Analysis of the linear dimensions of the high stability alginate cast models with casting delays

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ABSTRACT

Introduction: Dimensional stability of alginate impression is important to obtain an accurate cast. This study was to find the linear dimensional changes of the cast made from delayed pour high stability alginate impression after 5 days. **Methods:** This experimental laboratory study used 20 samples, divided into 4 groups. First and third group were the generated cast produced by immediately pour into high stability and conventional alginate impressions. Second and fourth group were the generated cast produced by delayed pour into high stability and conventional alginate impression for 5 days in storage with 100% humidity. Dimensional changes were measured on the upper part of the cast from buccal-lingual and mesial-distal direction beside measuring on the outer distance between the upper cast used Mitutoyo digital caliper scaled 0.01 mm. . The data were analyzed using ANOVA ($\alpha = 0.05$). **Results:** Mesial-distal (a) diameter average of group I, II, IV were respectively 8.410 mm, 8.520 mm, and 8.620 mm, compared with III as control was 8.420 mm. Meanwhile, diameter averages of mesial-distal (b) were 8.314 mm, 8.416 mm, 8.513 mm, and 8.315 mm. The averages of distance between each teeth (c) were 13.312 mm, 13.240 mm 13.191 mm, and 13.316 mm. The diameter averages of buccal-lingual (d) were 8.411 mm, 8.530 mm, 8.608 mm and 8.410 mm. The diameter averages of buccal-lingual (e) were 8.350 mm, 8.441 mm, 8.524 mm, and 8.340 mm. Hasil uji Anova pada hasil pengukuran jarak antar gigi (c), diperoleh nilai F hitung sebesar 147,850, lebih besar dari nilai F tabel (3,239). There were significant diferencess dimensional changes on gypsum cast made from high stability alginate impression and then poured after 5 days. **Conclusion:** There were diferencess linier dimensional changes on gypsum cast made from high stability alginate impression and then poured after 5 days.

Keyword: Alginate impression, delayed pour, gypsum cast, linear dimensional

INTRODUCTION

The fabrication of dental arch models is a critical step in many phases of dental procedures. These models are typically created from gypsum products using impressions that serve as negative reproductions of the oral cavity structures. The model must be accurate to provide a precise representation of the oral anatomy, which in turn depends on the accuracy of the impression itself[1,2,3]. One of the most commonly used impression materials in this process is alginate[4].

Alginate is widely used due to several advantages, such as ease of manipulation, patient comfort, and relatively low cost. However, despite these benefits, alginate has notable disadvantages. Once removed from the mouth and exposed to air, alginate impressions are susceptible to dimensional changes due to evaporation—a process known as **syneresis**. Conversely, when immersed in water, alginate may absorb moisture—a process known as **imbibition**—which can cause the impression to expand, thereby reducing the available space for the cast and compromising accuracy[1,3,5]. To prevent dimensional instability, the impression must be poured immediately with gypsum products[2,5,6].

According to Imbery *et al.* and Farzin & Panahandeh, pouring should be done no later than 12 minutes after the impression is taken, whereas Anusavice recommends pouring within 30 minutes of removal from the mouth[1,4,7]. When immediate pouring is not possible, impressions must be stored in sealed plastic bags with 100% humidity or wrapped in moist paper towels. The longer the delay before pouring, the greater the likelihood of distortion[2,3,8].

Type III gypsum is commonly used for cast model fabrication because it provides sufficient strength for use in denture construction procedures and allows for easy removal of the model after processing[1]. In contrast, incompatibility issues are frequently reported when alginate is used with type IV gypsum. In fact, several manufacturers of type IV gypsum recommend against using alginate for model fabrication due to this incompatibility[9]. Murata *et al.* reported that models produced from alginate combined with type III gypsum exhibit smoother surfaces compared to those combined with type IV gypsum[10].

