The effects of custom tray material on the accuracy of master cast reproduction

Hyun-Kyung Kim, DDS, Ik-Tae Chang, DDS, MSD, PhD,
Seong-Joo Heo, DDS, MSD, PhD, Jai-Young Koak, DDS, MS, PhD,
Department of Prosthodontics, College of Dentistryl, Seoul National University

The accuracy of master cast reproduction by a polyvinylsiloxane impression material using two visible-light curing resin and autopolymerizing polymethyl methacrylate resin custom tray material was investigated.
Custom trays were fabricated from a master cast that had three index points marked on both inner and outer vestibules and then poured in yellow stone. The distance between the reproduced index points were measured to be ± 0.001mm with a measuring microscope and the algebraic norms calculated for each tray material.
No differences were found in the algebraic norms of inner and outer dimensions for upper tray impressions by ANOVA($p>0.05$). However, T-test revealed that there were differences between upper and lower impressions and Tukey' s hsd test revealed that in lower tray impressions, the Palatray in inner, the Lightplast in outer dimensions respectively were different from other materials. The index points reproduced on the casts compared with the master cast, were closer together for upper tray impressions.
All four tray materials produced acceptable casts,

1. Algebraic norms of inner and outer dimensions of the test casts for upper trays were not statistically different irrespective of materials.($P>0.05$)
2. T-test showed that there were differences between means with upper and lower trays especially in outer dimension.($P>0.05$)
3. But, algebraic norms of inner and outer dimensions of the test casts for lower trays were statistically different between materials.
4. Palatray XL in inner, Lightplast-platten in outer dimensions respectively for lower trays were different from other materials, but, the nearest to the original model.

Key Words
Impression trays, casts, reproduction accuracy, visible-light-cured resin, acrylic resin

Custom-made trays for prosthodontic impression procedures are designed to provide a uniform thickness of impression material to improve the accuracy of the resultant working cast.[1,2] The use of such a tray can also reduce the amount of impression material needed. Dimensional stability of custom impression trays is an important factor in determining the degree of accuracy achieved in forming a master cast. Such trays must remain stable over time and must not exhibit permanent deformation when a completed impression is removed from the oral cavity. Measurement of the dimension of the cast allows comparison between various tray materials and is useful in selection of them.

Autopolymerizing acrylic resins traditionally have been used for the fabrication of these trays. However, concerns regarding the exposure of dental personnel to the acrylic resin monomer have prompted a search for alternative tray materials that are safe, economical and easy to use. Visible light-polymerizing resins were introduced several years ago,and manufacturers of these materials have suggested that they may be used with ease and success for making custom trays.

Regardless of the type of material used,the custom tray materials should be dimensionally stable, rigid, moisture resistant, retentive to impression materials or adhesive, easily fabricated, inexpensive and have long shelf life.

Trays made from shellac or through vacuum forming procedures have low moduli of elasticty, while those made of two-component composite resin materials have insufficient constancy of shape and volume.[3] The introduction of autopolymerizing acrylate polymers brought significant improvement to the mechanical properties of custom trays. Because it had some problems of dimensional stability, moisture sensitivity, etc., they are unsuitable to make for galvanic cast fabrication. Furthermore, the relatively complicated fabrication techniques, requiring work in the dental laboratory, all too frequently tempt the dentist to forsake use of a custom tray.

Dimensional stability of autopolymerizing acrylic resin tray materials has been the subject of many studies, with most recommending a waiting period of 20 to 24 hours before use.[4] However, a study of eight autopolymerizing acrylic resin tray materials showed that the only significant dimensional changes(0.2%) occurred during the polymerization stage and up to 30 minutes after initial set. It was concluded that these changes would have no effect on the resultant master cast, immediate use of the custom tray would be clinically acceptable.[5] A subsequent study concluded that impression made with trays aged for 24 hours were more accurate than trays used within 30 minutes, with both being more accurate than stock trays.[6] Other studies of autopolymerizing acrylic resins demonstrated that the most significant dimensional changes occured in the first 2 hours,and it was recommended that the custom trays be aged for 9 hours before use.[7] If, however, immediate use of the custom tray is required, boiling the tray for 5minutes accelerates the rate of polymerization and attendant dimensional changes.[7] A subsequent study showed that shrinkage of the resin occurred toward the master cast in the anterior and posterior areas. Furthermore there was shrinkage of the posterior flanges toward the anterior, with the lingual flange shrinking at a faster rate.[8] These dimensional changes occurred within the initial 20 to 40 minutes, with additional changes occurring up to 6 hours after curing. It was concluded that making an impression was acceptable after 40 minutes from the time of the tray was fabricated, but only if the impression was to be poured immediately. Visible light-polymerizing resins, however, have been reported to be dimensionally stable immediately after complete polymerization with the use of an appropriate light source and exposure time.[9] They are characterized by improved physical characteristics such as increased stiffness, good form and volume stability, and low sensitivity to moisture. In addition, these materials are easy to use and they save time. The dental assistant can use such materials in the operatory to make trays that can be used immediately and that are suitable for galvanic cast preparation. The ability to use a custom tray immediately after fabrication would be advantageous in many clinical situations.

