well adapted 0.3 mm thick aluminum foil.

. Table 1. Factorial design of tested combined variables.

Impression Material (M)	Tray Condition			
	Single Spaced (S,)		Double Spaced (S_2)	
	Non-perforated (P.)	Perforated (P,)	Non-perforated (Po)	Perforated (P,)
Polysulfide (M,)	M,S,P_0	-	M,S_2P_0	-
Regular Alginate	M_2S,P_0	$M_2S,P,$	$M_2S_2P_0$	$M_2S(P_1)_2P,$
Fast Alginate (M_3)	M_3S,P_0	$M_3S,P,$	$M_3S_2P_0$	$M_3S_2P,$

The ten trays were divided into five (5) groups. Each group consisted of one single spaced and one double spaced tray. One group of trays was used for regular body polysulfide impression of medium viscosity (Kerr Romulus, Mi, USA). The second group was used for Type 1 fast set hydrophilic alginate impressions (COE Hydrophilic Gel, GC America Inc., Chicago Illinois, USA). The third group was used for the regular set alginate impressions (Jeltrate, Caulk Dentsply International Inc. Milford Delaware, USA). For these three groups, the trays were non-perforated and the appropriate tray adhesive recommended by the manufacturer was used. The fourth and fifth groups were evenly perforated and were used for fast-set and regular set alginate impressions without tray adhesive. Using three impression materials, two tray spaces and two methods of attachment for two of the three materials, the ten combined experimental variables shown in Table 1 resulted.

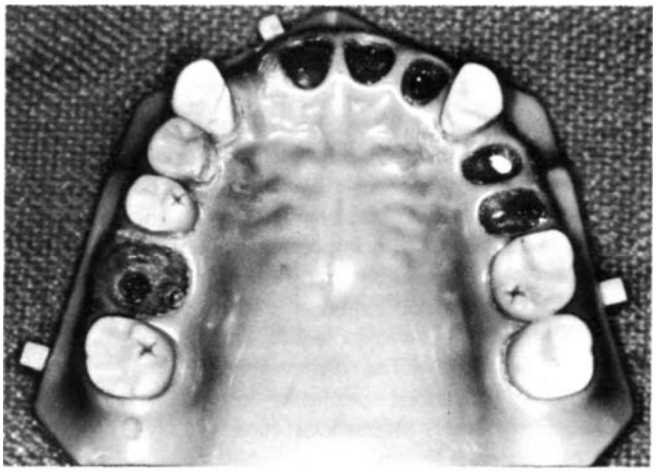

Figure 2. Three measured dimensions A-B, A-C and A-D.

Three (3) reference points A, B, C were prepared on flattened mesio-lingual cusp tip of #17, the lingual cusp tip of #15 and the disto-lingual cusp tip of #26 on the master model (Fig. 2). Each reference point was the intersection of the two v-shaped cuts forming a letter x. The acute angle corner of an inverted cone carbide bur #35 was used to effect the cuts. The reference points were reproduced on the casts by the various impressions. All impressions were poured immediately in die stone (Excaliber die stone, Gaereco Heberspings, CA, USA).

The die stone was firstly hand spatulated for 10 seconds and later vacuum mixed for 20 seconds (Vacuum Mixer, Whip Mix Corp., Louisville, KY, USA). Water/powder ratio of 22.0 ml/100.0 gm was used as recommended by the manufacturer. The stone casts were removed from the impressions at least 1 hour after they were poured. Measurements were made at least 24 hours after the stone had set. Eight (8) stone casts were reproduced from each of the ten impression trays yielding 80 casts. Three (3) measurements (AB, AC and BC dimensions) were made on each cast. Each measurement was repeated resulting in a total number of 480 readings [80 casts X 3 readings/cast X 2 repeats = 480] or 240 means. The distances between AB, AC and BC were measured using a travelling microscope with an accuracy of +10 ^m [Titan TM-8 measuring microscope. Titan tool Supply Co., Inc. Buffalo, NY, U.S.A.] (Fig. 3).

A one-way analysis of variance (ANOVA) was used to discern differences in mean dimension measurements for A-B, A-D and B-C between casts produced by each of the three combined variables of Table 1 and the master model. Differences within the combined variables were determined by Tukey's standardized range test. All results were considered statistically significant when the P-values was <.05.

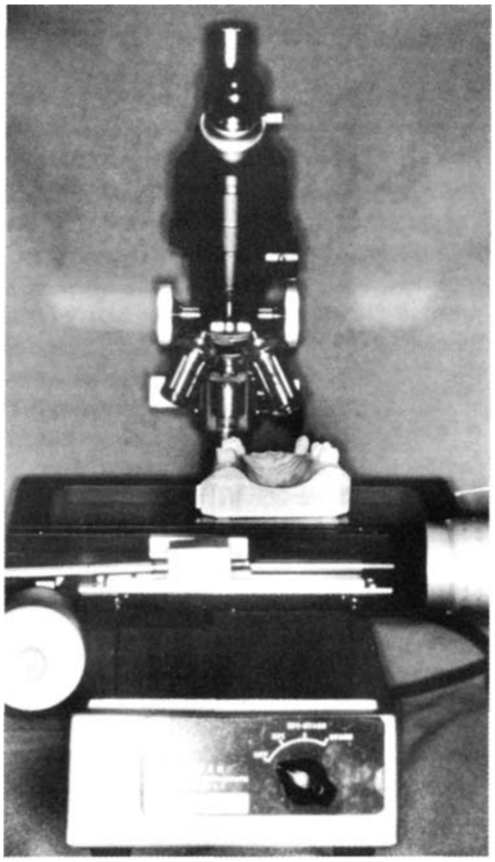

Figure 3. Measuring microscope in use.

