

Dimensional Stability of Alginates Molds Tridimensionally Scanned

Estabilidade Dimensional de Moldes de Alginatos Escaneados Tridimensionalmente

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Abstract

Alginate is among the most used materials in dentistry to create teeth negative printing and reproduction. The goal of this study was to compare dimensional changes of alginate scanned impression materials. Thirty impressions of a standard typodont were performed using three types of alginate (Hydrogum 5; Jeltrate Plus and Avagel). The impressions were scanned by the scanner 3Shape R700T and scans were performed immediately after molding. The analysis of digital models were performed at OrthoAnalyzer™ 3D software. Measurements were carried out in relation to the transverse dimension (intercanine, interpremolars and intermolar). Method error was evaluated through the Intraclass Correlation Coefficient (ICC) and Bland-Altman. One-way ANOVA, Dunnet Post-test were used to compare the different groups in relation to Typodont (gold standard) for the different outcome variables. The data were tabulated in Statistical Package for Social Sciences version 20.0 and Minitab 17.0 softwares to compare groups. The significance level was 5%. The posterior transverse variables (D1PM, D2PM and DM) presented a statistically significant difference regarding the gold standard (Typodont) for the plaster models performed after the Avagel molding. In the digital models performed just after molding, only in DM, the Avagel material group presented values statistically higher than the control group. The alginates Hydrogum 5 and Jeltrate Plus presented dimensions closer to the gold standard.

Keywords: Dental Impression Materials. Dental Models. Imaging, Three-Dimensional.

Resumo

O alginato está entre os materiais de moldagem mais utilizados na Odontologia para criar impressão e reprodução negativa dos dentes. O objetivo desse trabalho foi comparar alterações transversais de três marcas comerciais de alginato (Hydrogum, Jeltrate e Avagel) em moldes de alginatos. Trinta moldes de um Typodont padrão foram realizados, utilizando três tipos de alginato (Hydrogum 5; Jeltrate Plus e Avagel). Os moldes foram escaneados por meio do scanner 3Shape R700T e os escaneamentos realizados logo após a moldagem e logo após a obtenção dos modelos de gesso. As análises dos modelos digitais foram realizadas no software OrthoAnalyzer™ 3D. Foram realizadas mensurações em relação à discrepância transversal (inter-caninos, inter-primeiro pré-molar, inter-segundo pré-molar e inter-molares). O erro do método foi avaliado por meio do Coeficiente de Correlação Intraclasse (CCI) e Bland-Altman. Utilizou-se Análise de Variância (one-way ANOVA, Pós-teste Dunnet) para comparação dos diferentes grupos em relação ao typodont (padrão-ouro) para as diferentes variáveis de desfecho. A análise estatística foi realizada nos programas Statistical Package for Social Sciences versão 20.0 e no programa Minitab 17.0 para comparação dos grupos. O nível de significância foi de 5%. As variáveis transversais posteriores (D1PM; D2PM e DM) apresentaram diferença estatisticamente significativa em relação ao padrão-ouro (manequim) para os modelos de gesso realizados após a moldagem com Avagel. Nos modelos digitais realizados logo após a moldagem, apenas na DM, o grupo do material Avagel apresentou valores estatisticamente maiores do que o grupo controle. Os alginatos Hydrogum 5 e Jeltrate Plus apresentaram dimensões mais próximas do padrão-ouro.

Palavras-chave: Materiais para Moldagem Odontológica. Modelos Dentários. Imagem Tridimensional.

1 Introduction

The rapid and continuous advancement of computing science has resulted in an increase in the use of new technologies, at all levels of society. Orthodontics has also been influenced by this phenomenon. The use of models of digital study has been acquiring more and more space in Orthodontics, through a series of advantages such as: the accuracy and speed to obtain the diagnostic data and the easy access to data, the ease of information storage, reducing the physical space in the office, and the possibility of dividing the information via the internet with other professionals.²

The models of plaster, although considered standard and being abundantly used by Orthodontists for analysis, diagnosis and treatment planning have disadvantages in relation to digital models, which appear as a good option to replace the traditional methods.^{3,4} One of the methods for production of a digital model and, consequently, analysis by means of obtaining measures is the scanning of reproductions and models of plaster. These scanners collect data about the shape and appearance, transforming them into a three-dimensional scanned file, in which measurements are calculated with the aid of a software.⁵ Currently, three-dimensional image is obtained through direct scanning of the mold with alginate or

silicone. These moldings and three-dimensional models have been used to perform virtual setup, confection of aesthetic aligners and trays for indirect bonding⁶

