INDIAN JOURNAL OF DENTAL ADVANCEMENTS

Journal homepage: www.nacd.in

ORIGINAL RESEARCH

Accuracy of dies obtained from dual arch impressions as influenced by tray selection, viscosity of the impression material and sequence of pouring the cast

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Article Info
Received:
Review Completed:
Accepted:
Available Online:

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ABSTRACT:

AIMS: Dual arch trays are used to generate impressions of prepared teeth and of opposing arch simultaneously. The accuracy of the casts generated with this technique can be affected mainly by three variables i.e., tray type, impression material viscosity and sequence of pouring the cast. The objective of this study was to evaluate the influence of the above 3 variables.

METHODS AND MATERIAL: Impressions were made of a typodont mandibular arch containing a stainless steel standard die. Two types of the dual arch trays, plastic (Triple tray) and metal (Bite tray) and two viscosities of addition silicone for the tray (Imprint Regular body and Express Penta Putty) were used. Type IV gypsum (Fuji-rock) was used to generate the dies. The order of poring the impression side was randomized. A balanced design with independent samples was used (n=10). The dies were measured in three dimensions (buccolingual, mesiodistal and occlusogingival) using a measuring microscope and was compared with that of standard. The 3 variables were statistically analyzed by means of MANOVA test, with hypothesis testing at alpha=0.05.

RESULTS: Statistically significant differences were found with a selected tray and viscosity when compared to standard. Metal trays produced dies that were 12 m shorter in mesiodistal and 0.2 m taller in Occlusogingival dimension. Gypsum dies were 23 m and 4 m smaller in mesiodistal and Occlusogingival dimension when plastic trays were used. Regular body resulted in 15 m smaller dies in buccolingual and mesiodistal dimension. Rigid material produced dies slightly taller (1 m) and those from regular body were 5 m shorter. Buccolingual dimensions were accurate when working side was poured first and Occlusogingival when opposite side was poured first.

CONCLUSION: Within the limitations of this study, regular body when compared with rigid impression material was most accurate for buccolingual and mesiodistal dimension. Metal trays resulted in accurate dies in mesiodistal and occlusogingival dimensions. Occlusogingival dimension was accurate when opposite side was poured first. The magnitude of the difference obtained with respect to different variables in this study would not be clinically significant because they could be compensated with several coats of die spacer.

Key words: ***Dual arch impression technique; Dual arch trays; Addition silicone impression material; Sequence of pouring and Dimensional accuracy.***

Introduction:

The dual arch or double arch impression technique as described by Wilson and Werrin, is convenient in that it makes the required maxillary and mandibular impressions, as well as the interocclusal record in one procedure. This technique represents a significant advance in fixed prosthodontics and has many advantages over conventional impression techniques in fabrication of single crowns, onlays, posts and cores, full crowns and simple short-span bridges[1, 2, 3, 4, 5, 6].

Many authors state that many types of impression materials can be used with the dual arch trays, but a stiff bodied impression material is preferred to ensure tray rigidity than low viscosity impression material. Some authors suggest that the use of more rigid trays reduces the probability of distortion in the impression[1, 2, 3, 5, 7, 8, 9]. Authors also advocate that counter impression (opposing side) should always be poured first, followed by the working side (preparation side) impression[1]. Though several authors have described this dual arch impression technique, the accuracy of casts generated from this technique remains in question because there is little information available in the literature.

Distortion is a 3 - dimensional problem and when it was applied to a study on impression material accuracy, several factors were analyzed. With dual arch trays there is a lack of consensus about which impression tray should be used, what viscosity of impression tray material is needed and which side of the dual-arch impression should be poured first to minimize distortion. Investigation of these parameters will also help in planning an anticipated clinical trial[6].

So this study was conducted to know the accuracy of the working dies that were obtained by involving the above mentioned three variables.

The objectives of the study were:

To evaluate the accuracy of the dies obtained from dual arch impressions by :

1. Using metal and plastic dual arch trays.
2. Using two different viscosities of addition silicone as the tray material, i.e., putty and regular body.
3. Altering the side of the impression that will be poured first, i.e., working side or opposite side.

