Original Research Article

Effect of temperature on the dimensional accuracy of irreversible hydrocolloid material at different storage time intervals

ABSTRACT

Aims: In this competitive arena, dentists are inevitably searching for dimensionally more stable and accurate material to produce precise, effective prosthesis. Amongst many impression materials used on a day-to-day basis, irreversible hydrocolloid impression materials are most commonly utilized due to easy manipulation, hydrophilic nature, elastic recovery, accuracy and cost-effectiveness. The main objective of this study was to observe the effect of temperature and storage time on the accuracy of an irreversible hydrocolloid material.

Study design: In Vitro Study.

Place and Duration of Study: Department of Prosthodontics and Research Medical Centre, Liaquat University of Medical and Health Sciences, Jamshoro, February 2019 to July 2019.

Methodology: Total one hundred and five impressions cast models were made using irreversible hydrocolloid impression material (Hygedent) from ideal maxillary dentoform model. There were three temperatures (25°C,35°C and 45°C) and two storage timings (15 minutes and 25 minutes) along with one control group (immediate pouring). Measurements were taken utilizing digital Vernier Caliper. On each cast, two measurements were recorded in a linear manner including anteroposterior (AP) and Cross arch (CA).

Results: Results revealed that there is a significant difference between anteroposterior dimensional changes of distance from Mesial surface of maxillary right central incisor to distal surface of maxillary right first molar and cross-arch dimensional changes of distance from distal surface of maxillary right first molar to distal surface of maxillary left first molar at different storage temperatures and time intervals. This indicates that the dimensions are increasing directly as storage time and temperature increases which might be because of shrinkage of material due to increase in time of pouring. Shrinkage causes material to pull it towards the tray and increase the dimensions.

Conclusion: This study concluded that the best results could be obtained with immediate pouring at 25°C temperature as compared to other observed temperatures.

Keywords: Alginate, dimensions, irreversible hydrocolloids, impression material

1. INTRODUCTION

An accurate replica of the dental structures and surrounding tissues on dental casts is crucial in many fields including Prosthodontics and Implantology for the purpose of diagnosis, treatment planning, fabrication of custom tray, provisional and definitive prosthesis fabrication and many more [1,2]. Dimensional accuracy of impression materials is of prime importance for accurate casts reproduction and thus a biologically, mechanically, functionally, and aesthetically acceptable prosthesis [3].

Amongst many impression materials used on a day to day basis, irreversible hydrocolloid impression materials are being most commonly utilized due to user friendly, easy manipulation, availability, cost effective, hydrophilic nature, elastic recovery, ability to reproduce detailed anatomical impression and well tolerated by patients [4-7].

Although elastomers are progressing, the simplicity of handling and various functions allow to stand out the alginates. Fine hydrocolloid reproductions have a decreased rate of approximately 25%, which indicates that these materials are not utilized in impressions requiring an advanced level of accuracy, including inlays, crowns, stationary bridges, veneers [8]. Its application is restricted to fields of low retention since they are tear-prone. However, research has revealed that the final impression for indirect restoration can be made by alginates whilst chamfered margins are prepared [9].

Varying alginate alterations made it possible to enhance their characteristics. About providing a better reproduction of the structures, chromatic performances provide the dentist more convenience. Several researchers [6,10,11] have observed that dimensional modifications vary depending on the imprint during the gelation stages and therefore the recognition of chromatics is enhanced by gelation phase. In dental practice, alginates are generally assigned as the main impression material and it's physical and other limitations are often difficult to immediately empty the material and/or are postponed. Consequently, there is a possibility that the dimensions can be modified for the impression material.

Many investigators [12,13] has studied this aspect of irreversible hydrocolloids on different temperatures and durations of storage utilizing different tests. Some previous well established data reports that this material can be poured safely without significant changes up to 12 minutes [13] and almost all studies reported that best results obtained with immediate pouring [12,14] Some observers reported significant dimensional changes in material stored at 40°C for 20 minutes but found no change at 30°C for 20 minutes [15]. Another study did not report any significant changes when stored at 4°C for 15, 25, 45 minutes but after 60 minutes. This same study stated that changes happen after 25 minutes stored at 23°C [13].