Alginate is one of the most widely molding materials used in Dentistry.⁷ Its widespread use is a result of the ease of manipulation; the minimum necessary equipment; the flexibility of the impression material; the accuracy, if properly handled and also of low cost. Alginate is used extensively to prepare study models or a total or partial dental segment. Since that the alginate, after the pressing, is secured between the tray and the tissues, it is important to know the extent of any permanent deformation during the molding removal. However, there are few reports relating to permanent deformation of certain trademarks of alginate. The specification of the ANSI-ADA requires 97% of recovery (3% of permanent deformation) when the alginate is pressed 10% in 30 seconds, simulating the removal of the molding of the mouth. Several commercialized alginates have values of 98.5% recovery, 1.5% of permanent deformation.⁷

The accuracy of digital models is closely associated to the accuracy of printing⁴, and failures in shaping affect the procedures. Studies show that prints with alginate suffer dimensional changes in relation to the time and temperature-resistant.⁸ Due to the recognition that the main limitation of alginate is the volumetric changes that the mold presents after being removed from the mouth, materials with improved characteristics with respect to the distortion and more time for handling are produced.⁹ Therefore, the objective of this work was to evaluate the precision and accuracy of the dimensional stability of molds of different brands of Alginates scanned at different times of leakage.

2 Material and Methods

30 molds were made of the upper arch and after scanning, these were leaked to manufacture of plaster models of a pattern Typodont with different materials of alginate and divided into three groups: Avagel (Dentsply Caulk, Milford, DE, the USA); Hydrogum 5 (Zhermack, Badia Polesine, RO, Italy) and Jeltrate Plus (Dentsply Caulk, Milford, DE, the USA).

After the procedure of molding, the trays were placed on the R700™ scanning (3Shape, Copenhagen, Denmark) for the scanning process and digital models production. The scanning was performed immediately after molding. For each material, 10 molds were produced of the upper arch and 10 models of plaster, later. The pattern Typodont was also scanned and was used as the gold standard for evaluations in the scanner software.

2.1 Manufacture of digital models

The Alginate Impression materials were prepared following all the instructions of the manufacturers in an environment with controlled temperature and relative humidity (23 ± 2 °C and $50 \pm 10\%$), in order to minimize the factors that cause the dimensional change. It is important

to have all the powder dissolved in order not to compromise the properties of the material.¹⁰ The spatulation time is also paramount, being usually 45 seconds to 1 minute enough. Clean equipment is important, because many failures are attributed to contamination of the mixture and manipulation.¹⁰

After the material manipulation, the same was placed over the inner part of the tray, which subsequently was seated on the arcade of Typodont. All steps for the molds manufacture were performed by a single operator and following the manufacturer's guidelines. Soon after obtaining of molds, they were forwarded immediately, to scanner R700™ (3Shape, Copenhagen, Denmark) for scanning and production of digital models.

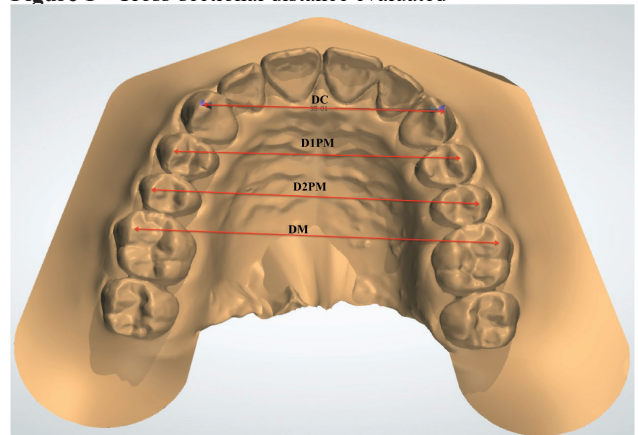
The digitized images of molds and obtaining of digital models were stored in the computer for later viewing, by means of the software OrthoAnalyser (3Shape, Copenhagen, Denmark). Immediately, the plaster was handled according to the manufacturer's guidelines and the mold was completed by the same, avoiding possible distortion, thus obtaining the models of plaster for subsequent scanning.

2.2 Evaluation of digital models

The evaluations were performed by two evaluators calibrated separately, after training and calibration. The measurements were performed on the models generated from the molds and models of plaster, being evaluated 5 pairs of digital models per day.

The following cross-sectional distances were performed: Inter-canines distance; inter-pre-molars distance (first and second) and inter-molars distance.^{8,11} The point of election to the measures in the upper arcade were: tip of the cusp of right canine to canine left (DC), tip of buccal cusp of the first pre-molar right to left first bicuspid (D1PM), tip of the buccal cusp of the second pre-molar right to left second bicuspid (D2PM), tip of the mesio-buccal cusp of the first molar right to the Mesio-buccal cusp of the left first molar (DM). *The union of these points formed linear measurements automatically generated by the software, thus determining the value of inter-transverse canines distances, inter-first pre-molar; inter-second pre-molar and upper and lower inter-molars* (Figure 1).