Subjects and Methods:

A machined, circular stainless steel standard die was prepared in the position of mandibular right second premolar, in a typodont teeth model. The dimensions of the standard die were as follows[6] (Figure 1).

Mesiodistal width	—	7.071mm
Buccolingual width	—	7.071mm
Occlusogingival height	—	6.250mm

Occlusal convergence/tapering on both sides — 3^0

At each side of the standard die i.e., buccal, lingual, mesial and distal sides there were four lines fabricated which were of 50mm in diameter. Gingival finish line was simulated at the base of the die which was 1mm in width. Sufficient clearance around the die was provided for adequate thickness of the material.

Impressions were made on the typodont model containing the machined, circular stainless steel standard die in the position of mandibular right second premolar. Three variables that could affect accuracy of working dies were studied: Type of dual arch impression tray, Viscosity of the tray material and Sequence of pouring the side of the impression.

A sample size of 10 was used for each combination of the above three variables, Thus 80 independent samples were used to study the 3 variables.

Selection of impression tray : The first step in dual arch impression technique is critical and consists of selection of tray that fits passively and does not impinge on any of the teeth or on any anatomical structure of the typodont jaw. The tray should not interfere with occlusion. The extent of the interarch distance distal to the most distal tooth to be included in the tray was evaluated. The metal and plastic dual arch trays that satisfied all the above mentioned criteria were selected[2].

Orienting the impression tray : A jig was fabricated and attached to the jaw table for the proper positioning of the tray. The jig was fabricated in such a way that, it had adjustable anterior, posterior and buccolingual stops. This facilitated a single path of insertion and removal for both metal and plastic trays. It also provided support for buccolingual flanges, crossbar and handle of the tray. This avoided tilting of the tray in any direction. Care was taken that when the tray was positioned it covered minimum of one tooth on either side of the standard die providing maximum intercuspation. Once the position of the tray was determined, the anterior, posterior and buccolingual stops of the jig were adjusted such that, for all the impressions, orientation of the tray was standardized (Figure 2).

Dual arch impression technique : In this study dual mix technique was followed, where both syringe material (Light bodied addition silicon, Express™, 3M ESPE) and the tray material (Regular body, Imprint™, II Garant™, 3M ESPE and Penta Putty, Express™, 3M ESPE) were automixed simultaneously.

Study was done in a temperature controlled room, where a 23^{0}c temperature was maintained. After the tray selection, a single coat of tray adhesive (Caulk Tray adhesive, Dentsply) was applied uniformly all over the tray in a unidirection using a brush. It was allowed to dry for 7minutes as per manufacturer's instructions. In a 2 ml disposable syringe (Unolock), 1.5ml of light bodied material was injected around and over the stainless steel standard die. Simultaneously 6 complete activations of the automix cartridge were used to dispense 11ml of the regular bodied tray material into both sides of the dual arch trays. When putty material was used as a tray material, 22 seconds were required to dispense 11ml of the putty from Pentamixer. Use of stop watch helped in assessing the time to dispense the material.

Dual arch tray with the loaded material was positioned in a predetermined position as explained earlier. The typodont model was then closed to maximum intercuspation. A 1.5kg weight was placed over the jaw to simulate occlusal load (figure 3). Impression was removed from the typodont model 10minutes after the start of mix, twice the manufacturers recommended setting time, to compensate for the extraoral environment.

First, combination of light body as a syringe material and regular body as a tray material was used in the plastic tray (Triple tray, Premier Dental Products Co) and then in the metal tray (Bite tray, Essago SBC, GC) to make 40 impressions.

Secondly, the combination of light body as a syringe material and putty material as a tray material was used in the plastic tray and then in the metal tray to obtain 40 impressions. This together yielded 80 impressions.

The impressions were then rinsed under tap water for 10 seconds, dried and poured in Type IV gypsum (Fuji Rock EP, GC Europe) after 60minutes.

