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Comparative evaluation of Dimensional Accuracy of Casts Made by Repeated Pouring of Different Non-Aqueous Elastomers – An In Vitro Study

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Abstract

Aim: The aim of the present study is performed by using three commonly available non- aqueous elastomers namely Addition Silicones, Condensation Silicones and Polyethers for evaluating their dimensional accuracy, dimensional stability and capability to undergo multiple pours.

Materials and methods: A Master model was prepared having a platform made up of Brass and two stainless steel dies, simulating prepared tooth surfaces, without any undercuts, having a gradual taper.

Three commercially available non-aqueous elastomeric impression materials were used. Each impression was poured at various intervals of time: Immediately, after two hours, after twelve hours, after 24 hours.

To determine the impression material accuracy, measurements of the dies were done using a digital vernier caliper, comparing them with the dimension of Master Model.

Results: Addition Silicones gave a die which was slightly bigger in diameter. Condensation Silicones showed unchanged diameter or bigger diameter at the time of the initial pour but as the time elapsed, dies of smaller diameter were obtained. The Polyether materials however always produced dies which were shorter in diameter.

Conclusion: All the materials showed deviation as function of time and multiple repeated pours, it was least for Addition Silicones. Condensation Silicones should be poured as soon as possible to avoid dimensional changes resulting from its distortion as a function of time. Polyether was good in giving accurate dies but retrieval of multiple casts was difficult. Most of the dimensional changes occurring in the first and second generation of dies were statistically insignificant while many values at third or fourth generation of dies were statistically significant.

Keywords: Addition Silicones, Condensation Silicones, Polyethers, Elastomers.

Introduction

An impression is a negative replica of teeth and surrounding oral structures. In prosthodontics, accurate and dimensionally stable impressions are the first step towards fabrication of a successful prosthesis. Dentistry has been looking for an ideal impression material for long and has evolved from the stage of impression plaster to non-aqueous elastomers. The introduction of non-aqueous elastomers revolutionized the concept of impression making by incorporating excellent dimensional accuracy, stability and excellent tear resistance in the impression materials. Because of the excellent elastic recovery and resistance to deformation these materials could be poured a number of times[1,2,3,4, 6.]

The present study was done to assess and evaluate the various claims made by the manufactures about the dimensional accuracy, stability and capability to undergo multiple pouring of non-aqueous elastomers. This in-vitro study was performed using three commonly available non- aqueous elastomers namely Addition Silicones, Condensation Silicones and Polyethers. Polysulfides were not used in this study because of their poor patient acceptance, messy nature and biocompatibility issues[7]. This study did not focus only on the behaviour and properties of a particular impression material but also on different techniques employed for making impressions using these materials[8,9,10,11,12]. The aim was to give an insight to the clinician about the various impression techniques commonly used with the elastomeric impression materials and their resultant accuracy.

Material & Methods

The present study was carried out to evaluate the dimensional accuracy & reproducibility of multiple pours of three commercially available non-aqueous elastomeric impression materials[13,14]. i.e., Addition Silicones, Condensation Silicones, Polyether (fig.1).

The pouring of the casts were done at various intervals of time and the time intervals were: Immediately, After two hours, After twelve hours, After 24 hours.

Materials Used

I. For Impression making:

a. For fabrication of custom tray

1. Self-cure acrylic resin
2. Sof- Tray Sheet (Vaccupress sheet) (2 mm)
3. Straight fissure bur for making perforations.

b. For mixing the materials

1. Auto mixing cartridges with mixing tip
2. Glass slab
3. Manufacturer's supplied mixing pad (Condensation Silicone & Polyether)
4. Mixing spatula

c. Adhesive for coating on the custom tray

d. Impression materials

Addition Silicones, Condensation Silicones, & Polyether.

II. For pouring of casts

1. Rubber bowl
2. Vibrator
3. Spatula
4. Die stone (Type IV)

III. For Evaluation

a. Digital Vernier Caliper

Methodology

For the present study, A Master model was prepared having a platform made up of Brass and two stainless steel dies, simulating prepared tooth surfaces, without any undercuts, having a gradual taper. The dies were electroplated with chromium to impart passivating effect (fig. 1,2).

