The effect of pouring time on the dimensional accuracy of casts made from different irreversible hydrocolloid impression materials

Supneet Singh Wadhwa, Richa Mehta, Nidhi Duggal, Kamlesh Vasudeva

Abstract

Aims and Objectives: To determine the time dependent accuracy of casts made from three different irreversible hydrocolloids. **Materials and Methods:** The effect of delayed pouring on the accuracy of three different irreversible hydrocolloid impression materials – Regular set CA 37(Cavex, The Netherlands), regular set chromatic (Jeltrate, Dentsply), and fast set (Hydrogum soft, Zhermack Clinical) was investigated. A brass master die that contained two identical posts simulating two complete crown-tapered abutment preparations with reference grooves served as a standardized master model. A total of 120 impressions were made using specially prepared stock-perforated brass tray with 40 impressions of each material. The impressions were further sub-grouped according to four different storage time intervals: 0 min (immediately), 12 min, 30 min, and 1 h. The impressions were stored at room temperature in a zip-lock plastic bag. Interabutment and intraabutment distances were measured in the recovered stone dies (Type IV, Kalrock) using a profile projector with an accuracy of 0.001 mm. The data so obtained was analyzed statistically. **Results:** Results of this study showed no statistically significant differences in the accuracy of casts obtained at different time intervals. **Conclusion:** Because it is not always possible to pour the impression immediately in routine clinical practice, all irreversible hydrocolloid materials studied could be stored in a zip-lock plastic bag for upto 1 h without any significant distortion.

Keywords: Accuracy, delayed pouring, dimensional stability, irreversible hydrocolloids, profile projector

Introduction

Impression making and pouring are critical steps in the process of producing successful dental prosthesis. Impression materials should reproduce hard and soft tissues accurately to obtain biologically, mechanically, functionally, and aesthetically acceptable restorations.[1] Accurate casts are required to perform multitude of functions like assisting in patient education, diagnosis of malocclusion, determination of the length and width of clinical crowns, identification of the need for surgical interventions, fabrication of custom trays, occlusal devices, and implant surgical guides. Hence, a precise, undistorted impression must be ensured for the accuracy of gypsum casts for correct treatment planning, constructing well-fitting removable and fixed prosthesis, and successful rehabilitation.

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Alginate, an elastic, irreversible hydrocolloid impression material has been the staple of most dental practices for many years. The general use of irreversible hydrocolloid far exceeds that of any impression material, because of its various advantages such as hydrophilicity, pleasant taste and odor, non-staining, inexpensive, ease of mixing and effective use in the presence of saliva. Alginate is used to generate gypsum casts for numerous applications such as in making diagnostic casts, provisional crowns and bridges, orthodontic study models, sports mouth guards, bleaching trays, and fabrication of removable prosthesis.[2-4]

As with any hydrocolloid, alginates are approximately 85% water and are prone to distortion caused by expansion associated with imbibition (absorption of moisture), shrinkage due to moisture loss by evaporation, or continued reaction of the sol (syneresis).[5-7] Due to host of contingencies, many dentists do not pour their own impressions immediately. Impression must be stable enough to produce accurate casts over extended periods of time. In general, the shorter this period, the higher is the accuracy. According to Morrow and colleagues, the most common error made in using alginate impression materials is not pouring the gypsum product into the impression immediately.[8] Various researchers and clinicians state that the casts produced from alginate impressions must be generated immediately or within 12 min after the impression is removed from the patient's mouth. Dahl *et al*., concluded that clinically acceptable working casts could be obtained from irreversible hydrocolloid impressions poured even after 3 h.[9] Recently, extended storage alginate impression materials have been marketed with claims that the materials exhibit dimensional stability same as that of elastomers and can be delayed poured even after 100 h.[10]

However, little information is provided in manufacturer's instruction sheet regarding the storage period and storage methods of alginate impression material. Thus, confusion continues to prevail regarding their storage time, and further research is required for a definite conclusion.

This study was thus undertaken to evaluate the effect of storage time on the dimensional accuracy of casts made from different irreversible hydrocolloids.

Materials and Methods

Three different irreversible hydrocolloids used in the study were CA 37 (Cavex, The Netherlands), regular set; Jeltrate (Dentsply), regular set chromaticandHydrogum soft, Zhermack Clinical) – fast set. A brass master die of size 52 × 24 mm, containing two identical posts, simulating complete crown-tapered abutment preparations served as the standardized master model. The abutments were prepared with reference cross grooves on occlusal and proximal surfaces for reference measurements. Reference measurements [Figure 1] (made by profile projector with an accuracy of 0.001 mm or 1 μm) of the standardized model were as follows [Table 1]

A specially prepared stock-perforated brass tray having a uniform space of approximately 4 mm for the irreversible hydrocolloid impression material was used to register the impression [Figure 2].

