Original Article

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Effect of different impression techniques and elastomeric impression materials on the dimensional accuracy of partially edentulous mandibular arch

Rafael Pino Vitti[1], Adriano Relvas Barreira de Oliveira[2], Mário Alexandre Coelho Sinhoreti[3]

[1]DDS, MSc, PhD, Associate Professor, Universidade de Taubaté (UNITAU), School of Dentistry, Department of Prosthodontics, Taubaté, SP, Brazil

[2]DDS, MSc student, Universidade de Taubaté (UNITAU), School of Dentistry, Department of Prosthodontics, Taubaté, SP, Brazil

[3]DDS, MSc, PhD, Full Professor, Universidade de Campinas (UNICAMP), Piracicaba Dental School, Department of Restorative Dentistry, Piracicaba, SP, Brazil

Abstract

Aim: Evaluate the dimensional accuracy of stone casts of a partially edentulous mandibular arch made by two impression techniques (1-step putty/light-body and 2-step putty/light-body) using addition and condensation silicones. **Methods:** A partially edentulous steel stainless cast with four markings on teeth 33, 37, 43, and 47 was used to obtain the impressions. The transverse (33-43 and 37-47) and anteroposterior (33-37 and 43-47) distances were measured by measuring microscope (30x magnification; 0.5µm accuracy). For the 1-step putty/light-body technique, both viscosities of the impression materials were handled together. For the 2-step putty/light-body technique, the impression materials of different viscosities were handled separately and a polypropylene spacer (2 mm thick) was used to create a relief. The same distances were measured on stone casts (n = 5). The values were submitted to normality test (Kolmogorov-Smirnov) and analyzed statistically by three-way ANOVA and Tukey's (5%). **Results:** All distances showed shrinkage (negative linear changes). The addition silicones showed better accuracy than condensation silicones ($p<0.05$) and no significant difference was found between the impression techniques ($p>0.05$). The edentulous zone (43-47) presented worst dimensional accuracy results. **Conclusions:** The accuracy of the casts is more related to the impression material than impression technique.

Keywords: Dimensional accuracy. Silicone elastomers. Dental impression technique.

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Corresponding author:
Adriano Relvas Barreira de Oliveira
University of Taubaté
Rua dos Operários, 09
Taubaté, SP, CEP: 12020-270
Phone/Fax: 55-12-3629-2130
e-mail: <relvasrj@yahoo.com.br

Introduction

Impression technique is a frequently performed procedure in the dental office that requires selection of an appropriate impression material[1]. Dental impression presents a negative imprint of buccal structures[2]. It is usually a first step during fabrication of indirect restorations[3,4] that have to be seated in or on prepared teeth. Dimensional accuracy during making impressions is crucial to the quality of fixed prosthodontic treatment and impression technique is a critical factor affecting this accuracy, since that an accurate impression has a significant role in the success of treatment[2,5,6]. Knowing the physical and biological properties as well as the advantages and disadvantages of different impression materials, is a prerequisite for adequate practical application of dental materials and contributes to the success of prosthetic therapy[7].

In Dentistry there are four groups of impression materials: polysulfides, polyethers, condensation, and addition silicones. These materials present four viscosities: putty- (type 0), heavy- (type 1), medium/regular- (type 2), and light-body (type 3). For the clinical use the most important difference between these materials is their dimensional stability[8]. Factors such as viscosity, hydrophilicity, thickness, soaking, polymerization shrinkage, incomplete elastic recovery of the impression materials, type of the adhesive used in tray, pouring time, thermal shrinkage between buccal cavity and room temperature[9] may affect the dimensional accuracy of the molds.

The different viscosities of the impression materials allows use several impressions techniques, such as 1-step putty/light-body technique and 2-step putty/light-body technique. The 1-step putty/light-body technique is performed using two impression materials with different viscosities at the same time. Both viscosities of the impression materials are handled and placed in the tray together[10,11]. On other hand, the 2-step putty/light-body technique was created to minimize the shrinkage of the condensation silicones[12]. In this technique, two impressions procedures are realized. The prior impression is performed using a tray with putty-material. After its polymerization a relief is performed in the initial mold and the light-body material is handled and placed on the putty material[10,11,13]. Clinically these techniques have some differences as simplicity, number of operators to handle the impression materials, chair time, and the control of the impression materials thickness[2,13,14]. There is no consensus in literature on the best method or ideal impression technique. Furthermore, if the same type of the impression material could have different behavior with the different impression techniques.

The aim of this study was to evaluate the dimensional accuracy of stone casts made by two impression techniques (1-step putty/light-body and 2-step putty/light-body) using addition and condensation silicones.

Material and Methods

Table 1 shows the materials used in this study. Two viscosities of silicone impression material were used during the impressions: putty- (type 0) and light-body (type 3).

Table 1 - Impression materials used.

