

Dimensional accuracy of stone casts made by a monophasic impression technique using different elastomeric impression materials

Rafael Pino Vitti¹, Lourenço Correr-Sobrinho², Mário Alexandre Coelho Sinhoretí³

¹MSD, Graduate student, Dental Materials Division, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, SP, Brazil

²MSD, DDS, PhD, Full Professor, Dental Materials Division, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, SP, Brazil

³MSD, DDS, Full Professor, Dental Materials Division, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, SP, Brazil

Abstract

Impression taking is a critical step in the process of producing successful crowns and fixed partial dentures in oral rehabilitation, and the impression material is an important factor related to clinical success. **Aim:** The aim of this in vitro study was to assess and compare the dimensional accuracy of stone casts made from a monophasic technique using 10 elastomeric impression materials. **Methods:** First, a stainless steel model with reference points in the teeth 33, 43, 37, and 47 was used to obtain the impressions. The distances were measured among teeth 33-43, 37-47, 33-37, and 43-47. For the impression technique, acrylic resin trays were made with an internal relief of approximately 2 mm. Specific adhesives for each material were used in the custom trays. Tray detachment movement was standardized by pneumatic equipment. After the impression procedures and obtaining of samples, the stone casts were observed in a measuring microscope at 30x magnification. Data recorded for each distance were analyzed statistically by one-way analysis of variance and Tukey's test at 5% significance level. **Results:** Stone casts made with elastomeric impression materials showed statistically significant ($p < 0.05$) differences when the dimensional accuracy values were compared. The order for the highest to lowest accuracy for the types of impression materials was as follows: polyvinylsiloxane (PVS), polyether, polysulfide and polydimethylsiloxane (PDMS). **Conclusions:** PVS were the most dimensionally accurate impression materials, and the PDMS showed the worst results of dimensional accuracy.

Keywords: impression technique, dimensional accuracy, dental materials.

Introduction

High accuracy impression materials (elastomeric impression materials) appeared in dentistry in the 1950s¹⁻². Nowadays, four different elastomeric impression materials are used namely polysulfide, polyether, polydimethylsiloxane (PDMS) and polyvinylsiloxane (PVS), and each one of them has specific chemical reactions and setting characteristics. The elastomeric impression materials made with a silicone base are found in four different viscosities: putty (type 0), heavy-body (type 1), regular or medium-body (type 2) and light-body (type 3). Polyether and polysulfide are already available in all consistencies, except putty¹⁻⁶.

The elastomeric impression materials possess elastic behavior after the set reaction; in other words, they resemble a rubber⁷⁻⁸. These materials are polymers

Received for publication: March 31, 2010

Accepted: July 13, 2011

Correspondence to:

Mário Alexandre Coelho Sinhoretí
Piracicaba Dental School
Dental Materials Department
Av. Limeira, 901. P.O. Box 52. - Piracicaba
SP - Brazil - ZIP CODE 13414-903
Phone: 55-19-2106-5348
E-mail: sinhoret@fop.unicamp.br

formed by large molecular chains. When tension is applied, these chains are uncoiled, elastically recovering after the load removal^{1,6}. Impression materials should reproduce hard and soft tissues in order to obtain biologically, mechanically, functionally and esthetically acceptable restorations⁹⁻¹⁰. However, dimensional changes in the molds inherent to the impression materials can occur, such as: wettability, handling properties¹¹, viscosity and thickness of the material existing between the oral structures and tray, fixation method of impression material to tray¹²⁻¹³, time elapsed for cast pouring¹³, material's hydrophilicity¹¹, byproduct loss, polymerization shrinkage, thermal shrinkage due the temperature change (from the mouth to room temperature), incomplete elastic recovery, and, in some cases, soak¹. Other factors, such as tray selection, impression technique and preparation design can also influence the impression quality¹⁴.

There are several brand names and categories of impression materials that can be used in dentistry. Dimensional stability of impression materials has been widely discussed in the dental literature^{10,15}, revealing significant differences in the properties of products of the same type. Some dentists still finds unclear which category of impression materials is best for clinical uses to obtain success of prosthodontic procedures¹⁰. The use of an appropriate impression material can reduce considerably the likelihood of inaccuracies in the molds⁷. New materials have been developed and subjected to continuous modifications with the aim of improving the impression quality, but these modifications do not guarantee maintenance of their properties¹⁶. Then, it is important to evaluate the dimensional accuracy of recently developed materials.

