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Comparison of Elastomeric Impression Materials' Thixotropic Behavior

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Abstract - *The improved flow characteristics of new elastomeric impression materials are significant factors in the selection of suitable products for clinical applications. The aim of this study was to assess the thixotropic behavior and compare the flow characteristics of seven different elastomeric impression materials using a shark fin test. One polyvinylsiloxane showed the highest shark fin height values, while the newly formed vinylsiloxanether material exhibited no significant differences when compared with two polyvinylsiloxanes. One of the five polyvinylosiloxanes presented significantly lower shark fin values than all other materials. It was concluded that flow characteristics for most of the tested materials are acceptable.*

KEY WORDS: impression material, thixotropic behavior, shark fin test, polyether, polyvinylosiloxane, vinylsiloxanether

INTRODUCTION

Impression making is a significant procedure during prosthodontic treatment, as it could directly affects the accuracy of the definitive cast and the passive fit of the final restoration[1]. Both physical and chemical properties of elastomeric impressions materials could affect the accuracy of impressions. Furthermore, an impression material should be selected according to its consistency and flow properties, its setting time, dimensional stability, and ease of handling[2].

Also, it must exhibit low viscosity to accurately record impression details such as the interproximal spaces, deep restorative preparations, and gingival crevices, as low viscosity allows for better flow of the material and consequently accurate record of fine details of the preparation[2].

The most common elastomeric impression materials currently used for making fixed and removable prosthodontic restorations are polyvinylsiloxanes (PVS) and polyethers (PE)[2,3]. Polyvinylsiloxane impression materials provide simplicity, high dimensional stability and accuracy, superior elastic recovery from undercuts and low viscoelastic properties, low distortion, adequate tear strength varying with filler rate and viscosity, high flow characteristics, short setting time, and multiple pouring from one impression[3,4]. The main disadvantage of using PVS impression materials was their hydrophobic characteristic because of their chemical structure; however, hydrophilicity of these materials was facilitated by adding polyether carbosilane surfactant[3-5]. Furthermore, in 2009 presented a newly impression material called vinylsiloxanether ("Identium"-PVSE) [Kettenbach Company (Eschenburg, Germany)]. It combined chemically a polyether material and a polyvinylsiloxane, achieving theoretically advantages of both materials.

A number of studies into the rheological or flow characteristics of elastomeric impression materials have been reported, including viscosity and thixotropy[2-5]. The rheological or flow characteristics of these materials are major determinants of handling properties and adaptation to the prepared teeth and the gingival cleft into the mouth[6-10]. The thixotropic behavior of impression materials is the ability to cease flowing- once the impression is fully seated into the mouth and it depends on the rheological or flow characteristics of the elastomeric material[11-12].

The shark fin test device was developed from 3M-ESPE for testing the flow characteristics of the polyether impression material. There are few studies available so far in the literature examining the thixotropic behavior of these materials using a "shark fin" measurement procedure to determine which exhibited superior flow characteristics[13-15], although the shark fin test is considered as an established method for analyzing flow properties of polyether impression materials throughout the entire manufacturer's recommended working time. The shark fin height recorded for testing the flow of each impression material tested, under applied low pressure. The applied force should closely approximates the average pressure used by a clinician while loading an impression tray into a patient's mouth.

Therefore, the aim of the present study was to assess the thixotropic behavior and compare the flow characteristics of seven different elastomeric impression materials; five low-viscosity polyvinylsiloxanes (PVS), one polyether (PE) and a polyether-polyvinyl siloxane hybrid material (PVSE) using a shark fin test.

