IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 13, Issue 3 Ver. V. (Mar. 2014), PP 40-45
www.iosrjournals.org

"Comparative study of Dimensional stability and accuracy of various elastomaric materials"

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Abstract:
Introduction: *Transfer of an accurate replication of the patient's hard and soft tissue to the dental laboratory is important. An accurate impression will result in a precise fitting cast restoration. Recently a new impression material Vinyl Siloxanether by the manufacturer has been made commercially available. The objective of this in vitro study is to compare the newer material with older ones in terms of accuracy.* ***Methodology*** *A stainless steel model containing two tapered abutments with cross grooves on occlusal and proximal surface for reference measurement was fabricated on a lathe. Total eighty samples were made. Sixteen impressions were made with polyether (medium body), poly Vinylsiloxane (medium body, heavy & light body) and vinyl siloxanether (medium body, heavy & light body) each. The recommended tray adhesive was used for all impression materials and was poured using Type IV gypsum. A Travelling microscope was used to assess dimensions (diameter, height and inter abutment distance) on stone cast poured from the impression of stainless steel model. One-way ANOVA test, Tukey HSD test were used for statistical analysis.* ***Results*** *All casts yielded from five study groups were bigger in the dimensions. The newly formulated vinyl siloxanether impression material yielded more accurate casts than those of addition silicone and polyether impression materials.* ***Conclusion*** ***T****he newly formulated vinyl siloxanether impression material yielded more accurate impressions. The vinyl siloxanether impression material yielded more accurate casts than those of addition silicone and polyether impression materials*

Key words: *Dimensional Accuracy; Addition Silicones; Polyether; Vinyl Siloxanether*

I. Introduction

Impression making to duplicate oral condition and tooth morphology is an integral part of prosthetic dentistry. Both, material and technique are important elements of impression accuracy.[1]

A variety of dental impression materials are available such as alginate, agar and elastomers. Elastomers were developed as an alternative to natural rubber during World War II. These materials have since been modified chemically and physically for use in dentistry.[2] Four basic types of elastomeric impression materials are currently in use: Polysulphide, Polyether, Condensation silicones and Addition silicones.

Polysulphides are good in surface detail reproduction but they are dimensionally unstable when stored for longer period of time. Polyether is hydrophilic and rigid material with high modulus of elasticity but because of its high cost, short working and setting time and high stiffness after setting, limits their use3.

The addition silicones have overcome the disadvantage of polymerization shrinkage over the condensation silicone as there is no by product release [5]. Polyvinyl silicones are widely used due to their excellent elastic recovery, dimensional accuracy, ability to produce multiple casts from single impression, good detail reproducibility, ease of handling and moderately short working and setting time[. 4, 5]

Development of material science has allowed integrating qualities of polyether and polyvinyl siloxane into a newer material vinyl siloxanether. It possesses good mechanical and flow properties along with excellent wetting characteristics in the unset condition when applied to the prepared tooth, and also in the set condition [2.]

Several factors influence the quality of impression including impression material, impression technique, and viscosity of material. Common clinical techniques used in the impression process have also been investigated and potential consequences have been reported [2]. Impression techniques can be categorized as monophase (using a single step medium viscosity material) or dual phase (using either a one step or two step putty or heavy body and a light body wash material) [5].

The purpose of the current study is to evaluate and compare the dimensional accuracy of three elastomeric impression materials that is polyether, polyvinyl siloxane and vinyl siloxanether by comparing the dimensional accuracy of working casts formed from master model. The null hypothesis is that no differences would exist in the dimensional accuracy of these three elastomeric impression materials irrespective of the technique and viscosity.

II. Materials And Methodology

A standardized definitive model with stainless steel base is fabricated having two tapered abutments with base prepared on lathe. According to ANSI/ ADA specification abutments had dimension of 8.015 mm in height, 6.330 mm and 8.450 mm base dimensions, with a 28.27 mm distance between the centers of the abutments as shown in fig 1 . The abutments were prepared with cross grooves on occlusal and proximal surfaces for the reference measurements. Deep orientation ledges were made on the base for positioning of tray. The measurements of the casts were recorded by a travelling microscope having accuracy of 0.001 mm.