Figure 1 - Cross-sectional distance evaluated



Source: The authors.

2.3 Statistical Analysis

To check the examiner's calibration, 30 days after the first evaluation measurements were repeated of 30% of the sample. The errors were evaluated by means of the Intraclass Correlation Coefficient (ICC) and Bland-Altman.

Analysis of variance (one-way ANOVA, Dunnet Post-test) was used for comparison of different groups (G1 x G2 x G3) in relation to the different outcome variables. The statistical analysis was performed in the program Statistical Package for Social Sciences, version 20.0 and the Minitab 17.0, having been established a confidence interval of 95% and a

significance level of 5% ($p < 0.05$) for all the applied tests.

3 Results and Discussion

Table 1 presents the results of the intraexaminer error. The intraclass correlation coefficient showed variations of 0.79 to 1.0 demonstrating an acceptable agreement¹² among the methods for this type of evaluation, as well as the value of the Bland and Altman¹³, that showed little variation in the upper (0.01 to 0.19) and lower limits (0.00 to 0.04). These results demonstrate that all the studied variables were accurate and consistent, certifying the examiner's calibration.

Table 1 - Average, standard deviation (SD) and difference of the first and second evaluation. Intraclass correlation coefficient (ICC) and Bland-Altman

Variables	1st Evaluation		2nd Evaluation		Dif.	CCI	Bland-Altman	
	Mean	SD	Mean	SD			Lim. Sup.	Lim. Inf.
DC (mm)	35.08	0.08	35.09	0.09	0.01	0.79	0.10	0.01
D1PM (mm)	39.91	0.15	39.91	0.12	0	1.00	0.01	0.00
D2PM(mm)	40.72	0.46	40.71	0.46	-0.01	1.00	0.08	0.02
DM (mm)	53.87	0.16	53.87	0.15	0	0.79	0.19	0.04

Dif: Difference; Lim. Sup: Upper Limit; Lim. Inf.: Lower limit

Source: Research data.

There was no difference between the molds of alginates and models of plaster of all the evaluated materials for inter-canine distance. However, for the posterior cross-sectional variables (D1PM; D2PM and DM) there was a difference in relation to the gold standard (manikin) for

models of plaster performed after molding with Avagel. As for the digital models performed immediately after molding, only in the DM, the group of Avagel material presented statistically higher values than the gold standard (Table 2, Figure 2).

Table 2- Comparison among the groups (ANOVA, followed by Tukey's test)

	Manikin		Plaster Model						Digital Model						P
			Avagel		Hydrogum 5		Jeltrate Plus		Avagel		Hydrogum 5		Jeltrate Plus		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
DC	34.56	0.16	35.93	0.20	35.87	0.25	35.84	0.26	35.35	0.77	35.41	0.28	34.50	0.23	0.316
D1PM	42.33 ^A	0.25	42.78	0.20	42.59	0.17	42.62	0.20	42.38 ^A	0.25	42.30 _A	0.17	42.34 ^A	0.26	0.000*
D2PM	48.13 ^A	0.25	48.37	0.20	48.19 ^A	0.17	48.21 ^A	0.15	48.16 _A	0.28	47.97 _A	0.17	47.92 _A	0.19	0.000*
DM	53.59 ^A	0.31	54.17	0.35	53.90 ^A	0.41	53.93 ^A	0.36	54.09	0.26	53.87 ^A	0.21	53.94 _A	0.37	0.004*

* $p < 0.05$ Statistically significant

Means with the letter A showed results similar to control group (manikin)

Source: Research data.

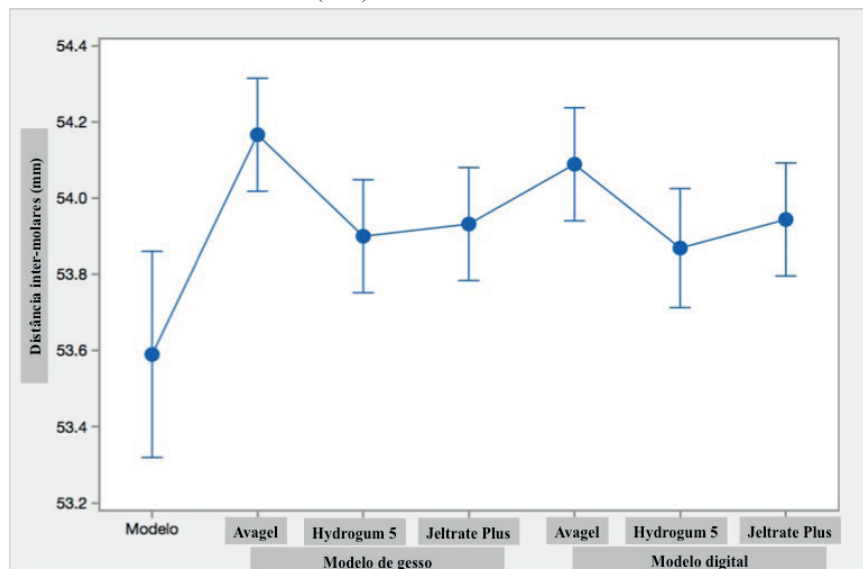
The models perpetuate, over time, the morphological conditions of the stomatognathic system captured in a certain stage. This allows, in addition to the diagnosis and the initial treatment plan, endless comparisons, establishing a dynamic analysis of the evolution of the clinical cases.¹⁴

