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Comparative evaluation of dimensional accuracy of casts generated from multiple mix impression technique, matrix impression system and dual arch impression technique – An in vitro study

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ABSTRACT

For a successful fixed partial prosthodontics, obtaining an accurate impression for making an accurate cast is of prime importance.

In the present study the three fixed prosthodontic impression procedures, multiple mix impression technique, matrix impression system and dual arch impression technique; have been compared in terms of dimensional accuracy. An articulated acrylic resin typodont prepared with reference points was used as a master model. Addition silicon impression materials in various consistencies were used for making impressions. The coordinate measurement machine (Lloyd, Germany) was used for three dimensional measurement of master model and stone casts with an accuracy of 0.0001 mm.

As per statistical analysis, all the impressions had a tendency to be oversized in horizontal dimensions and undersized in vertical dimensions. Dual arch impression technique used with flexible disposable plastic tray has found to be less dimensionally accurate as compared to multiple mix impression technique and matrix impression system whereas the other two techniques were comparable to each other.

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1. Introduction

Over the years, tremendous progress has been made in both impression materials and procedures for making fixed prosthodontic impressions. Various impression procedures using elastomeric impression materials include single mix/monophase impression technique, one-step putty wash technique, two-step putty wash technique, multiple mix technique, matrix impression system, prefabricated shell technique and dual arch impression technique.

Each of these techniques is better than the other in one or other aspects and uses various consistencies of elastomeric impression materials with several combinations in different types of trays. In the present study three impression techniques that is multiple mix impression technique,[1] matrix impression system[2] and dual arch impression[3] technique has been compared for dimensional accuracy.

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2. Aim & objective

The purpose of the present study is to compare dimensional accuracy of casts generated from various elastomeric impression techniques and to give clinical recommendations and indications based on the study and observations.

3. Materials and methods

3.1. *Preparation of master model*

The master model (typodont) consisting of articulated dentate maxillary and mandibular arches was used (Fig. 1).

Right mandibular first molar was removed to simulate a clinical case of three Unit Bridge. Mandibular second premolar and second molar were prepared as abutments with a finish line width of 1.2 mm. Three sharply defined notches were placed on each prepared tooth as reference points. The reference points were referred as:

1. Point a – on buccal finish line of right mandibular 2nd molar.
2. Point b – center of occlusal surface of right mandibular 2nd molar.
3. Point c – on lingual finish line of right mandibular 2nd molar.
4. Point d – on buccal finish line of right mandibular 2nd premolar.
5. Point e – center of occlusal surface of right mandibular 2nd premolar.
6. Point f – on lingual finish line of right mandibular 2nd premolar.

The various distances measured between reference points were:

Distances (a–b) and (d–e) which represented occluso-cervical dimension (vertical height) of right mandibular 2nd molar and right mandibular 2nd premolar respectively.

Distances (a–c) and (d–f) which represented bucco-lingual dimension (diameter) of right mandibular 2nd molar and right mandibular 2nd premolar respectively.

Distance (b–e) which represented inter-abutment distances between right mandibular 2nd molar and right mandibular 2nd premolar.

Addition silicones impressions (Aquasil, 3M ESPE, Germany) materials in various consistencies were used for making impressions. Types of trays used in the study were:

a) Rim lock perforated custom tray with acrylic resin stops in left central incisor and third molar region, fabricated with heat cure acrylic resin with 3 mm space for impression material.
b) Rim lock perforated stock tray with acrylic resin stops.
c) Disposable plastic dual arch trays (Premier Dental Co.) with sides for dual arch impression technique.

Fifteen impressions were made for each group and casts were poured and categorized as:

3.1.1. *Group A multiple mix impression technique (Fig. 2)*

Impression was made using custom made acrylic tray. The light body was dispensed on the each prepared tooth & edentulous space and simultaneously heavy body was loaded in the tray and seated on the mandibular arch typodont base of master model. The impression was removed after complete polymerization of impression material.