Recently, newer alginate materials have become commercially available with claims of high dimensional stability and accuracy that can be maintained for up to five days[4,11]. This may be attributed to their improved ability to retain water within the alginate mass[12]. Some manufacturers assert that high-stability alginate formulations contain polyvinyl siloxane (PVS), a type of elastomeric impression material known for its ability to maintain dimensional accuracy even when pouring is delayed for up to one week[1]. This feature is particularly beneficial for dental practitioners who are unable to pour impressions immediately due to scheduling or procedural constraints. The aim of this study is to analyze linear dimensional measurements of gypsum models to determine whether significant changes occur in the linear dimensions of gypsum models poured from high-stability alginate impressions after a five-day delay in casting.

METHODS

This study was a laboratory-based experimental research conducted on gypsum models obtained from high-stability alginate impressions whose casting was delayed for five days, with conventional alginate used as the control group. The total sample size used in this study was 20 specimens, divided into four groups with five samples each. Group I consisted of gypsum models made from high-stability alginate impressions that were cast immediately. Group II consisted of gypsum models made from high-stability alginate impressions with a five-day delay before casting.

Group III (control group) consisted of gypsum models made from conventional alginate impressions that were cast immediately. Group IV consisted of gypsum models made from conventional alginate impressions with a five-day delay before casting. The instruments and materials used in this study included a graduated cylinder, rubber mixing bowl, airtight storage containers, master model, a perforated rectangular impression tray made of aluminum sized to match the master model, digital scale, airtight plastic bags, alginate spatula, gypsum spatula, distilled water, Hydrogum 5 alginate, Cavex CA37 alginate, Moldano dental stone, facial tissues, and a Mitutoyo digital caliper with a resolution of 0.01 mm.

The independent variable in this study was the casting time—immediate and delayed for five days. The dependent variable was the linear dimension of the gypsum model, while the controlled variables included all procedures for specimen preparation, measuring instruments and testing procedures, laboratory temperature maintained at 23 °C ± 1, and relative humidity of approximately 47%. Manipulated alginate was used to take impressions from a master model that represents natural teeth. This master model is typically made of stainless steel. For Groups I and III, casting was performed immediately after the impression was removed from the master model. For Groups II and IV, the impressions were stored in airtight containers with a controlled 100% humidity level for five days prior to casting. To condition 100% humidity, a facial tissue weighing approximately 5 grams was moistened with 30 ml of distilled water and placed in the container 10 minutes before storage, ensuring it did not come into direct contact with the impression. The alginate impression sealed in an airtight plastic bag was then placed into another airtight container that contained an additional facial tissue weighing approximately 10 grams and moistened with 60 ml of distilled water. This method followed the protocol described in the study by Sedda et al.[12]

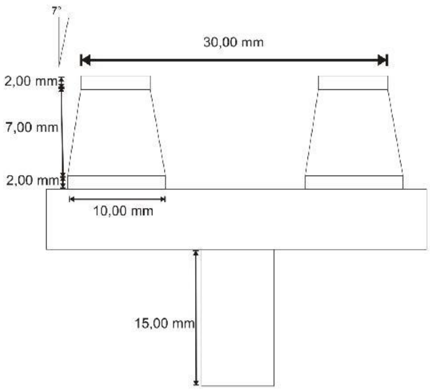

Figure 1 Master Model Design

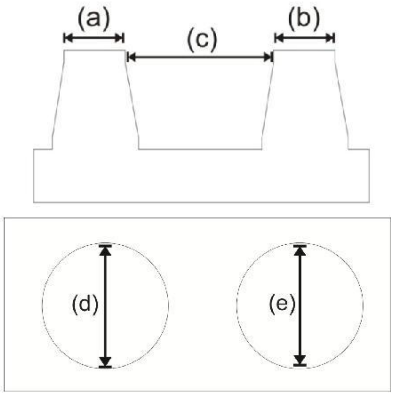

Figure 2 Resulting Gypsum Model and Measurement Aspects

After all groups had been cast, the resulting gypsum models were left to set for 24 hours before measurements were performed. The aspects measured included mesiodistal dimensions (a and b), interdental distance (c), and buccolingual dimensions (d and e), as illustrated in Figure 2. Once the measurement data were collected, statistical analysis was carried out using ANOVA (α = 0.05), along with calculations of the mean, standard deviation (SD), and the results of comparative testing.