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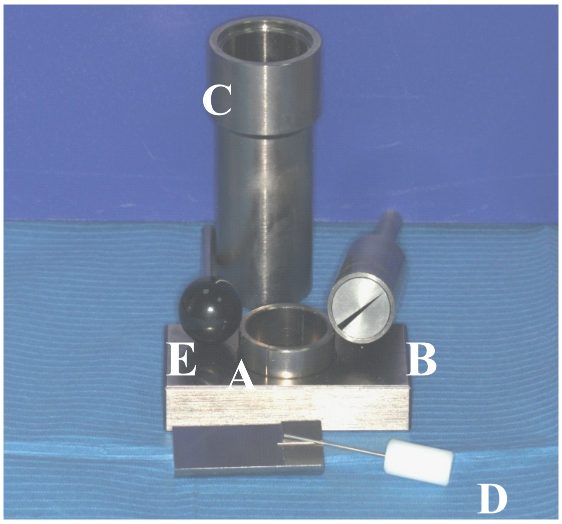

Figure 1. *Illustration of parts consist a shark fin device*

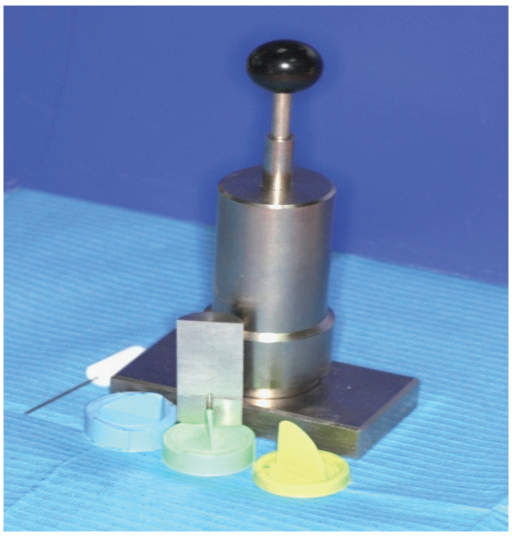

Figure 2. *Illustration of shark fin device and shark fin shape specimens*

MATERIALS AND METHOD

Five commercially available low-viscosity, automixed PVS, one polyether and a PVSE impression materials were investigated; Panasil (PVS1), Virtual (PVS2), Chromaclone (PVS3), Affinis (PVS4), Honingum (PVS5), Permadyne (PE) and Identium (PVSE), (Table I). They were supplied by dispensing from automixing cartridges and were used according to manufacturers' instructions.

Shark fin is a stainless steel device, consisted of a split ring (A), a cylindrical caste with a triangular notch (B), a housing to suspend the caste over the cup (C), a pin to attach the caste to the housing(D), and a weight to apply a force for the caste to drop into the cup (E) (Fig. 1). More specificly, after the impression material is dispensed in the ring (A) and allowed to flow freely, the housing, containing a round split cylinder with a V-shaped slit (B), is placed on top. Then the metal rod (pin) (D), attached to the split cylinder (C), was released, allowing the split cylinder to sink slowly into the freshly mixed impression material, loading the material (E) with approximately 150g[13]. The light body material flowed around the cylinder and entered the 1mm slit and thus a shark-fin-like shape was formed (Fig.1, 2). After setting, the device was disassembled, the shark fins were removed from the mold and the maximum height of the fin was counted using a digital caliper. The procedure was repeated and resulted in 5 specimens from each impression material tested. The data were analyzed using the One-way Analysis of Variance (ANOVA) method. Means were compared with Tukey-Cramer test. In all hypotheses testing procedures the significance level was predetermined at $p<0.05$.

RESULTS

Shark fin tests' heights were recorded and the mean heights are presented at table 2 and Fig. 3. The impression material with the highest shark fin height values was Affinis (PVS4), followed by Permadyne (PE), Virtual (PVS2), Honigum (PVS5), Identium (PVSE), Panasil (PVS1) and Chromaclone (PVS3).