Brand names	Manufacturers
Clonage	DFL, Rio de Janeiro, RJ, Brazil
Zetaplus/Oranwash L	Zhermack, Rovigo, Italy
Optosil/Xantopren VL Plus	Heraeus Kulzer GmbH, Hanau, Germany
Silon 2 APS	Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil
Futura AD	DFL, Rio de Janeiro, RJ, Brazil
Express Regular Set	3M Unitek, Monrovia, CA, USA
Elite HD+ Normal Setting	Zhermack, Rovigo, Italy
Aquasil Ultra Regular Set	Dentsply GmbH, Konstanz, Germany

A steel stainless model simulating a partially edentulous mandible with absence of the teeth 44, 45, and 46 and with four markings on buccal cusps of the teeth 33, 37, 43, and 47 was used to perform the impressions techniques. Using a measuring microscope (Olympus® Measuring Microscope STM, Olympus Optical Co., Japan) at 30x magnification the anteroposterior (33-37; 43-47) and transversal distances (33-43; 37-47) were measured.

A stock tray I-3 (Tecnodent, Casalecchio di Reno, Italy) was used for 1-step putty/light-body and 2-step putty/light-body techniques. The putty-body silicones were handled using plastic gloves to avoid the inhibition of polymerization reaction by contaminants as zinc diethyl dithiocarbamate present in latex gloves[15].

For the 1-step putty/light-body technique the putty- and light-body materials were handled together. Thus, a second calibrated operator handled the light-body material. Both impression materials were placed together on the stock tray. For the 2-step putty/light-body technique a polypropylene spacer (2 mm thick) was used on the stainless steel cast to form a relief. The putty-body material was manipulated and inserted on the stock tray to perform a first impression. Then, the spacer was removed and the light-body material was manipulated and inserted on the first mold. A second impression was made to obtain the final mold. All impression materials used in this study were handled according to the manufacturer's instructions. The set tray/impression material was positioned and seated manually on the stainless steel model, from posterior to anterior direction. After the setting time of the impression material the tray was removed from stainless steel model by a pneumatic equipment with 3 bar pressure. This movement standardized was used to avoid distortions caused in the mold by vertical movement. All impressions procedures were performed in a room with temperature and relative humidity controlled (23°C ± 2°C and 50% ± 10%).

Dental stone type IV (Durone, Dentsply, Petrópolis, RJ, Brazil) was used in a water/powder ratio of 28.5 mL/150 g for stone cast pouring ($n = 5$). The molds were poured after 30 min of the tray detachment in order to allow the elastic recovery of the impression material. For each distance between the teeth three readings were made by a single calibrated operator as in the stainless steel cast. The means were calculated and compared with those obtained from the stainless steel cast (%): negative values indicate a decrease in the distances (shrinkage) and positive values indicate an increase in the distances (expansion).

The values were submitted to normality test (Kolmogorov-Smirnov). The data were analyzed statistically by three-way ANOVA and the means compared by Tukey's test ($\alpha = 0.05$) (Bioestat 5.0, Instituto Mamiraua, AM, Brazil).

Results

Table 2 shows that all distances showed shrinkage. The anteroposterior distances showed greater dimensional changes than transverse distances. The edentulous region (43-47) presented the greatest dimensional change ($p < 0.05$), except for Express (1-step putty/light-body technique) and Elite HD+ (2-step putty/light-body technique) where no significant difference was found between both anteroposterior distances (33-37 and 43-47) ($p > 0.05$). No significant difference was found between transversal distances ($p > 0.05$). In general, the addition silicones showed better accuracy than condensation silicones ($p < 0.05$). No significant difference was found ($p > 0.05$) between impression techniques.

Table 2 - Dimensional accuracy of the impression materials, techniques and distances evaluated.

Distances	Materials	33-43	37-47	33-37	43-47
1-step putty/light-body	Clonage	-.244 (.025) b,C	-.200 (.019) b,C	-.462 (.022) a,B	-.566 (.033) b,A
	Zetaplus/Oranwash	-.238 (.028) b,C	-.195 (.022) b,C	-.353 (.037) b,B	-.512 (.020) bc,A
	Optosil/Xantopren	-.231 (.027) b,C	-.212 (.020) b,C	-.340 (.028) b,B	-.489 (.042) c,A
	Silon 2 APS	-.321 (.024) a,C	-.297 (.031) a,C	-.444 (.030) a,B	-.645 (.028) a,A
	Futura AD	-.056 (.010) c,C	-.062 (.018) c,C	-.157 (.025) c,B	-.277 (.026) d,A
	Express	-.032 (.008) c,C	-.024 (.006) d,C	-.132 (.026) c,A	-.192 (.022) e,A
	Elite HD+	-.039 (.006) c,C	-.043 (.012) cd,C	-.160 (.018) c,B	-.251 (.032) d,A
	Aquasil	-.043 (.006) c,C	-.039 (.011) d,C	-.158 (.024) c,B	-.246 (.017) d,A
2-step putty/light-body	Clonage	-.210 (.032) b,C	-.241 (.033) b,C	-.403 (.026) ab,B	-.602 (.026) a,A
	Zetaplus/Oranwash	-.215 (.023) b,C	-.180 (.024) c,C	-.355 (.032) b,B	-.555 (.032) b,A
	Optosil/Xantopren	-.201 (.022) b,C	-.193 (.027) c,C	-.364 (.024) b,B	-.471 (.040) c,A
	Silon 2 APS	-.298 (.019) a,C	-.306 (.030) a,C	-465 (.033) a,B	-.633 (.018) a,A
	Futura AD	-.062 (.018) c,C	-.042 (.015) d,C	-.182 (.020) c,B	-.254 (.058) d,A
	Express	-.030 (.014) c,C	-.016 (.011) e,C	-.119 (.019) e,B	-.201 (.020) e,A
	Elite HD+	-.046 (.009) c,C	-.028 (.016) e,C	-.142 (.016) d,A	-.196 (.028) e,A
	Aquasil	-.051 (.012) c,C	-.020 (.015) e,C	-.148 (.025) d,B	-.228 (.008) de,A