Previous studies comparing the physical properties and dimensional stability of two VLC resins and three autopolymerizing acrylic resins likewise confirmed the superior properties, typically strength, water sorption/solubility and dimensional stability of the VLC resins.[9,10] In Luis J. Martinez' s study[11], Triad Trutray (light curing types) produced the most accurate results, Ontray (autopolymerizing) followed that materials in reproductive accuracy. But another light curing types, Triad Blue, produced the casts that were slightly smaller than the master cast, their deviations from the original master cast were the greatest among them. Anyway, there were differences between light curing types.

The purpose of this study was to compare accuracy of master cast reproduction using four different custom tray materials which are used in clinics, namely two visible light polymerizing resins and two autopolymerizing acrylic resins.

MATERIAL AND METHODS

A brass edentulous master model on a stainless steel plate which has lower right ridge was modified with six index points,(Fig. 1) two located in the anterior region and four in the posterior buccal and lingual regions. The index points were placed with a 2mm diameter ball, creating circles. A relief of 2 baseplate wax thickness was created using a silicone with stops placed on the anterior crest of ridge and on the right and left posterior ridge crests(Fig. 2). The relief wax was packed in the flask and washed out and that space was filled with a silicone. If the inner portion of the arch was relieved simultaneously, that is the simulation of upper arch. When that portion is ruled out, it was that of lower arch.

A light coat of petroleum jelly was placed on the master cast and a relief silicone before mak-

Fig. 1. A brass edentulous model with six index points, circles with 2mm diameter.

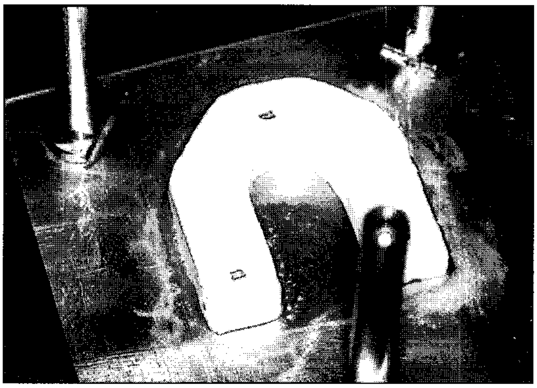

Fig. 2. A standard relief of 2 baseplate wax thickness using a silicone with 3 stops.

Table Ⅰ. Custom tray materials

Material	Type	Manufacturer
SR Ivolen	Autopolymerizing	IVOCLAR/Liechtenstein
QUICKY	Autopolymerizing	Nissin dental products/Japan
Palatray XL	Light polymerized	Heraeus Kulzer/Germany
Lightplast-platten	Light polymerized	Dreve DENTAMID GMBH/Germany

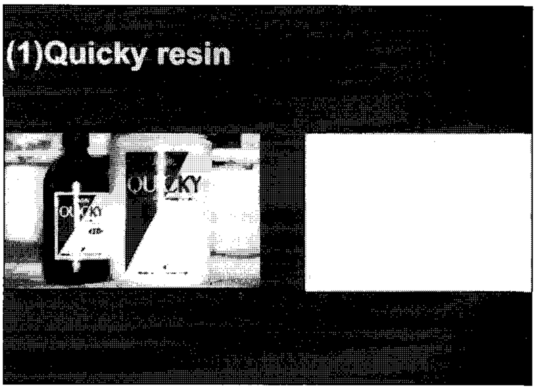

Fig. 3. QUICKY : Nissin dental products : lower arch simulated tray.

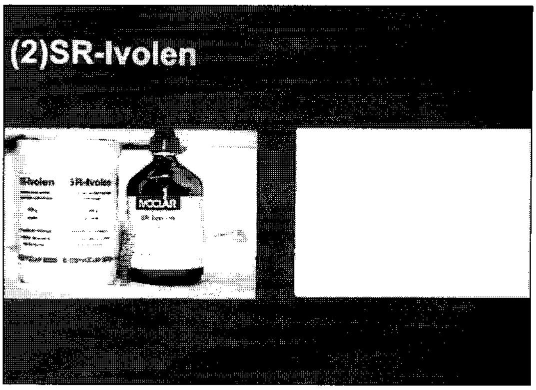

Fig. 4. SR-Ivolen : IVOCLAR : lower arch simulated tray.

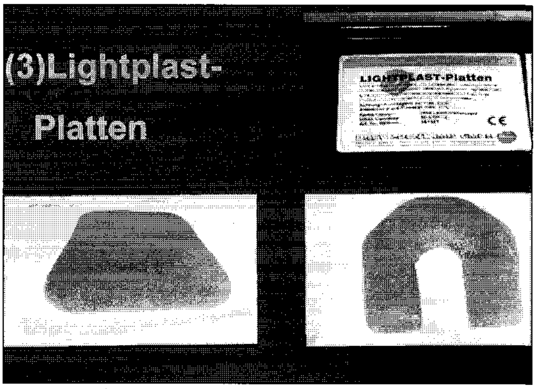

Fig. 5. Lightplast-platten :Dreve DENTAMID GMBH :lower arch simulated tray.

Fig. 6. Palatray XL : Heraeus Kulzer : lower arch simulated tray.

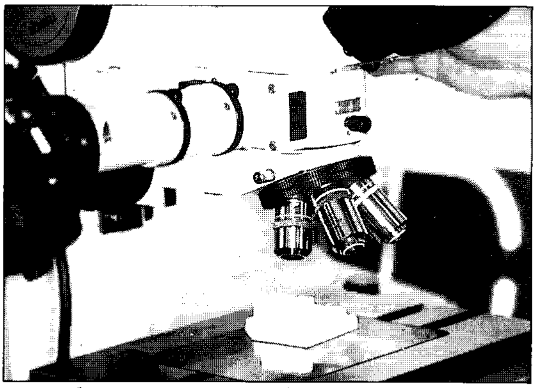

Fig. 7. The distances between the index points were measured using a measuring microscope.

ing all specimens. The custom tray materials are detailed in Table Ⅰ.