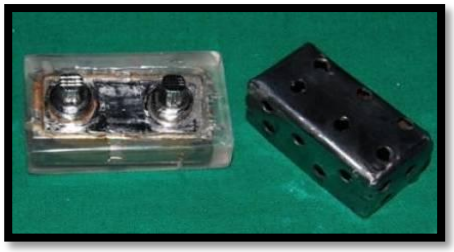

Fig. 1 Stainless steel model containing two abutments showing reference grooves and custom made tray

Fig 2. Dental surveyor

Impressions were made by perforated stainless steel custom tray which was positioned in the dental surveyor as it allows the path of insertion and removal of the tray to be standardized. In this study a total of three elastomeric impression materials of different viscosities were used: polyether (medium body; Monophase impression technique), poly vinylsiloxane (medium body & heavy & light body; Single mix single step and double mix single step impression technique), vinyl siloxanether (medium body & heavy and light body; Monophase and double mix single step impression technique). The impressions were stored under the manufacturer's recommended conditions.

A total of 80 impressions were made with 16 impressions in each group. The tray adhesive supplied by the manufacturer was evenly applied over the inner surface of the tray.

The impression making steps of various study groups were as follows:

Study Group I: Tray adhesive advocated by the manufacturer was applied to the impression surface of the stainless steel custom made perforated tray and allowed to dry for 5 minutes before loading the tray. Medium body material was mixed using automix mixing unit (Polyether: Pentamix 2; 3M ESPE) and the material was loaded into tray for monophase impression technique. The impression material was then allowed to set twice the manufacturer's recommended setting time as indicated in ADA specification number 19 for laboratory testing to compensate for the difference in room (21^{o} C + 2^{o} C) and mouth (37^{o} C) conditions.

Study Group II: Application of tray adhesive was done before loading the polyvinyl siloxane impression medium body material. The one step monophase technique was performed by mixing material using rubber base mixing gun (3M ESPE) and loaded into tray. Standardized impression making technique was performed as described for group I.

Study Group III: Tray adhesive was applied on the perforated tray. The one step heavy and light body combination impression technique was performed by mixing of heavy and light body using rubber base mixing guns, and simultaneously applying the material on custom made perforated tray and the abutments. Tray was positioned in the dental surveyor and impressions were made and allowed to set as mentioned for group I for standardization.

Study Group IV: After applying a thin coat of identium adhesive. Monophase impression technique was performed by mixing the vinyl siloxanether medium body material using (Vinyl Siloxanether: Plug & Press Dispenser; Kettenbach GmbH) Pentamix-2 and the material was loaded into tray. Tray was positioned in the dental surveyor and impressions were made and allowed to set as mentioned in group I.

Study Group V: Application of tray adhesive was done and allowed to dry the tray for 5 minutes. The one step heavy body-light body combination impression technique was performed by simultaneous mixing of heavy body using Pentamix-2 and light body in rubber base mixing gun, and loading the material on the tray and abutments. The impression procedure followed was same as in group I for standardization.

After the impression material had set tray was gently removed. Impressions were checked for voids and inaccuracies and were discarded when not found satisfactory. All impressions were stored at room temperature for half an hour before pouring with type IV gypsum product (Kalrock type IV Diestone, Kalabhai). To standardize the effect of the setting expansion of the improved stone, the powder was accurately weighed and the water was dispensed using a graduated cylinder in a ratio of 100 gm/20ml in a mixing bowl. The mix was placed into the impression and was allowed to completely set for a minimum of 1 hour before being separated from the impression.

