INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACEUTICAL SCIENCES

Published by JK Welfare & Pharmascope Foundation Journal Home Page: https://ijrps.com

Influence of tray type and different hardness of polyvinyl siloxane impression materials on the dimensional accuracy of dental implant impression

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Article History:

Received on: 15.11.2018
Revised on: 11.01.2019
Accepted on: 14.01.2019

Keywords:

Polyvinyl siloxane,
Dental implant impression,
Master casts,
Panasil

ABSTRACT

Dimensional accuracy is essential for the accurate construction of a dental implant impression. Materials used for taking an impression to play a significant role in producing an accurate implant impression. An acrylic master model of the lower dental arch with four parallel implant analogues was fabricated, and 90 implant impressions were made. Three groups (n= 30) were experimented using three different Polyvinyl Siloxane impression materials. Three types of impression trays were used, the first one was (self-cure acrylic) custom tray, and the other two were (plastic and metal) stock trays. The inter implant distances were measured on master casts using a digital microscope. Different hardness results were found, Mean and SD for Panasil (heavy body) were 58.600 (5.0959), while for Salginate (medium body) they were 51.800 (0.8465) and 49.433 (1.0367) were the values of Panasil (light body). On the other hand, values obtained from the analysis of dimensional accuracy results showed no significant difference (p= 0.01) in the casts obtained, it has been concluded that although different types of PVS impression materials have been used, no difference in dimensional accuracy has resulted. Furthermore, it has been found that accurate casts can be obtained by using different types of impression trays. The rigidity of different types of trays has not made a significant difference in the accuracy of implant impressions obtained.

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ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v9i4.1618

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INTRODUCTION

Dimensional accuracy is essential for the accurate construction of a dental implant impression. Materials used for taking an impression to play a significant role in producing an accurate implant impression. However, polyvinyl siloxane impression materials are greatly accepted clinically. PVS have applications in fixed prosthodontics, operative dentistry, removable prosthodontics, and implant dentistry. Hence, in cases that demand-cast accuracy of high degree, materials of dimensional stability and excellent detail reproduction must be used (Al-Azawi *et al.*, 2016). It is also reported to have precise detail reproduction, dimensional accuracy, and stability. In recent years. Panasil was one of the commonly used PVS materials all around the world. It showed good dimensional stability for most courses of treatment involving a provision of fixed and removable prostheses (Aalaei *et al.*, 2015). However, many variables may have effects on impression material accuracy. These have been included in many previous studies. The way of impression taking and materials used are of the elements that prominently advanced in the field of prosthodontics (Fathallah and Alsamaraay, 2017). Various materials have been experimented to obtain a detailed and accurate dental arch. Wostman B. (1998) mentioned that the selection of impression material is one of the essential factors that affect accuracy. Furthermore, the usage of impression material and impression tray design have been previously included in the literature (Tjan *et al.*, 1986). All these variables and others may interact positively, and sometimes the interaction works in a negative way. Other important variables influence the accuracy of implant impression is related to the rigidity and dimensional stability of the tray. The tray should be stiff and stable enough, so it does not deform during insertion and retrieval of the tray-impression complex from the mouth. Any tray deformation, particularly elastic deformation, will result in distortion errors. During the past few years, plastic trays were used more than custom ones for making a crown impression, bridges and implants. Different materials of various viscosity have been used with Plastic trays. Tray rigidity and hardness of impression materials hardness have been described as important factors to obtain an accurate impression (Eames *et al.*, 1979; Dixon *et al.*, 1994). It has been recognized that the tray should be rigid enough to stand the forces generated during the impression procedures without distortion (Wadhwani *et al.*, 2005). Metal trays are more rigid than plastic trays. Among plastic trays, there are different levels of rigidity. Valderhaug and Floystrand found no differences between impressions made with metal stock trays and rigid resin custom trays (Valderhaug and Floystrand, 1984). Custom trays must be made with dimensionally stable materials over time that does not deform as they are retrieved from the mouth or as impressions are made (Wirz *et al.*, 1990; Shillingburg *et al.*, 1997). In spite of the fact that custom trays produce impressions more accurately, stock trays remain the trays of selection because they are easy to use. Clinicians sometimes believe that distortion does not occur in uneven areas of impressions because they adhere to the tray by means of an adhesive and also, using different stock tray can minimize dimensional changes that occur on setting (Agar, 1971).