Results

A-B Dimension

The mean A-B dimension measurements for casts produced from the ten combined variables of Table 1 are shown in Table 2. None of the combined variables tested resulted in a mean A-B dimension significantly different from that measured on the master model (P=0.1080). Further, there were no significant differences in the dimension A-B among casts produced by the ten combined variables.

Table 2. Means and standard deviations of distance between reference points A and B on casts produced by various impression materials and tray conditions (n=8).

Impression Material	Tray Condition			
	Single Spaced		Double Spaced	
	Non-perforated (mm)	Perforated (mm)	Non-perforated (mm)	Perforated (mm)
Polysulfide	M,S,P_0 18.19 + 0.16	-	M,S_2P_0 18.22 + 0.09	-
Regular Set Alginate	M_2S,P_0 18.11 + 0.16	$M_2S,P,$ 18.20 + 0.17	$M_2S_2P_0$ 18.26 + 0.12	$M_2S_2P,$ 18.09 + 0.20
Fast Set Alginate	M_3S,P_0 18.17 + 0.16	M^P, 18.22 + 0.14	$M_3S_2P_0$ 18.32 + 0.18	$M_3S_2P,$ 18.13 + 0.17

Mean distance (A-B) value for master model = 18.13 ± 0.10

A-C Dimension

The mean A-C dimension measurements for casts produced from the ten combined variables of Table 1 are shown in Table 3. None of the combined variables tested results in a mean A-C dimension significantly different from that measured on the master model (P=0.7138). Further, there were no significant differences in the dimension A-C among the ten combined variables tested.

B-C Dimension

The mean B-C dimension measurements for casts produced from the ten combined variables of Table 1 are shown in Table 4. None of the combined variables tested resulted in a mean B-C dimension significantly different from that measured on the master model (P=0.7138). The mean B-C dimension measurements of all casts tended to be smaller (though not significantly) than the actual master model measurements.

There were significant difference in the B-C dimension for casts produced by the various combined variables. The casts poured from regular set alginate impression in single spaced, perforated trays showed significantly larger B-C dimensions than those of casts derived from fast set alginate impressions in double spaced, perforated trays (P<0.05).

present study does not support this finding. Both irreversible hydrocolloids (regular and fast set hydrophilic) impression materials produced casts that were dimensionally comparable to casts produced by polysulfide impression material and also to the master model.

Accuracy of the casts are directly related to the water loss or gain by the irreversible hydrocolloid impression materials.[24] When the impression material loses water by syneresis, shrinkage is possible. This shrinkage could cause the measured reference points to be farther apart. However, if water is gained by imbibition, this may cause the material to swell. The swelling may cause the measured reference points to be closer together. The immediate pouring of irreversible hydrocolloid impression materials minimizes the effect of syneresis and imbibition. The alginate impressions used in this study were mixed and manipulated according to

Table 4. Means and standard deviations of distance between reference points B and C on casts produced by various impression materials and tray conditions (n = 8).

Impression Material	Tray Condition			
	Single Spaced		Double Spaced	
	Non-perforated (mm)	Perforated (mm)	Non-perforated (mm)	Perforated (mm)
Polysulfide	M,S,P_{fl} 45.04 + 0.16	-	**M,S_2P_0** 44.94 **+ 0.18**	-
Regular Set Alginate	M_2S,P_0 44.90 + 0.17	**$M_2S,P,$** § 45.16 + 0.26	**$M_2S_2P_0$** 44.89 + 0.18	**$M_2S_2P,$** **44.96 + 0.43**
Fast Set Alginate	M_3S,P_0 44.91 + 0.24	**$M_3S_1P_1$** 44.96 + 0.20	**$M_3S_2P_0$** 44.97 + 0.25	**$M_3S_2P,$** *t* 44.74 + 0.27

Discussion

Relative to hydrocolloids, elastomers are stiffer impression materials. The stiffness is a desirable attribute as it prevents permanent deformation upon withdrawal from undercuts and seems to neutralize the expansion of the die stone. It is, therefore, not surprising to find in this study as in others[13] that polysulfide impression material produced accurate casts that are dimensionally comparable to the master model.

Hydrocolloid impression materials, on the other hand, are reported to be less dimensionally accurate than elastomers.[13] The

manufacturers recommendations and poured immediately. This may explain why accurate casts were produced as in other studies."[24-25]

The tray conditions tested in this study did not have any effect on the accuracy of casts poured from either polysulfide or either of the irreversible hydrocolloid impression materials.

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