Preparation of gypsum dies : Type IV gypsum (Fuji Rock EP, GC Europe), with a water powder ratio of 1:5 was hand mixed for 10 seconds and then mixed under vacuum using vacuum mixer (Easy Mix, Bego) for 40 seconds. Stone was then poured into the impression while being vibrated over vibrator[10] (Disor I EWL544, Kavo). One side of the dual arch impression was poured first with 35g of stone and allowed to set for 1hour before the other side was poured. The tray handles were placed in a tray holder to ensure that impressions were suspended for 60minutes, for the gypsum to set. The order of pour was randomized and all casts were allowed to set for 24hours at room temperature before removal[11].

The casts were removed from the impression and sectioned using a saw blade (Pindex system handsaw with blade 0.007 inch, Coltane/Whaledent Inc), to form individual gypsum dies. The base of the dies were then prepared using model trimmer (Ray Foster, Model No MT10, Kavo) and sand papered to obtain parallel walls (figure 4). Thus 80 gypsum dies were obtained. Samples were measured for buccolingual, mesiodistal and Occlusogingival dimensions.

Measurement of dimensions / microscopic evaluation: Two custom jigs were fabricated to hold the gypsum dies and to permit their measurement at a fixed, reproducible position under the microscope. Measuring microscope (Nikon Measurescope; Nikon, Tokon, Japan) was used to measure the dimensions of the die (figure 5). Three aspects of each die were measured (buccolingual, mesiodistal and Occlusogingival) with reference to the lines that were reproduced over the gypsum dies. Thus 3 dimensional representation of the accuracy could be assessed. Each dimension of the working dies was measured 3 times and the mean was used for the sample value.

Method of Statistical analysis: The results were averaged (mean + standard deviation) for each parameter which is presented in Tables (1 to 4).

Tables are showing the overall means and ranges for types of measurement. The effect of 3 main variables- type of tray, viscosity of the impression material for the tray and sequence of pouring the impression were analyzed by means of MANOVA using a General Linear Model (GLM) along with the effects of main interaction between them. Because there were 2 groups within each factor, there was no need to conduct the post hoc tests for the difference of mean difference since any significant mean effect ($p<0.05$) would indicate a statistically significant difference between the 2 groups.

In above test, P values less than 0.05 were taken to be statistically significant. The data was analyzed using SPSS (Statistical Package for Social Science, v10.5) package.

RESULTS :

Eighty gypsum dies obtained from dual arch impression technique were measured for buccolingual, mesiodistal and Occlusogingival dimensions and were statistically analyzed.

All cross product interactions were significant if $P < 0.05$.

Table 1 depicts the mean values, standard deviations and tests between the subjects as influencing the buccolingual dimension.

Mean standard deviation associated with the stainless steel standard die was 0.001mm and that for working dies were 0.00424mm.

When all the variables were analyzed together for buccolingual dimension, there were appreciable differences in the mean values between metal and plastic trays when rigid impression material was used and whether working or opposite side was poured first.

Measurable differences were also found in the mean values between metal and plastic trays when regular body impression material was used and whether working or opposite side were poured first.

However, Statistical analysis of the combined variables for buccolingual dimension (i.e., tray, viscosity and order of pouring the cast) showed significant difference (i.e., $P<0.05$) with respect to:

Viscosities: P = 0.000

Between Tray and Viscosities: P = 0.000

Between Viscosities and Pouring: P = 0.001

For better illustration see Figure 6.

Table 2 depicts the mean values, standard deviations and tests between the subjects as influencing the mesiodistal dimension.

Mean standard deviation associated with the stainless steel standard die was 0.001mm and that for working dies were 0.008198mm.

When all the variables were analyzed together for mesiodistal dimension, there were appreciable differences in the mean values between metal and plastic trays when rigid impression material was used and whether working or opposite side was poured first. Measurable differences were also found between metal and plastic trays when regular body impression material was used and whether working or opposite side were poured first. However, Statistical analysis of the combined variables for mesiodistal dimension (i.e., tray, viscosity and order of pouring the cast) showed significant difference (i.e., $P<0.05$) with respect to;

Trays: P = 0.000

Viscosities: P = 0.000

Tray and Viscosities: P = 0.000

Tray and Pouring: P = 0.000

Viscosities and Pouring: P = 0.001.

For better illustration see Figure 7.

Table 3 depicts mean values, standard deviations, and tests between subjects as influencing the Occlusogingival dimensions.

