International Journal Dental and Medical Sciences Research
Volume 6, Issue 5, Sep - Oct 2024 pp 504-511 www.ijdmsrjournal.com ISSN: 2582-6018

Comparative Evaluation of Extended Pour Alginate Impression Materials and Dimensional Accuracy of The Gypsum Casts Obtained at Different Storage Times – An In-Vitro Study.

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Submitted: 20-10-2024 Accepted: 30-10-2024

ABSTRACT: Regular Alginate impressions are still the most reliable method to obtain gypsum casts with an acceptable degree of precision. However, the dimensional instability due to the phenomena of syneresis and imbibition is considered the main drawback of the conventional alginates. The extended-pour alginates have been developed with the ability to maintain the dimensions of the impressions stable through the extended storage time intervals. The analysis of the dimensional stability of alginates has usually been based on the ADA specifications and ISO standards, which do not specify the acceptable percentage of dimensional variation for irreversible hydrocolloids, but only for elastomeric materials The accuracy analysis of alginates is based on the evaluation of the material's ability to correctly reproduce specific lines impressed on a small mold. This strategy might not be the best way to evaluate the stability of large impressions, and it might be better to simulate an oral arch with specific models to consider the complexity of 3D changes. When large impressions are analyzed, shrinkage and swelling might occur, thus altering the distances from the details which might not be detected by the conventional methods of stability analysis. The purpose of this in vitro study was to explore digital methods of evaluating the accuracy of large impressions made with commercially available extended pour alginate impression materials poured with Gypsum Product at different time intervals on delayed pouring to co-relate the dimensional changes.

KEYWORDS: Alginate, Gypsum Product, Dimesional changes, Impressions

I. INTRODUCTION

Irreversible hydrocolloid, or alginate, is one of the most widely used materials in dentistry for impression making as it is cost effective, provides adequate accuracy, is easy to handle, has good physical properties, and good patient acceptability[1–3]. Regardless of the modern digital approaches, regular dental impressions are still the most reliable method to obtain gypsum casts with an acceptable degree of precision [4,5]

Dimensional instability in response to the syneresis and imbibition phenomena is considered the main drawback of the conventional alginates[6].These inherent phenomena are dependent on the impression's ambient storage condition and time gap in pouring the impressions[7]. In some situation, the process of immediate/early pouring of cast may not be possible. Accordingly, the extended-pour alginates have been developed with the ability to maintain the dimensions of the impressions stable through extended storage time intervals prior to pouring the cast[7–10].

The analysis of the dimensional stability of alginates has usually been based on the American Dental Association (ADA) specifications and International Standards Organization (ISO) standards, which do not specify the acceptable percentage of dimensional variation for irreversible hydrocolloids, but only for elastomeric materials[11].

The accuracy analysis of alginates, as described in ADA standards, is based on the evaluation of the material's ability to correctly reproduce specific lines impressed on a small mold[2,9]. This strategy, however, might not be the best way to evaluate the stability of large impressions, and it might be better to simulate an oral arch with specific models to consider the complexity of 3-dimensional changes[11,12].

Indeed, alginate impression materials may reproduce details with adequate accuracy, but when large impressions are analyzed, shrinkage and swelling might occur, thus altering the distances which might not be detected by the conventional methods to analyze the stability of the material [7,11].

The aim of the present in vitro study was to digitally evaluate the accuracy of large impressions made with commercially available extended pour alginate impression materials and poured with Die stone at different time intervals.

Null Hypothesis: - There will be no effect on the dimensional accuracy of the extended pour alginate impression materials when poured at extended time intervals.

II. MATERIALS AND METHODOLOGY

This study was conducted in the Department of Prosthodontics and Crown & Bridge of Mahatma Gandhi Dental College & Hospital.