A rectangular brass plate was fabricated with a slit in the centre that allowed the handle of the master die to pass. This stabilized the master model on the index during impression making and thus standardized the positioning and thickness of the impression material [Figure 3].

According to the manufacturer's recommended water/powder ratio for each material, a pre-weighed amount of alginate was mixed manually with distilled water at room temperature for indicated time periods. The brass master die that was maintained at 37°C to closely simulate the oral environment was removed from the oven and placed on the index just before making the impression. The alginate mix was loaded in the perforated brass tray and the impression was taken within the setting time as indicated by the manufacturer at room temperature [Figure 4]. The impressions were not rinsed with water or immersed in any disinfecting solution.

A total of 120 impressions were made using three different irreversible hydrocolloids with 40 impressions of each material. The 40 impressions of each material were further sub-grouped according to the four different storage time intervals to which these impressions were subjected, with 10 impressions into each time interval. The four different storage time intervals studied were 0 min (immediately), 12 min, 30 min, and 1h.

Table 1: Dimensions of the brass master model

Diameter of each post	6.25 mm
Height of each post	6.25 mm
Inter-abutment distance between the centre of two posts	21.5 mm

For the storage time indicated as 0 min, the casts were poured immediately after removal from the master model. Impressions, other than those that were poured immediately, were stored at room temperature in a zip-lock plastic bag in which a paper towel wetted with 50 ml of distilled water had been inserted 10 min earlier.

To control the amount of moisture, each paper towel was squeezed for 10 s between two glass slabs of size 13 × 13 cm^2. The paper was positioned to avoid a direct contact with the tray and alginate [Figure 5].

After the designated time interval, the impressions were poured with type IV die stone. The die stone was allowed to set for a minimum of 1 h before being separated from the impression. Casts obtained were numbered and subjected to measurements.

A profile projector with 15X magnification was utilized for the measurements of the stone casts. The following interabutment and intraabutment dimensions on the stone casts were measured and compared to the master model [Figures 6 and 7].

Each stone cast measurement was repeated three times and the mean for all distance measurements was calculated. The readings thus obtained were put to statistical analysis.

Results

The results of the study indicated that all the materials exhibited a continuous decrease in the interabutment (AB) distance with delay in pouring [Figure 8]. The mean difference in interabutment dimension ranged from 0.0143 mm at 0 min to 0.0531 mm at 1 h for the regular set Cavex, 0.0164 mm at 0 min to 0.0447 mm at 1 h for the regular set chromatic Jeltrate, and 0.0134 mm at 0 min to 0.0525 mm at 1 h for fast set Hydrogum.

On the other side, an increase in each intrabutment dimensions measured (CD, EF, GH, and IJ) was observed with delay in pouring in all the three hydrocolloid impression materials [Figures 9-12]. In all intra-abutment dimensions, the minimum increase from master value was observed in stone casts poured immediately, whereas maximum increase was observed in the casts poured at an interval of 1 h. The mean difference in intra-abutment dimensions ranged from −0.009 mm to −0.0746 mm for Cavex, −0.0168 mm to −0.0798 mm for Jeltrate, and −0.0075 mm to −0.0747 mm for Hydrogum.