Comparison between shark fin height of Virtual (PVS2) or Affinis (PVS4) exhibited no statistically significant difference ($p>0.05$), as well as comparison between Honigum (PVS5) and Panasil (PVS1) ($p>0.05$). Identium (PVSE) exhibited no statistically significant differences when compared with Panasil (PVS1) or Honigum (PVS5) ($p>0.05$) and Permadyne(PE) also exhibited no significant differences when compared to Virtual (PVS2) and Affinis (PVS4) ($p>0.05$). The last three impression materials seemed to exhibit higher shark fin values comparing with the other tested ones.

Table 1. *Materials used in the study together with their manufacturer*

Panasil (PVS1)	Kettenbach, Germany
Virtual (PVS2)	Ivoclar – Vivadent, Lichtenstein
Chromaclone (PVS3)	Ultradent, USA
Affinis (PVS4)	Coltene Whaledent, Switzerland
Honigum (PVS5)	DMG, Germany
Identium (PVSE)	Kettenbach, Germany
Permadyne(PE)	3M-ESPE, Germany

Table 2. *Shark fin mean values of tested materials*

	Panasil	*Virtual*	*Chromaclone*	*Affinis*	*Honigum*	*Identium*	*Permadyne*
Mean Height (mm)	19.57	22.16	17.53	22.91	20.32	20.05	22.47
SD	0.86	1.55	0.35	0.98	0.62	0.59	0.93

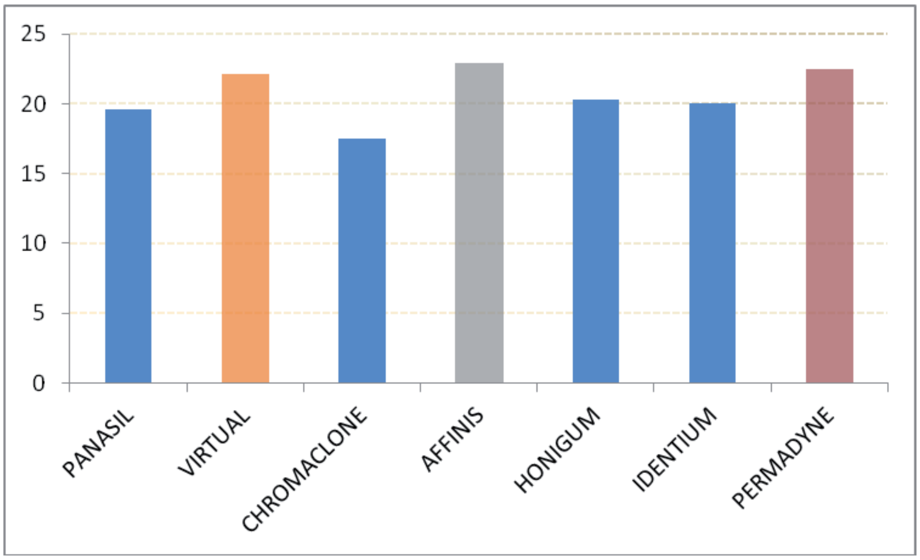

Figure 3. *Diagram of shark fin mean values height of the tested materials*

By contrast, significant differences were noted when fin height of Panasil (PVS1) was compared with Affinis (PVS4) or Permadyne (PE), and when Affinis (PVS4) was compared with Identium(PVSE) (p<0,001). Chromaclone (PVS3) showed significant differences compared with every other material (p<0.001) exhibiting lower values, except for Panasil (PVS1) (p<0.05).

DISCUSSION

PVS and PE impression materials are widely used in prosthetic dentistry due to their favorable physical and mechanical properties[4, 8, 15-17]. The ability of the impression material to reproduce minute detail in the area of 20 to 70 μm is necessary for high quality restorations[18]. This ability is influenced by rheological characteristics, as viscosity and thixotropicty. More specific, it is reported that viscosity determines the handling and adaptation to prepared teeth and surrounding mucosa in the mouth[19]. Furthermore, Chai and colleagues reported that time required -in order an impression material to reach certain value of viscosity and be workable- exhibited variations among PVS impression materials[20]. It was reported that viscosity of the impression material could also be affected by the filler content and the viscosity of pre-polymers [21]. At the same in vitro experimental study it was demonstrated that the higher the viscosity of the material, the greater the ability of the impression material to flow[21]. Moreover, Martinez and colleagues reported that thixotropicity in combination with yield stress could prevent the undesirable drip of an impression material once it had been injected around the prepared tooth, until the impression tray is loaded and seated[22].

