



Elastomeric Impression Materials: A Comparison of Accuracy of Multiple Pours

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ABSTRACT

Aim: The aim of the present study is to compare the various elastomeric impression materials in terms of accuracy and dimensional stability, with respect to obtaining multiple casts from a single elastomeric impression at various times of pours.

Materials and methods: Three master dies were prepared for the impression making, two of these were made of brass containing a central hole with undercuts. The third die simulated a conventionally prepared typodont maxillary central incisor. Three elastomeric impression materials were chosen for the study. Each impression was poured at various time periods. Casts thus obtained were evaluated under a traveling microscope to evaluate various dimensional changes.

Results: Addition silicones provided dies which were shorter in height and bigger in diameter. Polyethers provided dies which were shorter in both height and diameter. Condensation silicones showed insignificant changes from the master die at the immediate pour but deteriorated rapidly after that in subsequent pours.

Conclusion: None of the impression material showed a consistent behavior up to the fourth pour. They occasionally showed deviation from the pattern, but all these values were statistically insignificant. Polyethers showed lesser ability than both the addition silicones as well as the condensation silicones to recover from induced deformation.

Clinical significance: Addition silicones as well as the condensation silicones have better ability to recover from induced deformation when compared to polyether.

Keywords: Addition silicones, Condensation silicones, Polyethers.

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INTRODUCTION

In dentistry, accurate and dimensionally stable impressions are the first step toward fabrication of a successful

prosthesis. An impression is a record, a facsimile of the mouth tissues taken at an unstrained rest position or in various positions of displacement.¹ Some materials have been developed to accomplish specific goals, and at the time at least were considered desirable for the purpose.²⁻⁴ In modern times, dentists have a variety of impression material at their disposal. Selection of material is generally left at the discretion of the dentist, who makes choices based on personal preference and experience.⁵ Elastomeric impression materials have emerged as the material of choice for a variety of reasons including excellent reproducibility and dimensional stability.⁶⁻⁸ In the last decade, several investigators have recommended using newer elastomeric impression materials such as polyvinylsiloxanes and polyethers to replace the older and more traditional materials.⁹⁻¹¹ Four basic types of elastomeric impression materials are currently in use in the dental profession namely (1) Polysulfides (2) Addition silicones (3) Condensation silicones (4) Polyethers. Good results are obtained with less expenditure of time as well as less discomfort and inconvenience for the patient even in the hands of an inexperienced operator.¹²⁻¹⁴

The present study is a step toward comparing the various elastomeric impression materials in term of accurate reproducibility, dimensional stability and ability to produce multiple casts from the same impression at various times intervals. The reason to check the maintenance of accuracy by the impression materials while undergoing multiple pouring and retrieval of the stone casts is of clinical importance because many a times a dentist wishes to have two or more casts out of the same impression, to avoid the problems associated with repeated impression making. In this study, an attempt to compare three elastomeric impression materials toward two different situations have also been attempted by using undercut and nonundercut dies. It is hoped that this attempt to assess various elastomeric

impression materials available, will help in choosing the right material for making accurate and dimensionally stable impressions in the field of dentistry, with respect to obtaining multiple casts from a single elastomeric impression at various time of pours.

MATERIALS AND METHODS

An *in vitro* study was conducted to evaluate the reproducibility of various elastomeric impression materials available at the time of initial pour and repeated multiple pours at various time intervals of 8 hours, 16 hours, and 24 hours with regards to their linear dimensions and surface detail reproduction of gypsum casts produced from different impressions.

Materials and Equipment

The materials and equipment used in the study were as follows:

1. Master die assembly (Fig. 1): Die assemblies consisting of three individual dies, were taken. Two of these dies were made of brass and chromium plating was done over it so that impression material did not stick to it. The dies simulated two complete crown preparations as abutments for fixed partial denture. Two steps were provided in the cervical third to protect the impression from tearing. The master dies were self-designed and

locally machined to have a flat circular occlusal part with a hole in the center. A third die, called die C, which was a prepared typodont maxillary central incisor for a complete crown, was used for the study (Table 1). All the three dies could be attached and detached to the base with the help of the screws.

2. Impression trays: Custom made acrylic trays with multiple perforations were used for taking the impression.^{15,16} A uniform 2 mm space was provided for the impression material.¹⁷
3. Impression materials (Fig. 2): For this study, various elastomeric impression materials were procured from the local market.
4. Dental stone: All casts were poured in die stone, type II plasters.
5. Vibrator: An electric vibrator was used for the study.
6. Optical traveling microscope (Fig. 3): An optical traveling microscope was used for the study. The precision of the measurement of the master die was ± 0.01 mm.
7. Miscellaneous instruments: Mixing pad and stainless steel spatula were used for mixing of elastomeric impression materials. Rubber bowl and stainless spatula were used for mixing die stone. BP Knife, Lecron carver and measuring cups were used for various other specific purposes in this study.