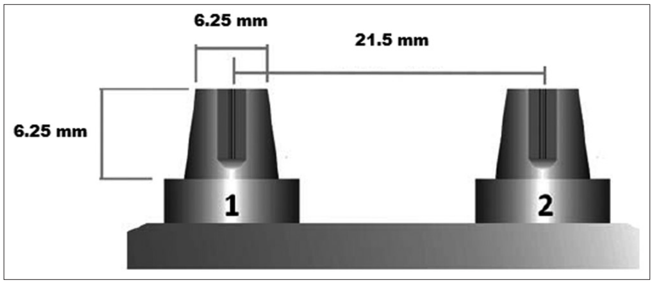

Figure 1: Schematic representation of master model

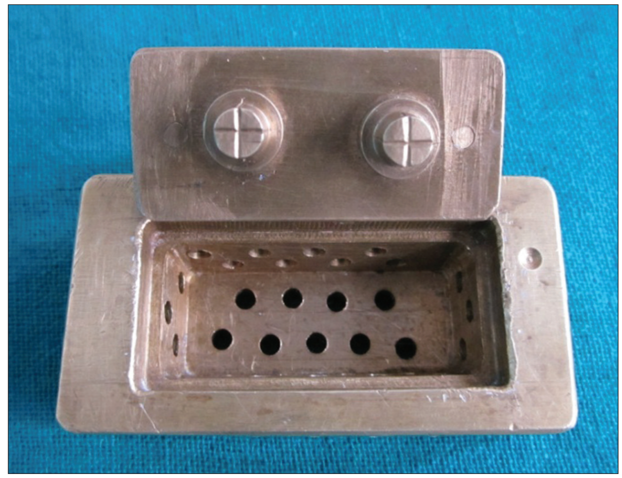

Figure 2: Brass master die and perforated stock tray

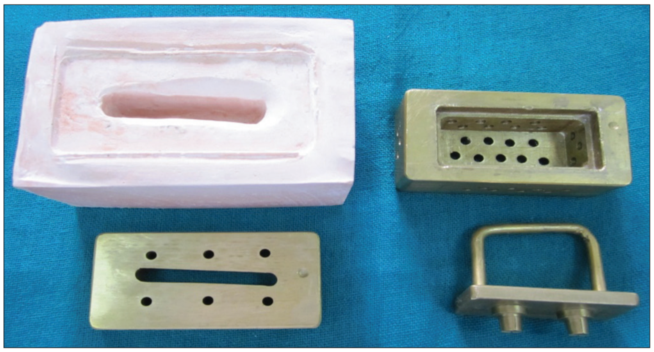

Figure 3: Die stone slab, model index, perforated stock tray and master die

Figure 4: Tray placement during impression making of the master model

Figure 5: Storage of the impression in a zip lock plastic bag

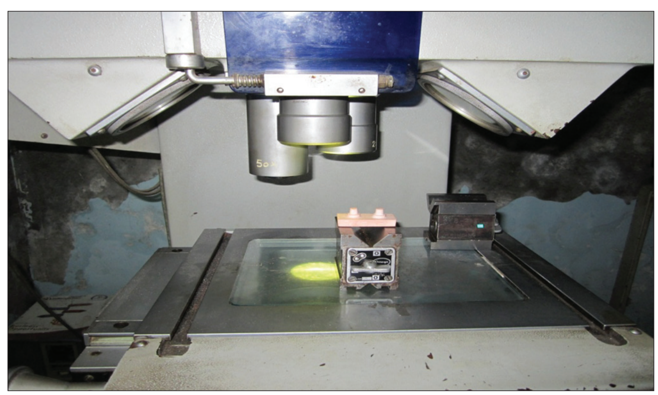

Figure 6: Die stone measurements with profile projector

These observed changes showed that the immediate pouring produced the most accurate casts for all the irreversible hydrocolloid materials studied. The one-way analysis of variance (ANOVA) analysis showed that this decrease in interabutment dimension and the increase in intraabutment dimensions with time for each hydrocolloid material was statistically insignificant ($P > 0.05$).

Discussion

Despite its numerous advantages, the dimensional accuracy of alginate-based impression material is one of the major concerns regarding the usage of this material.[1] The most common cause for error associated with the clinical and laboratory use of hydrocolloids is the distortion of the material following the removal of the impression from the mouth and the pouring of the cast. Hydrocolloid gel is approximately 80% water and is susceptible to dimensional changes when exposed to different environments. It may

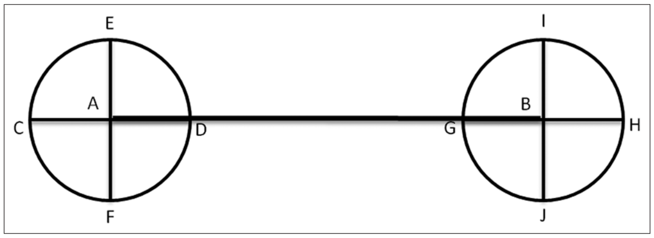

Figure 7: Reference points and linear dimensions measured. AB - interabutment dimension, CD, EF, GH, IJ - interabutment dimension

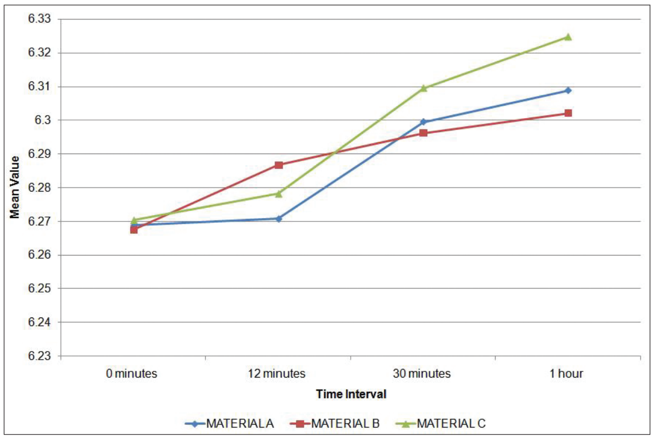

Figure 9: Line diagram showing mean values for the intraabutment distance (CD) for each group at four different time intervals