Considering above disparities of results on different temperatures and storage duration and the fact that environmental temperature rises in our locality for almost more than half a year it was felt of deemed importance to conduct a study using different time and temperature scales so that necessary and economical methods can be evolved for precise production of casts and thus the prosthesis.

2. METHODOLY

After approval of synopsis from institutional ethical review committee, the data was collected. After following all infection control measures, 105 impression molds were made using irreversible hydrocolloid impression material (Hygedent) from ideal maxillary Dentoform model. Impression material was handled according to manufacturer instructions. A hygienic, rubber bowl and plaster spatula were used to blend material manually. A large sized prefabricated metal perforated tray

was selected and used. The metal tray was loaded and then placed on dentoform model. After setting the impression was removed from the model. The impression was then stored in incubator. The temperature of incubator was maintained at 25°C, 35°C and 45°C. These impression molds were divided into three main groups. One control group (impressions were poured immediately) and two other groups based on storage time (Group A - stored for 15 minutes and Group B - stored for 25 minutes). Each of the time storage group was further divided into three sub groups based on storage temperature (Group 1 - 25°C, Group 2 - 35°C and Group 3 - 45°C). All the seven groups were including 15 impressions each. Impression molds were poured using (Kopo-Hard CKH-52) hard plaster following manufacturer instructions and final casts were made. Casts were retrieved after standard time required for setting (minimum 30 minutes) and measurements were taken utilizing Vernier Caliper. On each cast, two measurements were recorded in a linear manner including anteroposterior (mesial side of right central incisor to the distal side of right 1st molar) and cross arch (distal side of 1st molar of right side to the distal side of 1st molar of the left side). In each cast, measurements were recorded and mean was calculated to verify the accuracy and repeatability of measurements. Then, the measurements were compared with the measurements taken on the control group for evaluation of dimensional accuracy due to temperature changes. Statistical analysis was conducted using statistix 8.1 with two factorial designs to determine the storage time and temperature on dimensional accuracy. Multiple comparisons were carried out with LSD test at 5% probability level. Statistical analysis was conducted using statistix 8.1 with two factorial designs to determine the storage time and temperature on dimensional accuracy. Multiple comparisons were carried out with LSD test at 5% probability level.

3. RESULTS

Results shows that there is a significant difference (P<0.001) between Anteroposterior dimensional changes of distance from Mesial surface of maxillary right central incisor to distal surface of maxillary right first molar at different storage times as shown in **Table 1**. Results indicate that the dimensions are increasing directly as storage time increases this might be because of shrinkage of material due to increase in time of pouring. Shrinkage causes material to pull it towards the tray and increase the dimensions.

Table 1. Anteroposterior dimensional changes from mesial surface of maxillary right central incisor to distal surface of maxillary right first molar with respect to time

S.no	Time(min)	Mean	P value
1	0	41.551^{C}	
2	15	42.262^{B}	0.00

3	25	42.611^{A}

Results further reveals that there is a significant difference (*P*<0.001) between anteroposterior dimensional changes of distance from mesial surface of maxillary right central incisor to distal surface of maxillary right first molar at different storage temperatures as shown in **Table 2**. Results indicate that the dimensions are increasing directly as storage temperature increases this might be because of shrinkage of material due to increases in temperature of pouring.

Table 2. Anteroposterior dimensional changes from mesial surface of maxillary right central incisor to distal surface of maxillary right first molar with respect to temperature

S.no	Temperature(°C)	Mean	P value
1	25	42.056^{C}	
2	35	42.144^{B}	0.00
3	45	42.224^{A}	

Dimensional changes noted at different temperatures when poured at different storage times shows that there is a significant difference (*P*=0.01) from one another between anteroposterior dimensional changes of distance from mesial surface of maxillary right central incisor to distal surface of maxillary right first molar at different storage times and temperatures as shown in **Table 3**. Comparison results indicates that the dimensions are slightly increasing directly as storage time and temperature increases. Increase in dimensions indicates direct relation with storage time and temperature.