Fig 1: Materials used for impression making and die fabrication

Fig 2: Master Model

Customized Special trays were fabricated with vacupress sheet and acrylic resin. The thickness of vacupress sheet was kept to a thickness of 2mm (fig. 4). This was done on the basis of multiple studies present in the literature which state that a spacer thickness of 2mm gives the best results[15,16,17,18]. After fabrication of tray, spacer was removed and multiple perforations were made with a round bur. This was done to increase the mechanical interlocking of the impression material to the tray. The holes also act as vents for release of extra material.

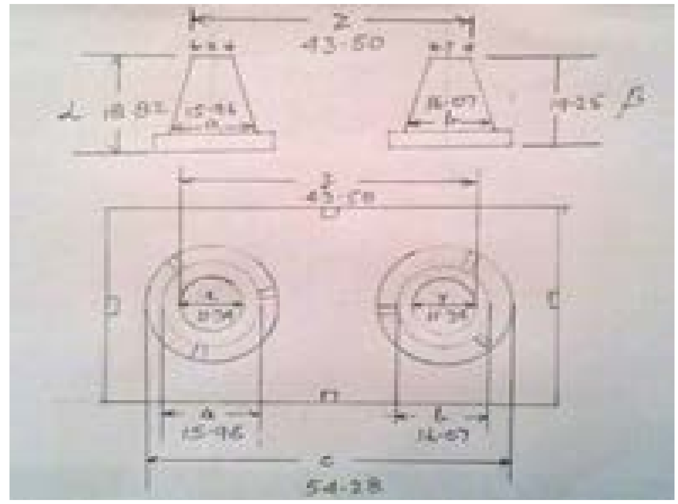

Fig 3: Measurement of Master Model

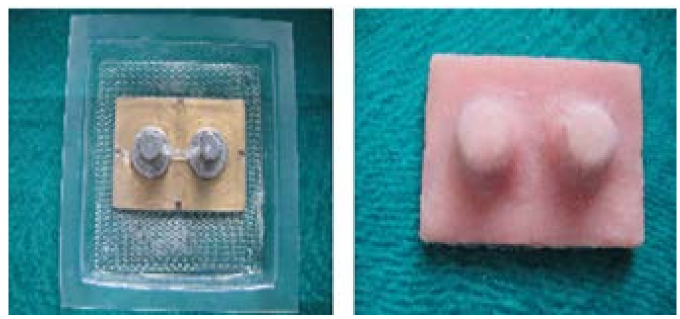

Fig 4: Special Tray Fabricated over the Master Model

For impression making, each impression material was mixed according to the manufacturer's instructions. Impressions were made by using Putty Wash reline technique, multiple mix technique and single mix technique[12]. All the impressions made were inspected for defects, if any. If it was found satisfactory it was used for study by pouring multiple casts at various time intervals.