Three different dimensions measured on cast were: the diameter, height of abutment and inter abutment distance determined by reference cross grooves. Thus mean reading of all 80 impressions were taken as final reading written in master chart. All of these measurements were made by travelling microscope (ELFO, India Pvt. Ltd) having accuracy of 0.01 mm as shown in figure 5

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Fig.3 loading of impression from petamix-5

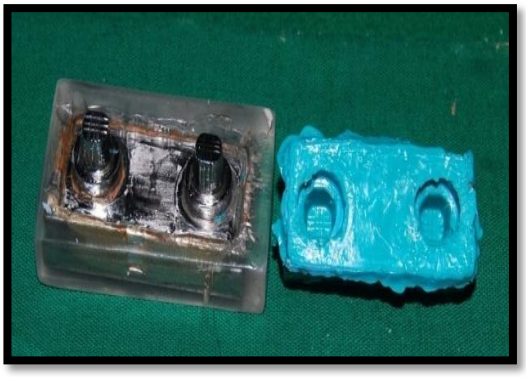


Fig 4. final impression

Fig 5. 16 samples made from VSE

Fig.6 Travelling microscope with cast

III. Result

Within the limitations of this study, it can be concluded that the newly formulated vinyl siloxanether impression material resulted in more accurate casts.

1. The medium body and heavy/light body of vinyl siloxanether impression material yielded more accurate results than those of addition silicone and polyether elastomeric impression material.
2. The medium viscosity of polyether and medium & heavy/ light body viscosity of polyvinyl siloxane that is addition silicone elastomeric impression material resulted in casts that were less accurate but was clinically acceptable.
3. Although some statistically significant differences were observed among the five groups, it can be concluded that the overall accuracy of all the casts obtained was high.

IV. Discussion

Over the past four decades, tremendous progress has been made in the field of impression materials and procedures. Various materials have been used to make impressions in fixed prosthodontics. However, recent fixed prosthodontics impressions have domain of the elastic impression materials that produces an accurate negative likeness of oral tissues.[7] The dimensional accuracy of impressions plays a crucial role in the success of fixed prosthesis. Apart from the operator's clinical ability and the technique followed, the chosen material can critically affect accuracy.

Elastomeric impression materials have been popularly used in dentistry. Recently a new impression material Vinyl siloxanether has been made commercially available. This material is essentially a combination of polyether and addition silicone. Hence the dental surgeon has advantages of both addition silicone and polyether. This material possesses good mechanical and flow properties along with excellent wetting characteristics in the unset condition.[8]

Polyether and polyvinyl siloxane are compatible with Type IV gypsum products are most commonly used die materials.[8, 9]. In this study all impressions were poured with type IV gypsum (Kalrock Diestone, Kalabhai).

According to Markus B et al, [10] the use of metal trays is superior regarding the dimensional accuracy and reliability of impression making. Also according to Carrotte, [11] the impressions made with flexible plastic trays produced considerable discrepancies due to flexibility of the tray under heavy impressions. Custom trays provide uniformity of materials which minimizes the dimensional changes that might distort an impression. Gilmore [12] explained the use of custom tray produced dies that were much more accurate than the stock trays. Glen Johnson [13] and Craig RG [14] in their study stated that the accuracy of impressions in the custom tray was found to be more accurate in the vertical dimension then in the stock tray. Same accuracy was achieved with putty/wash, single mix and double mix techniques when addition silicones were used. The most replicative impression and resultant die were found with full adhesive application to perforated custom made trays [15].

De Araujo[16] assessed the effect of material bulk and undercuts on the accuracy of impression materials. The data revealed that the increase in thickness of impression material from 1 to 4 mm caused a greater distortion. Accuracy decreased as the thickness of material increased so material should be uniform all over the surface. According to Craig, [17] automixing tips should be used for all materials because of its simplicity, convenient to use, no spatulation, consistent mix, and is cost effective. [18] According to Winston Chee[19] the numbers of bubbles incorporated in the mix are reduced with automix system. So in this study, 3M ESPE automix machine with tips as supplied by the manufacturer were used for all the impression materials.