Table 3. Specifications of anteroposterior dimensional changes from mesial surface of maxillary right central incisor to distal surface of maxillary right first molar with time and temperature

S.no	Temperature(°C)	Time(min)	Mean	P value
1	45	25	42.713^{A}	
2	35	25	42.613^{A}	
3	25	25	42.500^{B}	
4	45	15	42.400^{B}	0.01
5	35	15	42.267^{C}	
6	25	15	42.120^{D}	
7	45	0	41.560^{E}	
8	35	0	41.547^{E}	
9	25	0	41.547^{E}	

Results further indicates that there is a significant difference (P<0.001) between Cross-arch dimensional changes of distance from distal surface of maxillary right first molar to distal surface of maxillary left first molar at different storage times as shown in **Table 4**. Results indicate that the dimensions are increasing directly as storage time increases this might be because of shrinkage of material due to increases in time of pouring. Shrinkage causes material to pull it towards the tray and increase the dimensions.

Table 4. Cross-arch dimensional changes from distal surface of maxillary right first molar to distal surface of maxillary left first molar with respect to time

S.no	Time(min)	Mean	P value
1	0	55.010^{C}	
2	15	55.287^{B}	0.00
3	25	55.509^{A}	

Results further reveals that there is a significant difference (P=0.001) between Cross-arch dimensional changes of distance from distal surface of maxillary right first molar to distal surface of maxillary left first molar at different storage temperatures as shown in **Table 5**. Results indicate that the dimensions are increasing directly as storage temperature increases this might be because of shrinkage of material due to increases in temperature of pouring, but the rate of change of dimensions is very small.

Table 5. Cross-arch dimensional changes from distal surface of maxillary right first molar to distal surface of maxillary left first molar with respect to temperature

S.no	Temperature(°C)	Mean	P value
1	25	55.207^{B}	
2	35	55.275^{A}	0.001
3	45	55.324^{A}	

Dimensional changes noted at different temperatures when poured at different storage times shows that there is no significant difference (*P*=0.09) between Cross-arch dimensional changes of distance from distal surface of maxillary right first molar to distal surface of maxillary left first molar at different storage times and temperatures as shown in **Table 6**. Comparison results indicates that the dimensions are increasing directly as storage time and temperature increases. Increase in dimensions indicates direct relation with storage time and temperature.

Table 6. Specifications of cross-arch dimensional changes from distal surface of maxillary right first molar to distal surface of maxillary left first molar with respect to time and temperature

S.no	Temperature(°C)	Time(minutes)	Mean	P value
1	45	25	55.627A	
2	35	25	55.500^{B}	
3	25	25	55.400^{BC}	
4	45	15	55.327^{CD}	
5	35	15	55.313^{CD}	0.09
6	25	15	55.220^{D}	
7	45	0	55.017^{E}	
8	35	0	55.012^{E}	
9	25	0	55.01^{E}	

4. DISCUSSION

Several rigid, thermoplastic or elastic impression materials are available for dental impression making but irreversible hydrocolloid material is among the extensively utilized material due to its elasticity, adequate detail reproduction, ease of use and certain other advantages [16]. Many studies in the past have been conducted to delineate the material properties [16-18].

Although having numerous benefits, the dimensional accuracy of alginate impression material remains questionable [4]. Previous studies determining the precision and dimensional accuracy of irreversible hydrocolloid impression material revealed the requirement for instant pour or on removal of the material from the mouth [10,11,19].

Spontaneous faults could arise in several sources during impression and preparation, for instance, the wrong water powder ratio, the incorrect size of the tray, gel movement, the unbound impression material from the tray, inadequate removal of the tray and gypsum prolong contact [3].