RESULTS

The results of the study are presented in the form of a data table (Table 1) and a bar chart (Figure 1).

The ANOVA test conducted on the mesiodistal (a) measurement results yielded an F-value of 168.593, which is greater than the critical F-table value of 3.239. Additionally, the resulting p-value was 0.000, which is less than 0.01, indicating a statistically highly significant difference in linear dimensions among the four groups studied. The percentage change in linear dimension compared to Group III (control) was 0.12% for Group I, 1.19% for Group II, and 2.38% for Group IV.

Table 1. Measurement Results of Mesiodistal Dimension (a)

No Sample	Group			
	I	II	III	IV
1	8.41	8.52	8.42	8.60
2	8.40	8.52	8.41	8.59
3	8.40	8.51	8.42	8.61
4	8.42	8.53	8.43	8.66
5	8.42	8.52	8.42	8.65
Mean	8.41	8.52	8.42	8.62
Stdev	0.010	0.007	0.007	0.033
F-value		168.593		
F-table		32.239		
p-value		0.000		

Treatment group desriptions
I : High-stability (immediately)
II : High-stability (after a 5-day delay)
III : Conventional (immediately)
IV : Conventional (after a 5-day delay)
P<0,05 statistically significant difference ,p < 0,01

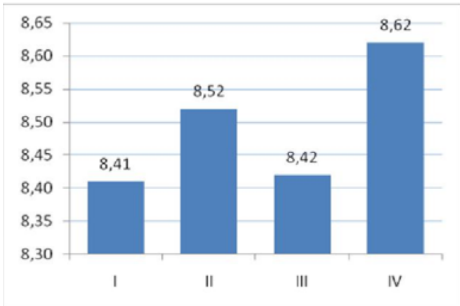

Figure 1. Measurement Results of Mesiodistal Dimension (a)

Based on the ANOVA test results for the mesiodistal (b) measurements, the calculated F-value was 319.345, which is greater than the F-table value of 3.239. The corresponding p-value was 0.000, which is less than 0.01, indicating a highly significant difference in linear dimensions among the four groups analyzed.

The percentage change in linear dimension compared to Group III (control) was 0.01% for Group I, 1.21% for Group II, and 2.38% for Group IV.

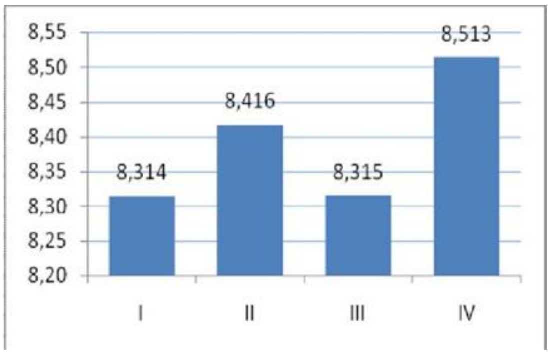

Figure 2. Measurement Results of Mesiodistal Dimension (b)

Table 2. Measurement Results of Mesiodistal Dimension (b)

No Sample	Group			
	I	II	III	IV
1	8.33	8.41	8.30	8.51
2	8.31	8.42	8.33	8.52
3	8.32	8.42	8.31	8.51
4	8.30	8.43	8.31	8.53
5	8.31	8.40	8.33	8.50
Mean	8.314	8.416	8.315	8.513
Stdev	0.010	0.011	0.012	0.012
F-value		319.345		
F-table		3.239		
p-value		0.000		

Treatment group descriptions
I :High-stability (immediately)
II : High-stability (after a 5-day delay)
III : Conventional (immediately)
IV : Conventional (after a 5-day delay)
P<0.05 statistically significant difference ,p < 0.01

The corresponding p-value was 0.000, indicating a highly significant difference (p < 0.01) in linear dimensions among the four groups studied. The percentage change in linear dimension relative to Group III (control) was 0.03% for Group I, 0.59% for Group II, and 0.94% for Group IV.