The aim of this in vitro study was to evaluate the dimensional accuracy of stone casts made with different elastomeric impression materials by a monophasic impression technique. The hypothesis tested in the present study was that there are differences on dimensional accuracy in stone casts among the elastomeric impression materials.

Material and methods

Table 1 shows the materials used in the study.

Table 1 - Materials (brand names) used and manufacturers.

Brand names	Manufacturers	Batch Number
Clonage (PDMS)	DFL, Rio de Janeiro, RJ, Brazil	08010080
Oranwash L (PDMS)	Zhermack, Rovigo, Italy	107165
Xantopren VL Plus (PDMS)	Heraeus Kulzer GmbH, Hanau, Germany	R330335
Silon 2 APS (PDMS)	Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil	349629
Futura AD (PVS)	DFL, Rio de Janeiro, RJ, Brazil	462216
Express Regular Set (PVS)	3M Unitek, Monrovia, CA, USA	387100
Elite HD+ Normal Setting (PVS)	Zhermack, Rovigo, Italy	110577
Aquasil Ultra Regular Set (PVS)	Dentsply GmbH, Konstanz, Germany	0811003044
Impregum Soft (Polyether)	3M Unitek, Monrovia, CA, USA	1026300114
Permlastic (Polysulfide)	Kerr Corporation, Romulus, MI, USA	0-1088
Rubber Base Adhesive	Kerr Corporation, Romulus, MI, USA	8-1099
Polyether Adhesive	3M Unitek, Monrovia, CA, USA	0003061
Universal Adhesive	Heraeus Kulzer GmbH, Hanau, Germany	280023

Stainless steel model evaluation

At first, a stainless steel model of the mandibular arch partially edentulous with reference points in the teeth 37, 47, 33, and 43 was made¹⁷. The transversal distances among teeth 33-43 and 37-47, and anteroposterior among teeth 33-37 and 43-47 (Figure 1), were measured by a measuring microscope at 30x magnification (Olympus® Measuring Microscope STM, Olympus Optical Co., Japan).



Fig. 1. Distances considered in the measurements.

Monophasic impression technique

All elastomeric impression materials were handled following the manufacturers' instructions, and impressions procedures were made in a room with temperature and relative humidity controlled ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 10\%$)^{2,4,18}.

Custom acrylic resin trays (Vipi Flash, VIPI, Pirassununga, SP, Brazil) were made with an internal relief of approximately 2 mm¹⁸⁻¹⁹ to provide an adequate and standard thickness to the impression material²⁰⁻²¹. A 2-mm-thick polypropylene spacer was used on the stainless steel model. Then, the acrylic resin was placed on the set polypropylene

spacer/model to obtain the custom trays with 2 mm of relief. Initially, an adhesive layer was applied to each elastomeric impression material, throughout the internal surface of all trays, which left on a bench for 5 min for adhesive drying^{18,22}. Afterwards, the light-body elastomeric impression materials were handled following the manufacturer's instructions and used to cover the whole internal surface of the tray, being careful with possible excesses.

The set tray/impression material was positioned and seated manually on the stainless steel model, from posterior to anterior. After the setting time recommended by the manufacturer, the tray was attached to the pneumatic equipment and detached from stainless steel model by a movement standardized, in order to avoid distortions in the mold (Figure 2)¹⁸ due to material expansion that occur by tension release after the impression removal²⁰. The detachment pressure was 3 bar. This procedure was repeated five times for each impression material brand name (n=5).

Following the manufacturers' instructions, a ratio of 150 g of dental stone type IV (Durone IV, Dentsply, São Paulo, SP, Brazil) and 28.5 mL of water was used. Each of five elastomeric casts was poured after 30 min of the tray detachment, in order to allow a correct elastic recovery. In the same way as in the stainless steel model evaluation, three measurements were made by a single calibrated operator in each one of the four distances among the teeth (33-43, 33-37, 43-47, and 37-47), and the respective means were recorded.