Mean standard deviation associated with the stainless steel standard die was 0.001mm and that for working dies were 0.0055619mm.

When all the variables were analyzed together for occlusogingival dimension, there were appreciable differences in the mean values between metal and plastic trays when rigid impression material was used and whether working or opposite side were poured first.

Measurable differences were also found between metal and plastic trays when regular body impression material was used and when working side of the impression was poured first. However, Statistical analysis of occlusogingival dimension for the combined variables (i.e., tray, viscosity and order of pouring the cast) showed significant difference (i.e., $P<0.05$) with respect to;

Trays: P = 0.000

Viscosities: P = 0.000

Tray and Pouring: P = 0.000

Tray and Viscosities: P = 0.009

For better illustration see Figure 8.

Table 4 depicts the comparison of the trays, materials and pouring sequence with standard values.

In general, results showed that when :

1. Buccolingual dimensions were measured :

   Trays: plastic trays were more accurate

   Material: regular body impression material was more accurate

   Pouring of the cast: dies were more accurate when working side of the impression was poured first.

Statistical analysis showed that there was significant difference between rigid and regular body impression material when buccolingual dimensions were measured (regular body impression material was more accurate, P=0.0049).

For better illustration see figure 9.

2. Mesiodistal dimensions were measured:

   Trays : metal trays were more accurate

   Impression material : regular body impression material was more accurate.

   Pouring of the cast : dies were more accurate when opposite side was poured first.

Statistical analysis showed that, there was significant difference between metal and plastic trays (metal rays were accurate, P=0.0104), and between rigid and regular body impression material (regular body was accurate, P=0.0051).

For better illustration see Figure 10.

3. Occlusogingival dimensions were measured:

   Trays: metal trays were more accurate

   Impression material: rigid impression material was more accurate.

   Pouring of the cast: there was no difference between the sides poured first

Statistical analysis showed that there was significant difference between metal and plastic trays (metal trays were accurate, P=0.0039), and between rigid and regular body impression material (rigid material was accurate P= 0.0039).

For better illustration see Figure 11.

DISCUSSION :

Distortion is a three dimensional problem that is inherent in all of the steps involved in fabricating an indirect dental restoration. The intra-abutment distortion of a crown preparation and the distortion of the die in a buccolingual, mesiodistal, and Occlusogingival direction were investigated in this study. The change in the inter-abutment distances that occur among multiple crown preparations and the surrounding teeth was not included in this study.

The clinical relevance of this study is that the distortion observed could be extrapolated to that of a single crown preparation, but not to one involving multiple restorations.

The gypsum dies obtained from the impressions in this study were generally smaller in all three dimensions than the standard. During the polymerization reaction, the impression material shrinks towards the centre of mass. The use of a tray adhesive, however, should redirect this shrinkage towards the impression tray walls resulting in dies larger in diameter but shorter in height[6,12]. Inadequate thickness or absence of a tray adhesive can result in unrestricted polymerization shrinkage of the impression material, resulting in a die that is smaller in diameter and height[6,13]. In this study the amount of tray adhesive used was not standardized. A single thin layer of tray adhesive may not be sufficient to control polymerization shrinkage. This might be one of the causes for a smaller die. Although the length and width of the plastic and metal trays selected in the study was same, the design of the flanges of the metal and plastic trays were of different shapes. This might have incorporated another variable along with the tray adhesive, and both variables were not analyzed in this study.

Mesh fabric used in the dual arch trays may separate the teeth, and because of the flexibility of these materials there is a tendency to recover after occlusal pressure has been released. This could have resulted in distortion of the elastomeric impression material[9,14].

Also when the addition silicone impression material is used, greater accuracy can be obtained in custom trays or with two stage putty wash technique than with impressions made in stock trays. However, studies have concluded that the difference between two stage putty/wash impression technique and one stage putty/wash impression technique is not clinically significant and also accuracy depends on the impression materials used rather than the technique[13,15,16,17,18,19,20].