Sr No.	Material	Manufacturer
1.	Hydrogum 5	Zhermack, S.p.A, Italy
2.	Alginplus	Major Prodotti Dentari, S.p.A, Italy
3.	Cavex Cream Alginate	Cavex, Netherlands
4.	Kromopan	Lascod, S.p.A, Italy
5.	Millenium	Lascod, S.p.A, Italy
6.	3D-Printed (PLA-Infused) Model	
7.	Digitally designed 3D-Printed (PLA Infused) perforated trays with Rim-Lock Design	
8	MEDIT T310 LAB SCANNER	
9	EXOCAD 3.1 DENTAL CAD Software	
10	Die Stone- type 4	Kalabhai Ultrarock
11	Weighing Scale	
12	Ziploc Bags	
13	Rubber bowl	
14	Mixing Spatula	

Table.1: Materials used

Following an approach similar to that of Sedda et al[7], a master model was prepared incorporating the simulated clinical conditions. The master model (Fig.1) was designed by modifying a standardized quadrangular plate digital model. Four cylinders engraved with a cross were added on the upper surface of the master model and used as reference points for the measurements. The location for these cylinders were decided to be at the canine and 2nd molar position. Three stops were added to the lateral surface of the model, 2.5 mm below the upper surface to standardize the impression procedure and the thickness of the impression materials. The digital model was printed in Polylactic acid by 3D Printer (Fig 2).

(A)

(B)

Fig.1: 3-Dimensional design of the model

Trays were designed according to the specifications of the modified digital model and also maintained a uniform space or gap of 4mm for the impression material. The digitally designed tray (Fig.2) was 3D-printed with infused polylactic acid. A Rim-Lock and undercut design was also be incorporated to lock the material within the tray. Small diameter perforations were made in the tray to improve the mechanical locking of the material. The impressions of the model were made after wetting it with distilled water to facilitate easy removal.

(A)

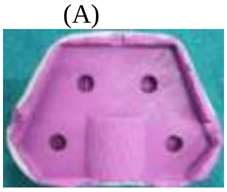
(B)

Fig.2: 3D printed (A) Master model and (B) Tray.

Material was mixed (Fig.3) using distilled water stored at room temperature. Powder-Liquid ratio will be followed according to the manufacturer. Each impression was stored in a zip-lock plastic bag at room temperature before pouring. For each material, 5 impressions were made. One Impression each were poured immediately, after 1 day, 2 days, 3 days and 4 days of storage to obtain gypsum casts.

Fig.3 Mixing the material and loading on the tray.

(A)



(B)

Fig.4 (A) Recording the impression (B) inspecting the impression after retrieval

5 different impression materials were selected for this in-vitro study as mentioned in Table.1. On the basis of study done by Porrelli et al[13], Sample size of 16 was selected taken into consideration for each group and sub-groups.

<u>EVALUATION OF DIMENSIONAL ACCURACY:</u>

Impressions was poured using Kalrock Die Stone (Kalabhai). The powder was hand mixed with a plaster spatula in rubber bowl using 23 ml of distilled water for each 100gm of gypsum powder (as per manufacturer's instruction). The bowl was placed on the vibrator for 30s to remove any entrapped air bubbles. The alginate impression was then filled with the gypsum mix under vibration to minimize the chances of air bubbles formation within the gypsum cast. The poured impressions was left in air at room temperature for 1 hour to ensure complete setting of gypsum casts before retrieval. The poured casts was scanned using MEDIT T310 3D scanner and linear measurements in a form of triangular mesh (Fig.5) was recorded for each cast of each impression group using EXOCAD 3.0 DENTAL CAD software. Distance between center point of the engraved cross of each cylinder was measured and these measurements were designated individually as shown in Fig.5

