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Effect of Different Viscosity and Tear Strength of Polyvinyl Siloxane Impression Material on the Accuracy of Dental Implant Impressions

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ABSTRACT

Introduction: *The impression material accuracy is necessary for its direct effect on the precision of the impression of dental implants.* ***Aims:*** *This study aims to evaluate the effect of viscosity and tearing strength of 4 syringable polyvinyl siloxane impression materials (light body panasil, medium body silginat, medium body monopren, and heavy body panasil) all were manufactured by Kettenbach, Germany on the precision of dental implant impressions.* ***Materials and methods:*** *To evaluate the dental implant impression accuracy a polyvinyl siloxane was used with different types of viscosity and tear strength, and then the impression has been compared with the master cast which has been fabricated from the acrylic resin as a lower dental arch. For this, 4 parallel Straumann dental implant analogs, manufactured in Switzerland, were used. About 20 impressions were fabricated from each group (n=20) of the materials. To measure the impressions accuracy, the distance between each pair of analogs was measured using a digital microscope (Dino-Lite Digital Microscope, UK).* ***Results:*** *It was found that the tear strength of silginat (medium body) is higher than that of the rest of materials and the tear strength of monopren (medium body) is the least compared to the rest of the materials.* ***Conclusion:*** *Finally, it was concluded that the different viscosities and tear strength of polyvinyl siloxane impression material have no significant effect on the accuracy of the dental implant impressions.*

Keywords: Impression material, Dental implants, Viscosity, Polyvinyl siloxane, Tear strength, Accuracy

INTRODUCTION

The ability to make an impression record of a tooth preparation accurately is a crucial stage in dental prosthesis fabrication [1]. Dental implants are widely used in clinical practices. They have been helping greatly to elevate problems which occurred to patients. Today, patients increasingly demand more proper esthetic and functional prostheses [2]. Dental impression serves the purpose of producing the forms and relation of certain teeth and the surrounding tissues of the oral cavity [3]. Reporting good accuracy of implant impression is necessary when it comes to select the material so that to record the fine details of oral soft and hard tissues [4]. Accuracy is considered one of the primary requisites of impression materials thus, it has been the traditional goal of researchers and stakeholders [3,5]. Dental implant impression can be made with different materials like plaster, hydrocolloids and 4 basic type elastomers of polysulfide, polyether, PVSs as additions silicones, and condensation silicones [6]. Different factors affect the dental impression quality like impression materials, difference in the viscosity of materials, and impression techniques [3]. At present, the most popular dental implant impression material used is the polyvinyl siloxane (PVS). It is widely used since the late 1950s [7]. The PVS impression material is widely used for having minimal dimensional change, short setting time, and desirable elastic recovery and tear resistance [8,9]. It is available in 4 viscosities: heavy, medium, light, and putty.

Excellent detail reproduction, dimensional stability, and good tear strength are the qualities of elastomeric impression materials that made these materials used when a high degree of accuracy is essential [10]. Literature has demonstrated an increase in the accuracy, loading higher filler is acquired, and the less constriction results in a higher viscosity

[3,11]. Materials of low viscosity showed significant change due to the lower content of the filler [12]. Moreover, the lowest viscosity can be found in light body material. It is used to record precise details of tooth preparations. On the other hand, medium body is widely used during bridge and crown work or for edentulous penitents. The higher viscosity can be obtained when using heavy body material. It is generally used to support the light body material by placing it on impression tray [12]. Regarding the effect of material viscosity on implant impression accuracy, American Dental Association (ADA) specification 19 mentioned that the accuracy of detail reproduction depends on the viscosity of the impression material clarifying that, when the viscosity is low, the higher is the reproduction of details [13]. Moreover, elastomeric materials which are used to fabricate precision castings should result in fine details of 25 μm or less [14]. Detail reproduction of 1 μm to 2 μm can be recorded by PVS impression materials [15].

The ADA also illustrated on tear strength as another essential factor which affects the accuracy of impression material. Tear strength is "the ability of the material to resist tearing under tensile stress". When removed from the oral cavity or from gypsum models, impression material is subjected to tensile stresses [16]. The ADA does not specify tear strength determination method of elastomeric impression materials in specification 19. However, it defines a tear strength testing method in specification 20 for dental duplicating materials [17,18]. This test method specifies the use of an ASTM standard D624-54 "notched" mold for fabrication of specimens. These specimens are loaded in tension at 254 cm/min and the load at failure is recorded as the tear strength (ANSI/ADA Specification No. 19, 2004). There is no ISO specification for tear strength (International Standardization Organization, 2000).