Breeding and Dixon found similar results with the metal dual arch impression trays, where dies were undersized but they could not explain why the plastic dual arch tray impression yielded dies that were oversized. However, they only studied the buccolingual dimension of the dies and only poured the working side of the impression. It is possible that the weight of the gypsum in the plastic trays distorted the unsupported impression because the opposing impression was never poured[5].

Also in this investigation when buccolingual and mesiodistal dimensions were measured, dies obtained from plastic trays using rigid and regular body impression material respectively showed large variation (smaller dies). This may be because of the trays being flexed outward by the impression material during seating on the prepared tooth and then any rebound on removal of the impression should result in a reduced buccolingual and mesiodistal dimension[5,21].

A study by Jeffrey A. Ceyhan and Glen H. Johnson, it was also noted that when the monophase tray material was used with the plastic dual arch trays, there was a larger standard deviation for all 3 dimensions when the working side of the impression was poured first[6]. In this investigation it was noted that Occlusogingival dimensions were more accurate when opposite side of the impression were poured first. This explains the protocol of Wilson and Werrin that 'always pour the counter impression before pouring the working side impression'[1,22].

Also when opposite side was poured first, the weight of the stone can cause movement of the impression material towards the working side of the impression. This can be compensated by setting expansion of the stone in occlusogingival direction. Thus the dies obtained from the metal tray and rigid impression material was more accurate occlusogingival dimension[22].

The machined stainless steel standard used in this investigation provided certain advantages in obtaining the measurements over that of a prepared plastic typodont tooth. The well-defined line angles of the stainless steel standard were clearly observed under the microscope, thereby reducing measurement error. This could explain the smaller standard deviations observed for measuring the standard in this investigation (1mm) compared with the study of Breeding and Dixon[5] where the standard was a prepared typodont tooth (16mm). The circular nature of the standard allowed observation of the relationship between the change in buccolingual and mesiodistal dimensions of the gypsum dies. With the plastic trays, the gypsum dies had a tendency to change from a cylindrical shape into an oblong shape, and they were generally narrower mesiodistally than buccolingually.

In clinical situation, it should be kept in mind that the results are applicable only to a single tooth situation and only to the types of impression materials and trays tested. Different trays and impression materials may yield different results.

The effect of lips, cheek, saliva and intraoral environment in containing the impression material is not simulated in this study, nor could the influence of an occlusal force in excess of 1.5kg used in this investigation.

Finally, this investigation yielded some statistically significant differences between tray types; impression material viscosity and sequence of pouring. However, the differences were of a magnitude that would probably have little clinical significance. The thickness of one coat of die spacer has been shown to vary from 8 to 40mm[6,23]. The greatest difference in the group mean values occurred here is 23mm. However, this difference would be insignificant clinically with the application of die spacer.

CONCLUSION :

Within the limitations of this study the following conclusions were made :

The gypsum dies produced from the dual arch impressions were generally smaller in all 3 dimensions than the stainless steel standard die.

In general, plastic trays resulted in more accurate dies when regular body impression material was used and metal trays when rigid or regular body impression material was used.

The buccolingual dimensions of the gypsum dies obtained were smaller than the standard. However, dies made from the regular body impression material and those when the working side of the impression was poured first were more accurate. The mesiodistal dimensions of the gypsum dies obtained were smaller than the standard. However, dies generated from the plastic dual-arch trays were smaller than the ones generated from the metal trays when regular body impression material was used. Working dies obtained from metal trays and regular body was more accurate in mesiodistal dimension. The occlusogingival dimensions of the gypsum dies were smaller than the standard. However, dies generated from the rigid impression material was larger than the gypsum dies that was obtained from regular body impression material. Metal trays, rigid impression material, and when opposite side of the impression was poured first, produced more accurate dies in Occlusogingival dimensions.

Although statistically significant differences were found, the magnitude of these differences are clinically insignificant since the difference can be compensated by 2 coats of die relief.

