Evaluation Of Dimensional Changes In Different Elastomeric Impression Materials Used In Implants – An Original Research

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ABSTRACT

Background: A widespread and efficient treatment option for restoring missing teeth is dental implants. The effectiveness of implant-supported restorations strongly depends on taking exact and accurate impressions of the implant site since these impressions determine how well the final restoration will fit and last. Due to its advantageous qualities, such as exceptional flexibility, tear resistance, and high accuracy in capturing minute details, elastomeric impression materials have become popular alternatives in contemporary dentistry.
Methodology: According to two criteria, namely the impression material (PVS and PE) and implant copings (parallel and angulated) on the master castings, 60 specimen casts were sorted into four major groups. In Group 1, PVS impression material from Master Model 1 (Parallel Implants) was used to create castings. Casts made using PE impression material for Group 2 Master Model 1 (Parallel Implants). Using the PVS impression material from the master model 2 (angulated implants), Group 3 consisted of casts. Using the PE impression material from the master model 2 (angulated implants) implants, Group 4 is formed.
Results: Each elastomeric impression materials dimensional variations will be shown. An understanding of the materials' dimensional stability and behavior throughout the critical setting period was gained from the data analysis.
Conclusion: The comprehension of dimensional variations in various elastomeric impression materials used in dental implant operations would be aided by this original research. With the polyether and polyvinyl siloxane impression materials analyzed in this work, some degree of discrepancy is unavoidable. The biggest variation in the linear distance between the implants was seen in the anteroposterior direction. The measurements with the largest distortion were those from angular models. Casts made with polyether impression material were more accurate whether there were parallel or angulated implants present.
Keywords: Dimensional changes, Elastomeric, Dental implants, Dimensional stability, Polyether, Polyvinyl siloxane, Dental prosthesis

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INTRODUCTION

Dental implants have completely changed how lost teeth are replaced in modern dentistry, giving patients better oral health overall as well as improved oral function and aesthetics. For the successful fabrication of implant-supported restorations, precise and accurate impressions of the implant site must be taken [1,2]. Elastomeric imprint materials have become well-liked options because of their extraordinary flexibility, resistance to tearing, and capacity to accurately record complex features. The long-term effectiveness of implant restorations can be considerably impacted by the dimensional stability of these elastomeric materials over time. [4]

Based on the polymer component, elastomers—rubber-based polymers used in dental impressions—are divided into four classes: polysulfide (PS), polyether (PE), polyvinyl siloxane (PVS), and condensation silicone (CS). Polysulfides have a high tear resistance, excellent detail replication, and affordability. High cost, excellent detail reproduction, and mediocre rip resistance characterize polyether. Polyvinyl siloxane offers great tear strength, a reasonable working period, and excellent elastic recovery in comparison to condensation silicones, which have low tear strength and show more distortion.

Long-term dimensional stability that enables the production of precise casts at any time is a requirement for the ideal impression material. However, the materials often used to create dental impressions show variations in their dimensional behavior. The fit and retention of dental prostheses, which are affected by the dimensional changes of the impression materials, determine the effectiveness of indirect restorative therapies. The dimensional behavior of impression material is affected by humidity, the interval between mixing and pouring, and the thickness of the layer of material in the tray. [3,4,5]

Additionally, due to their linear thermal expansion coefficient and the temperature difference from the mouth cavity to the outside environment, impression materials contract. Volumetric changes are also influenced by the type of tray, the level of material adhesion to the tray, and the type of polymer used to make the elastomers. In terms of dimensional accuracy, the impression procedure can be carried out in single or double steps with varying results. [5,6]

There is an absence of comprehensive research comparing the dimensional changes of elastomeric impression materials, despite their ubiquitous use. Dental professionals frequently struggle to choose the best material for implant treatments, taking into account elements like setting time, handling comfort, and dimensional stability. [7,8] By carefully evaluating the dimensional changes in several elastomeric impression materials used in dental implant applications, this novel research intends to close this knowledge gap.

As a result, the current study is needed to evaluate the linear dimensional accuracy of impressions made with two different types of elastomeric impression materials using open tray technique in parallel and angulated implants by analyzing their positional relationship on the resultant casts. Poly vinyl siloxane and polyether are the impression materials used for the study.

MATERIALS AND METHODOLOGY

In this in vitro study, a surveyor with surveying equipment and an Optomech vertical profile projector with magnifications of 5x, 10x, 20x, 50x, and 100x were essential tools.