Fig. 1: Master dies assembly consisting of dies A, B and C



Fig. 2: Materials and equipment used in the study

Table 1: Dimensions of the master die

Dies	Occlusocervical height (mm)	Diameter of outer circle (mm)	Diameter of inner circle (mm)	Distance between upper shoulder and lower shoulder (mm)
Die A	8.44	9.46	2.92	2.46
Die B	8.45	10.38	2.95	2.52
Die C	Cervicoincisal length at labial surface	Cervicoincisal length at lingual surface	Mesiodistal width	NA
	7.94	7.94	5.45	

NA: Not applicable

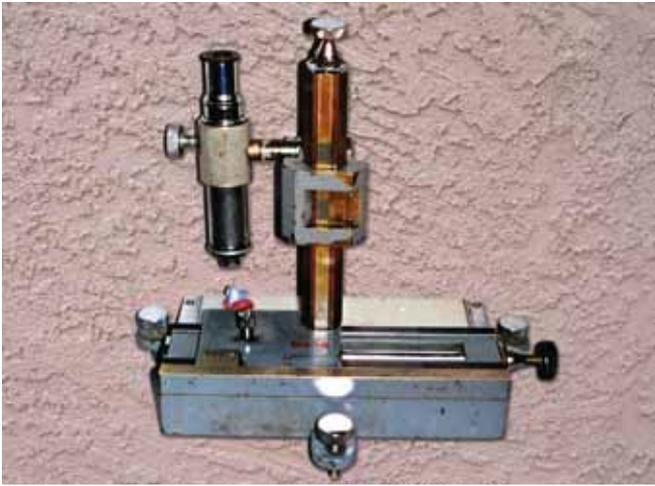


Fig. 3: Traveling microscope used for the study

Method

For taking the impression, required quantities of base and accelerator pastes were mixed until a homogeneous color was obtained and then loaded on the impression tray. The loaded tray was then properly seated on the die so as to ensure complete contact with the base of the die. The impression material was allowed to set for the recommended time. The whole procedure was done according to the manufacturer's directions. On removal from the die, the impression was carefully examined to detect any imperfections. The impressions were then poured in measured die stone with the help of an electric vibrator at the time intervals of (a) immediately, (b) after 8 hours, (c) after 16 hours, (d) after 24 hours.

Every time, the cast was allowed to set for 30 minutes before being separated from the impression.

These impressions were used to evaluate the dimensional reproducibility of the impression material at the repeated pours. Each time the stone cast was retrieved from the impression taking care not to damage the impression, then storing the impression as required and again pouring it (Fig. 4).



Fig. 4: Stone dies made from master dies A, B and C

The set casts were measured in the laboratory for the linear dimensional changes at various reference points by a traveling microscope having a calibration of 0.00. Traveling microscope contained a main scale gauze and Vernier scale gauze. For the reading, the main scale reading was taken and added to the Vernier scale reading to give the final reading. The lens of the microscope has a cross wire which was flushed with the reference points and the table was moved.

Each cast was measured five times at one reference point and the average reading was taken. The microscope was always moved in one direction between the two reference points. This procedure ensured that the same gear tooth side was always engaged on the same pitch surface in the screw thread. The tolerance error was not expressed as dimensional movement that occurs when the opposite gear tooth surface engages the opposite pitch surface of the screw on the reversal of direction. The measuring scale was calibrated in division of 0.01 mm. The findings and comparisons were studied under various comparative evaluation. In total, 48 stone dies were measured in this fashion to detect the linear dimensional changes occurring from the time of initial pour and multiple repeated pours.

The data obtained were subjected to statistical analysis. Mean and standard deviation were calculated for all groups. Intergroup mean difference for each measurement was assessed with two way 'analysis of variance' (ANOVA). The student 'Newman Keul's test' (NKT) was employed to test the equality of mean of two groups.

RESULTS

The present study was carried out to compare three elastomeric impression materials for their accurate reproducibility and dimensional stability at immediate pour and multiple pour at the time intervals of 8, 16, and 24 hours.

Here, in the present study following elastomeric impression materials, e.g. addition silicones—low viscosity and monophasic, condensation silicones and polyethers were chosen as they are commonly used in contemporary dentistry.¹⁸ Polysulfides were not taken for the study because of their decreasing popularity as well as some safety and allergy issues.¹⁹⁻²¹ An assembly of standard master dies which were stable dimensionally and simulated complete crown preparation, were got prepared for making impressions from the above-mentioned materials. The linear dimensional changes from the standard master dies to the stone dies were compared to evaluate the accurate reproducibility and dimensional stability of the impression materials. The reason behind the repeated pours in the same impression was based on the view that in clinical practice many a times a clinician wishes to have two or more casts

from the same impression without resorting to repeated impression making.