Impression techniques can be categorized as monophase and dual phase. The monophase technique is accomplished in a single-step procedure, using materials with a medium viscosity to allow the material itself to record the finer details while avoiding the slumping of the material in the tray, it is economical, less time consuming and simple to perform.[5, 20] The most replicative impression and resultant die were found in a single mix technique with full adhesive application to the custom trays [15]. The single step technique resulted in slightly larger dies, while the 2-step technique without relief produced significantly smaller dies, when compared to the original stainless steel die. No significant differences were observed in dies obtained from either polyether or vinyl polysiloxane with the single-step technique. Hassan AK[21] carried out a study to measure changes in silicone impression materials which can affect fitness of prosthesis in his study single mix gave more accurate casts than double mix technique.

Techniques that use dual-phase materials such as the putty/heavy and light-body wash method may be accomplished in 1 or 2 steps (single mix single step and double mix single step impression techniques). The 1-step heavy/light-body technique requires less chair time. It reduces the cost of material considerably as it uses less material. In the 2-step heavy/ light-body technique, the details are recorded by the light-body material while putty /heavy body comprises of the bulk of the impression. Both the techniques were found to be accurate and not significantly different from each other [22].

In most of the studies reported in literature so far, precision measurement was done using instruments such as travelling microscope, [23,16] micrometer,[24] vernier caliper, [25] and laser probes. In the present study, a travelling microscope (ELFO, INDIA) was used. It had a least count of 0.01mm, fitted with a10X magnification.

This study was conducted to compare the dimensional accuracy of resultant models made of improved stone using addition polysilicone, polyether and the vinyl siloxanether elastomeric impression material. The null hypothesis was that no difference would exist in the dimensional accuracy of casts fabricated with the different viscosity of elastomeric impression materials. The hypothesis was rejected since there were significant differences among the five groups. In most situations, the differences detected were small in magnitude and of minor clinical significance.

In this study a statistical analysis of the differences in dimensions (diameter, height and inter abutment distance) was done between the stainless steel model and the resultant casts in order to verify the effects of each impression material and their viscosity. This confirms the hypothesis that selection of impression material is crucial in determining the dimensional accuracy of the impression. This was in accordance to the studies by authors like W.Chee et al and Craig RG.[19,17]

The study revealed that there was an increase in the all dimension of stone cast (diameter, height and inter-abutment distance) for all the five groups of elastomeric impression materials. When group I, group II, group III, group IV and group V were compared to control group for diameter, height and inter-abutment distance, it was seen that $p < 0.001$. This indicates an increase in overall dimensions of the stone cast. The similar results were shown by the studies conducted by various authors such as Linke[26], Panichutrra, Johnson[13] and Craig[27]. A study by Linke concluded that the perimeter of the arch of test cast was larger than the standard reference models.[28]

When group IV and group V were compared to group I, group II and group III for inter-abutment distance, it was seen that $p < 0.001$. This indicates a increase in the inter abutment distance for group I, group II

and group III casts than those of group IV and group V. The indicated increase in the inter-abutment distances may be explained by linear expansion of the die material throughout the entire bulk of the stone block.

The impression material will shrink toward the walls of the tray where the adhesive is placed, which causes a resultant increase in the inter abutment distance in the casts than the actual distance on the master model or in the mouth.[29] As the expansion of the die is infinitesimal, it is reasonable to assume that the distortion or shrinkage observed on the dies was primarily caused by the polymerization shrinkage of the impression materials.[20]

On comparison group I, group II and group IV, significant differences were observed. The dimensions were shown to be larger compared to master model and these dimensional changes of working dies are comparable to studies done by Johnson, Wadhwani and Kang.[30,8,31] Vinyl siloxanether shows most accurate result among all three groups. The Polyether casts were more accurate compared to the casts obtained from addition silicone. Similar results were seen in a study carried out by Wadhwani.[8]