Table 3. Measurement Results of Mesiodistal Dimension (c)

No Sample	Kelompok			
	I	II	III	IV
1	13.31	13.24	13.32	13.20
2	13.32	13.25	13.33	13.21
3	13.31	13.24	13.31	13.20
4	13.31	13.24	13.31	13.17
5	13.31	13.22	13.31	13.18
Mean	13.312	13.238	13.316	13.191
Stdev	0.004	0.011	0.009	0.016
F-value		147.850		
F-table		3.239		
p-value		0.000		

Keterangan perlakuan
I : High-stability (immediately)
II : High-stability (after a 5-day delay)
III : Conventional (immediately)
IV : Conventional (after a 5-day delay)
P<0,05 statistically significant difference ,p < 0,01

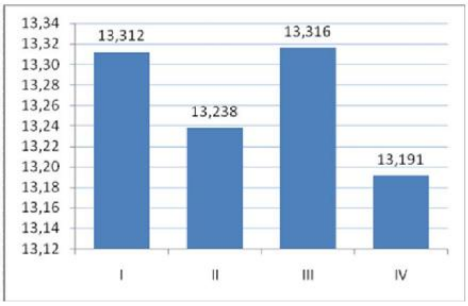

Figure 3. Measurement Results of Mesiodistal Dimension (c)

The ANOVA test for the buccolingual (d) measurements yielded an F-value of 381.061, which exceeds the F-table value of 3.239. Similarly, the resulting p-value was 0.000, indicating a highly significant difference (p < 0.01) in linear dimensions among the four groups analyzed. The percentage change in linear dimension compared to Group III (control) was 0.01% for Group I, 1.43% for Group II, and 2.35% for Group IV.

Table 4. Measurement Results of Mesiodistal Dimension (d)

No Sample	Kelompok			
	I	II	III	IV
1	8.41	8.53	8.40	8.60
2	8.40	8.53	8.41	8.60
3	8.41	8.54	8.40	8.63
4	8.42	8.53	8.42	8.59
5	8.42	8.52	8.42	8.62
Mean	8.411	8.530	8.410	8.608
Stdev	0.010	0.007	0.010	0.016
F-value		381.061		
F-table		3.239		
p-value		0.000		

Treatment group descriptions
I :High-stability (immediately)
II : High-stability (after a 5-day delay)
III : Conventional (immediately)
IV : Conventional (after a 5-day delay)
P<0.05 statistically significant difference ,p

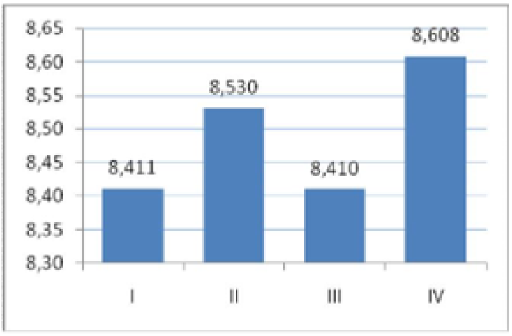

Figure 4. Measurement Results of Mesiodistal Dimension (d)

Table 5. Measurement Results of Mesiodistal Dimension (e)

No Sample	Kelompok			
	I	II	III	IV
1	8.35	8.44	8.35	8.54
2	8.35	8.43	8.36	8.52
3	8.33	8.45	8.35	8.53
4	8.34	8.45	8.35	8.52
5	8.33	8.44	8.34	8.51
Mean	8.340	8.441	8.350	8.524
Stdev	0.010	0.010	0.007	0.011
F-value		381.061		
F-table		3.239		
p-value		0.000		