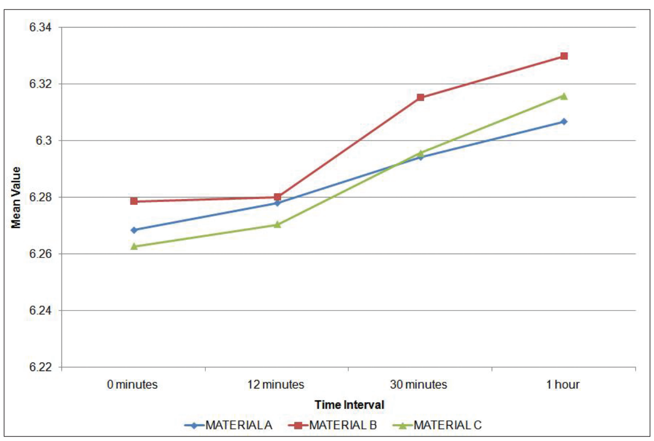

Figure 11: Line diagram showing mean values for the intraabutment distance (GH) for each group at four different time intervals

undergo expansion by absorbing water (imbibition) or shrinkage by losing water through evaporation and continued reaction of the sol (syneresis).[3,6,11] Imbibition, water evaporation, and syneresis may result in the production of inaccurate casts. The first two processes depend primarily on storage conditions, and syneresis is affected by the proprietary constituents of the alginate.[11,12] In addition to water balance, alginate impression may also be distorted

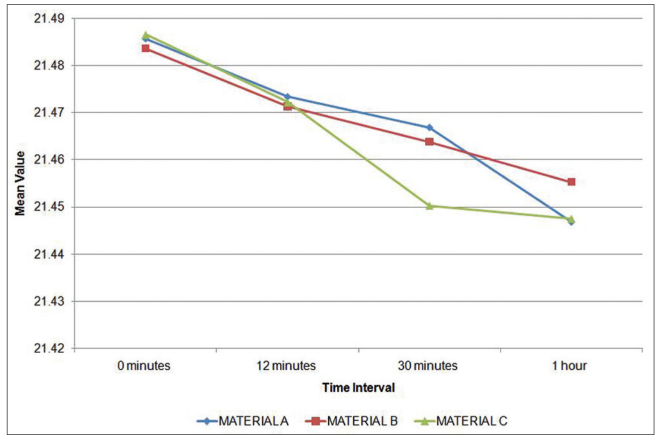

Figure 8: Line diagram showing mean values for the interabutment distance (AB) for each group at four different time intervals

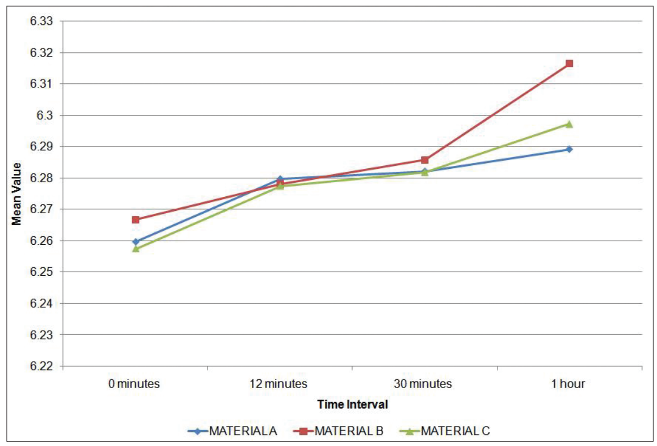

Figure 10: Line diagram showing mean values for the intraabutment distance (EF) for each group at four different time intervals

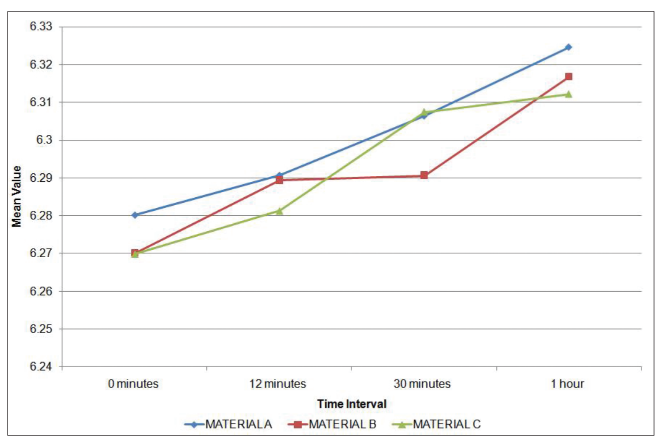

Figure 12: Line diagram showing mean values for the intraabutment distance (IJ) for each group at four different time intervals

because of release of stresses which are induced by the application of pressure on the tray during the gelatinous stage. If the impression is not immediately poured, the stresses will become almost completely relaxed, resulting in serious distortions.[13,14]