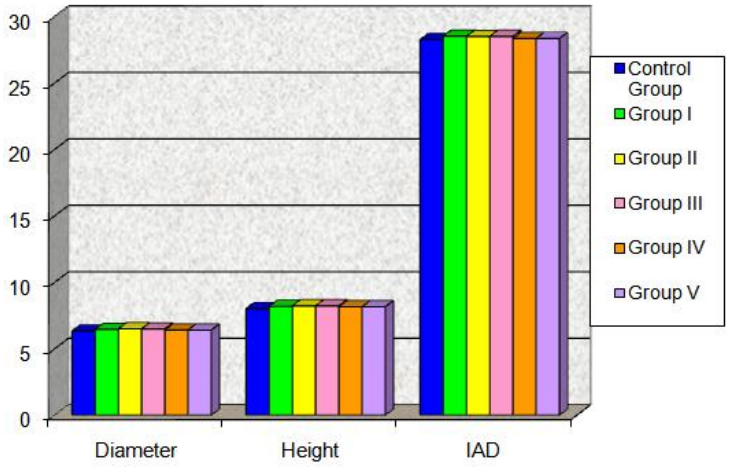
On comparison between group II & group III and group IV & group V significant differences were observed between group II and group III where as medium body viscosity and heavy/ light body viscosity of Vinyl siloxanether shows almost same values in terms of diameter, height and inter abutment distance which dictates their superiority.

Percent deviation was least for single step light body-heavy body technique using vinyl siloxanether and medium body vinyl siloxanether impressions, which concludes that the newly formulated vinyl siloxanether impression materials gave more accurate casts when compared to the viscosity of other impression materials. This could be related to the composition of this new material which is intended to incorporate the natural hydrophilicity of conventional polyether materials along with the desirable properties of addition polysilicone materials, such as elastic recovery and tear resistance. To further improve the wetting characteristics and flowability, a surface tension eraser (STES) and wetting conditioner surfactant (WCS) have been incorporated into the vinylsiloxanether, as per the manufacturer. This result also coincides with the study done by Thomas Stober.[8]

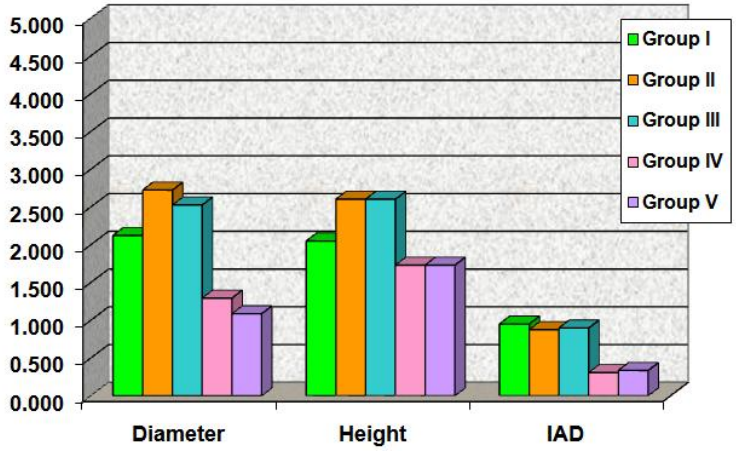
The results of the present study may be useful to the clinicians when selecting impression material. Further study should be done on the biological, rheological and wetting properties of this new material in order to ascertain its equivalence with polyether and addition silicone and for its clinical acceptability. The difference detected was small in magnitude and of minor clinical significance. Also, since the dimensional accuracy of impression materials is a primary basis for all successive treatment steps, all the factors that could exercise a further influence on dimensional accuracy were standardized or excluded in the current study.

V. Summary

Measurements of casts obtained from all five groups showed slight increase in dimensions. Although these differences when compared to the master die were significant, such a small discrepancy between the five groups of casts obtained from the different study group in relation to the overall dimensions might be considered clinically insignificant. The new Vinyl Siloxanether impression material showed good dimensional accuracy among all five study groups.



Graph-1 Percent deviations of mean dimensions of stone casts of five study groups from those of stainless steel model



Graph-2 Mean for diameter, height and inter abutment distance of stainless steel control and models obtained from five study groups

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