Ten custom trays(upper 5, lower 5) were fabricated on the master cast with each of the four test materials:SR Ivolen(Fig. 3), QUICKY(Fig. 4), Palatray XL(Fig. 5), Lightplast-platten(Fig. 6). All materials were handled carefully with the manufacturer' s directions and were maintained on the master cast until the final set was achieved. Acrylic tray materials were fabricated and stored for 24 hours before their use, while the light curing resins were used immediately.

The internal surfaces and borders are roughened with an acrylic bur. The inner tray surfaces were coat-

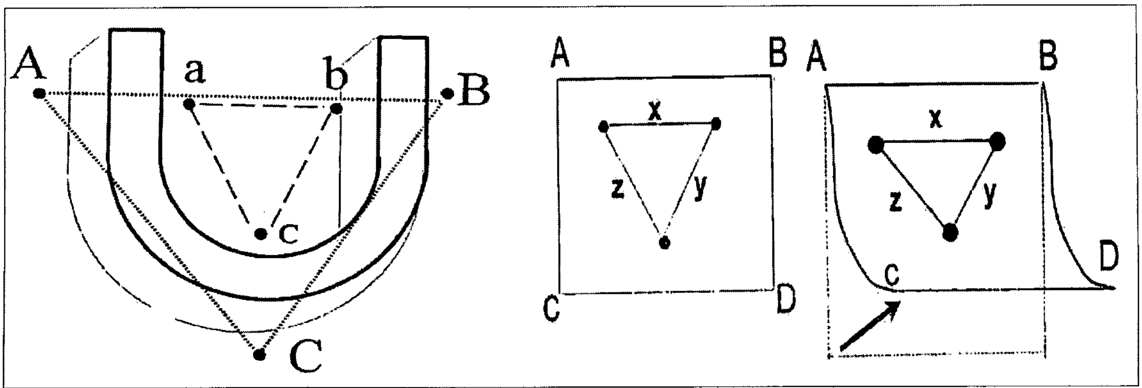

Fig. 8. Algebraic norms reflects dimensional changes. If the lower sheet ABCD is lifted and twisted slightly,there will be changes in distances x,y and z.

ed with adhesive(KERR silicone adhesive/USA), allowed to stand for 20 minutes, and then loaded with a polyvinylsiloxane impression material(Exaflex GC/Japan,Hydrophilic polysiloxane impression material--Injection type) to make impressions of the master cast. After setting for 10 minutes, the tray and impression were removed from the master cast and the excess carefully trimmed using a sharp scalpel. All impressions were examined for surface irregularities on or near the reference markers and to ensure that the markers were reproduced clearly. In accordance with clinical practice, all impressions were stored at room temperature (22℃) and normal relative humidity(68%) for 24hours.[12]

The impressions were poured with yellow stone(Whip-mix silky-rock yellow model stone/USA, with W/P 23ml/100g) measured and vacuum spatulated according to manufacturer' s directions. The poured impressions were allowed to set for 1 hour and then separated. At this stage, the resultant casts were inspected for absence of surface irregularities and bubbles, and clear reproduction of the markers. The casts were leveled by trimming the base to that of a constant thickness using a model trimmer with a guide.

The distances between the index points A-B,B-C, C-A, a-b, b-c and c-a were measured to ±0.001mm by one operator with four repetition per measurement using a measuring microscope(Fig. 7). These measurements were used to calculate the algebraic norms[13](Fig. 8) of the inner and outer sets of index points for each tray, where the algebraic norm(AN) is defined as:

$$AN=\sqrt{(x^2 + y^2 + z^2)}$$

and x, y and z are linear measurements of the distances AB,BC,CA and ab,bc,ca,etc. The algebraic norm is a convenient method of defining the dimensions of the cast, because its value reflects change in three dimensions.

The data were subjected to a one-way ANOVA, and where differences were detected, they were identified by a post-hoc Tukey hsd test at an priori α=0.05. The differences between the algebraic norm for each custom tray material and the master cast were determined, and the mean values and their standard deviations were calculated for these data. These mean values were used to indicate the nature of the difference between the master cast and the cast poured from the four custom impression trays.

Table Ⅱ. Algebraic norms of inner dimension(unit:mm)

(means-measuring 5 models respectively with 4 repetition per measurement for each custom tray material)

(U)=Upper tray (L)=Lower tray

Original brass model		54.851	
Palatray(U)	54.420	Palatray(L)	54.868
Lightplast(U)	54.459	Lightplast(L)	54.446
Quicky(U)	54.326	Quicky(L)	54.584
Ivolen(U)	54.439	Ivolen(L)	54.559

Table Ⅲ. Algebraic norms of outer dimension(unit:mm)

(means--measuring 5models respectively with 4repetition per measurement for each custom tray material)

Original brass model	83.233		
Palatray(U)	83.204	Palatray(L)	83.427
Lightplast(U)	83.079	Lightplast(L)	83.202
Quicky(U)	83.174	Quicky(L)	83.408
Ivolen(U)	83.078	Ivolen(L)	83.468

Table Ⅳ. T - test procedure (Inner dimensions)

Mat=1 : palatray Treat 1 : UPPER TRAY

Mat=2 : lightplast Treat 2 : LOWER TRAY

Mat=3 : quicky

Mat=4 : ivolen

** Palatray XL **

TREAT	N	Mean	Std . Dev	Std .Error	Variances	T	DF	Prob > I T I
1	5	0.43086000	0.06081762	0.02719847	Unequal	5.8089	5.1	0.002
2	5	-0.01684000	0.16124892	0.07211271	Equal	5.8089	8.0	0.0004

For H0:Variances are equal , F' = 7.03 DF = (4,4) Prob > F' = 0.0853

RESULTS

The mean values of the algebraic norms of the inner and outer dimensions are listed together. That of original master cast is also provided.