Throughout gelation, stress may occur due to inequitable pressure and are relieved when the trays are withdrawn from the mouth, which can contribute to the impression being distorted [10]. For maxillary impression materials in our research, the distortion is greater.

When the material is firmly bound to the trays during shrinkage, the material will be shifted to the tray, resulting in an acceleration in the width of both the tooth and the arch. When dental impressions are postponed for a long time, anteroposterior and cross-arch expansion and shortening take place for alginate impression [13]. However, it would have been an advantage for irreversible hydrocolloid utilizers to manage their practices, when the impression could be stored before pouring for a reasonable time.

4.1 Anteroposterior and Cross-arch Dimensional Changes with respect to Time

This study showed significant increase in anteroposterior (AP) dimensions by increasing the storage time. On the contrary, Wadhwa SS et al. observed impression storage in a plastic zip-lock bag for up to 1 hour without substantial changes and he also concluded that casts should be obtained from the conventional alginate impression material within two days [3].

Our study showed changes in cross-arch measurements have been less significant; whilst modifications in anteroposterior measurements took place significantly. The increase in AP dimensions was somehow supported by research [13]; however, cross-arch (CA) increase in dimensions is not identified in previous studies [20].

4.2 Anteroposterior and Cross-arch Dimensional Changes with respect to Temperature

Our study showed significant changes in dimensions when stored at different temperatures (25°C, 35°C, 45°C). Some observers reported significant dimensional changes in material stored at 40°C for 20 minutes but found no any change at 30°C for 20 minutes [15]. Another study did not report any significant changes when stored at 4°C for 15, 25, 45 minutes but after 60minutes. This same study stated that changes happen after 25 minutes stored at 23°C [13].

Dimensional stability of irreversible hydrocolloid impression material also depends on composition of the material. This study was performed on a single type of Alginate impression material. However, Mosharraf and Mokhtari demonstrated in 2006 that Alginoplast alginate products in wet environments have not changed significantly in their measurements for up

to 3 hours [21]. Mosharraf stated in 2011 that the impression of alginmax, elastic cromo, and hydrogum alginate did not significantly alter until 120 hours of processing, but not effective following 5 storage days [14].

5. CONCLUSION

This study concluded that the best results could be obtained with immediate pouring at 25°C temperature as compared to other observed temperatures.

6. LIMITATIONS

Since this was a vitro study, we were unable to assess the impact of clinical variables like blood, saliva or oral cavity on the precision of the impression products. Furthermore, only one type of Alginate impression material was investigated in our study. Within these limitations, our study concluded that whenever alginate is used as an impression material, the cast should be poured immediately for better results. It is fair to say that the results would be better with immediate pouring at 25°C as compared to other observed temperatures.

CONSENT (WHERE EVER APPLICABLE)

It is not applicable.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

It is not applicable.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. Perry R. Dental impression materials. J Vet Dent. 2013; 30 (2): 116-24. doi: 10.1177/089875641303000213

2. Ashley M, McCullagh A, Sweet C. Making a good impression: (a 'how to' paper on dental alginate). Dent update. 2005; 32 (3): 169-75. doi: 10.12968/denu.2005.32.3.169

3. Wadhwa S. S., Mehta R, Duggal N, Vasudeva K. The effect of pouring time on the dimensional accuracy of casts made from different irreversible hydrocolloid impression materials. Contemp Clin Dent. 2013;4(3):313–18. doi: 10.4103/0976-237X.118368

4. Faria A. C, Rodrigues R. C, Macedo A. P, Mattos Mda G, Ribeiro R. F. Accuracy of stone casts obtained by different impression materials. Braz Oral Res. 2008;22(4):293-8. doi: 10.1590/s1806-83242008000400002

5. Carr A. B, Brown D. T. McCracken's Removable Partial Prosthodontics. 13th ed. St. Louis, Missouri, U.S.A: Mosby Publishers; 2015.