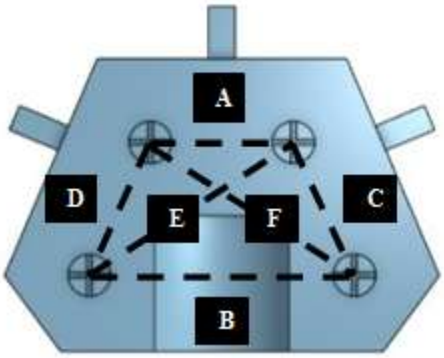


Fig.5: Linear measurements designated as A, B, C, D, E & F

III. OBSERVTION AND RESULTS

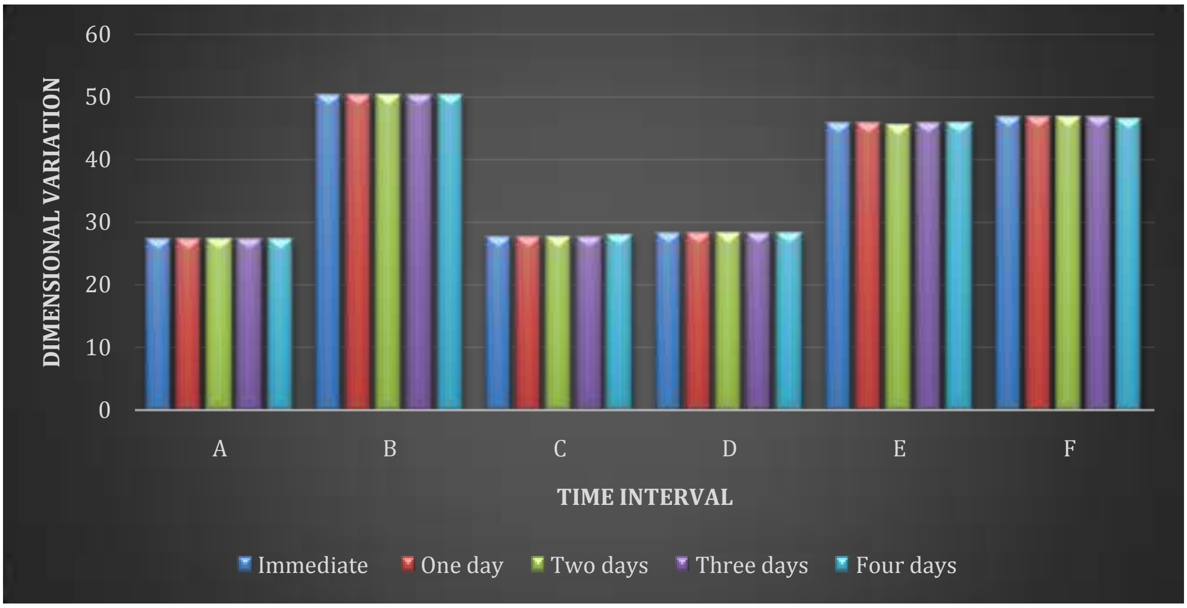
A Regulated 5V DC power supply is feed to Arduino board and IC 7805 Voltage regulator. All microcontrollers operate at low voltages and require a small amount of current to operate while solenoids require higher voltages and current. Hence current cannot be supplied to the solenoid from the microcontroller .This is the primary need for IC L293D.A diode(**IN4007**) and a voltage regulator (**7805**) IC are connected in the path ,the diode is used as a one-way check valve. Since these diodes only allow electrical current to flow in one direction.IC 7805 is a 5V Voltage Regulator that restricts the voltage output to **5V** and draws 5V regulated power supply. A digital signal generated by Arduino based on the input program is feed to the L293D IC .L293D Is a voltage amplifier that amplifies the 5V into 12V.The L293D IC receives

International Journal Dental and Medical Sciences Research
Volume 6, Issue 5, Sep - Oct 2024 pp 504-511 www.ijdmsrjournal.com ISSN: 2582-6018