Factors such as temperature, humidity, base-catalyst ratio, way of mixing, wetability, fast kinetics and setting velocity, could affect thixotropicity. More specific, studies examining temperature revealed significant changes in the kinetics of setting with differences in the development of viscoelastic rheological properties[20] as setting time decreased. This evidence is quite important as most rheological tests were conducted at room and not oral conditions hydrophilicity may improve flowing during impression taking [23-25]. Another parameter connected with thixotropy could be seating velocity, which in laboratory testing is connected with the weight of the shark fin device cylinder. It was demonstrated that seating velocity has a significant effect on the peak pressure produced during simulated impressions[26] and may as a result affect shark fin height values. By contrast, the thixotropic behavior of PVS in clinical circumstances does not seem to be affected by the shear load applied during syringing[21, 27].

It generally suggested that the thixotropic behavior is of great importance for an accurate impression. Although, several methods of assessing thixotropic behavior have been described, only few studies examine and compare the flow characteristics of the elastomeric impression materials, using the shark fin test[13-15]. In this in vitro study, flow characterisics of seven elastomeric impression materials were examined and compared.

In agreement with other studies, in this study some PVS impression materials were found to reproduce smaller shark fin height than PE[13, 14]. Also, the newly formed PVSE exhibited no statistically significant differences when compared with three PVS. Furthermore, in a clinical comparative study between vinylsiloxane, polyethere and vinylsiloxanether materials and besides the inherent disadvantage of standardizing clinical protocols, the newly formed material reported to be equivalent or even superior from polyether to other examined materials both for dental technicians, dentists and patients[28]. In contrast, statistically significant differences were found among some of the examined PVS impression materials, while other studies reported no difference in shark fin heights. Also, it has been reported significant correlation between shark fin height, phase angle and storage modulus but not between shark fin height and dimensional accuracy or surface detail reproduction[14]. A decrease in shark fin height is possibly caused by changes in rheological characteristics connected to filler type or monomer characteristics[14]. Thus, in the literature shark fin test results were more correlated with rheological properties such as thixotropicity, rather than surface detail reproduction[14].

Besides, the phase angle and the storage modulus were two parameters, considered as appropriate measurements to describe changes of the rheological characteristics of an impression material during setting [29, 30].

Although shark fin test had been already used and recommended for flow characteristics' examination, it does not accurately replicate conditions in the mouth. Besides it has already been mentioned that different variables would restrict an intraorally study[14.] So, the main limitation of this in vitro study was that many intraoral parameters and factors that are said to affect thixotropicity were not taken into account.

CONCLUSION

Within the limitations of this study, it was concluded that flow characteristics for the most of the tested elastomeric impression materials are acceptable.

Greatest shark fin heights and flow characteristics were recorded for one PVS (PVS4). Furthermore, two polyvinilosiloxanes (PVS2, PVS4) and one polyether (PE) of the examined impression materials exhibited no significant differences and higher values than the other impression materials- comparing height of shark fin tests. Newly formed vinylsiloxanether material exhibited no significant differences when compared with two polyvinylsiloxanes (PVS1 and PVS5). Moreover, PVS3 presented a significantly reduction of flow ability and lower shark fin values compared to all other examined impression materials.

Further experimental studies in this area are necessary to be done, reproducing intraoral and clinical conditions that may affect the quality of the final impression.

CLINICAL IMPLICATION

Assessment of flow characteristics of elastomeric impression materials is of great importance, as it is supported that these characteristics determine handling properties of the material and affect the ability to cease into the gingival cleft, in order to provide an accurate impression.

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