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Table - 1: Mean values and standard deviations - Buccolingual dimensions

Trays	STD		Study Value		Rigid			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	7.071	0.001	7.0519	0.00424	7.049	0.002	7.047	0.001
Plastic					7.051	0.002	7.051	0.002

Trays	STD		Study Value		Regular Body			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	7.071	0.001	7.0519	0.00424	7.053	0.004	7.058	0.002
Plastic					7.052	0.005	7.054	0.003

Source	Sig. P<0.05
VISCOSITY	.000
TRAY * VISCOSITY	.000
VISCOSITY * POURING	.001

Table - 2 : Mean values and standard deviations - Mesiodistal dimensions

Trays	STD		Study Value		Rigid			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	7.071	0.001	7.053	0.008198	7.049	0.003	7.054	0.002
Plastic					7.05	0.001	7.05	0.004

Trays	STD		Study Value		Regular Body			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	7.071	0.001	7.053	0.008198	7.065	0.003	7.065	0.003
Plastic					7.049	0.006	7.043	0.002

Source	Sig. P<0.05
TRAY	.000
VISCOSITY	.000
TRAY * VISCOSITY	.000
TRAY * POURING	.000
VISCOSITY * POURING	.001

Table - 3 : Mean values and standard deviations - Occlusogingival dimensions

Trays	STD		Study Value		Rigid			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	6.25	0.001	6.248	0.0055619	6.252	0.003	6.257	0.003
Plastic					6.25	0.002	6.247	0.002

Trays	STD		Study Value		Regular Body			
					Opposite		Work	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metal	6.25	0.001	6.248	0.0055619	6.245	0.003	6.246	0.003
Plastic					6.245	0.003	6.242	0.004

Source	Sig. P<0.05
TRAY	.000
VISCOSITY	.000
TRAY * VISCOSITY	.009
TRAY * POURING	.000

Table - 4 : Comparison of trays, materials and sequence of pouring with standard deviations

		N	Mean	Std. Deviation	Minimum	Maximum
Difference in buccolingual dimension	Metal tray	40	-0.019	0.005	-0.026	-0.011
	Plastic tray	40	-0.019	0.003	-0.030	-0.011
	Rigid	40	-0.022	0.003	-0.026	-0.015
	Regular body	40	-0.017	0.004	-0.030	-0.011
	Working side	40	-0.019	0.005	-0.026	-0.011
	Opposite side	40	-0.020	0.004	-0.030	-0.011
Difference in mesiodistal dimension						
	Metal tray	40	-0.013	0.008	-0.027	0.000
	Plastic tray	40	-0.023	0.005	-0.031	-0.013
	Rigid	40	-0.021	0.003	-0.029	-0.014
	Regular body	40	-0.015	0.011	-0.031	0.000
	Working side	40	-0.018	0.009	-0.031	-0.002
	Opposite side	40	-0.018	0.008	-0.031	0.000
Difference in Occlusogingival dimension						
	Metal tray	40	0.000	0.006	-0.010	0.011
	Plastic tray	40	-0.004	0.005	-0.015	0.007
	Rigid	40	0.002	0.005	-0.008	0.011
	Regular body	40	-0.006	0.004	-0.015	0.007
	Working side	40	-0.002	0.006	-0.015	0.011
	Opposite side	40	-0.002	0.005	-0.011	0.008

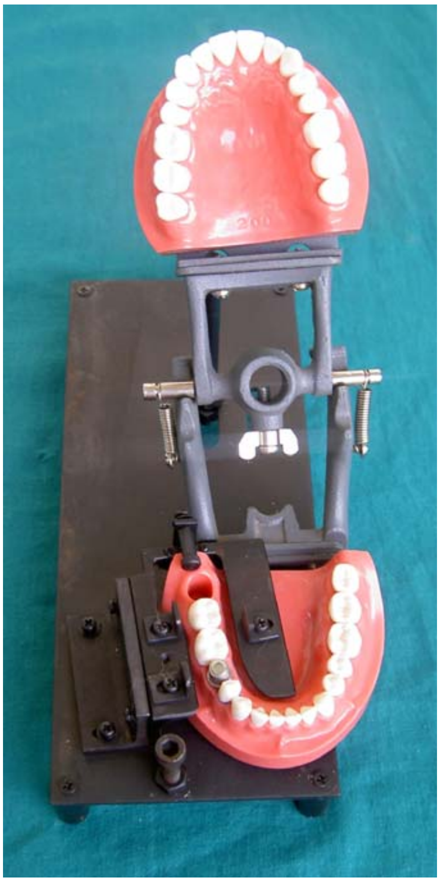

Figure 1: stainless steel standard die in the position of mandibular right second premolar