At Northwestern University, Dr. Alan Boghosion presented a method for testing the tear strength of impression materials at the International Association of Dental Research meeting in 2005. His method uses a bar shaped specimen with a notch in the center (resulting in a 0.2 mm thick film). The specimen is tested to failure in tension [18].

In fact, PVS is said to have the highest tear strengths because it tears before permanent deformation limit [19]. These materials will deform within the range of their yield strength, hence they are suitable for clinical usage [20].

Accuracy is an essential factor for the success of implant prosthesis. Although advanced impression techniques and excellent impression materials are available, inaccuracy of dental implant impression is still a problem. Inaccuracy may be either due to the inaccuracy of impressions or dimensional changes of an impression. Hence, the current research was undertaken to study the effects of PVS impression materials with different viscosities and tear strength on the accuracy of the dental implant impressions obtained. Different techniques of impression making can also influence the precision. The 2 commonly used techniques are direct and indirect ones. It was suggested that direct technique are more favorable, while, some studies prefer the indirect one [2,3,6,8,14,21-23]. Research shows that direct technique is commonly used with implants of different angulations, whereas, the indirect technique can be used with divergent or parallel implant situation [23]. Besides, most clinicians find that indirect technique is more appropriate particularly with the posterior position of the implant or when the intermaxillary distance is insufficient in an opening, or the patient shows an excessive tendency for gag reflex [24].

PATIENTS AND METHODS

Tear Strength Test

According to ISO, an angle test sample without neck was made with a thickness of 2 mm ± 0.2. Testing procedure according to ISO 34-1: 2010 digital caliper was used to measure the thickness in the region of the right angle and at the ends of each sample, and then mean of these readings was taken. Each sample was marked by blue line 15 mm away from each end so that it will gripe symmetrically by Instron machine (Mensanto, England, Model WDW-IOOE, No. TC914). The sample was stretched at 500 mm/min until it breaks, and the maximum force of breakage was recorded. Tear strength has been calculated using the following formula: Tear strength=F/d, where: F=maximum force in Newton, d=thickness of the sample in millimeters. Samples are shown in Figure 1.

Figure 1 Tear strength models

Fabrication of the Master Model

A lower dental arch master cast was constructed using acrylic resin. First, 4 parallel holes have been made between mental foramina, using implant hand-piece with drills. Then, 4 implant analogs were used (analog for RN synOcta L 12 mm, W 3.5 mm, stainless steel, Straumann, Switzerland) to fixed in the holes made above the surface of the alveolar ridge in 1 mm, then, the analogs have been fixed using cold-cure acrylic resin (Vertex, Netherlands) (Figure 2).

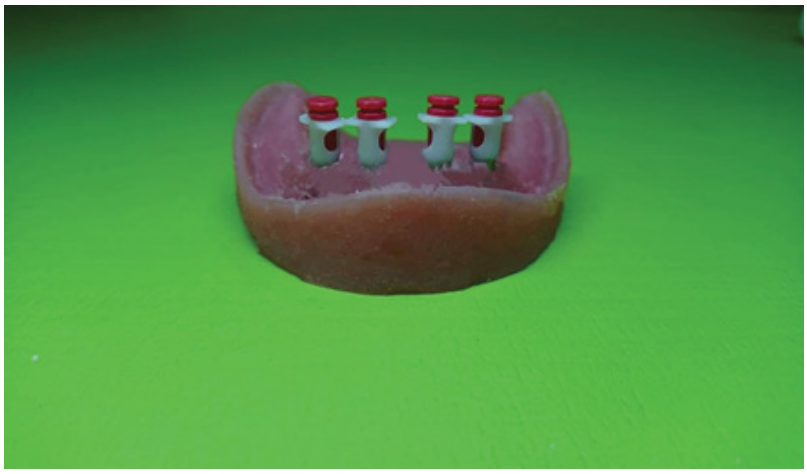

Figure 2 Distance measurement

Afterwards, the distance between each pair of analogs was measured using a digital microscope (Dino-Lite Sigital Microscope/ UK) (Figure 3).