3.1.2. *Group B matrix impression system (Fig. 3)*

A putty matrix was prepared over the selected abutments including one extra tooth adjacent to each abutment. The matrix was trimmed inter-dentally for escape of impression material and proximal surface of adjacent unprepared teeth were relieved to prevent wedging and distortion of matrix while seating. Escape ways were prepared in the matrix. Heavy viscosity impression material was mixed & dispensed into the matrix and placed on prepared abutments. Simultaneously a mix of medium body impression material was loaded in the stock tray and seated on the matrix to make a

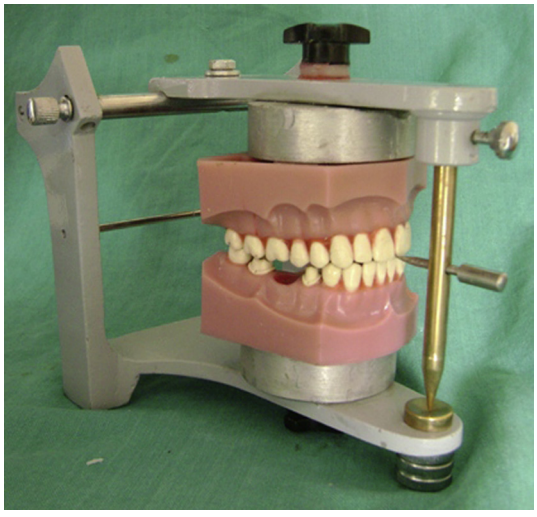


Fig. 1 – Master model.



Fig. 2 – Multiple mix impression technique.



Fig. 3 – Matrix impression technique.

pick up impression. The impression was removed after complete polymerization of impression material.

3.1.3. *Group C dual arch impression technique (Fig. 4)*
Disposable dual arch plastic trays with sides were selected that fitted passively on the right side of the mounted master model and did not interfere with occlusion.

Low viscosity elastomeric impression material was mixed and loaded over each prepared tooth and edentulous space. Simultaneously heavy viscosity impression material was mixed and loaded on both upper and lower sides of the triple tray and placed on the prepared teeth. The articulator was closed with the teeth in maximum intercuspation. After setting of the impression material, impression was removed. The impression was recorded with the prepared teeth, adjacent teeth and the opposing teeth in occlusion.

The various measurements of master model and stone casts were done with the help of coordinate measurement machine (CMM, Lloyd, Germany) with an accuracy of 0.0001 mm. All forty five casts were measured and the mean distances were taken as:

Vertical distances: a–b, d–e (molar height & premolar height respectively).

Horizontal distances: a–c, d–f, b–e (molar diameter, premolar diameter and inter-abutment distance respectively).

4. Observations and results

After the readings were obtained they were compared with the dimensions on master model using one sample *t*-test and the comparisons in between the groups and within the groups were done by performing ANOVA. The difference between readings of stone casts and model was calculated as follows:

Mean difference = mean distance on master model–mean distance on stone model. The distances measured on the master model and casts obtained from three different groups were subjected to statistical analysis for comparisons. The observations and results of the study can be summarized in the following tables:

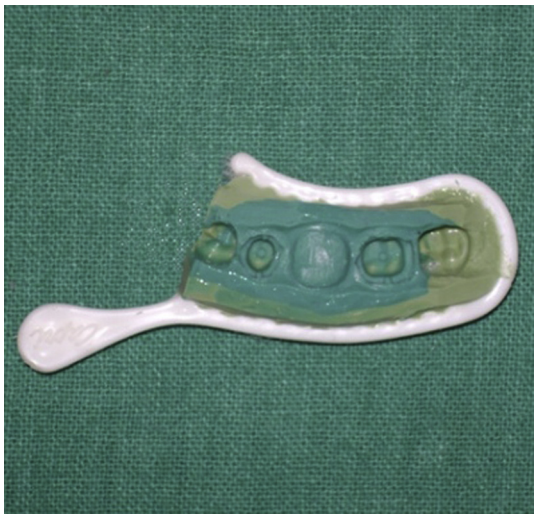


Fig. 4 – Dual arch impression technique.

5. Discussion

Numerous impression materials and techniques have been proposed for obtaining an accurate impression of the dental and dento-alveolar structures. Any inaccuracy in obtaining a perfect positive replica leads to failure of the prosthesis. In other words, the success of the prosthesis depends upon the accuracy and dimensional stability of the impression materials used and the impression techniques utilized.

Polyvinyl siloxanes show the smallest dimensional changes on setting & are considered to reproduce the greatest detail of all the impression materials.[1] Amongst them the low viscosity, medium viscosity and high viscosity polyvinyl siloxanes show the same degree of detail reproduction.[4] Various techniques have been developed to improve the accuracy of impressions used in making crowns and fixed partial dentures. Fusayama et al and Wassel et al[8] reported that one-step putty wash technique produced more accurate casts whereas Chee W et al[5] and Nissan et al[6] & Johnson GH et al[7] reported that dimensional accuracy was better with two-step technique. Wassell and Ibbetson (1991)[8] reported that heavy body and wash impressions were more accurate than putty and wash impression.