Treatment group descriptions
I :High-stability (immediately)
II : High-stability (after a 5-day delay)
III : Conventional (immediately)
IV : Conventional (after a 5-day delay)
P<0.05 statistically significant difference ,p

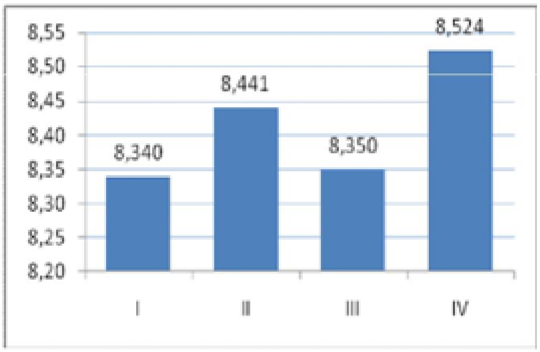

Figure 5. Measurement Results of Mesiodistal Dimension (e)

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dimension (e) yielded an F-value of 387.892, which is greater than the F-table value of 3.239. The resulting p-value was 0.000, which is less than 0.01, indicating a highly significant difference in linear dimensions among the four groups studied. The percentage change in linear dimension compared to Group III (control) was 0.12% for Group I, 1.09% for Group II, and 2.08% for Group IV.

Statistical analysis demonstrated that gypsum models produced from alginate impressions with a five-day delay in casting experienced significant changes in linear dimensions. High-stability alginate that underwent delayed casting showed a statistically significant dimensional change compared to conventional alginate that was cast immediately (control group).

However, conventional alginate subjected to the same five-day delay exhibited greater dimensional changes than high-stability alginate. No statistically significant difference was observed between the control group and the group using high-stability alginate with immediate casting, indicating that delayed casting impacts accuracy more than alginate type alone.

The findings suggest that delayed casting of alginate impressions likely causes syneresis, leading to shrinkage of the impression. This shrinkage results in gypsum models appearing larger in tooth dimensions and reduced in interdental spacing. It is presumed that syneresis occurs multidirectionally, causing expansion across tooth dimensions and contraction in the space between teeth.

This was confirmed by the fact that all samples produced from delayed-cast impressions in this study showed enlarged measurements in all tooth aspects and narrowed interdental distances compared to expected values.

These findings are consistent with those of Noort, who stated that alginate impressions shrink toward the impression tray, creating additional space within the mold previously occupied by soft and hard tissues. Consequently, the resulting gypsum model appears larger than the actual anatomical structures.[5]

CONCLUSION

There were diferencess linier dimensional changes on gypsum cast made from high stability alginate impression and then poured after 5 days.

ADA Specification No. 18 does not specify acceptable dimensional change limits for alginate impression materials. Therefore, it remains unclear whether the measurements obtained in this study are still clinically acceptable. However, Imbery et al. and Walker et al. suggest that the acceptable dimensional change for alginate impressions should not exceed 0.50%, based on maximum average dimensional changes of 0.40% for polysulfide and 0.60% for silicone impression materials, as outlined in ADA Specification No. 19 for elastomeric impression materials.[4,11]

In the present study, all measurements—from both high-stability and conventional alginate impressions with five-day delayed casting—exceeded the 0.50% threshold for dimensional change. Referring to the criteria proposed by Imbery et al. and Walker et al., it can be concluded that alginate impressions subjected to a five-day casting delay are not clinically acceptable.[4,11]

Manufacturers of high-stability alginate claim that their materials maintain dimensional stability and accuracy up to five days after the impression is taken.[4,11] This claim is supported by research conducted by Sedda et al., although certain factors may differentiate the present study's outcomes. These factors include ambient humidity, geographic location, and the use of an automatic mixing device during alginate manipulation.