Figure 3 Distance measurement

Impression-Taking Procedure

The impressions were taken with metal tray (Dimeda, Germany) using indirect technique, and 4 different viscosities of syringable PVS impression material (light body panasil, medium body silginat, medium body monopren, and heavy body panasil) manufactured by Kettenbach, Germany, were used for 4 groups using an auto mixing gun (Figure 4).

Figure 4 Metal tray with mixing gun and 4 different viscosities of PVS

The procedure was as follows:

- Applying light-body material on the tray and around the transfer copings
- Medium body silginat material was applied on the tray and around the transfer copings
- Medium-body monopren material was applied on the tray and around the transfer copings
- Heavy body panasil material was applied on the tray and around the transfer copings

The impressions were removed after the specified time passed (recommended by the manufacturer), then implant dental analogs were placed and tightened with hand. After that, the casts were poured using vacuum-mixed type IV stone (Zhermack, Italy) (30 g powder/100 mL water) as recommended by the manufacturer. Accordingly, the casts made were coded and prepared for measurement after passing 24 hours of the preparation. In total, for each of the 4 groups, 8 impressions were constructed (n=32).

Accuracy Measurement

The copings were placed on the master dies, and then a digital microscope fixed on the desktop stand (AM 413 Fit Dino- Lite Pro; Dino- light, Taipei, Taiwan) was used to measure the distance between 2 indentations. The digital microscope was connected to a computer and photographs were taken at 15x magnification. Data obtained from the measurements of this research were analyzed using SPSS Statistical software version 22 (SPSS Inc., Chicago, IL, USA) with the level of statistical significance set at p=0.05. Descriptive statistics were applied to describe the tear strength measurement in mean and standard deviation (SD) of the different PVS impression materials. One-way statistical analysis of variance (ANOVA) together with Tamhane post-hoc test was applied to compare the effect of the different tear strength of the PVS materials on the dimensional accuracy.

RESULTS

The tear strength test of monopren (medium body), panasil (heavy body), panasil (light body) and silginat (medium body) PVS impression materials indicated that tear strength of silginat (medium body) is higher than that of the rest of the materials. While tear strength of monopren (medium body) is the least compared to the rest of the materials. Tear strength of panasil (light body) is less than that of silginat (medium body) but more than the tear strength of panasil (heavy body) and monopren (medium body). Finally, panasil (heavy body) has found to have more tear strength than monopren (medium body) (Table 1).

Table 1 Results of the tear strength of PVS impression materials

Material	N	Mean	Std. Deviation	Std. Error Mean
Monopren (Medium Body)	6	4.2967	0.73620	0.30055
Panasil (Heavy Body)	6	4.5400	1.08705	0.44379
Panasil (Light Body)	6	5.1100	0.86796	0.35434
Silginat (Medium Body)	6	5.4733	0.94716	0.38668

Data analysis by Kolmogorov-Smirnov test illustrated the normal distribution of data obtained (p=0.05). ANOVA results confirmed that there were no significant differences in the accuracy of the casts prepared of different viscosities of PVS impression material (p=0.188). Also, no significant interaction existed between the tear strength of the PVS impression materials and the different viscosities of the 4 PVS impression materials. Mean and standard deviation of impression accuracy in master arch and casts were illustrated in Table 2.

Table 2 Results of the effect of materials on impression accuracy of casts

Material	Mean	Std. Deviation	F stat.	p-value
Monopren (Medium Body)	5.518	0.192	1.754	0.188
Panasil (Heavy Body)	5.568	0.162		
Panasil (Light Body)	5.380	0.093		
Silginat (Medium Body)	5.475	0.153		

Thus, there is no combined effect between tear strength and viscosity of PVS on the accuracy of dental implant impressions.

DISCUSSION

The endurance of any prosthesis depends especially on the material from which it was fabricated. Thus, any defect in the properties of materials may reduce the service life of prosthesis [25]. The past 4 recent decades have witnessed a prominent advancement in the domain of dental impression materials and impression taking procedures. To take impressions in fixed prosthodontics, different elastic impression materials have been used to produce a precise negative similarity of the dental arch and the surrounding tissues [26].

The dimensional precession of dental implant impression is important to produce a successfully fixed prosthesis.