After evaluating the results on the basis of statistical analysis, following observations were made (Table 2):

1. For addition silicone LV, contraction of the impression material occurs toward the tray, resulting in dies which were shorter in height and bigger in diameter. The changes for dies A, B and C ranged from -0.32 to -0.40% in the vertical dimensions and +0.15 to +0.34% in the horizontal dimensions, at the fourth pour. Most of the linear dimensional changes in the dies obtained at various time intervals were statistically insignificant while some were statistically significant.
2. For polyethers, the expansion of the impression material due to absorption of water and moisture from the poured stone, resulted in dies which were shorter in both height and diameter. The change for dies A, B and C ranged from -0.23 to -2.22% in vertical dimensions and -0.32 to -0.34% in horizontal dimensions. A few of the changes for die A and die B were found to be highly significant.
3. Condensation silicones showed insignificant changes from the standard dimensions at initial pour but as a function of time resulted in production of dies which were shorter in both vertical and horizontal dimensions. The change for dies A, B and C ranged from -0.43 to -1.14% in vertical dimensions and -0.27 to -0.44% in horizontal dimensions in the fourth generation of casts.
4. Monophase addition silicones behaved in the same fashion as addition silicones LV but showed slightly more variations. At the fourth generation of obtained dies, the change for dies A, B and C ranged from -0.2 to -1.14% in vertical dimensions and +0.04 to +0.27% in horizontal dimensions.
5. Polyethers showed lesser ability than both the addition silicones as well as the condensation silicones to recover from induced deformation as judged by its better performance for die C as compared to die A and die B (in the case of die C, there were no undercuts involved).

6. None of the impression materials studied always showed a consistent behavior upto the fourth pour. They occasionally showed deviation from the pattern, but all these values were statistically insignificant.

DISCUSSION

To compare the consistency of the performance of the material, three master dies were chosen rather than one die. Each die created a different situation for the impression materials and therefore helped to understand the behavior of various elastomers during those situations. Die A and die B simulated two complete crown preparations except one deviation and that was the presence of central hole in the middle of the die. There were multiple minute grooves at the end of the hole to simulate a bit of undercut as well. The purpose of the study was not to measure the depth of the hole but to see how various elastomers coped with repeatedly induced deformations due to this hole and maintained their accuracy. The surface of the brass dies A and B were electroplated with chromium to impart passivity to the dies so that chance of any reaction with silicones be kept to a minimum, while the third die, die C was a prepared typodont central incisor.

To take the impressions, custom made acrylic resin tray was used. A uniform 2 mm of space was provided for the impression material as elastomeric impression material give least dimensional changes when the thickness of the impression material is kept to a minimum of 2 mm.^{17,22} Acrylic tray was made at least 24 hours in advance before taking the impression.^{16,17}

The impression material chosen was mixed by stropping technique.²³ In this technique, the material was repeatedly scraped up and then stropped with forceful sweeping motion over a broad area of the pad. It minimized the formation of voids in the impression.

After complete setting of the impression material, the loaded impression tray was removed from the master die with a snap jerk to eliminate chances of tearing due to the drag of the material. After removal, the impressions were

Table 2: Reference point—inner circle diameter

Time of pour	Addition silicones			Condensation silicone			Polyether			Monophase addition silicone		
	X	SD	%	X	SD	%	X	SD	%	X	SD	%
Immediate	2.92	0.01	0.00	2.92	0.01	0.00	2.91	0.01	0.02	2.92	0.01	0.00
8 hours	0	2		0	0		4	1		0	6	
	2.92	0.00	0.00	2.92	0.01	0.07	2.91	0.00	—	2.91	0.01	—
	0	7		2	9		6	6	0.32	2	3	0.27
16 hours	2.92	0.01	0.07	2.92	0.01	0.07	2.92	0.00	—	2.92	0.00	0.00
	2	3		2	6		0	7	0.32	0	7	
24 hours	2.93	0.00	0.34	2.91	0.01	—	2.91	0.00	—	2.91	0.00	—
	0	7		6	1	0.14	4	9	0.32	8	8	0.07

X: Mean; SD: Standard deviation

carefully studied under light to detect imperfections if any. It was also noted that impression of the hole was perfect with the mark of indentations clearly visible over it. It was also observed that maximum defects in the impression marking were in the region of the distance between the first and second shoulders, which were then made again.

After retrieval of the stone dies, the impressions were stored at room temperature (18°-22°C), in the air, for the required period of time and then poured again as required.