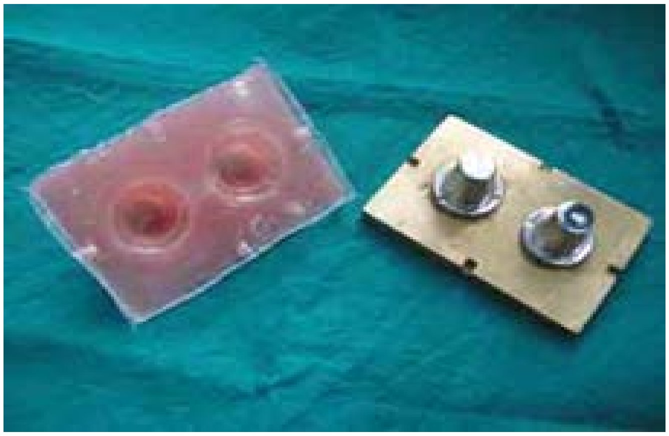

Fig 5: Vaccupress Sheet of 2 mm was used as Spacer

Fig 6: Digital Vernier Caliper

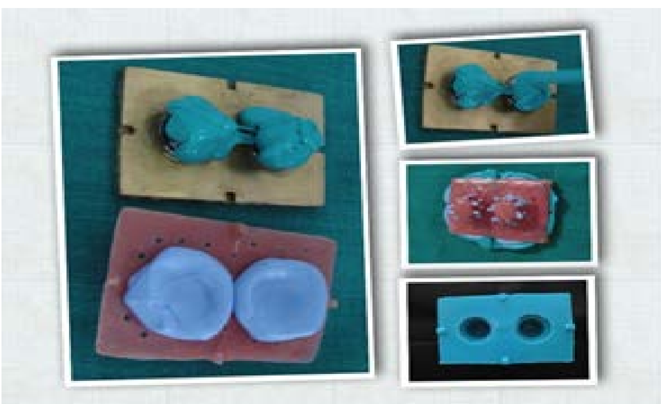

Fig 7: Dies made

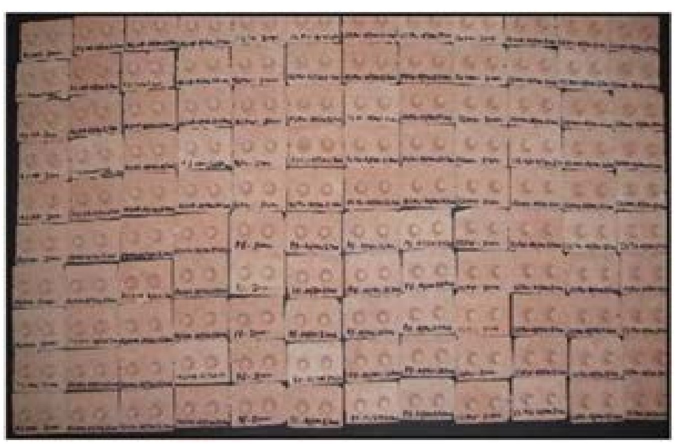

Fig 8: Dies made and Labeled According to the Material, Technique and Time of Pour

For each technique i.e. Putty Wash reline technique, Multiple Mix technique and single mix technique, a total no. of five impressions were made and poured in Type-IV Dental stone at various time intervals. These dies were then labelled according to the material, technique and time of pour. A total of 120 dies were obtained and used in the study (fig. 7)

To determine the impression material accuracy, measurements of the dies were done using a digital vernier caliper, comparing them with the dimension of Master Model (fig. 8,). Each reading was repeated three times and an average value was taken. These measurements were subjected to statistical evaluation by Active research group, Lucknow and a comparative evaluation was done.

The statistical analysis was done using SPSS (Statistical package for social sciences) version 15.0 Statistical analysis software. The values were represented in number (%) and mean +_SD.

Result

On the basis of observations and statistical analysis following results was obtained (Table-1).

1. Addition Silicones were found to be the most accurate – both in terms of dimensional accuracy and reproducibility even while undergoing multiple pours. The elastic recovery was such that even after retrieval of multiple casts from the same impression very little variation or no variation was observed in the results.

2. Condensation Silicones were comparable in dimensional accuracy in initial pours but then deteriorated rapidly. It is suggested not to use this material if prolonged storage or multiple casts are desired.

3. Polyethers, are reasonably accurate and stable impression materials but slightly inferior in results as compared to Addition Silicones. Hydrophilicity, which

is a big positive for intraoral impressions, can be a drawback while pouring these impressions in gypsum products. Water available in gypsum is readily absorbed by polyethers, resulting in dimensional changes. However, these changes are very small and the clinical relevance of this is debatable.

4. All the impression materials used in the study, except for late pours of condensation silicones, were very accurate and no differences in results were noted by using different impression techniques.