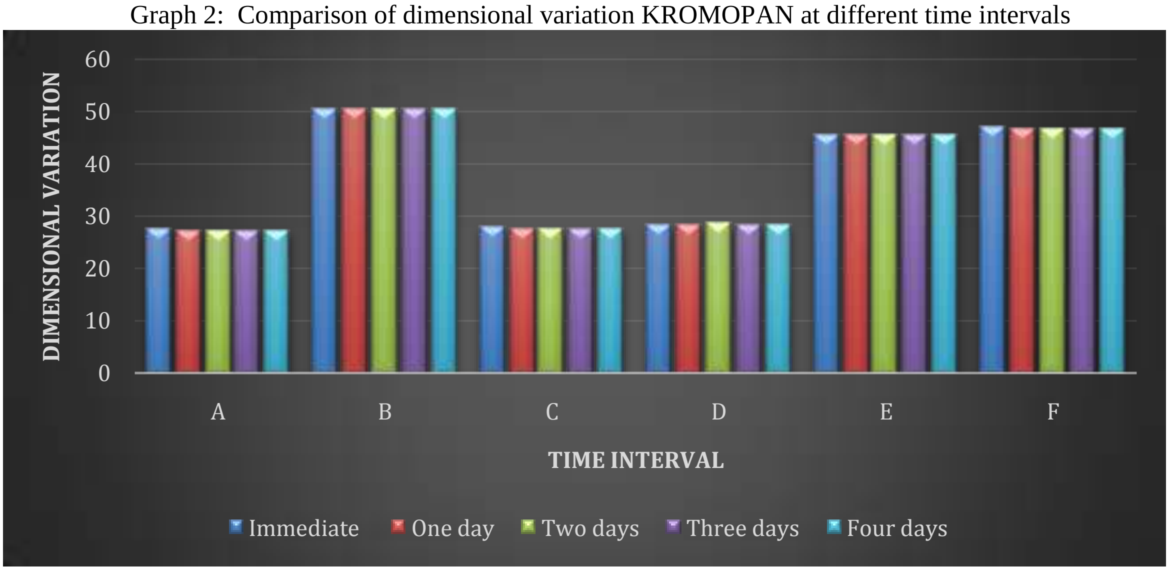
signals from the micro controller and transmits the relative signal to the solenoids .A L293D IC consists of 16 pins in total. 4 ground pins,4-input pins,4-output pins,2 voltage and enable pins. The digital signal output from 7 pin of arduino is feed to 10^{th} pin of L293D(input),output from 7^{th} pin is feed to 14^{th} pin of L293D(output).The 4^{th},5^{th} and the 13^{th},12^{th} pins of L293D are grounded. L293D has an enable facility which helps you enable the IC output pins. If an enable pin is set to logic high, then state of the inputs match the state of the outputs. If you pull this low, then the outputs will be turned off regardless of the input statesDepending upon our power requirements we can use Transistors/MOSFETs as switches.

As shown in the graphs, applying one-way ANOVA test , obtained results among Hydrogum 5k (graph 1) were statistically significant, p =≤0.05 with reference to point C and E, whereas for material Kromopan (graph 2) p value was found to be significant from reference point A,C and F respectively. Similarly for material Millennium (graph 3), outcome for p value was statistically significant from point C & D followed by Cavex (graph 4) material where results were statistically significant from point C,D and E whereas for Alginplus (graph 5) except point B all points were statistically significant.

Graph 1: Comparison of dimensional variation of HYDROGUM 5 at different time intervals