Results show that addition silicones, both low viscosity and monophasic, gave a die which was slightly bigger in diameter than the standard master die. The reason behind this could be attributed to the fact that the addition silicone impression material shows polymerization shrinkage toward the walls of the impression tray resulting in a die which was oversized in diameter. Shrinkage caused by cooling of the impression was not a factor in this study because impression always remained at room temperature at which the impressions were made. Condensation silicone showed a generally unchanged diameter or a bigger diameter at the time of initial pour but as the time elapsed, shorter dies in diameter than the standard ones were obtained. The reason behind this was though condensation silicones are understood to go considerable polymerization shrinkage, they showed stress relaxation as a function of time causing the material to come toward the imaginary center of the impression, leading to production of dies which were shorter in both horizontal and vertical dimensions. The polyether material, however, produced models with smaller diameters than the standard die for all time periods. Since, polyether impression materials are hydrophilic in nature, they could absorb water from the stone and swell in contact of it. This expansion would then result in a smaller diameter than the standard dies. However, from a clinician's point of view, it is desired to have a larger diameter than the smaller one, because larger diameters are always preferred to facilitate seating of the casting on the prepared tooth. However, it was observed that impression material did not always follow the theoretical pattern of behavior which was in accordance to the studies done by Johnson, Craig et al.²⁴

The heights of the stone dies were shorter than the standard for all materials. This finding confirms to that of Stackhouse.²⁵ Dies were shorter in dimensions because the vertical component of contraction was toward the occlusal portion of the preparation where the impression was adhering to the tray for addition silicone and condensation silicone. Addition silicones generally give the least change in vertical height compared to the polyethers and condensation silicone. For condensation silicones, distortion of the impression material as a function of time leading to

its slumping toward the center of the impression added to the decrease in vertical height. Therefore, the change in vertical height was more than the change in horizontal dimensions. The change in vertical height for polyether could be attributed to the expansion of the material due to the presence of water in the poured stone. According to Johnson et al,²⁴ silicones—both addition and condensation, show best recovery from the distortion arising from removal of the repeated pours in the impression than polyether, because silicones are shown to have a better recovery from deformation. According to them, addition silicone and condensation silicone were nearly unaffected by the repeated pours, whereas polyether were affected at each location to some extent. The deviation from the mean in silicones, especially condensation silicones were more as a function of time rather than the effect of pour while in the case of polyethers, both time factor and multiple retrieval of stone casts play a role. This factor is more significant in case of die A and die B where the impressions were jerked out of the central hole, the stiffness of the polyether played a major role in the deteriorating dimensional reproducibility of the material. The study of Yeh et al²⁶ also gave the view that silicones have lower value of permanent deformation than polyether. According to Jorgensen,^{27,28} 60% deformation was induced in an elastomeric impression material when removing it from structures with undercuts 1 mm high and 1 mm deep. This factor was one crucial factor in determining or selecting an impression material when multiple pours were desired. When there were no undercuts involved, polyether showed least dimensional changes, especially in vertical dimensions as compared to addition silicone and condensation silicone.

All the results gave the conclusion that all of them were quite accurate in reproducing the details and preserving the details for quite some time. It should be understood that 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 in consideration—one was the elapsed period of time, and another was repeated induced distortion while withdrawing of 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 silicone. But for example, polyether, according to the earlier studies was 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 especially, in the dies having undercuts, while 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 rather repeatedly with time, with pouring or without pouring.

The study confirms the conclusion drawn by the studies of Johnson,²⁴ Tjan et al.^{5,29,30} They also reported undersized dies from these impression materials. Though this study, was not done to simulate actual clinical conditions, where the impressions are made at mouth temperature of 37°C, it still gives an insight about the nature and behavior of the impression material. The studies done by Corso et al³¹ states that storage room temperature of impression material play a role in the dimensional stability of the impression material. This study was carried out at a room temperature of near about 18° to 22°C. The earlier studies reported by Corso M et al³¹ say that changes in storage temperature has a statistically significant effect on the dimensional stability of horizontal and vertical dimension reproduction. Keeping all these factors and variables in mind, still it would be rational to judge that during this study addition silicones were found to be better than both condensation silicones and polyethers—both in term of dimensional reproducibility, dimensional stability as well as ability to undergo multiple pouring without much change. Though all the materials showed deviation as a 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. Polyethers were good in giving accurate dies but fared better when less deformation was induced especially in the case of die C where it gave better results than even addition silicones in vertical dimensions. 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 dies gave statistically insignificant dimensional changes especially for condensation silicone and polyether (die A and die B).

CONCLUSION

None of the impression material always showed a consistent behavior up to the fourth pour. They occasionally showed deviation from the pattern, but all these values were statistically insignificant. Polyethers showed lesser ability than both the addition silicones as well as the condensation silicones to recover from induced deformation. Overall addition silicones showed better results than others in most of the situations.

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