Alginate is an irreversible hydrocolloid because of its chemical reaction, i.e., a powder that upon being mixed with water goes from the solid state to the gel state.^{10,15-17} It provides reproduction of sufficient details to make it suitable for routine use in Dentistry. In Orthodontics is used for both diagnostic models and work models for preparation of appliances for

therapeutic purposes.¹⁸ Although it is frequent in the dental clinic, concerns about its performance include a dimensional instability when the leakage of plaster is delayed, and inability to produce accurate molds, when there is re-leakage.

Digital orthodontic models have a series of advantages in terms of storage, retrieval, diagnostics, diagnosis versatility and durability.¹⁹ Indisputably, the question of the space for the storage of plaster models in the daily practice of the orthodontist became a big problem, generating discussions about the possibility of the patient himself or herself being responsible for storing his or her documentation.¹⁴

Figure 2 - Graph of the interaction among the groups in relation to the gold standard for the variable transverse distance (DM)



DC: Intercanines distance; D1PM: Distance between the first pre-molars; D2PM: Distance between the second pre-molars; DM: Distance between the first molars.

Source: Research data.

The method of this research consisted of three-dimensional scanning of 30 upper molds of alginate and 30 upper models of plaster on scanner 3Shape R700T (3Shape A/S, Copenhagen, Denmark) by a previously calibrated examiner. It is worth remembering that both the scanner and the used software have proven accuracy and reproducibility in the literature, revealing considerable accuracy and reliability, which allows its clinical applicability and in scientific studies.¹ Moreover, the alginate impression materials have been prepared following all the manufacturers' instructions, in an environment with controlled temperature and relative humidity (23 ± 2 °C and $50 \pm 10\%$), in order to minimize the factors that cause the dimensional change.¹⁰ The powder was completely dissolved in order not to compromise the properties of the material.^{10,20} The time of spatulation was also paramount, and was carried out between 45 seconds to 1 minute. Being careful with the equipment cleaning is also important, because many failures are attributed to contamination of the mixture and the manipulation apparatus.¹⁰

There was no difference between the trademarks of Alginates for digital models obtained out of the molds and models of plaster. However, there was a difference among the measurements obtained with the gold standard. In the variable D1PM there was a difference of plaster models in relation to the manikin (gold standard). The plaster digitized models digitized presented higher values than the manikin. In contrast, the scanned molds generated digital models with high reproducibility and similar to the manikin. Regarding the distance D2PM, only the plaster model of Avagel group showed statistically significant difference in relation to the manikin, and in DM just the model of plaster and the mold, such as digital images, made with Alginate Avagel showed

difference in relation to the gold standard. In general, all molds and digital models were higher than the original, corroborating with Carvalho *et al.*¹⁵, with average growth of 0.42 in Avagel; 0.21 in Hydrogum 5 and 0.24 in Jeltrate in models of plaster and 0.19; 0.03 and 0.05 in the virtual models to Avagel, Hydrogum 5 And Jeltrate, respectively. The Alginates Hydrogum 5 and Jeltrate presented dimensions closer to the gold standard.

However, despite significant differences were found among various measurements of the virtual models, according to Leifert *et al.*²¹ and Santoro *et al.*¹¹, differences less than or equal to 0.5 mm are considered clinically insignificant, and still, according to Tomassetti *et al.*²², only differences greater than or equal to 1.5 mm are considered clinically significant. According to the Grading System for dental casts and panoramic radiographs (ABO)²³ discrepancies in vertical, transverse and anteroposterior dimensions exceeding 0.5 mm are considered significant.

4 Conclusion

The trademarks of Alginates for both the plaster model as for the mold were similar among themselves. However, the alginates Hydrogum 5 and Jeltrate Plus presented dimensions closer to the gold standard.

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