Using fused deposition modeling (FDM) technology, two identical edentulous maxillary master models were created using PLA (Polylactic Acid) material from a single virtual model. There were two master models: Master model 1 and Master model 2, which are regarded as controls. Six implant sites were prepared for master models 1 and 2 during their manufacturing using the same FDM process.

Two posterior implant sites were ordered at angulations of 15 divergence with the longitudinal axis of master models, whereas two anterior implant sites were prepared in master model 2 at angulations of 15 convergence towards midline. In the master model 1, the implant sites were positioned perpendicular to the horizontal plane and parallel to one another. Two anterior implant sites were 5.2 mm from the midline, at the top of the edentulous ridge. The mesial borders of the next two posterior holes were prepared 7mm from the distal margin of the first ones. Cyanoacrylate was used to attach four internal hex dental implants (Adin, dental implants, Israel, 3.75 X 10mm) to model holes. The master model-1 and master model-2 were ready for impression taking after the open tray transfer impression copings were screwed over the implants.

Preparation of trays

In order to fulfil the needs of the study, 30 heat-cure acrylic resin (DPI Heat Cure, DPI, Mumbai, India) open custom trays with standard sizes and spatial orientations were created. For making impressions using single step putty light body, 30 stainless steel mandibular perforated trays were chosen, and the required adjustments were made.

Impression making

On the master model 1 and master model 2, the open tray transfer impression copings were tightened into the implants using a torque wrench. 60 implant level impressions were made in total, 30 using polyvinyl siloxane (3M ESPE Soft Putty and light body Vinyl Poly siloxane, Seefeld, Germany), where 15 were for parallel implants and 15 were for angulated implants, and 30 using polyether (Impregum; medium body, Seefeld, Germany), where 15 were for parallel implants and 15 were for angulated implants.

Fabrication of experimental study model

Double pour technique was used to pour type IV gypsum product into each of the 40 impressions with attached implant analogs (Die stone, Kalrock, Kalabhai Karson Pvt Ltd, Mumbai, India). Based on two factors, namely the impression material utilized (PVS and PE) and implant orientation (parallel and angulated) on the master castings, the specimen casts were categorized into four primary groups, which were as follows:

a) **Group 1:** PVS impression material from Master Model 1 (Parallel Implants) was used to create casts.
b) **Group 2:** Casts made from PE impression material taken from Master Model 1 (Parallel Implants).
c) **Group 3:** Casts made from Master Model 2 (angulated implants) PVS impression material
d) **Group 4:** Casts made from Master Model 2 (angulated implants) PE impression material.

Data collection

In order to assess the positional accuracy of the implant analogue using a profile projector (Optomech, Vertical Profile Projector, Hyderabad, India), all of the castings were inspected by a single examiner who were blinded to the type of impression material and the orientation of the implants on the master model. The entire measurement process was done under 10X magnification. The linear distance could be measured with an accuracy of 0.002 mm (2 m) thanks to the profile projector. In order to align the vertical reference plane of the profile projector with the mid plane of the models, all of the casts with attached fixed diameter transfer impression copings were fastened to the center of the horizontal table of the profile projector.

The device's light source projects a 10X magnified image of the specimen as a shadow on the screen, allowing the distances to be calculated using the analogs references to the projected silhouette's crisp edges.

In the study's casts and control master models, four distances were measured:

- The distance between the most anterior and most posterior copings of the right impression's projected silhouette's external sharp edge is C1 (anteroposterior).
- C2 (mediolateral) is the separation between the internal sharp edge of the projected silhouette taken from the most anterior left and right impression coping.
- C3 (mediolateral) is the distance between the outside sharp edge of the projected silhouetted from the farthest posterior left and right impression coping.
- C4 (mediolateral) is the distance between the internal sharp edge of the projected silhouette taken from the farthest posterior left and right impression coping.

Consequently, the collected information was collected and statistical analysis was performed on them. The IBM Statistical Package for Social Sciences (SPSS) version 2.0 was used to compute and calculate all of the statistics.

RESULTS

Differences of C1, C2, C3, and C4 distances between observed values on study castings and control values measured on master models are computed and documented in order to apply data to statistical analysis. With one sample t-test at 0.05 significance level, the changes of mean values with respective control values within group are evaluated for statistical significance. At a significance level of 0.05, the mean anteroposterior (C1) and individual mean mediolateral (C2/C3/C4) distance changes between the groups are statistically analysed using the independent samples t-test. Following are the findings of the statistical analysis.