The dimension of Palatray XL impressions was the nearest to that of the original model. Inner dimensions of test groups tended to be smaller than those of original model. However, outer dimensions were larger in lower tray impressions.(Table Ⅱ)

Also in outer dimensions, Palatray XL(U) was the closest to that of the original model. But, their differences were small.(Table Ⅲ)

T-test showed that the results of upper trays were different from those of lower trays in algebraic norms of inner and outer dimensions(Table Ⅳ) and upper arch simulated trays tended to reproduce the master cast with index points closer together. Table Ⅳ. is the T-test for Palatray XL in inner dimensions. Other materials produced the similar results and so were in outer dimensions. But their differences were very small.

Then, for the comparison of tray materials, analysis of variance was performed.

Table Ⅴ. Inner Dimensions—Upper tray : ANOVA TEST

TREAT=1

Class	Levels	Values
MAT	4	1 2 3 4

Number of observations In by group = 20

TREAT=1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.06039053	0.02013018	1.64	0.2203
Error	16	0.19667963	0.01229248		
Corrected Total	19	0.25707016			

TREAT=1

Tukey 's Studentized Range (HSD) Test for variable: STRI

α= 0.05 df = 16 MSE = 0.012292

Critical Value of Studentized Range = 4.046

Minimum Significant Difference =0.2006

Means with the same letter are not significantly different.

Tukey Grouping	Mean	Number	Material
A	0.52140	5	3
A	0.43086	5	1
A	0.41162	5	4
A	0.37132	5	2

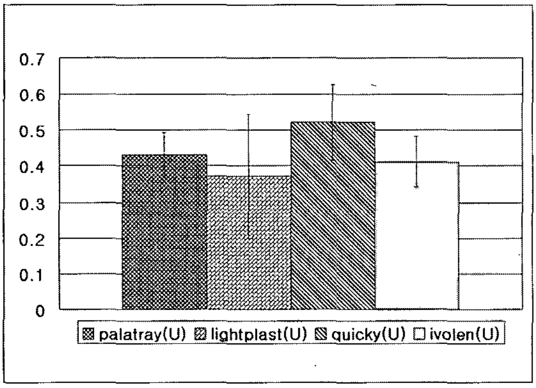

Fig . 9. Inner dimensions with upper trays.

According to Table Ⅴ and Fig. 9, in upper arch simulated tray impressions, inner dimensions showed no significant difference between them.(P>0.05)

But lower arch trays showed differences(Table Ⅵ, Fig. 10,11). The results of Palatray XL were different from others. However, the dimesions were the closest to those of the original brass model.

Also , outer dimensions of the cast with upper arch simulated trays showed very little differences between tray materials .(Table Ⅶ, Fig. 12)

But lower tray impressions in outer dimensions were different between tray materials as inner dimensions. Lightplast, light curing type, produced different results, the nearest to the original model. (Table Ⅷ, Fig. 13 and 14) In fact, the means of Palatray XL for upper tray were near the zero, so that material produced the most accurate casts.

Table Ⅵ. Inner dimensions — Lower tray : ANOVA TEST

TREAT=2

Class Levels Values

MAT 4 1 2 3 4

Number of observations by group = 20

TREAT=2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.48182993	0.16060998	16.06	0.0001
Error	16	0.16005536	0.01000346		
Corrected Total	19	0.64188529			

TREAT=2

General Linear Models Procedure

Tukey 's Studentized Range (HSD) Test for variable: STRI

NOTE: This test controls the type I experimentwise error rate , but generally has a higher type II error rate than REGWQ.

Alpha = 0.05 df = 16 MSE = 0.010003

Critical Value of Studentized Range = 4.046

Minimum Significant Difference = 0.181

Means with the same letter a re not significantly different.

Tukey Grouping	Mean	Number	Material
A	0.40456	5	2
A	0.29150	5	4
A	0.26676	5	3
B	-0.01684	5	1

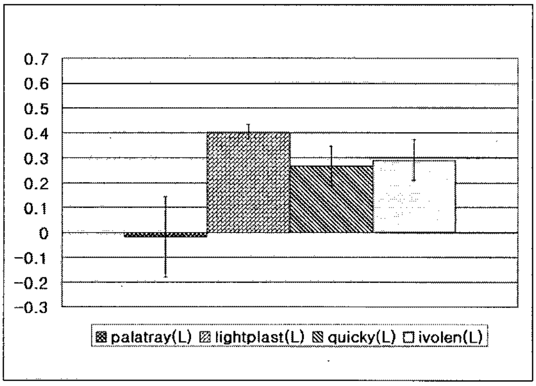

Fig. 10. Inner dimension with lower tray.