It has been shown that elastomeric materials are used widely in the impression taking process. Hence, the PVS impression materials possess good mechanical properties that make it desirable by clinicians, for its production of accurate detail of implant impression [27]. The current study has used different PVS materials to compare the accuracy of the resultant impressions. However, results found that no differences existed in the accuracy of casts fabricated

since no significant difference resulted among the 4 groups. Hence, it proved that impression material selection is crucial in determining the precision of implant impressions. This result was incompatible with previous studies by Craig RG and Sun Z, it was compatible with Chee, WW and Donovan TEs' [28,29].

The current study was an attempt to evaluate the effect of tear strength and 4 different brands and viscosities of PVS impression material on the accuracy of the dental impressions obtained. From the results, it was clear that the impressions produced from the 4 PVS materials were alike.

Several previous studies reported that the different PVS impression materials are dimensionally stable [30,31]. It was found that the casts made from silicon impression materials are in a clinical range [32]. The results of the present study are in accordance with those conducted in the literature, which proved that the good tear strength and viscosity of PVS impression materials could result in an accurate implant impression [31-33].

According to the results in a study conducted by Ahmad, et al., taking impressions using PVS material that differs in viscosity showed no significant change in the accuracy of that impression [34]. However, some previous studies like the one that was conducted by Vojdani and authors used different impression materials to investigate the dimensional accuracy. Although their findings showed that polyether, PVS, and vinyl siloxanether have no marked effect on the precession of impressions with parallel implants, still PVS showed better results. Yet, there were studies that consider VSE as the material of choice when the impression is to be made [35,36].

However, research has been made previously on tear strength of several impression materials to show their effect on impressions constructed but little studies have been conducted to evaluate the effect of the tear strength of PVS materials used in the current study. Hence, tear strength of PVS impression materials, especially the ones used for this study, and their effect on the accuracy of dental implant impression has not been focused on sufficiently in the literature.

Tear strength refers to the material resistance to fracture when it is subjected to a tensile force acting perpendicular to a surface flaw. Having sufficient strength allows impression materials to remove from the gingival sulcus without tearing. It has been mentioned that the residual remnants of some impression materials can produce inflammation in the gingival sulcus [37,38]. Consequently, the tear strength of selected impression materials is an essential factor in the clinical practice [38,39]. It was confirmed that the PVS impression materials have desirable properties, such as high tear strength, good dimensional stability, elastic recovery, and good reproduction of details [40]. The thing that has made it a good selection for the current study.

From the clinical application point of view, materials that own high tear strength are not inevitably considered superior to those with low tear strength. However, the material that tears before it deforms past a critical limit is preferable. PVS materials have the characteristic that they deform at a slower rate and they tear at a point of no remarked permanent deformation as compared to other elastomeric materials. Also in comparison to other elastomers, PVSs are capable of absorbing 3 times more energy to the point of permanent deformation [41,42].

PVS materials are considered dimensionally stable because during the polymerization reaction no by-products were produced. Accordingly, their physical and mechanical properties were more favorable to use for impressions making [43].

The present study has found that tear strength of the 4 selected PVS materials created no significant effect on the accuracy of implant impressions. The results were confirmed with a study conducted by Thomas, et al., on the accuracy of implant impressions in dentistry, and they reported that different tear strength rates of silicon impression materials do not significantly affect the accuracy of impressions fabricated [44].

On the other hand, Nathaniel, et al., measured the tear strength of different types of impression materials at different setting times. Among the materials used, 4 addition silicone materials also experimented in their study (Aquasil, Imprint3, Stand Out, and Virtual). Findings showed a difference between the materials used in all groups. They concluded that most addition silicone impression materials own higher tear strengths than other materials experimented in their study [45].

Another study has been conducted by Sun, et al., in which they have made a laboratory evaluation of tear strength of 3 elastomeric impression materials PE, PVS, and VPES. In their study, they came out with the results that the tear strength of PE was higher than that of PVS or VPES, while PVS has slightly higher tear strength than VPES [46]. It

is concluded that PVS is the more desirable material of selection for the current study and it is highly recommended for clinical and laboratory use as well [47].

CONCLUSION

According to the results of this study, no significant differences occurred in the accuracy of dental implant impressions made of PVS impression materials with different viscosities in comparison to the main cast. Also, no significant effect has been found in the implant impressions of the different tear strength rated materials.

DECLARATIONS

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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