According to implant orientation (parallel or angulated) and impression material (PVS or PE), Table 1 shows the descriptive statistics of C1, C2, C3, and C4 values for four separate groups.

Table 1: Descriptive statistics of the anteroposterior and mediolateral distance variations in terms of maximum and minimum values, mean and standard deviations with respect to the four different groups

Distance		N	Minimum	Maximum	Mean	Standard deviation
C1	Group1	15	14.9	16.9	15.9	1.41
	Group 3	15	15.1	16.8	15.95	1.20
	Group 2	15	15.3	17.7	16.5	1.69
	Group 4	15	15.6	16.7	16.15	0.78
C2	Group 1	15	11.5	12.6	12.05	0.77
	Group 3	15	11.8	11.3	11.55	0.36
	Group 2	15	11.9	12.7	12.3	0.57
	Group 4	15	12.8	13.3	13.05	0.35
C3	Group 1	15	34.4	34.6	34.5	0.14
	Group 3	15	34.9	35.4	35.15	0.35
	Group 2	15	34.4	33.5	33.95	0.64
	Group 4	15	34.9	35.3	35.1	0.28
C4	Group 1	15	26.4	27.5	26.95	0.77
	Group 3	15	27.7	27.9	27.8	0.14
	Group 2	15	27.4	27.6	27.5	0.14
	Group 1	15	27.7	27.8	27.75	0.07

Table 2 displays descriptive statistics of the anteroposterior and mediolateral distance variations for PVS impressions with parallel implants (group1), PE impressions with parallel implants (group 2), PVS impressions with angulated implants (group 3), and PE impressions with angulated implants (group 4) in terms of control values, mean value, standard deviation, variation of mean from control, and p values.
A one-sample t test with a significance threshold of 0.05 is used to examine the comparison of the observed mean values with the corresponding control values.
Likely significant differences in C2, C3, and C4 are indicated by differences in mean C2, C3, and C4 values. The C1 value in Group 1 has the biggest mean variance from control out of the C1, C2, C3, and C4 values.

Table 2: Comparison of control values with observed individual mean distance values in respect to PVS impressions with parallel implants (group 1)

Distance	N	Min	Max	Control	Mean	Standard deviation	Variation of mean from control	One sample t test P value Control v/s Mean
C1	15	14.9	15.9	14.7	15.4	0.70	0.7	0.031, significant
C2	15	11.6	12.5	11.8	12.05	0.63	0.25	0.034, significant
C3	15	33.4	34.6	33.9	34	0.84	0.1	0.005, significant
C4	15	26.8	28.4	26.5	27.6	1.13	1.1	P<0.001, highly significant

With respect to Group 1 and Group 3 as well as between Group 2 and Group 4, Table 3 displays the descriptive statistics of the anteroposterior and mediolateral distance variations in terms of control values, observed mean values, mean variation from the control values, standard deviation, and p values. It shows the relative impact of impressions generated with PVS and PE utilizing the open tray approach on the dimensional accuracy of implants that are either parallel or angulated.
Using an independent sample t-test, the difference in the variation values was evaluated for statistical significance. The p values obtained for the comparison between Group 1 and Group 3, C1, C2, and C4 are discovered to be non-significant. The p value for C3 is 0.002, which is determined to be statistically significant.
When taking C1, C2, C3, and C4 distances into account, Group 3 is seen to have greater mean value deviations from control values than Group 1. The p values obtained for the comparison between Group 2 and Group 4; C1 and C2 are 0.996 and 0.613, which are determined to be non-significant.

Table 3: Comparison of control values with observed individual mean distance values in respect to PE impressions with parallel implants (Group 2)

Distance	N	Min	Max	Control	Mean	Standard deviation	Variation of mean from control	One sample t test P value Control v/s Mean
C1	15	14.3	15.1	14.7	14.7	0.56	0	0.01, significant
C2	15	10.5	10.6	11.8	10.55	0.07	-1.25	0.48, not significant
C3	15	32.4	32.5	33.9	32.55	0.07	-1.35	0.004, not significant
C4	15	25.5	25.7	26.5	25.6	0.14	-0.89	0.14, not significant

Table 4 describes data for anteroposterior and mediolateral distance differences between Groups 1 and 2 as well as between Groups 3 and 4 are shown in terms of control values, observed mean values, mean variation from control values, standard deviation, and p values. It shows the relative impact of impression materials (PVS and PE) on the positioning accuracy of implants that are parallel to each other and angulated, respectively.