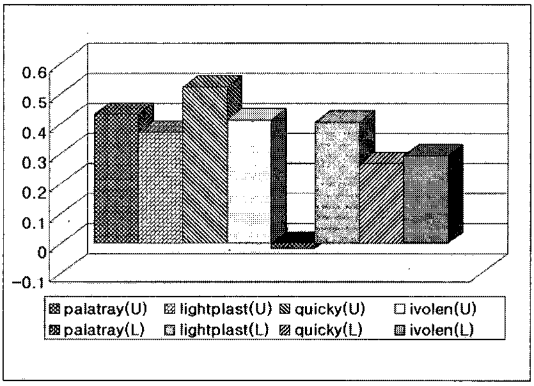

Fig. 11. Comparison of inner dimension respective of materials.

Table Ⅶ. Outer dimension—Upper tray : ANOVA TEST

TREAT=1

Class Levels Values

MAT 4 1 2 3 4

Number of observations in by group = 20

TREAT=1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.06325971	0.02108657	0.92	0.4512
Error	16	0.36474192	0.02279637		
Corrected Total	19	0.42800163			

TREAT=1

Alpha = 0.05 df = 16 MSE = 0.022796

Critical Value of Studentized Range = 4.046

Minimum Significant Difference = 0.2732

Means with the same letter are not significantly different.

Tukey Grouping	Mean	Number	Material
A	0.15476	5	4
A	0.15388	5	2
A	0.05928	5	3
A	0.02862	5	1

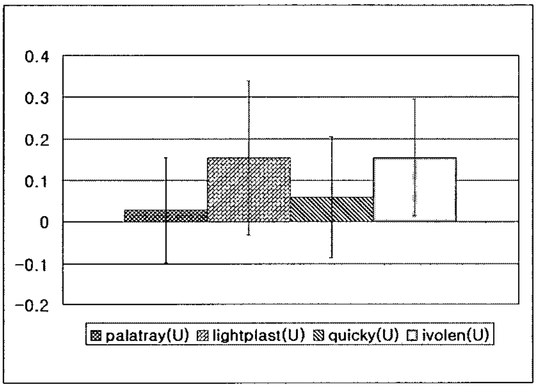

Fig. 12. Outer dimensions with upper trays.

DISCUSSION

The use of a custom tray is indispenable for the fabrication of precision working casts.[1,2] recovered from impressions made with elastomeric materials(thiokols, siloxane, poly[vinyl siloxanes]), and polyethers. Volume changes resulting from coefficients of thermal expansion and setting shrinkage(cast materials) can be compensated by such trays.[14] For that goal to be achieved, however, the tray material and its manipulation must meet high standards. So in this study, several tray materials that are used widely in clinics were compared.

Many sources of errors are present when fabricating a master cast, including the intraoral environment, operator' s experience and dexterity, the tray, adhesive and impression materials used, the mixing, the trimming and manipulation of the master cast. Most of these sources of inaccuracy may be controlled or eliminated by careful attention to the proper manipulation of materials and clinical technique. The selection of a custom tray versus a stock tray is determined totally by the clinician and is independent of other clinical variables.

Table Ⅷ. Outer dimensions —Lower tray :ANOVA TEST

TREAT=2

Class	Levels	Values
MAT	4	1 2 3 4

Number of observations by group = 20

TREAT=2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.21240135	0.07080045	10.93	0.0004
Error	16	0.10362888	0.00647680		
Corrected Total	19	0.31603023			
	R-Square	C.V.	Root MSE		BTRI Mean
	0.672092	-56.17660	0.0804786		-0.14326000
Source	DF	Type I SS	Mean Square	F Value	Pr > F
MAT	3	0.21240135	0.07080045	10.93	0.0004
Source	DF	Type III SS	Mean Square	F Value	Pr > F
MAT	3	0.21240135	0.07080045	10.93	0.0004

TREAT=2

Alpha = 0.05 df = 16 MSE = 0.006477

Critical Value of Studentized Range = 4.046

Minimum Significant Difference = 0.1456

Tukey Grouping	Mean	Number	Material
A	0.03114	5	2
B	-0.17464	5	3
B	-0.19412	5	1
B	-0.23542	5	4

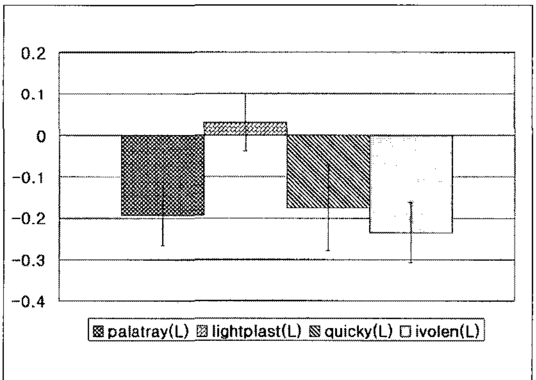

Fig. 13. Outer dimensions with lower trays.

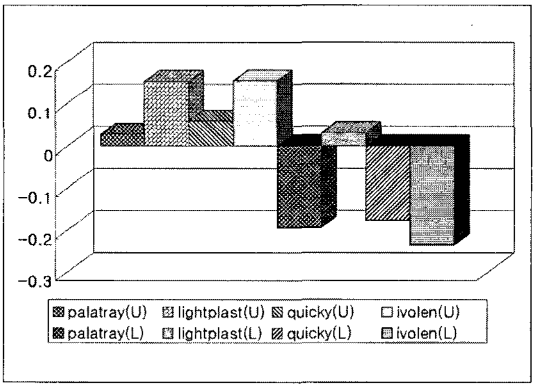

Fig. 14. Comparison of outer dimensions respective of tray materials.