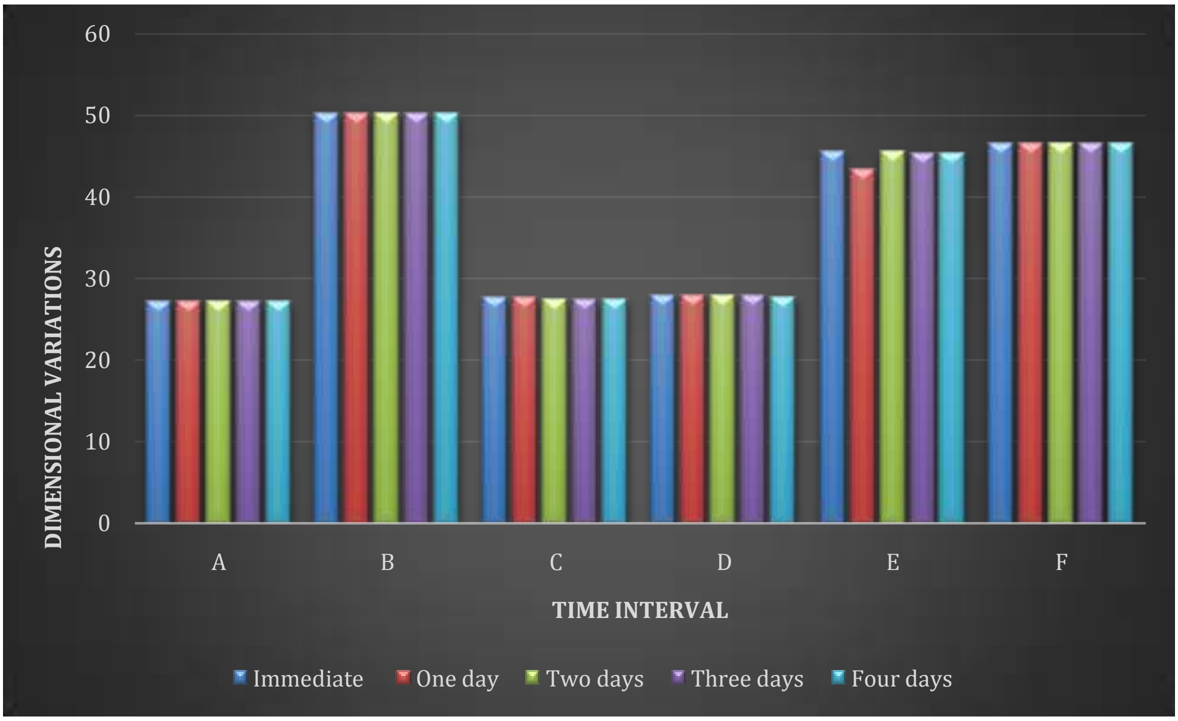


Graph 2: Comparison of dimensional variation KROMOPAN at different time intervals

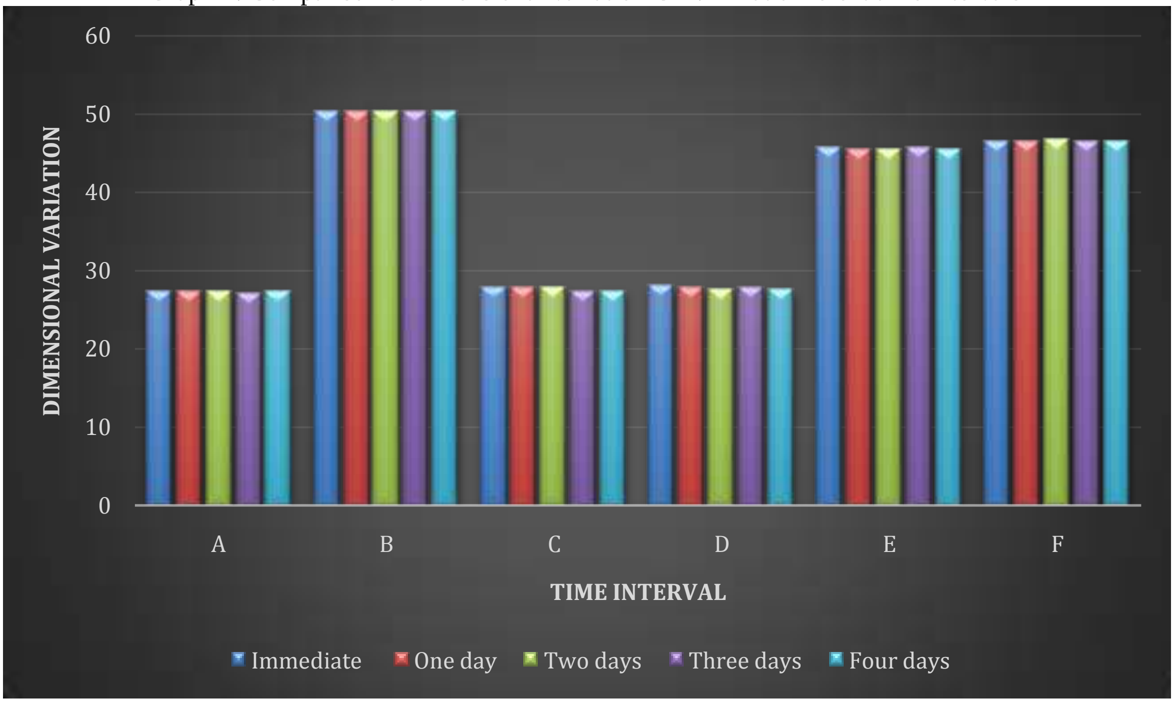


International Journal Dental and Medical Sciences Research
Volume 6, Issue 5, Sep - Oct 2024 pp 504-511 www.ijdmsrjournal.com ISSN: 2582-6018