5. Addition Silicones, generally produced dies which were bigger in diameter and smaller in height. The condensation silicones also showed the same trend. Polyethers however produced dies which were shorter in diameter and shorter in height. As stated previously, these differences were not very significant and the probability of these to be of any significance clinically is questionable.

Table 1: Dimensional Discrepancies at different location in different groups (ANOVA).

Para-meter	ASMM Group I		ASMP Group II		ASPW Group III		CSPW Group IV		CSMM Group V		PE Group VI		Statistical significance (ANOVA)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	p
OVERALL (All time intervals) (n=20 each)														
x	0.021	0.020	0.018	0.011	0.021	0.022	-0.047	0.047	-0.033	0.050	-0.031	0.069	11.194	<0.001
y	0.017	0.021	0.015	0.013	0.013	0.015	-0.048	0.062	-0.027	0.050	-0.027	0.016	12.228	<0.001
Z	0.013	0.022	0.035	0.026	0.027	0.033	-0.007	0.103	-0.103	0.221	-0.039	0.030	5.039	<0.001
A	-0.038	0.228	0.006	0.013	0.020	0.020	-0.039	0.104	-0.016	0.097	-0.057	0.060	1.346	0.250
b	-0.018	0.201	0.030	0.036	-0.034	0.200	-0.109	0.276	0.362	1.228	-0.096	0.152	2.143	0.065
alpha	0.012	0.006	0.049	0.192	0.014	0.006	-0.051	0.041	-0.041	0.031	-0.096	0.224	3.734	0.004
beta	-0.441	1.798	-0.038	0.048	-0.083	0.073	-0.218	0.499	-0.029	0.114	-0.176	0.274	0.808	0.546
Immediate (n=5 each)														
x	0.040	0.000	0.028	0.011	0.024	0.029	-0.004	0.022	-0.038	0.035	0.028	0.103	1.902	0.131
y	0.024	0.022	0.010	0.010	0.016	0.017	-0.002	0.023	-0.014	0.021	-0.016	0.018	3.740	0.012
z	0.018	0.027	0.046	0.045	-0.010	0.039	-0.020	0.034	-0.020	0.016	-0.046	0.031	4.747	0.004
a	0.004	0.009	0.006	0.013	0.032	0.026	0.064	0.111	-0.044	0.034	-0.032	0.044	2.945	0.033
b	0.028	0.016	0.028	0.044	-0.168	0.398	0.016	0.037	-0.062	0.062	-0.092	0.076	1.117	0.378
alpha	0.008	0.005	0.182	0.379	0.014	0.006	-0.012	0.025	-0.026	0.021	-0.060	0.014	1.486	0.231
beta	-0.028	0.011	-0.048	0.063	-0.028	0.024	-0.022	0.025	-0.012	0.052	-0.092	0.184	.599	0.701
2 hr (n=5 each)														
x	0.012	0.016	0.016	0.013	0.020	0.025	-0.030	0.014	0.010	0.040	-0.026	0.020	4.598	0.004
y	0.020	0.028	0.020	0.019	0.014	0.017	-0.018	0.016	-0.004	0.018	-0.026	0.017	5.210	0.002
z	0.008	0.018	0.026	0.024	0.026	0.009	-0.042	0.027	-0.084	0.083	-0.052	0.030	6.778	<0.001
a	0.014	0.009	-0.002	0.011	0.022	0.016	-0.028	0.037	-0.072	0.028	-0.086	0.082	6.586	0.001
b	0.024	0.009	0.018	0.021	0.004	0.009	-0.006	0.031	0.740	1.767	-0.072	0.059	.902	0.496
alpha	0.014	0.006	-0.002	0.027	0.012	0.008	-0.084	0.047	-0.072	0.036	-0.230	0.453	1.248	0.318
beta	-1.660	3.589	-0.076	0.058	-0.140	0.076	-0.014	0.015	-0.028	0.036	-0.018	0.005	1.004	0.437
12 hr (n=5 each)														
x	0.010	0.027	0.012	0.005	0.012	0.018	-0.044	0.040	-0.022	0.025	-0.040	0.014	6.093	0.001
y	0.016	0.022	0.016	0.017	0.022	0.015	-0.026	0.015	-0.026	0.036	-0.032	0.008	7.552	<0.001
z	0.022	0.030	0.030	0.010	0.036	0.021	-0.036	0.033	-0.072	0.023	-0.030	0.041	12.31	<0.001
a	0.028	0.039	0.002	0.005	0.022	0.019	-0.068	0.042	-0.044	0.017	-0.040	0.042	8.232	<0.001
b	0.024	0.017	0.048	0.054	0.020	0.000	-0.044	0.037	0.764	1.809	-0.040	0.037	0.899	0.498
alpha	0.014	0.006	0.004	0.006	0.016	0.006	-0.060	0.026	-0.046	0.011	-0.054	0.036	18.01	<0.001
beta	-0.048	0.042	-0.008	0.011	-0.086	0.099	-0.018	0.005	-0.094	0.085	-0.044	0.059	1.619	0.193
24 hr (n=5 each)														
x	0.020	0.014	0.016	0.006	0.028	0.018	-0.108	0.030	-0.080	0.058	-0.084	0.061	<0.001	<0.001
y	0.006	0.009	0.012	0.005	0.000	0.000	-0.146	0.031	-0.062	0.087	-0.032	0.018	<0.001	<0.001
z	0.004	0.006	0.036	0.018	0.054	0.018	0.072	0.193	-0.234	0.440	-0.026	0.018	0.187	0.187
a	-0.196	0.450	0.016	0.015	0.004	0.009	-0.124	0.113	0.098	0.142	-0.068	0.064	0.257	0.257
b	-0.146	0.406	0.024	0.022	0.010	0.033	-0.402	0.461	0.004	0.071	-0.178	0.293	0.163	0.163
alpha	0.012	0.008	0.010	0.000	0.014	0.006	-0.046	0.032	-0.020	0.028	-0.038	0.027	<0.001	<0.001
beta	-0.026	0.009	-0.018	0.005	-0.076	0.039	-0.816	0.766	0.020	0.204	-0.550	0.287	0.002	0.002