Stock trays may provide acceptable clinical results when used for small restorations, such as single units, but when used for larger restorations, any inaccuracies in the impression may be magnified.[5,15] Inaccuracies in the working cast may result in poorly fitting, clinically unacceptable restorations. The latter may necessitate adjustments, an increase in chairside delivery time, a need for a new impression, patient discomfort, biologic changes, increased cost, and an increase in stress and frustration for the dentist.

When deciding whether to use a custom tray rather than a stock tray, the dentist must decide if the advantages outweigh the disadvantages. Clearly the custom tray produces more accurate and reliable results for interabutment distance at the occlusal and gingival level than do stock trays. These are supported by Fuerstein[14], Gordon et al.[5], Myers and Stockma[17], Ciesco et al.[18], and Johnson and Craig[1], who all recommended custom acrylic trays for accurate impressions for a small number of prepared teeth.

However, Bomberg et al.[16] and Vaulderhaug and Floystrand[19] found no difference in linear dimensional accuracy obtained from either custom or stock trays. But, Bomberg et al. assessed impression material accuracy using tests which employed the use of dies and castings. The castings were seated on the dies under pressure exerted by a rubber band, which was not a standardized technique. Measurements of the casting on each stone die were performed once only. These researchers recommended perforated stock trays as the tray of choice due to the retentive ability of the perforations. It has, however, been established that a uniform space between abutment and tray of 3~4mm for impression material is necessary for accurate, reliable results.[14,18] Stock trays do not fulfil these criteria. Considering the experimental technique involved, the results obtained may be attributed to the lack of sensitivity of the tests used by Bomberg et al.[16]

Vaulderhaug and Floystrand[19] found no difference between custom and stock trays when measuring stone models produced from a metallic model of the upper jaw. Impressions were repeated three times only for each tray design. A T - test was performed, but no analysis of variance(ANOVA) to assess interaction between tray design and impression material type was conducted and the small number of repeated measurements involved makes a statistically significant result unlikely. Also the measurements taken were from indentations in the center of each abutment, and the size of these markings could create inaccuracies in the interabutment dimensions recorded. Problems with the design of this experiment cause the conclusions to be of questionable significance.

The material thickness in the tray is affected by the way in which the tray is made as well as the manner in which it is used.[20] When either tray is used, complete seating of the tray and orientation and centering of the tray during placement must be considered. The most recurrent problem noted was the eccentric orientation and improper extension of the tray.

However, the overall thickness of impression material was apparently not a factor in the accuracy of the dies. While the thickness of material above the metal coping was at least 2mm for all of the trays, there were areas in dual-arch impressions where the impression material was so thin that it was nearly transparent.[21] In this study, as there were a constant relief (3mm) and seating-guide poles, same conditions of each tray material were provided.

The light curing types produced resultant casts that were less consistent than those of autopolymerizing types, and this difference in behavior may be caused by their greater lability[11] in the hands of the operators in this study compared with that of the other two materials. This lability may lead to an uneven thickness of tray material throughout the tray, especially at the margin. Light curing types have lower viscosity than the other materials and also have a tacky feel during manipulation, both characteristics possibly leading to a thinner, poorly adapted tray margin that may not resist the forces applied to it during and after impression making. The light curing types have been marketed as products that are dimensionably stable immediately after fabrication, which suggests that polymerization shrinkage is not an only factor determining the reproductive accuracy of tray resins. But light curing types produced results nearest to the original brass model. Their dimensional stability contributed to their reproductive accuracy.

In the present study, the trays were coated with an adhesive(KERR silicone adhesive / USA) and allowed to set for 20 minutes before use, and this procedure produced accurate impressions, as shown by the closely similar dimensions of the reproduced casts relative to the master cast. Except a few samples, there were absent of tearing or detachment of the impression material from the tray. However, it is possible that the bond strength could increase significantly if the adhesive were allowed to set for 10 hours or longer.[4] The previous studies stated that the retention and replication properties of elastomeric impression materials become significant when 1) the impression material is particularly rigid, 2) tooth and / or tissue undercuts are present, or 3) one is dealing with multiple implant fixtures, all with varying angulations. In these situations excessive force may be required to remove the tray-impression material combination. The actual minimum bond strength between the impression-adhesive system and custom tray material is unknown.[22] An approximation of forces involved may be found in a recent study.[23] Forces ranging from 224N to 514N were involved in removing impression-filled custom trays from an in vitro simulation model. To maintain impression custom tray integrity, the bond strength between the impression material / resin tray interface would need to exceed these values. However, Dixon et al.[23] did not report what the actual strength values were.

In this study, the original model had no undercuts and an addition type silicone was used, so 20 minutes were sufficient. But if the bond between the adhesive and impression materials is very high while the tray has low strength at the periphery, it might be possible for the impression material, during its continued polymerization, to exert a tensile force on the tray and cause distortion. The result of the present study showed that light curing types reproduced the most accurate casts, however, also showed inconsistent results with lower arch simulation trays. Lower trays had more peripheries than upper trays. As stated earlier, light curing types had labile character, they tended to be thinner at line angles and peripheries. In fact, variations of tray margin properties were more frequent in light curing types, since in drawing the trays out of the brass flask, they were not in completely cured state, accordingly there were more sources of distortions. For those reasons, they produced inconsistent casts with statistical significance. In upper tray impressions, when compared to lower trays, they had less tray margins, the reproductive accuracy of them depend more upon impression materials than tray resins. Addition silicone has been said to be the most accurate in impression materials. So, the casts with the upper tray produced the consistent results.