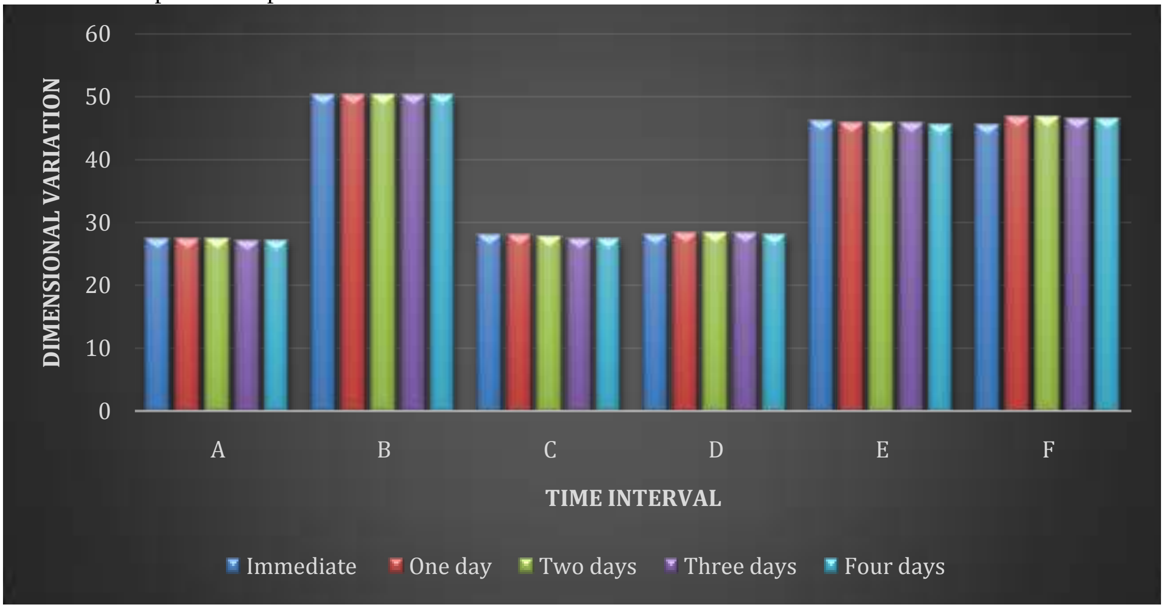
Graph 3: Comparison of dimensional variation MILLENIUMduring at time intervals



Graph 4: Comparison of dimensional variation CAVEX at different time intervals



Graph 5: Comparison of dimensional variation ALGINPLUS at different time intervals



IV. DISCUSSION

Obtaining successful dental prostheses requires accurate reproduction of soft and hard oral tissues. Accordingly, the selection of both impression and cast materials seems critical for optimum biological, functional, and esthetic treatment outcomes[14,15]. Irreversible hydrocolloids are one of the most frequently used impression materials in everyday dental practice as they are cost-effective and easily manipulated [4,5].

Alginate alternatives with polyvinyl siloxane additives (siliconized alginates) have also been marketed with the possibility of maintaining the impression dimensions through prolonged storage (100+h) in addition to the possibility of re-pouring the gypsum casts[16].

In some instances, the process of immediate/early pouring could relatively be impossible especially if the impression is planned to be transferred to a dental laboratory. Accordingly, the extended-pour alginates have been developed with the ability to maintain the dimensions of the impressions stable through the extended storage time intervals.

In the current study, dimensional accuracy of the gypsum cast obtained was evaluated for each material over a period of 4 days (96 hrs). Considering the expansion to be constant as the die stone used for pouring was same for each group, maximum accuracy was seen in Hydrogum 5, followed by Millenium. The least accurate among all material was Alginplus.