On the other hand, it was suggested that the rigid plastic stock tray and metal trays are more accurate than those of flexible plastic (Carrotte *et al.*, 1998). Mitchell and Damele26 found that distortion was reduced by using a rim-lock lubricated tray and was minimized by using an undercut lubricated tray. Moreover, Dixon and authors in 1994 illustrated that it is possible that by using thick custom trays (4 mm), the rigidity of a plastic tray can be enough to withstand the forces involved in impression seating and removal, and therefore producing similar results as with metal trays (Tjan and Whang, 1987). Also, by Tjan *et al.,* in 1981, they published a paper that emphasizes the importance of rigid trays for elastomeric impressions. Their research project was about crowns construction on 15 working casts which made from impressions of a full crown preparation on a typodont (plastic replica of a dental arch). Impressions were made in rigid stock trays, disposable trays, and reinforced disposable trays. Not one of the crowns made on the cast dies produced from impressions made with disposable trays fit the master die. All ten of those made on the models from impressions made in rigid or reinforced trays were assessed as satisfactory. Gordon *et al.,* in 1990 compared the dimensions of working casts made from impressions made in either custom tray (using two different tray materials) or plastic stock trays. They found that the plastic stock tray which was much less rigid, produced casts with greater dimensional change than the two custom trays, so that, plastic stock trays should be used where there is no need for cast reproduction to be greatly accurate (Gordon *et al.*, 1990) while another study showed that metal tray and the most rigid plastic tray produced the best fitting. It showed no difference in the dimensions of casts poured from irreversible hydro- colloid taken in perforated or non-perforated metal rim-lock trays (Heartwell *et al.*, 1972). In this study, we decided to test the hypothesis the hat higher tray rigidity and better impression material selection would produce more accurate implant impressions. Therefore, the purpose of the present study was to evaluate the dimensional accuracy of dental implant impressions made of different hardness of PVS impression materials, using different rigidity of impression trays with a closed tray impression technique.

The hardness of Dental Material

Hardness is the ability of dental material to withstand or resist scratching or indentation. It is measured by scientific instruments that press a special tip into the surface of the tested material. Dental materials lacking hardness that can be scratched or dented may eventually demonstrate wear patterns in the mouth. These are sometimes referred to as wear facets. Hardness may also cause wearing away of natural teeth as a result of frequent contact with dental materials that are harder than enamel (Dietz-Bourguignon, 2006). A material is considered hard if it strongly resists indentation by a hard material such as diamond. One would expect that hardness would be related to yield strength and wear resistance; how- ever, the property is complex. In general, no direct relationship exists between hardness and these two properties. The only exception is in the comparison of materials of the same type, such as a series of similar gold alloys. The hardness of dental materials generally is reported in Knoop hardness. The Knoop hardness is obtained by measurement of the length of the long diagonal of an indentation from a diamond indenter and calculating the number of kilograms required to give an indentation of 1 mm. Thus, the larger the indentation, the smaller the value. Enamel and ceramic are two of the hardest, and unfilled acrylic is the softest 0f the materials listed. Knoop hardness is a satisfactory method for evaluating many restorative materials. Although the indentations are small, they are not small enough to evaluate the hardness of the resin- dentin bonding region of dental composites. Studies of the hardness of this region have used a nano- indentation method. The nanoindentation technique measures much smaller indentations under small loads and allows the hardness of extremely small areas to be determined. However, the nano- indentation values cannot be directly compared with Knoop values, because the Knoop hardness is calculated from the permanent surface deformation after removal of the load and the nanoindentation hardness values are calculated from the penetration while under load. An additional advantage of the nano-indentation method is that it allows the calculation of the elastic modulus (John, 2013). Hardness tests are included in numerous specifications for the dental material developed by ADA and standards promoted by the ISO. There are several different methods that can be used to test surface hardness. Determining hardness of any dental material is done by using the tests known by (Vickers Barcol, Brinel, Shore, knop, and Rockwell). However, the selection of the test should be determined on the basis of the material being measured (Kenneth *et al.*, 2013). The hardness test used for the present study is the Shore test which is less sophisticated than the others. It is a compact portable unit provided with a metal indenter that is spring loaded. The hardness number is based on the depth of penetration and is read directly from a gauge (John and Manappallil, 2010).

MATERIALS AND METHODS

Test samples

According to the specification of ISO 7619-1:2010, the thickness of samples used for hardness test should be 6mm at least, and the outer outline allows 5 points of reading with distance 6mm at least between each other. The dimensions of fabricated samples for this study were (25mm×25mm×6mm) (Figure 1).