And we could think that the variable retention between the adhesive and an impression material and tray materials might produce errors. For, the combination of impression materials and adhesives are important to the retention between them. Hydrosil impression material exhibited the greatest bond strength in Dixon' s study. High bonding strengths associated with Hydrosil impression material have been reported in other investigations.[24,25] Hogan and Agar[26] reported that the high adhesive tensile strength of Hydrosil impression material exceeded their experimental design.

Previous studies have indicated that roughening custom tray material before adhesive application can result in improved bonding of nonaqueous elastomeric impression materials to light-activated and autopolymerizing tray materials.[22,27-30] However, variations in bond strength of impression material, adhesive agent and custom tray material combinations appear related to (1)the chemistry of the adhesive agent (2)the surface chemistry of the resin tray materials. Philips[31] reported that the adhesive supplied with silicone rubber impression materials contained poly dimethyl siloxane or a similar reactive silicone, and ethyl silicate.

Retention of impression material to custom tray resin ultimately depends on the ability of the adhesive solvent to dissolve the tray resin, and the action of other in vivo variables, namely direction and force of removal, flexure of resin tray material, and contamination of resin surfaces before adhesive application, may lead to an overall deterioration of the bond strengths.

There are a number of variables in a reproductive system that may affect the subsequent accuracy of the restoration. Errors can be produced in the impression as a result of setting[32], thermal contraction[33], or distortion on removal from the mouth. Inaccuracies may also occur, however, stone used to make the working cast. It has been shown that compatible impression materials and dental stone must be chosen.[34,35] from the number of different elastomeric impression materials now available.

The temperature of the water that is used for mixing has an effect on the setting reaction of the gypsum stone when pouring elastomeric impressions.[36] This variable is likely to be poorly controlled in the laboratory, as the water is often taken directly from the tap. In Saunders' s[37] study showed that there was no significant interaction between the temperature of the water and the accuracy of casts(18-24℃). The accuracy of impression materials has frequently been investigated using stone casts rather than measuring the impressions directly.[38-40] Other factors that may affect accuracy include the manipulation of the impression materials and the compatibility of the impression material with the stone.[34,35] In Saunders' s[37] study an interaction between one modeling stone(Fuji) used with one of the impression materials(Express) was found and resulted in significantly less accurate casts.

Chong YH[41] reported that the greater the contact angle of the die stone on impression material, the greater the probability of surface imperfections in the stone cast. The contact angle values correlated significantly with the number of voids found at margins and line angles on rough surfaces but not with those on smooth surfaces of the stone casts.

CONCLUSIONS

The accuracy of master cast reproduction by a polyvinylsiloxane impression material using two visible-light curing resin and autopolymerizing polymethyl methacrylate resin custom tray material was investigated.

All four tray materials produced acceptable casts,

1. Algebraic norms of inner and outer dimensions of the test casts for upper trays were not statistically different irrespective of materials. ($P>0.05$)
2. T-test showed that there were differences between means with upper and lower trays especially in outer dimensions. ($P>0.05$)
3. Algebraic norms of inner and outer dimensions of the test casts for lower trays were statistically different between materials.
4. Palatray XL in inner, Lightplast-platten respectively in outer dimensions for lower trays were different from other materials, but, the nearest to the original model.

REFERENCES

1. Johnson GH, Craig RG. Accuracy of addition silicones as a function of technique. J Prosthet Dent 1986;55;197-203.
2. Eames WB, Sieweke JC, Wallace SW, Rogers LB. Elastomeric impression materials:Effect of bulk on accuracy.J Prosthet Dent 1979;41;304-7.
3. Rehberg HJ:The impression tray-an important factor in impression precision. Int Dent J 1977;27:146-152.
4. Philips RW:Skinner' s Science of Dental Materials,