Environmental conditions such as temperature and humidity significantly influence alginate impressions. High temperatures and low humidity levels accelerate syneresis. In Sedda's study, room humidity was maintained at 50%, while in the present study, it was approximately 47%.[12]

The use of an automatic mixing device has been shown to increase compressive strength and tear resistance of the impression material. Clinically, this method also provides better homogeneity and flowability of the alginate mixture compared to manual mixing.[14] In this study, alginate mixing was conducted manually, which may have influenced the results.

REFERENCES

1. Anusavice, K.J. 2003. *Philip's Science of Dental Materials*. 11th ed. Philadelpia: Saunders Company. 207, 238-240, 243-248, 256,261, 274-275
2. Bhat, V.S. and B.T. Nandish. 2006. *Science of Dental Materials Clinical Applications*. New Delhi: C.B.S. 73, 107-110, 149
3. Gladwin, M. and M. Bagby. 2009. *Clinical Aspects of Dental Materials*. 3rd ed. Philadelpia: Lippincott Williams & Wilkins. 105, 111-112

4. Imbery, T. A., *et al*. 2010. *Accuracy and dimensional stability of extended-pour and conventional alginate impression materials*. JADA; 141; 32-35. Available online at http://jada.ada.org/content/141/1/32.full (diakses 3 Januari 2012)
5. Noort, R.V. 2007. *Introduction to Dental Materials*. 3rd ed. London: Mosby Elsevier. 195, 211, 213
6. Mc Cabe, J.F.; and A.W.G. Walls. 2008. *Applied Dental Materials*. 9th ed. Singapore: Blackwell Publishing. 32, 37, 161
7. Farzin, M.; and H. Panahandeh. 2010. *Effect of pouring and storage temperature on dimensional stability of cast made from irreversible hydrocolloid*. Journal of Dentistry, Tehran University of Medical Science Vol. 7, No. 4. 179. Available online at http://jdt.tums.ac.ir/index.php/jdt/article/view/244 (diakses 16 Juni 2012)
8. Powers, J.M.; and R.L. Sakaguchi. 2006. *Craig's Restorative Dental Materials*. 12th ed. St Louis: Mosby Elsevier. 270-278.
9. Phillips, R.W. and B.K. Moore. 1994. *Elements of Dental Materials for Dental Hygienist and Dental Assistants*. 5th ed. Philadelphia: W. B. Saunders Company. 68-69, 71-73.
10. Murata, H., *et al*. 2004. *Physical properties and compatibility with dental stones of current alginate impression materials*. Journal of Oral Rehabilitation Nov Volume 31. 1121. Available online at http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=d3d478af-3260-465c-9ab5-b6ef7c581c87%40sessionmgr11&vid=4&hid=24 (diakses 3 Juni 2012)
11. Walker, M.P., *et al*. 2010. *Dimensional change over time of extended-storage alginate impression materials*. Angle Orthodontist Vol. 80. 1110. Available online at http://www.scribd.com/doc/45323472/Dimensional-Change-Over-Time-of-Extended-storage-Alginate (diakses 4 Maret 2012)
12. Sedda, M., *et al*. 2008. *Effect of storage time on the accuracy of cast made from different irreversible hydrocolloids*. Revista Românâ De Stomatologie Vol. LIV. 178, 184. Avalaible online at http://www.medica.ro/reviste_med/download/stoma/2008.3-s/Stoma_Nr-3-s_2008_Art-5.pdf (diakses 20 Januari 2012)
13. Nassar, U., *et al*. 2012. *Dimensional accuracy of 2 irreversible hydrocolloid alternative impression materials with immediate and delayed pouring*. J Can Dent Assoc Jan; Vol 78: c2. 1-2. Available online at http://www.jcda.ca/article/c2/ (diakses 9 Juni 2012)
14. Inoue, K., *et al*. 2002. *Effect of mixing method on rheological properties of alginate impression materials*. Journal of Oral Rehabilitation July Vol 29. 615, 618-619. Available online at http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2842.2002.00726.x/pdf (diakses 29 Mei 2012)