Figure 1: Hardness test samples of PVS impression material

Testing procedure

Figure 2: Shore A hardness durometer

According to ISO 7619-1:2010 specification, the samples were marked at the centre with four points marked around. Points were 6mm away from each other at each direction. Measurements were done by using Shore A hardness durometer, Figure 2 . This method based on penetrating the indenter of the durometer the sample surface at five points previously marked, the durometer was pressed firmly for 3 seconds, and the mean of 5 reading was recorded.

Fabrication of the Master Model

Using acrylic resin, a master cast of the lower dental arch has been constructed, then, with the use of implant handpiece with drills, 4 parallel holes were drilled between mental foramina. Four analogs (RN synOcta W 3.5 mm, L 12 mm, stainless steel, Straumann, Switzerland) have been fixed in the holes 1mm above the alveolar ridge surface. After that, a cold-cure acrylic resin (Vertex, Netherlands) has been used to fix the analogs. A digital microscope has been used to measure the distance between each pair of analogs (Dino-Lite/ UK).

Impression-taking procedure

Impressions have been taken using close tray impression technique with three different types of trays, a self-cure acrylic custom tray, a metal stock tray (Dimeda, Germany) and a plastic stock tray.

Three syringable PVS impression material with different hardness have been used (light body Panasil, medium body Silginat, and heavy body Panasil, Kettenbach/ Germany), and loaded on the trays using auto mixing gun. Each of the PVS materials has been applied to each of the selected trays and around the transfer copings. Then, after the specified time recommended by the manufacturer has passed, impressions have been removed, and implant analogs fixed and tightened. The next step has been pouring the casts using vacuum-mixed type IV stone (Zhermack, Italy) (30g pow- der/100mL water). After passing 24 hours of preparation, the previously coded casts have become ready for measurement. Twenty impressions were made (n=30) for each of the three groups.

Impression Groups

The distribution of the impression groups

1. Self-cure acrylic custom tray in which light body Panasil, medium body Silginat, and heavy body Panasil PVS materials were used with the close tray technique. Tray adhesive was applied at least 10 min prior to the impression.

2. Plastic stock tray in which light body Panasil, medium body Silginat, and heavy body Panasil PVS materials were used with the close tray technique. Tray adhesive was applied at least 10 min prior to the impression.

3. Metal tray in which light body Panasil, medium body Silginat, and heavy body Panasil PVS materials were used with the close tray technique. Tray adhesive was applied at least 10 min prior to the impression.

The device of Impression Making

The master model has been attached to an aluminium plate (half-inch thick, seven inches long and five inches' width) using two screws. Three stainless steel pins (three eights of an inch long and five inches' height) have been positioned on the aluminium plate vertically, two in the front and one in the back of the master model. On the other hand, each of the trays has been attached to a second plate guided by the three vertical pins on the base plate.

The holes made on the top plates have made them slide on the master model during the impression procedures via the rods of the base plate. Three plastic stops have joined the pins to control the seating of the tray against the model. Different sets of vertical stops have been built, for the three trays, Figure 3. The impressions have been fabricated at room temperature (23° to 25°C). They have been measured under the digital microscope after being kept at room temperature for 24 hours before measurement. Thirty impressions per group have been made.

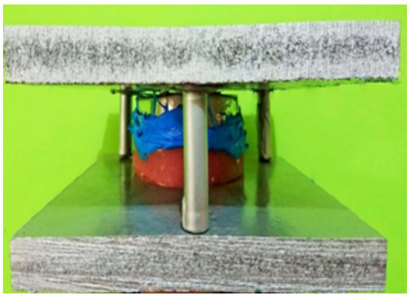

Figure 3: Impression making device

Accuracy Measurement

The copings were placed on the master model, and the distance between two indentations has been measured using, and a digital microscope (AM 413 Fit Dino- Lite Pro; Dino- light, Taipei, Taiwan) fixed on a desktop stand. Photographs of the digital microscope taken at $\times$ 15 magnification were saved to the computer that the digital microscope had been connected to. Statistical analysis of the data obtained from the measurements has been done using SPSS Statistical software 22 (SPSS Inc., Chicago, IL, USA) with a statistical significance level (p= 0.05). Descriptive statistics were used for hardness measurement in mean and standard deviation (SD) the PVS impression materials used. One-way statistical analysis of variance (ANOVA) together with Bonferroni post hoc test was applied to compare the effect of the different hardness of the PVS materials and different tray types on the dimensional accuracy of implant impressions.

RESULTS

The hardness test results of 18 specimens obtained from three PVS impression materials (Panasil heavy body, Salginate medium body, and Panasil light body) showed that the Panasil heavy body impression material is the hardest comparing with the other two materials. On the other hand, Salginate medium body found to be harder than Panasil light body which means that Panasil light body has the least hardness. Table 1 shows the Mean value and SD of each of the PVS materials used for this study.