The dimensional accuracy of the cast obtained at different times was compared with the cast poured immediately of that group. At 24hrs Alginplus & Kromopan showed dimensional variation while the others were dimensionally stable. After 48 hours some changes were seen in each group but they weren't statistically significant and also no significant change was seen in Alginplus & Kromopan between 24-48 hours. At 72hrs, Cavex showed changes along with Alginplus and Kromopan. After 96hours significant changes were seen for both Hydrogum 5 and Millenium as well.

In the present study, on comparing dimensional variation of extended pour alginate material at different time intervals dimensional variations were found to be statistically significant but were within clinically acceptable limits but Hydrogum 5 showed the least variations out of all. This corelates well with the study done by Rania Sharif et al (2021)[16], results of which concluded that all the tested alginate materials showed comparable and superior surface details especially Hydrogum 5.

In another study carried out by M.Sedda et al (2008)[7]to evaluate the accuracy of casts made from alginate impression materials poured immediately and after specific storage periods, the dimensional stability of the alginate impressions was both material and time-dependent ($p<0.05$). After 24 hours of storage, only Alginoplast (Alginplus) and Hydrogum 5 (Hydrogum 5) complied with the master model ($p>0.05$). After 72 and 120 hours, only Hydrogum 5 was dimensionally stable ($p>0.05$) and they concluded that dimensional stability of the alginate impressions is influenced by the material and the storage time.

Similarly in a study done by Mary P. Walker et al (2008)[9]to evaluate the dimensional change over time of two extended-storage alginate impression materials, results showed significant differences in dimensional change between materials across time (P, .05). All materials exhibited shrinkage after 30 minutes, with the conventional alginate continuing to shrink over time and the extended-storage alginates expanding with increased storage time. The conventional alginate was most accurate after 30 minutes. In contrast, one extended-storage alginate demonstrated minimal dimensional change at all storage times, and another was most accurate after 100-hour storage. However, in the current study only Kromopan and Alginplus showed shrinkage immediately which can be corelated with study done by Walker et al where other materials started shrinkage within 30 minutes . Walker et al concluded that study shows delayed pouring with dental gypsum should not adversely affect the dimensional accuracy of the generated casts with both extended-storage alginates.

Also, in the present study Hydrogum 5 & Millenium was found to be most effective after storage of over 4 days that is 96+ hours which compared well with results of Walker's studywhich found that extended pour alginate was most accurate at 100 hours.

Porrelli et al (2020) compared the stability of extended pour alginate material using optical scanning and digital methods for evaluation where Hydrogum 5 and Alginoplast were the materials used. The design configuration of the models in both the studies are also similar but, in this study, we have also used customized trays which was a drawback in Porrelli's study. Porrelli concluded that extended pour alginates have adequate dimensional stability for delayed pouring which is consistent with the results of this study.

In the present study, the materials were stored in a plastic bag under normal room temperature and not in a humidor or any other source of moisture. Zelezinska K et al (2018) [1] showed the storage conditions like humidor or with moist cloth expanded the impressions significantly. In this study, comparison between different types of storage was not done as the study was designed to get results in a normal environment.Dimensional stability of alginate impression materials in mainly dependant on the amount of shrinkage due to syneresis which can be measured by observing the change in weight over time. This would conclusively give a relation based on the amount of dimensional change related to the loss of weight. Assessment of weight variation was not included in the current study which is a limitation here .

V. CONCLUSION

Based on the findings of this study, following conclusions were drawn:

1. Cast obtained from each material showed significant dimensional changes at certain point of time but these changes were not clinically significant.
2. The dimensional accuracy of the cast obtained from extended pour alginate materials was clinically acceptable and hence storing the impression for delayed pouring can be a viable option.

Amongst the materials studied, Hydrogum 5 showed the best dimensional accuracy over a 4-day period and least was by Alginplus

SOME OF THE ADVANAGES FROM THE ABOVE RESULTS

1. Extended pour alginate materials can be a cost-effective choice of impression material in situations where pouring is delayed.
2. Extended pour alginates can be an alternative to conventional PVS impression materials.

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