The present study was aimed at evaluating the effect of delayed pouring on the accuracy of three different irreversible hydrocolloid impression materials (regular set, regular set chromatic, and fast set). The objective was to determine if the hydrocolloid impression material would maintain their accuracy on being poured at the convenience of the operator over a reasonable time period.

Irreversible hydrocolloid exhibited a net contraction on conversion from sol to insoluble gel. The shrinkage of the material mostly occurred toward the centre of the mass or the bulk of the material. As the maximum bulk of the material was between the two posts, the shrinkage resulted in decrease of the interabutment distance, causing the centre of the two posts to come closer with delayed pouring. This measured change was similar to the change observed in the clinical situations. During full-arch impressions, the greatest amount of alginate was visibly located in the palatal zone, and the shrinkage occurred toward the larger bulk in the palatal region as compared to the other portions.[11,15] Therefore, the palatal part of the casts would be smaller than the palatal part of the mouth. Although the major connector crossing the palate fit the cast well, they would not be snug against the palate in the mouth.[15,16]

If the impression material was bonded firmly to the tray, shrinkage would result in the impression material being pulled toward the tray, causing an increase in die diameter.[17] As the material was firmly bonded to the perforated brass-stock tray, due to continued shrinkage, the impression material around the die was subjected to the centrifugal tensile forces, resulting in an increase in die diameter. This explained the increase in intraabutment distances that resulted in wider dies as compared to the master model.

All the impression materials studied had undergone shrinkage, possibly due to syneresis and evaporation of water. The amount of shrinkage caused by syneresis was always higher than evaporation.[18] In 100% relative humidity, the alginate materials first expanded and then shrink with time.[19] Maintenance of 100% relative humidity might lead to absorption of water from the humid environment (imbibition), resulting in distortion.[18,20,21] This could be avoided by storing the impressions in zip-sealed bags. To minimize the distortion caused by water changes in the irreversible hydrocolloid, the manufacturers add filler and smaller amounts of other proprietary ingredients to control the dimensional changes.

According to Thongthammachat *et al*., (2002) the deviation is clinically acceptable, if distortion occurred within the limit of the periodontal ligament space, which is in the range of 90-240 μm.[22-25] In the present study, the deviation measured for all the impressions stored up to 1 h were well within this acceptable range, suggesting that the studied irreversible hydrocolloid impression materials could be used to produce clinically acceptable casts even on delayed pouring up to 1 h.

Rudd (2001) suggested that, by metal grinding, incorrectness of up to 150 μm in the cobalt chromium metal framework could be easily adjusted during try in stage for removable partial denture; therefore, this discrepancy might be considered acceptable.[26-28] This distortion is larger than the greatest dimensional change recorded for all the materials in the present study. This implied that even if the pouring of alginate is delayed by up to 1 h, it still produces stone casts that are clinically acceptable for partial denture framework construction.

Thus, the results of the present study suggested that all the three tested impression materials when stored properly for up to 1 h were dimensionally stable enough for fabrication of diagnostic casts, occlusal splints, acrylic appliances, and master casts for removable partial dentures.[29,30] The decades old tenet that alginate impression materials must be poured immediately and wrapped in a damp towel or stored before pouring in gypsum may no longer be valid for every alginate impression, if it is stored adequately for limited times. As delayed pouring of alginate by up to 1 h did not significantly affect the dimensional accuracy of casts obtained, it might provide the clinician sufficient time to finish necessary chair-side procedures, leading to improved operator efficiency and clinical time management. Although the present *in vitro* study showed no statistically significant difference in the accuracy of casts obtained at different time intervals, it did not simulate the oral conditions such as effect of oral fluids, soft tissues, presence of undercuts, and different arch forms. The present study evaluated only the effect of delayed pour on the dimensional accuracy of alginate impression material. There are various other factors that may influence the precision of dental cast such as type of impression material, various impression techniques, type of trays used, the materials used for making casts, and various disinfectant procedures to which impressions are subjected. All these factors need further investigation under more closely simulated clinical conditions.

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