Statistically, Two-Way ANOVA results showed no significant difference in the dimensional accuracy of study models obtained using different hardness of PVS impression materials and different rigidity of impression trays (*P*= 0.01) as shown in Table 2 .

Table 1: Hardness results of Panasil (heavy body), Salginate (medium body) and Panasil (lightbody) PVS impression materials

Material	N	Mean	Std. Deviation	Minimum	Maximum
Panasil (heavy body)	6	58.600	5.0959	51.6	63.9
Salginate (medium body)	6	51.800	.8462	50.5	52.7
Panasil (light body)	6	49.433	1.0367	48.0	50.8

Table 2: Results of the effect of PVS impression materials and tray rigidity

Material	Tray Type	Mean	Std. Deviation	N	P value
Panasil (heavy body)	Metal	5.55400	.1643938	10	0.01
	plastic	5.45180	.1681407	10	
	self-cure	5.42100	.1291451	10	
Salginate (medium body)	Metal	5.47440	.1289601	10	
	plastic	5.41840	.1709407	10	
	self-cure	5.20410	.0175718	10	
Panasil (light body)	Metal	5.34260	.1707299	10	
	plastic	5.32960	.1722332	10	
	self-cure	5.49220	.1347325	10	
Total		5.409789	.1717626	90	

DISCUSSION

One of the factors related to the accuracy of the impression is the rigidity of the tray (Dixon *et al.*, 1994). In the current study, it was hypothesized that no difference would be shown in the accuracy of the study casts obtained using the custom and stock tray types. However, it was resulted from the analysis of measurements, that there was no difference in the accuracy between the four tray types. Thus, it is very important to select a proper impression tray. Various studies in the literature showed that the precision of custom trays is higher than those of stock ones. This is attributed to their good properties of dimensional stability and distortion resistance. As it was confirmed in a study conducted by Burns *et al.,* that custom trays are more accurate as compared to stock ones (Burns *et al.*, 2003; Millstein *et al.*, 1998; Wassell and Ibbetson, 1991) . Whilst, some previous studies confirmed that the accuracy of casts is not affected by the types of tray selected (Brosky *et al.*, 2002, 2003) and clinicians prefer using stock trays more than customs, and they can use them in a single visit even for the unanticipated situation (Barghi and Ontiveros, 1999; Bomberg *et al.*, 1985).

Stock trays have been used by most clinicians, as it was reported by Shillinburg *et al.* (1980) While, the use of stock trays appears to be popular especially with elastomeric impressions, whereas the custom tray is a good selection to obtained better impression accuracy (Donovan and Chee, 2004; Chee and Donovan, 1992; Valderhaug and Floystrand, 1984). Though previous studies demonstrated that using high viscosity impression material with disposable plastic stock trays should be avoided (Cho and Chee, 2004) but the present study concluded that using a high viscosity PVS impression material with the same tray types make no change in the dimensional accuracy of impressions obtained. In the present study, statistical results showed no significant difference in the dimensional accuracy of casts obtained using stock and custom trays with the various hardness of PVS impression materials. The results of the present study demonstrated that the appropriate selection of a good quality of metal and plastic trays, that exhibit sufficient rigidity to resist the deformation during use of different hardness of PVS impression materials, would not affect the accuracy of implant impression. Del'acqua and colleagues compared the rigidity of plastic and metal stock trays and their effect on implant impression precession. Furthermore, they stated that clinicians prefer using stock trays because, in their opinion, the fabrication of custom trays is impractical in clinical settings (Del'acqua *et al.*, 2012). Along with Del'acqua's study, in the current study, it was demonstrated that light cured trays dis- played the least distortion as compared to self-cure acrylic trays. Also, it resulted that impressions obtained using light-cured custom trays showed less distortion when compared with those resulted from using stock trays. The uniform thickness of the trays played a role in lessening that distortion and allowed uniform distribution of impression material. However, the difference was not statistically significant. Therefore, it can be concluded that with the usage of various types of stock and custom trays, with various hardness of the PVS impression materials, had not affected the dimensional accuracy of implant impression.

CONCLUSION

According to the limits of the present research, it has been concluded that although different types of PVS impression materials have been used, no difference in dimensional accuracy has resulted. However, the results suggested that the Panasil (light body) impression material showed less hardness. Furthermore, it has been found that accurate casts can be obtained by using different types of impression trays. The rigidity of different types of trays has not made a significant difference in the accuracy of implant impressions obtained.

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