Figure 2: orienting the dual arch impression tray

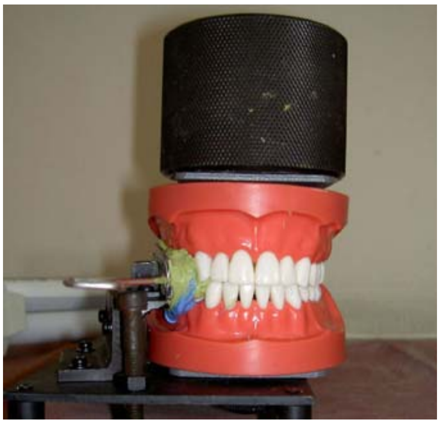

Figure 3: dual arch tray with the loaded impression material in position

Figure 4: prepared gypsum die

Figure 5: measuring microscope used to measure gypsum dies

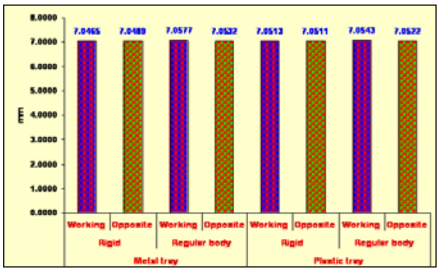

Figure 6: Comparison of Mean Buccolingual dimensions according to tray, viscosity and sequence of pouring (Study Values)

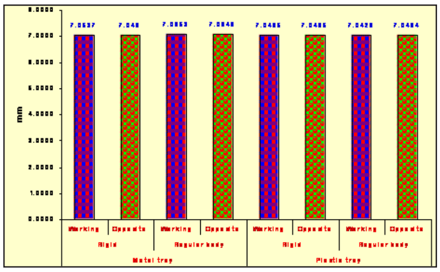

Figure 7: Comparison of Mean - Mesiodistal dimensions according to tray, viscosity and sequence of pouring (Study Values)

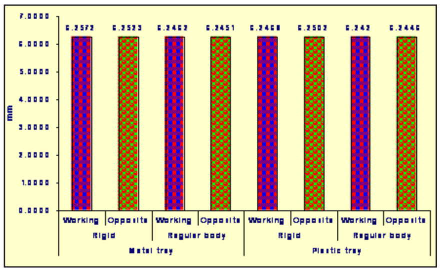

Figure 8: Comparison of Mean-Occlusogingival dimensions according to tray, viscosity and sequence of pouring (Study Values)

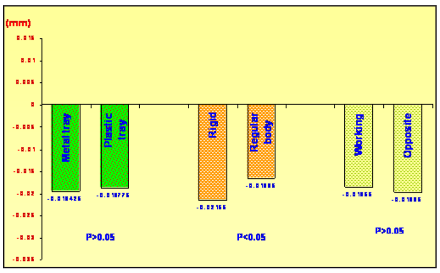

Figure 9: Factor Level mean differences of Buccolingual dimensions for working die and standard (mm)

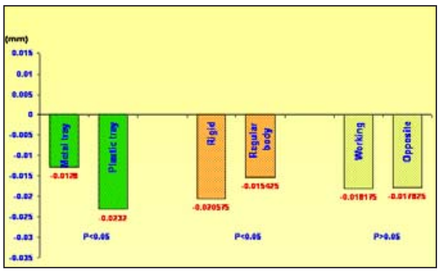

Figure 10: Factor Level mean differences of Mesiodistal dimensions for working die and standard (mm)

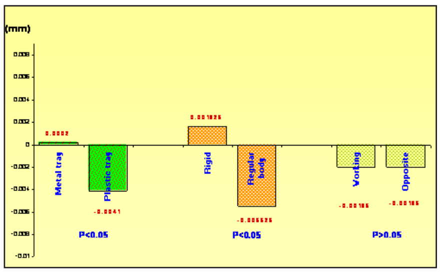

Figure 11: Factor Level mean differences of Occlusogingival dimensions for working die and standard (mm)