Discussion

In this study was carried out to compare the performance of three commonly available non-aqueous elastomeric impression materials for their dimensional accuracy and reproducibility at immediate pour and multiple pours at time intervals of 2 hours, 12 hours and 24 hours. The impression materials used in this study were Addition Silicones, Condensation Silicones and Polyether (fig. 1).

Polysulfide impression materials were not used in the study because of their poor patient acceptance, messy nature & bio-compatibility issues[7]. A master model was prepared for this study which had two mounted dies, having a gentle taper and were free of any undercuts. The dies were made up of stainless steel, over which chromium plating was done to impart passivating effect (fig.2).

Condensation Silicones and Addition Silicones were used in soft putty and low viscosity consistency. Apart from this, Addition Silicones was used in a monophase consistency. Polyether was only used in monophase consistency. Wherever possible, auto mixing cartridges were used to ensure proper dispensing and mixing. However, wherever the impression material was to be mixed manually it was done by stropping technique. In this technique the material is repeatedly scraped up with forceful sweeping motion over a broad area of the pad. This technique minimizes formation of voids in the mixed material[19,20]. Each and every impression was closely inspected for defects, if any.

To make the impressions, custom made acrylic resin trays were used, using a 2mm spacer. A uniform space of 2mm was given because this thickness of impression material gives least dimensional change (fig. 5). The trays were made 24 hours before the impression[17,21,22].

After complete setting of the impression material, the tray was removed from the die with a snap jerk to avoid tearing due to the drag of the material. The die stone was poured in the impression using a vibrator to avoid air bubbles. After retrieval of the stone dies and their subsequent inspection, impressions were stored at room temperature (20-25ºC), in the air for the required period of time, till they were poured again.