Table 1 – Basic statistics of molar height (a–b) measured on casts of different groups, compared with master model by one sample *t*-test.

Techniques	Mean	SD	Mean differences	*p*-Values	*t*-Values
Master model	3.5400	0.006	–	–	–
Group A	3.5392	0.002	−0.00077	0.0765	1.9127ns
Group B	3.5395	0.001	−0.0005	0.1579	1.4921ns
Group C	3.5200	0.03	−0.02	0.0519	2.1247ns

ns = not significant, ($p > 0.05$) df = 14, s = significant, ($p < 0.05$)
SD = standard deviation.

Table 2 – Basic statistics of premolar height (d–e) measured on casts of different groups, compared with master model by one sample t-test.

Techniques	Mean	SD	Mean differences	p-Values	t-Values
Master model	4.3316	0.004	–	–	–
Group A	4.3307	0.002	−0.0009	0.0727	1.9408ns
Group B	4.3313	0.001	−0.0003	0.4504	0.7763ns
Group C	4.3052	0.03	−0.0263	0.0019	3.8238s

ns = not significant, ($p > 0.05$) df = 14, s = significant, ($p < 0.05$)
SD = standard deviation.

The purpose of the present study was to compare the dimensional accuracy of three elastomeric impression procedures that is multiple mix impression technique (Group A), matrix impression system (Group B), dual arch impression technique (Group C). Among the various distances measured the horizontal distances were measured to know the change in bucco-lingual dimensions and in inter-abutment distances, whereas vertical distances signified the occluso-cervical measurements.

It was observed from the study that none of the casts obtained from different techniques was similar to the master model in three dimensional measurements.

All impressions had a tendency to be slightly undersized in vertical dimensions (occluso-cervical) and oversized in horizontal dimensions (bucco-lingual and inter-abutment). This phenomenon occurred because of contraction of the impression material toward the tray walls, making the stone dies wider in horizontal aspect and shorter in vertical one.[6]

The increase in horizontal distance seen may also be explained by linear setting expansion of the die material (Kalrock, 0.1% maximum) throughout the entire bulk of stone model and because of the constraint imposed by an effective adhesive on uniform shrinkage upon setting, abutments in resultant cast may tend to be greater distance apart than they are actually. This discrepancy in behavior may be attributed in part to the difference in the bond strength of tray adhesive. The impression material producing the larger die shrank toward the tray surface due to stronger bond. Marcinak et al (1980)[9] reported that the direction of dimensional changes of impression material was dependent upon the bonding of the material to the tray. It was because of rigid tray and good adhesion to the tray, that the impression shrank toward the tray and produced a larger die.

In the present study from Tables 1 and 2, it can be interpreted that the vertical distances that is molar and premolar height showed a decrease in dimensions as compared to the master model. The vertical dimension was most accurately reproduced by matrix impression system. This was further followed multiple mix impression technique. This can be attributed to the fact that in matrix impression system there is low polymerization shrinkage because of controlled bulk and uniform thickness of heavy and medium viscosity impression material. In multiple mix impression technique lesser accuracy may be because of greater polymerization shrinkage in low and medium viscosity impression material as compared to heavy viscosity impression material.[4] For dual arch impression technique, decrease in vertical distance is more than two techniques but yet was not significant.

Tables 3 and 4 depicted that horizontal dimensions that is molar and premolar diameter showed an increase in dimensions as compared to master model. The horizontal dimensions were most accurately reproduced by Group A multiple mix technique followed by Group B matrix impression system because putty is used as a matrix, which is somewhat resilient and hydraulic pressure creates undetectable distortion in the impression.[10] Lesser accuracy of this technique can also be attributed to the fact that due to pressure of stock tray over the matrix, matrix can flex in bucco-lingual direction thus increasing the die in bucco-lingual dimensions.[2,5] The Group C dual arch technique showed a statistically significant difference. This can be because of uneven thickness of impression material resulting in non-uniform polymerization shrinkage producing distortion in the impression. Use of plastic tray, which easily flexes while making impression, adversely affects the accuracy of the impression.