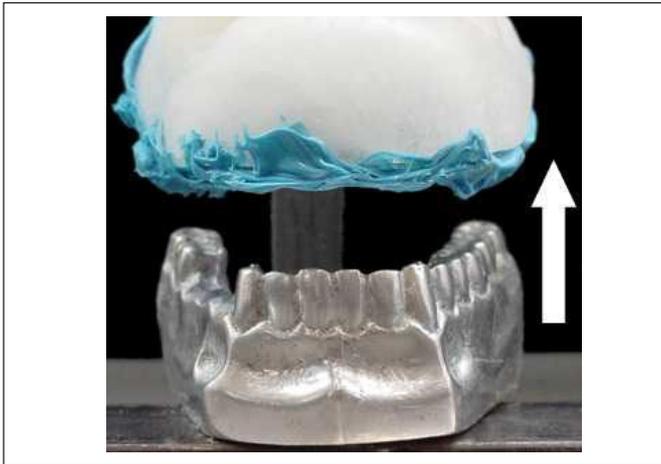


Fig. 2. Mold removal with single movement. After setting of the impression material, the tray was attached to the pneumatic equipment and the device actuated. Then, the tray was detached from the stainless steel model by upright movement.

Statistical analysis

Data recorded for each distance were analyzed statistically by one-way analysis of variance and Tukey's test at 5% significance level.

Results

Tables 2 and 3 show that there was a significant difference in the dimensional change means when the impression materials were compared for all distances: 33-43

Table 2 - Dimensional change means and SD (%) of stone casts made with the elastomeric impression materials (transversal distances).

37-47 distance		33-43 distance	
Silon 2 APS	-0.29 (0.02) a	Silon 2 APS	-0.33 (0.02) a
Clonage	-0.20 (0.02) b	Clonage	-0.23 (0.02) ab
Permlastic	-0.19 (0.03) bc	Permlastic	-0.21 (0.03) b
Xantopren VL	-0.17 (0.01) bcd	Xantopren VL	-0.20 (0.03) b
Oranwash L	-0.15 (0.01) cd	Oranwash L	-0.19 (0.02) b
Impregum	-0.13 (0.01) d	Impregum	-0.17 (0.02) b
Futura AD	-0.04 (0.01) e	Futura AD	-0.06 (0.02) c
Elite HD+	-0.03 (0.01) e	Elite HD+	-0.06 (0.02) c
Aquasil Ultra	-0.03 (0.01) e	Aquasil Ultra	-0.05 (0.02) cd
Express	-0.01 (0.01) f	Express	-0.02 (0.01) d

Means followed by different lowercase letters differ significantly ($p < 0.05$)

Table 3 - Dimensional change means and SD (%) of stone casts made with the elastomeric impression materials (anteroposterior distances).

33-37 distance		43-47 distance	
Silon 2 APS	-0.43 (0.02) a	Silon 2 APS	-0.45 (0.03) a
Clonage	-0.42 (0.03) a	Clonage	-0.44 (0.03) a
Oranwash L	-0.38 (0.01) ab	Oranwash L	-0.40 (0.02) ab
Xantopren VL	-0.37 (0.02) ab	Xantopren VL	-0.39 (0.03) ab
Permlastic	-0.30 (0.01) bc	Permlastic	-0.32 (0.02) bc
Impregum	-0.24 (0.02) cd	Impregum	-0.26 (0.02) cd
Futura AD	-0.19 (0.02) de	Elite HD+	-0.25 (0.02) cd
Elite HD+	-0.18 (0.03) de	Futura AD	-0.23 (0.04) cd
Aquasil Ultra	-0.17 (0.01) de	Aquasil Ultra	-0.22 (0.02) d
Express	-0.13 (0.02) e	Express	-0.18 (0.02) d

Means followed by different lowercase letters differ significantly ($p < 0.05$)

($p < 0.0001$), 33-37 ($p < 0.0001$), 43-47 ($p < 0.0001$) and 37-47. In general, the PVS showed the best results, followed by polyether. On other hand, polysulfide and PDMS had the worst results. The stone casts made with Express presented the smallest dimensional change means among all impression materials. Silon 2 APS and Clonage produced casts with the largest dimensional change means.