Different letters indicate statistically significant difference: lowercase letters for comparison between impression materials (in columns) and capital letters for comparison between distances within each impression techniques (in rows) ($p < 0.05$). The Greek letters indicate comparison between impression techniques.

Discussion

The results of this study showed that addition silicone provided greater accuracy in the stone casts and greater reliability in impression structures than condensation silicone in both impression techniques evaluated.

These results are consequence of the excellent physical and mechanical properties of the addition silicone, such as no formation of byproducts during and after the set reaction by the terminal group ethylene or vinyl with hydride groups[11,16]. These properties provide the obtainment of more than one accurate stone casts from the same mold due to excellent elastic recovery (approximately 99%)[17] and tear strength of the addition silicone[18]. The dimensional changes that occur with the silicone-based impression materials are related to the temperature differences between the buccal environment and the room where the mold will be stored (thermal shrinkage)[19] and their polymerization shrinkage, besides the incomplete elastic recovery (approximately 1%)[17]. Hung et al. (1992)[12] reported that the small differences found in the dimensional accuracy among the addition silicone materials can be due to the variability in the composition of each brand name, especially in the matrix-filler ratio, which can provide different levels of shrinkage polymerization and elastic recovery.

The condensation silicones showed the largest dimensional change values corroborating with others studies in both impression techniques[20]. Silon 2 APS and Clonage were similar and showed the worst results of all impression materials tested. The strong and continuous setting reaction of this category of impression materials form volatile byproducts, such as ethyl alcohol. These byproducts cause greater shrinkage affecting the dimensional stability and, consequently, the accuracy of the condensation silicone[16,20]. In this study, some Silon 2 APS molds were discarded after mold-cast separation, since its light-body viscosity has low cohesive strength.

The elastomers undergo shrinkage during the polymerization in direction to center of the mold[21-23], while the gypsum undergoes expansion during its setting process. So, the negative linear changes in the stone casts showed in Table 2 show that the expansion of dental stone type IV is not enough to minimize the shrinkage occurred in the elastomers. Comparing all percentages of the dimensional changes occurred in the studied distances, it was found that all transversal distances suffered less change than anteroposterior distances. This fact can be explained by the bilateral adherence of the casting to tray when considered the transversal direction and just an unilateral adherence due the presence of free end of the tray (anteroposterior distance). This free end could offer less restrictive resistance to shrinkage of the impression material, allowing dimensional changes in these distances.

The partially edentulous region (43-47) showed greater dimensional changes values except for Express (1-step putty/light-body technique) and Elite HD+ (2-step putty/light-body technique). The greater volume of impression material due to the absence of three teeth on this side may be the reason for the greater shrinkage by volume of mold's mass and, consequently, greater dimensional change.

The results of this study showed no statistical differences between impression techniques, which corroborates with other studies [16-18] . However, different results were showed in studies where matrices[11,24,25] or fully dented casts[26,27] were used instead partially edentulous casts, polypropylene with different spacer thick[27], different temperature[24,25,27] and storage times[25,27] and when the casting were made under water[24]. These different protocols may explain the different results. Thus, the accuracy of the casts is more related to the impression material used than to the impression technique chosen[12]. From the results obtained, it is recommended to use addition silicone. Based on the results of this study, some clinical factors, such as the correct replacement of mold in the patient's mouth and the longer time required in 2-step putty/light-body technique and the simultaneous shrinkage of different materials with different viscosities, details reproduction by the putty material caused by excessive pressure applied during the impression and consequent flow of the light-body material and the need for a second person to handle the putty-body material in 1-step putty/light-body technique, should be the most important factors to influence the professional's choice. Therefore, as there was no statistical difference between the impression techniques, it is recommended that dentists use impression technique that they are most familiar considering the limitations of each technique and checking all variables, since some procedures as impression material handling, and its removal from the buccal cavity and pouring are under control in laboratory studies. The choice of the impression material is the primarily responsable for dimensional precision of the stone casts obtained. The addition silicones produce more accurate stone casts than the condensation silicones, while there are no significative differences when the same impression material are used with different impression techniques.

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