6. Bayindir F, Yanikoglu N, Duymus Z. Thermal and pH changes, and dimensional stability in irreversible hydrocolloid impression material during setting. Dent Mater J. 2002;21(2):200-9. doi: 10.4012/dmj.21.200

7. Rodrigues S. B, Augusto C. R, Leitune V. C. B, Samuel S. M. W, Collares F. M. Influence of delayed pouring on irreversible hydrocolloid properties. Braz Oral Res. 2012;26(5):404-9. doi: 10.1590/S1806-83242012000500005

8. Anusavice J. K. Phillips' science of dental materials. 11th ed. St. Louis, Missouri, U.S.A: Saunders Publishers; 2003.

9. Ratnaweera P. M, Yoshida K, Miura H, Kohta A, Tsuchihira K. A clinical evaluation of the agar alginate combined impression: dimensional accuracy of dies by new master crown technique. J Med Dent Sci. 2003;50(3):231-8. doi: 10.11480/JMDS.500305

10. Sedda M, Casarotto A, Raustia A, Borracchini A. Effect of storage time on the accuracy of casts made from different irreversible hydrocolloids. J Contemp Dent Pract. 2008;9(4):59-66. doi: 10.5005/jcdp-9-4-59

11. Cohen B. I, Pagnillo M, Deutsch A. S, Musikant B. L. Dimensional accuracy of three different alginate impression materials. Journal of prosthodontics: J Prosthodont. 1995;4(3):195-199. doi: 10.1111/j.1532-849x.1995.tb00340.x

12. Penfold R. R. S, Brandt W. C, Miranda M. E, Vitti R. P. Evaluation of dimensional stability and details reproduction of alginate molds storage in different times and temperature. Braz Dent Sci. 2018; 21(1): 37-43. doi: 10.14295/bds.2018.v21i1.1501

13. Farzin M, Panahandeh H. Effect of Pouring Time and Storage Temperature on Dimensional Stability of Casts Made from Irreversible Hydrocolloid. J Dent(Tehran). 2010; 7(4): 179-84.

14. Mosharraf R, Nasouhian S, Salehi M. Effect of storage time on the dimensional stability of Extended-Pour irreversible hydrocolloid materials. Journal of Isfahan Dental School. 2011;7(3):246-55.

15. Kulkarni MM, Thombare RU. Dimensional Changes of Alginate Dental Impression Materials-An Invitro Study. J Clin Diagn Res. 2015; 9(8): 98-102. doi: 10.7860/JCDR/2015/13627.6407

16. Nandini V. V, Venkatesh K. V, Nair K. C. Alginate impressions: A practical perspective. J Conserv Dent. 2008;11(1):37-41. doi: 10.4103/0972-0707.43416

17. Fellows C. M, Thomas G. A. Determination of bound and unbound water in dental alginate irreversible hydrocolloid by nuclear magnetic resonance spectroscopy. Dent Mater. 2009;25(4):486-493. doi: 10.1016/j.dental.2008.10.001

18. Lewinstein I, Craig R. G. Accuracy of impression materials measured with a vertical height gauge. J Oral Rehabil. 1990; 17:303-10. doi: 10.1111/j.1365-2842. 1990.tb00013.x

19. Chen S. Y, Liang W. M, Chen F. N. Factors affecting the accuracy of elastomeric impression materials. J Dent. 2004; 8:603-09. doi: 10.1016/j.jdent.2004.04.002

20. Rohanian A, Ommati Shabestari G, Zeighami S, Samadi M. J, Shamshiri A. R. Effect of storage time of extended-pour and conventional alginate impressions on dimensional accuracy of casts. J Dent (Tehran). 2014;11(6):655-64.

21. Mosharraf R, Mokhtari M. The effect of storage time on the accuracy and dimensional stability of two irreversible hydrocolloid im-pression materials. Majallah-I-Dandanpizishki. 2006;18(2):92-9.