Discussion

The hypothesis tested in the present study was accepted, as the results showed that, in general, PVS provided greater accuracy in the stone casts and greater reliability in impression structures than polysulfide, polyether and PDMS. These results can be attributed to the excellent physical and mechanical properties of this type of material, such as good dimensional stability and elastic recovery (approximately 99%)¹⁰, in addition to an appropriate tear strength⁷. PVS materials possess a set reaction by the terminal group ethylene or vinyl with hydride groups¹⁻², without the formation of by-products and with non-occurring impression material shrinkage, allowing that these materials stay dimensionally stable after impression removal^{1,23}.

In general, PVS materials showed results that did not differ significantly among themselves. The small differences found in the dimensional accuracy among the PVS materials

can be attributed to the variability in the composition of each brand name, mainly in the matrix-filler ratio, which can provide the material with different levels of shrinkage polymerization and elastic recovery^{4,24}.

The stone casts made with the polyether material behaved, statistically, in the same manner as stone casts made from PVS in the anteroposterior measures (43-47 and 33-37) and as the PDMS Oranwash L (Zhermack, Rovigo, Italy) and Xantopren VL (Heraeus Kulzer GmbH, Hanau, Germany) in the distance 37-47. For the other transversal distance, 33-43, the polyether did not differ among Oranwash L, Xantopren VL, and Permlastic (Kerr Corporation, Michigan). These results differ from those found results in other studies^{7,25}, in which polyether presented better dimensional accuracy than condensation silicone-based materials and polysulfide. However, these results corroborate those of another study⁹ in which polyether had an intermediate behavior between PDMS and PVS. A possible explanation for these conflicting results is that the behavior of this material is easily influenced by the room humidity as this material has a hydrophilic nature^{1,6}. In laboratorial studies, the material stays in a dry room and does not absorb water from the room. It is speculated that, under clinical conditions, water sorption could compensate partly for the shrinkage observed in the laboratorial tests, as seen in this study. Besides, the polyether has inferior tear strength than PVS, so this may avoid its indication for use in interproximal and subgingival prepared tooth areas²⁶.

PDMS materials, specifically Silon 2 APS and Clonage, were the materials that created stone casts with the largest dimensional change values, as found in other studies²⁶⁻²⁷. The worst performance for that material class is due to the continuous polymerization that occur after setting of the impression material and is more accentuated than in other materials, which causes the evaporation of volatile byproducts, such as ethyl alcohol, and affects the dimensional stability and the accuracy of the PDMS^{2-3,26,28}.

Polysulfide polymerization occurs by the condensation reaction between the lead oxide and the pending and terminal groups with the mercaptan groups^{2,6}. In that reaction, as in PDMS polymerization, there is byproduct formation (water), which can evaporate and distort the mold. Therefore, polysulfide had similar behavior to that of PDMS. Furthermore, the elastic recovery of this material is smaller and more incomplete than in other elastomeric materials². Other factors, such as short handling time, prolongable time of polymerization, high sensitivity to temperature and humidity and higher tear strength can affect the dimensional accuracy²⁶.

The ISO 4823 specification admits that dimensional changes less than 1.5% to elastomeric impression materials are clinically acceptable. Within the limitations of this study, despite the statistical differences found among the elastomeric impression materials, when poured in 30 min after impressions in a room with temperature and relative humidity controlled, all the stone casts made with those impression materials showed satisfactory dimensional accuracy. Future studies are needed to verify the use of the elastomeric impression materials with others impression techniques and the clinical

relevance. The choice of a product for a particular clinical application should be based on material's properties rather than on the type and class of impression material. The dental professionals should be informed about the advantages and disadvantages of each material to adequately use them in clinical practice and provide adequate clinical longevity to the prostheses.

Acknowledgements

The authors thank CAPES for the financial support.