ed 9. Chapter11:Denture base resins:Technical considerations, miscellaneous resins and techniques, philadelpphia, PA, Saunders, 1991, p207.
5. Stackhouse JA:Dimensional change of custom acrylic impression trays. J NY Dent Assoc. 1976;47;28-29.
6. Gordon GE, Johnson GH, Drennon DG:The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63:12-15.
7. Pagniano RP, Scheid RC, Clowson RL, et al.:Linear dimensional change of acrylic resins used in the fabrication of custom trays. J Prosthet Dent 1982;47:279-283.
8. Fehling AW, Hesby RA, Peileu GB:Dimensional stability of autopolymerizing acrylic resin impression trays. J Prosthet Dent 1986;56: 497-506.
9. Wirz J, Jaeger K, Schmidli F. Light-polymerized materials for custom impression trays. Int J Prosthodont 1990;3:64-71.
10. Breeding LC, Dixon DL, Moseley JP:Custom impression trays:Part Ⅰ-Mechanical properties. J Prosthet Dent 1994;71:31-34.
11. Luis J. Martinez, J.A. von Fraunhofer:The effect of custom tray material on the accuracy of master casts. J Prosthod 1998;7:106-110.
12. Lacy AM, Fukui T, Bellman T, Jenderson MD. Time dependent accuracy of elastomer impression materials. Part Ⅱ:polyether, polysulfides, and polyvinyl siloxane. J Prosthet Dent 1981;45:329-33.
13. O' Toole TJ, Furnish GM, von Fraunhofer JA:Linear distortion of acrylic resin. J Prosthet Dent 1985;53:53-55.
14. Fuerstein RM. Physical properties and use of rubber base impression material J Prosthet Dent 1960;10:179-89.
15. Boulton JL, Gage JP, Vincent PF, et al.:A laboratorary study of dimensional change for three elastomeric impression materials using custom and stock trays. Aust Dent J 1996;41: 398-404.
16. Bomberg TJ, Goldfogel MH, Hoffman W. Bomberg SE. Considerations for adhesion of impression materials to impression trays. New Mexico Dent J 1985;54:170-172.
17. Myers EG, Stockman DG. Factors affecting the accuracy and dimensional stability of the mercaptan rubber-base impression materials. J Prosthet Dent 1960;10:525-35.
18. Ciesco JN, Malone WFP, Sandrik JL, Mazur B, Comparison of elastomeric impression materials used in fixed prosthodontics. J Prosthet Dent 1981;45:89-94.
19. Valderhaug J, Floystrand F. Dimensional stability of elastomeric impression materials in custom made and stock trays. J Prosthet Dent 1984;52:514-7.
20. T.J.Bomberg R.A. Hatch, W. Hoffman. Jr Impression material thickness in stock and custom trays J Prosthet Dent 1985;54:170-172.
21. Richard D. Davis, DDS & Richard S. Schwartz, DDS. Dual-arch and custom tray impression accuracy Am J Dent 1991:4:89-92.
22. John A. Payne, Barry P. Pereirs, B Eng. Bond strength of two nonaqueous elastomeric impression materials bonded to two thermoplastic resin tray materials. J Prosthet Dent 1995;74:563-8.
23. Dixon DL, Breeding LC, Bosser MJ, Nafso AJ. The effect of custom tray material type and surface treatment on the tensile bond strength of an impression material/adhesive system. Int J Prosthodont 1993;6:303-6.
24. Chai JY, Jameson LM, Moser JB, Hesby RA. Adhesive properties of several impression material systems:part Ⅰ. J Prosthet Dent 1991;66:201-9.
25. Mohd-Sulong MZA. Setchell DJ. Properties of the tray adhesive of an addition polymerizing silicone to impression tray materials. J Prosthet Dent 1991;66:743-7.
26. Hogans WRⅢ, Agar JR. The bond strength of elastomer tray adhesives to thermoplastic and acrylic resin tray materials.J Prosthet Dent 1992;67:541-3.
27. Nicholson J, Porter K. Comparing addition silicone adhesive bond strength to other elastomeric adhesive[abstract]J Dent Research 1983;62(Special issue):299.
28. Chai JY, Jameson LM, Moser JB, Hesby RA. Adhesve properties of several impression material systems:part Ⅰ. J Prosthet Dent 1991;66:201-9.
29. Davis GB, Moser JB, Brinsden GI. The bonding properties of elastomer tray adhesives. J Prosthet Dent 1976;36:278-85.
30. Grant BE, Tjan AH. Tensile and peel bond strengths of tray adhesives. J Prosthet Dent 1988;59:165-8.
31. Philips RW. Skinner' s science of dental materials. ed. 9. Philadelphia:WB Sanders, 1991:150.
32. Ohsawa M, Jorgensen KD:Curing contraction of addition type silicone impression materials. Scand J Dent Res 1983;91:51-4.
33. Jorgensen KD:Thermal expansion addition polymerization(Type Ⅱ) silicone impression materials. Aust Dent J 1982;27:377-381.
34. Gerrow JD, Schneider RL:A comparison of the compatibility of elastomeric impression materials, typeⅣ dental stones, and liquid media. J Prosthet Dent 1987;57:292-297.
35. Schelb E, Mazzocco CV, Jones JD, Prihoda T:Compatibility of type Ⅳ dental stones with polyvinyl siloxane impression materials. J Prosthet Dent 1987;58:19-22.
36. Craig RG:Restorative Dental Materials, ed 8. St Louis, CV Mosby Co, 1989, p350.
37. Saunders WP, Sharkey SW, The effect of water temperature on the accuracy of stone casts recovered from addition reaction elastomeric impression materials. Int J Prosthodont 1990;3:577-581.
38. Lacy AM, Fukui H, Bellman T, et al.:Time dependent accuracy of elastomer impression materials. Part Ⅱ:polyether, polysulphides and polyvinyl-

siloxane. J Prosthet Dent 1981;45:329-333.
39. Odman PA, Jemt TM:Accuracy of impression materials in a semi-clinical model. Dent Mater 1988;4:64-67.
40. Lin CC, Ziebert GJ, Donegan SJ, et al.:Accuracy of impression materials for complete arch fixed partial dentures. J Prosthet Dent 1988;59:288-291.
41. Chong YH, Soh G, Setchell DJ, Wickens JL. The relationship between contact angles of die stone on elastomeric impression materials and voids in stone casts. Dent Mater 1990;6(3): 162-166.

Reprint request to:
Dr. Ik-Tae Chang
Dept. of Prosthodontics, College of Dentisity,
Seoul National Univ.
28-1 Yeongun-Dong, Chongno-Gu, 110-749, Korea
Tel:+82-2-760-2661, Fax:+82-2-760-3860