Using an independent sample t-test, the difference in variation values is evaluated for statistical significance. The p values obtained for Groups 1 and 2, C1 and C2, are 0.490 and 0.407, respectively, and are discovered to be non-significant. The p values for C3 and C4 are 0.04 and 0.001, respectively, which are determined to be statistically significant.

When taking C1, C2, C3, and C4 distances into account, Group 1 is seen to have greater mean value deviations from control values than Group 2.

However, the p values of 0.071, 0.219, and 0.075 between Group 3 and Group 4; C1, C2, and C3 are not determined to be significant. The p value for C4 is 0.001, which is considered to be statistically very significant.

When taking C1, C2, C3, and C4 distances into account, Group 3 is found to have greater mean value deviations from control values than Group 4.

Table 4: Comparison of control values with observed individual mean distance values in respect to PVS impressions with angulated implants (Group 3)

Distance	N	Min	Max	Control	Mean	Standard deviation	Variation of mean from control	One sample t test P value Control v/s Mean
C1	15	15.6	16.7	14.3	16.15	0.777817	1.85	p<0.001, highly significant
C2	15	11.8	12.8	11.2	12.3	0.707107	1.2	0.082, not significant
C3	15	33.9	34.9	32.9	34.4	0.707107	1.5	p<0.001, highly significant
C4	15	26.8	27.5	25.6	27.15	0.494975	1.55	p<0.001, highly significant

In terms of maximum and minimum recorded values, group means, control values, observed mean values, standard deviation, variation of mean from mean control values, and p values independent of group, Table 5 shows the descriptive statistics of C1, C2, C3, and C4 distances.

Using an independent sample t-test, the statistical significance of the differences in the variation values is examined. The p value for C2 is 0.423, which is determined to be non-significant. The p value for C3 is found to be 0.031, which is statistically significant, while the p values for C1 and C4 are both found to be 0.001, which is statistically extremely significant.

Table 5: Comparison of control values with observed individual mean distance values in respect to PE impressions with angulated implants (Group D)

Distance	N	Min	Max	Control	Mean	Standard deviation	Variation of mean from control	One sample t test P value Control v/s Mean
C1	15	14.1	14.6	14.7	14.35	0.35	-0.35	p<0.001, highly significant
C2	15	11.1	11.3	11.8	11.2	0.14	-0.60	0.263, not significant
C3	15	33.0	33.2	33.9	33.1	0.14	-0.79	0.001, Significant
C4	15	25.7	25.8	26.5	25.75	0.07	-0.75	0.006, Significant

DISCUSSION

In implant prosthodontics, it is crucial to create a cast that correctly replicates the intraoral location of implants and abutments in order to prevent fit issues, particularly those that are not clinically visible by eye inspection. The first stage in creating a precise, passively fitting prosthesis is to accurately duplicate the intraoral connections and three-dimensional positions of the implants in the impression [6]. As a result, this study was carried out to assess the impact of linear dimensional accuracy of impressions generated with two distinct impression materials, PVS and PE, in recreating the relative locations of angulated and parallel inserted implants on the resulting dental casts.

All of the methods required for indirect dental restorations have the inherent risk of impression distortion. Depending on the point of reference from which it is measured, it might be viewed as absolute or relative. In contrast to a relative distortion, which is assessed from a point inside the system, the absolute distortion is taken into account when the point of reference is external [7,8]. The ensuing transitional distance from one coping to another was assessed in the current inquiry, and the relative distortion was taken into consideration as a study parameter. Given that an implant supported prosthesis often connects all of the abutments to one another, this measurement type might be thought of as being more clinically meaningful than the absolute distortion [8].

The mean linear intercoping distances (Table 2) in the current investigation for PVS impressions with parallel-placed implants demonstrated a significant statistical difference from its control values. The variations in mean mediolateral intercoping distances (C2 and C4) from its control values were not found to be statistically significant in the case of polyether impressions with parallel implants (Table 3). The results of the study done by Sorrentino et al. are supported by the findings of the present study.