References

1. Shen C. Impression materials In: Anusavice KJ. Dental materials. 11th ed. Rio de Janeiro: Elsevier; 2005. p.193-238.
2. Giordano R 2nd. Impression materials: basic properties. Gen Dent. 2000; 48: 510-6.
3. International Organization for Standardization. Dentistry. Elastomeric impression materials. N° 4823:2000(E); Third edition.
4. Ciesco JN, Malone WFP, Sandrik JL, Mazur B. Comparasion of elastomeric impression materials used in fixed prosthodontics. J Prosthet Dent. 1981; 45: 89-94.
5. Braga AS, Braga SRS, Catirse ABCEB, Vaz LG, Mollo Júnior, FA. Quantitative analysis of lead in polysulfide-based impression material. Mater Res. 2007; 10: 161-3.
6. Craig RG. Restorative dental materials. 9th ed. Saint Louis : Mosby; 1993. p.298.
7. Lacy AM, Fukui H, Bellman T, Jendresen MD. Time-dependent accuracy of elastomer impression materials Part II: polyether, polysulfides, polyvinylsiloxane. J Prosthet Dent. 1981; 45: 329-333.
8. Stackhouse Junior JA. The accuracy of stones die made from rubber impression materials. J Prosthet Dent. 1970; 24: 377-86.
9. Perakis N, Belser UC, Magne P. Final impressions: a review of material properties and description of a current technique. Int J Periodontics Restorative Dent. 2004; 24: 109-17.
10. Christensen GJ. What category of impression material is best for your practice? J Am Dent Assoc. 1997; 128: 1026-8.
11. Pratten DH, Novetsky M. Detail reproduction of soft tissue: a comparison of impression materials. J Prosthet Dent. 1991; 65:188-91.
12. Johnson GH, Craig RG. Accuracy of addition silicones as a function of technique. J Prosthet Dent. 1986; 55: 197-203.
13. Reisbick MH. Effect of viscosity on the accuracy and stability of elastic impression materials. J Dent Res. 1973; 52: 407-17.
14. Nam J, Raigrodski AJ, Townsend J, Lepe X, Mancl LA. Assessment of preference of mixing techniques and duration of mixing and tray loading for two viscosities of vinyl polysiloxane material. J Prosthet Dent. 2007; 97: 12-7.
15. Craig RG. Review of dental impression materials. Adv Dent Res. 1988; 2: 51-64.
16. Franco EB, Cunha LF, Benetti AR. Effect of storage period on the accuracy of elastomeric impressions. J Appl Oral Sci. 2007; 15: 195-8.
17. Yoder JL, Thayer KE. Rubber-base impression technique for fixed partial dentures. J Prosthet Dent. 1962; 12: 339-46.
18. Gilmore WH, Schnell RJ, Phillips RW. Factors influencing the accuracy of silicone impression materials. J Prosthet Dent. 1959; 9: 304-14.
19. Al-Bakri IA, Hussey D, Al-Omari, WM. The dimensional accuracy of four impression techniques with the use of addition silicone impression materials. J Clin Dent. 2007; 18: 29-33.
20. Faria ACL, Rodrigues RCS, Macedo AP, Mattos MGC, Ribeiro RF. Accuracy of stone casts obtained by different impression materials. Braz Oral Res. 2008; 22: 293-8.

21. Donovan TE, Chee WW. A review of contemporary impression materials and techniques. *Dent Clin North Am.* 2004; 48: 445-70.
22. Custer F, Updegrove L, Ward M. Accuracy and dimensional stability of a silicone rubber base impression material. *J Prosthet Dent.* 1964; 14: 1115-21.
23. Hung SH, Purk JH, Tira DE, Eick JD. Accuracy of one-step versus two-step putty wash addition silicone impression technique. *J Prosthet Dent.* 1992; 67: 583-9.
24. Carlo HL, Fonseca RB, Soares, CJ, Correr AB, Correr-Sobrinho L, Sinhoretí MAC. Inorganic particle analysis of dental impression elastomers. *Braz Dent J.* 2010; 21: 520-7.
25. Shah S, Sundaram G, Bartlett D, Sherriff M. The use of a 3D laser scanner using superimpositional software to assess the accuracy of impression techniques. *J Dent.* 2004; 32: 653-8.
26. Pereira JR, Murata KY, Valle AC, Ghizoni JS, Shiratori FK. Linear dimensional changes in plaster die models using different elastomeric materials. *Braz Oral Res.* 2010; 24: 336-41.
27. McCabe JF, Wilson HJ. Addition cure silicone rubber impression materials. *Br Dent J.* 1978; 145: 17-20.
28. Camarinha SMLB, Pardini LC, Garcia LFR, Consani S, Pires-de-Souza FCP. Cast metal core adaptation using two impression materials and intracanal techniques. *Braz J Oral Sci.* 2009; 8: 128-31.