Our result showed that Addition Silicones, both putty and low viscosity as well as monophase gave a die which was slightly bigger in diameter. The reason behind this could be that Addition Silicones show polymerization shrinkage towards the walls of the impression tray resulting into a die which was oversize in diameter. Shrinkage caused by cooling of the impression material was not relevant in the study because the impression material always remained at the room temperature.

Condensation Silicones showed unchanged diameter or bigger diameter at the time of the initial pour but as the time elapsed, dies of smaller diameter were obtained. Condensation Silicones undergo considerable polymerization shrinkage and show stress relaxation as a function of time causing the material to come towards the imaginary centre of the impression, leading to production of dies which were smaller in both horizontal and vertical dimensions.

The Polyether materials however always produced dies which were shorter in diameter. The reason could be the hydrophillicity of the material which results into absorption of water from the die material resulting into swelling of the impression and subsequently giving shorter diameter dies. From a clinical point of view it is always better to have a die having a larger diameter as compared to the shorter diameter, because larger diameter dies results into easy seating of the castings[8,9,16,23,24]. The height of the stone dies was shorter than the standard for all the impression materials[5,6]. This could be because of the contraction towards the occlusal portion of the preparation. Addition Silicones gave the least change in the vertical height followed by Polyether and Condensation Silicones. For Condensation Silicones distortion of the impression material as a function of time leads to a remarkable decrease in vertical height. The changes in the vertical height are more remarkable as compared to the changes in horizontal dimensions. The change in vertical height for Polyether could be due to the expansion of the material.

The American Dental Association (ADA) admits dimensional changes of elastomers less than 0.5 % as clinically acceptable. In our study Addition Silicones gave values which were significantly lesser than 0.5%. However Condensation Silicones deteriorate fast and in the later pours the error reaches to 3-4%. The Polyether also gives consistent results however slightly inferior than Addition Silicones.

In our study we used three techniques for impression making. These were; putty wash reline technique, multiple mix technique, and single mix technique. The different techniques resulted into no change or very little change in the results[12]. This study was different from just evaluating the dimensional stability of any given elastomeric impression material at any given period of time, because here two factors are under consideration – one was the elapsed period of time and another was repeated induced distortion while removing multiple casts from the same impression. The impression materials which were quite good in resisting the induction of undue stresses over it while removing the casts gave better results like Addition Silicones. Polyether though quite good in maintaining the same dimensional accuracy at any given period of time, e.g. 24 hours, was not as good when multiple casts were poured in the same impression and retrieved repeatedly. Silicones which were quite good in resisting the stresses which were induced, fared better than most of the others, though Condensation Silicones had a tendency to deteriorate with time. Though all the material showed deviation as function of time and multiple repeated pours, it was least for Addition Silicones. Condensation Silicones should be poured as soon as possible to avoid dimensional changes resulting from its distortion as a function of time. Most of the dimensional changes occurring in the first and second generation of dies were statistically insignificant while many values at third or fourth generation of dies gave significantly dimensional results especially for Addition and Condensation Silicones.

This study more or less confirms that the modern non-aqueous elastomers commonly used in dental practice are very accurate and can give multiple casts at various time intervals maintaining the dimensional accuracy. Addition Silicones were found to be the most accurate, and different impression techniques did not make much of a difference till the time thickness of the impression material is regulated. Condensation Silicones though very accurate; have the tendency to deteriorate rapidly with time. It is therefore recommended that they should be poured as soon as possible and possibly multiple pouring of the impression after a certain time should be avoided. Polyethers are very accurate but stiff in nature making the retrieval of multiple casts a tedious job. Apart from this the hydrophilic nature of the material makes it prone to dimensional changes.

Conclusion

All the materials showed deviation as function of time and multiple repeated pours, it was least for Addition Silicones. Condensation Silicones should be poured as soon as possible to avoid dimensional changes resulting from its distortion as a function of time. Polyether was good in giving accurate dies but retrieval of multiple casts was difficult. Most of the dimensional changes occurring in the first and second generation of dies were statistically insignificant while many values at third or fourth generation of dies were statistically significant.

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