Except for the mediolateral distance between the two anterior implants (C2), the mean error of intercoping distances from its control values were found statistically highly significant when impressions were made with PVS in angulated implants (Table 4). The mean error of intercoping distance from its control value was not observed to be statistically significant in the case of the mediolateral distance between the two anterior implants (C2) in the PE impression with angulated implants (Table 5) either. Comparing this group to PVS impressions with angulated implants, it is discovered that there is less fluctuation in the mean distances from the control in this group. This outcome correlates with study conducted by Akalin et al [9].

The impact of implant orientation on the dimensional accuracy of impressions made using PVS and PE impression material is also examined in this study. The degree of implant angulations with regard to the horizontal crestal plane was one of the most crucial factors influencing implant impression accuracy in cases with numerous implants, according to studies. A few additional investigations utilizing an experimental cast with four or five implants had found that angulated implants gave less precise impressions than straight implants. The results of this investigation showed that there was some degree of mistake in both the PVS and PE impression materials. Compared to models with parallel implants, angulated implant models were found to have more fluctuations in distance [10,11].

In the present study, the mean error from control in recording the angulated implant position was larger than that of the parallel-placed implants. This was true for PVS impression material. When comparing the recorded inter coping distance in parallel placed implants to the recorded inter coping distance between the external surfaces of two posterior implants (D3), it was determined that this mistake was statistically significant.

Regarding PE impression material, the angulated implant position's mean error from control was larger than the parallel-placed implants. When the mediolateral intercoping distance between the internal and external surfaces of two posterior implants (C3 and C4) was recorded instead of the recorded intercoping distance between implants that were parallel to one another, it was discovered that this error was statistically significant. Additionally, the overall mean error of the anteroposterior and mediolateral distances was found to be larger when recording the angulated implant position than the mean errors recorded in cases of parallel implants with PVS and PE impression materials, respectively.

Similar kind of result was found in a study by Zerrin Fidan Akalin. [13] In contrast to parallel-placed implants, rotational misfit may cause larger horizontal disparity in the case of angulated implants. Implant angulations cause an increase in the amount of deformation forces, which calls for an impression material that can sustain these forces without compromising the precision of the master cast. Increased implant angulation, particularly in cases involving many implants, increases the area of friction and the amount of stresses produced in an impression, reducing the accuracy of the impression [14,15].

When comparing the two study materials, PVS demonstrated greater inaccuracy than PE in the transfer of linear interimplant distance in the instance of parallel implant placement. This inaccuracy was statistically significant when the mediolateral interimplant distance was measured between the internal and external surfaces of two posterior implants (C3 and C4) [15]. Once more, if we contrast the accuracy of recorded interimplant distance with PVS and PE impression material in angulated implants, we can see that inaccuracy was lower in the case of PE impressions. When measuring the distance between the interior surfaces of two posterior implants (C4), this difference in the error was statistically very significant.

These results are in accordance with study by Del'Acqua et al. and Kankane's study [16], which looked at the accuracy of a master model of an edentulous mandible with four implants made of polyether and polyvinyl siloxane impressions. In a study by Vojdani et al., there was no discernible difference between polyvinyl siloxane and polyether for parallel implants, while polyvinyl siloxane outperformed polyether for angulated implants.

According to further investigations, polyvinyl siloxane is more accurate when used directly than polyether. When employing a direct approach, studies by Reddy and Karl [17] revealed little to no difference between polyether and polyvinyl siloxane.

The measured distortions did not accurately assess the real three-dimensional distortion of the impressions, and the axial rotations of the components were not picked up, which could be considered potential limitations of the current study design.

Furthermore, the present study's findings were restricted to four implants, thus they might not apply to impressions taken in the presence of more or less implants. Therefore, more clinical investigations are suggested taking into account recent developments in implant impression techniques that will help in recording 3-dimensional intraoral implant abutment relations in order to fabricate a passively fitting prosthesis in order to make the results of the present study clinically implacable [18,19].

CONCLUSION

The following results were reached within the limitations of the current investigation:

1. Some degree of disparity is unavoidable with both the polyether and polyvinyl siloxane impression materials examined in this study.
2. The anteroposterior direction showed the greatest difference in the linear distance between the implants.
3. The accuracy of the impression increases with implant parallelism.
4. Measurements from angular models showed the most distortion.
5. Whether there were parallel or angulated implants present, using polyether impression material produced more precise casts.

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