Table 5 showed an increase in inter-abutment distance as compared to the master model. The order of accuracy of various distances measured on the stone cast produced by different techniques deviated from the distances on master model was, Group B > Group A > Group C. Dual arch technique showed a statistically significant mean deviation. The results can be attributed to uneven or non-uniform bulk of impression material and variations in the direction of polymerization shrinkage for different impression techniques and flexibility of plastic tray.[2]

On the basis of the study it was found that there are no statistically significant differences between the various techniques except for dual arch impression technique. So it can be stated that, each of these techniques is suitable for particular

Table 3 – Basic statistics of molar diameter (a–c) measured on casts of different groups, compared with master model by one sample t-test.

Techniques	Mean	SD	Mean differences	p-Values	t-Values
Master model	7.4100	0.013	–	–	–
Group A	7.4102	0.001	0.0002	0.6380	0.4809ns
Group B	7.4113	0.003	0.0013	0.0707	1.9562ns
Group C	7.4200	0.015	0.010	0.0192	2.6450s

ns = not significant, ($p > 0.05$) df = 14, s = significant, ($p < 0.05$)
SD = standard deviation.

Table 4 – Basic statistics of premolar diameter (d–f) measured on casts of different groups, compared with master model by one sample t-test.

Techniques	Mean	SD	Mean differences	p-Values	t-Values
Master model	6.5955	0.006	–	–	–
Group A	6.5966	0.003	0.0011	0.1588	1.4884ns
Group B	6.6046	0.036	0.0091	0.3541	0.9584ns
Group C	6.6482	0.037	0.0527	<0.0001	5.5087s

ns = not significant, ($p > 0.05$) df = 14, s = significant, ($p < 0.05$)
SD = standard deviation.

Table 5 – Basic statistics of inter-abutment distance (b–e) measured on casts of different groups, compared with master model by one sample t-test.

Techniques	Mean	SD	Mean differences	p-Values	t-Values
Master model	19.3911	0.017	–	–	–
Group A	19.3929	0.011	0.0018	0.5184	0.6624ns
Group B	19.3927	0.004	0.00165	0.1453	1.5423ns
Group C	19.4246	0.029	0.0315	0.0011	4.0988s

ns = not significant, ($p > 0.05$) df = 14, s = significant, ($p < 0.05$)
SD = standard deviation.

situation and advantageous in one or other way. For example multiple mix impression system uses a custom fabricated tray to control the bulk/thickness of elastomeric impression material and thus reducing the polymerization shrinkage.

The matrix impression system used a precisely designed matrix which can provide a mean to better control the unpredictable dentogingival environment while making impressions, which significantly improves the gingival displacement and sulcular cleansing phases.[10,11]

The dual arch impression technique represented a significant advancement in fixed prosthodontic impression procedures and had additional advantages over conventional impression technique especially in fabrication of single crowns. The technique uses the tray known as triple tray; the name signifies its function as: bite registration, crown and bridge impression, counter impression. They enabled the dentist to use one tray and a single, double sided impression to imprint the prepared teeth, the adjacent teeth and the opposing teeth, all in their normal, physiological positioning of maximal intercuspation.[3,12,13] Various types of triple trays available are disposable plastic trays (with sides and side less), metal trays (with sides and side less). The technique is indicated while making impression for fabrication of single crown.

The present study showed a statistically significant distortion in dual arch impression technique so it is not recommended for a long span bridge framework. These results are in favor with the study conducted by Cox et al (2002)[14] which stated that dual arch impression technique may have superior accuracy than those fabricated with a single complete arch impression. However, lack of rigidity may lead to flexure of impression/tray complex, resulting in inaccurate dies. These results are not in agreement with the study of Ceyhan et al (2003)[15] which reported that the dimensions of working die from a custom tray impression did not differ significantly from those created with dual arch trays.

The limitation of the present study is that the dimensional changes in the present study were recorded indirectly by performing measurements on stone cast; the results include the variables of both impression and die materials. Also the results of this investigation might not be directly applied clinically because the oral environment was not simulated in this study.

6. Summary and conclusion

Within the limitation of this in vitro study it can be concluded that

1. None of the casts obtained from various impression techniques were similar to that of master model in all three dimensions.
2. As per statistical analysis, all the impressions had a tendency to be oversized in horizontal dimensions and undersized in vertical dimensions.
3. When comparing the accuracy of casts as per statistical analysis Group C (dual arch technique) casts were least accurate.
4. All other three techniques produced statistically insignificant mean deviation from the master model.

It can be concluded that all these impression procedures are suitable for use in a particular situation and have various advantages and disadvantages associated with them.

Conflicts of interest

All authors have none to declare.

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