Original Article

DOI: 10.7860/JCDR/2015/13627.6407

Dentistry Section

Dimensional Changes of Alginate Dental Impression Materials-An Invitro Study

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ABSTRACT

Background: Dentists are always looking ahead for more dimensionally stable material for accurate and successful fabrication of prosthesis in this competitive world. Arrival of newer materials and increased material market puts dentists in dilemma for selection of material.

Aim: The study evaluated the effect of variations in time of pour and temperature on dimensional stability of three brands of commercially available alginates.

Materials and Methods: Velplast, Marieflex & Zelgan alginate impression materials were evaluated by measuring dimensional accuracy of the master cast. A die was prepared and mounted on the apparatus for the ease of impression making.The prepared casts were categorized into five groups and made up of three brands of alginate impression material with variation in time of pour viz: immediate, 20&40 minutes interval and with varying temperature of 25^{0}C, 30^{0}C & 40^{0}C.

Results: Impressions showed least distortion at varying degrees of temperature for 20 minutes, but the values obtained by storing of alginate impressions for 20 minutes at 30^{0}C were found to be nearly accurate than the values obtained by storing of impression at 40^{0}C. However, storing showed shrinkage of impressions.

Conclusion: Marieflex showed better accuracy in comparison with other two materials. Maintenance of temperature and humidity play key role during storage & transport to prevent distortion. But the study suggests immediate pouring which will minimize the distortion. The manipulation instructions, temperature of mixing water, environment & water powder ratio also plays key role in minimizing the distortion.

Keywords: Accuracy, Cast distortion, Dimensional stability, Marieflex, Velplast, Zelgan

INTRODUCTION

Fabrication of successful and accurate prosthesis requires judicious application of experience and knowledge of dental materials. Obtaining an accurate cast of a dental arch is an important step in the success of various dental treatments.Because of time constraint pouring of impression by dentists themselves is on decline, as they prefer to send impressions to dental laboratories for making cast [1]. Thus, considerable delay is caused in pouring the model, after removal of the impression from the mouth; which is one of the reasons for causing dimensional changes in the impression, there by threatening the dimensional accuracy of the prosthesis [1,2]. Alginate is used as a major dental impression material worldwide in many clinical procedures. However, it begins to distort with the storage time for more than ten minutes and it cannot be used for clinical procedure like crown and bridge preparation after one to three hours. Because of these facts, the present study was planned to evaluate the dimensional accuracy of different brands of Alginate impressions available in Indian market and provide insights for best possible time of pour to prevent distortion of commercially available impression materials.

MATERIALS AND METHODS

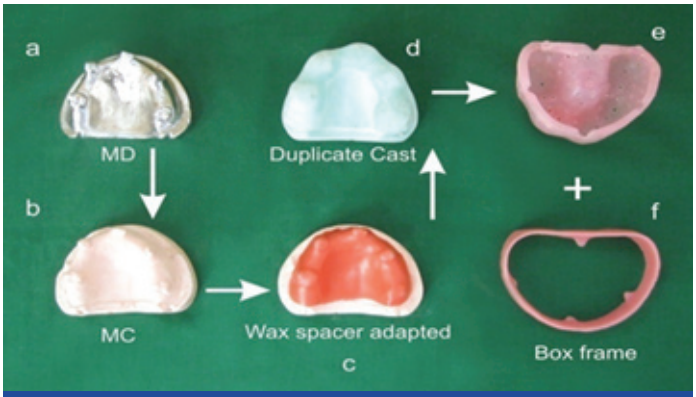
The study was designed and conducted in the Department of Prosthodontics, Crown and Bridge Sharad Pawar Dental College, Wardha. Maharashtra, India during 2009-2010 to evaluate dimensional accuracy of irreversible hydrocolloid (alginate) impression material by pouring impressions with variations in time of pouring and temperature.

A-Velplast (Keller laboratories), B-Marieflex (Dentsply Ltd.), C-Zelgan (Dental Product of India), Gypsum Type IV die material Kalrock (Kalabhai manufacturers, Mumbai) & Heat cure acrylic resin (Dental Product Of India Ltd) [Table/Fig-1] were used in the study. Instruments & Equipments used in this study were Vernier calliper, Alginator (Algimax-II;Holy medical Ltd), Humidor, Electrical balance (Aiwa, India Ltd), Vaccum mixer (Cuumyx; confident), Room heater (Lazer; quality appliances, India), Custom made Nickel-Chromium plated Aluminium die [1], perforated acrylic impression tray [Table/Fig-2], acrylic Box frame for pouring cast. A custom made apparatus was designed to maintain standardization and ease for impression making [Table/Fig-3]. Travelling microscope (INCO, Ambala, Haryana India) [Table/Fig-4].

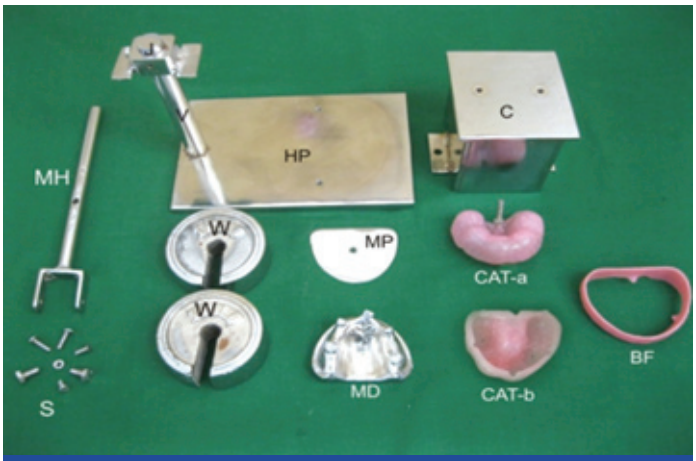
Making the impression

Nickel-Chromium plated Aluminium (metal) die, custom made perforated acrylic impression tray, metal stand with handle and platform, custom made acrylic Box frame for pouring cast. analuminium die was specially prepared for this study [1]. [Table/Fig-5]. Standard maxillary dentulous stone cast was used. Markings were done on mesiobuccal cusp tip of right first molar, cusp tip of right canine, mesioincisal angle of left central incisor, buccal cusp tip of first left premolar, distobuccal cusp tip of left second molar. This modified stone cast was then viewed under travelling microscope for clarity of vision of selected points for ease of recording of distance between these selected points. 'V' shaped notches were made at the horizontal land of the cast to facilitate proper orientation of the custom made acrylic tray while making impression each time. This helped in maintaining uniform space of 3 mm between the metal die and custom acrylic tray to provide uniform thickness of the alginate

[Table/Fig-1]: Showing the materials used in the study -three brands of alginate-Velplast, Marieflex, Zelgan, type IV gypsum and heat activated autopolymerising resin



[Table/Fig-2]: Showing the metal die with acrylic perforated tray and box frame



[Table/Fig-3]: Showing the apparatus for impression making

impression material everywhere, as alginate is a 'bulk' impression material.

A special impression tray was fabricated in heat cure acrylic resin. A stone master cast (MC) obtained by duplicating the metal die. A baseplate wax spacer of 3 mm thickness was adapted as per the outline marked over the cast, then the cast was duplicated using alginate material to obtain a duplicate master stone cast, over which the custom acrylic tray was fabricated. Flasking of this cast along with wax pattern was done in varsity flask using plaster mix following conventional method. After deflasking, a space of 3 mm all over was thus maintained to accommodate alginate mix of proper consistency. The perforations were then drilled all over using round stainless steel bur having 1 mm diameter and at a distance of about 1 cm from each other. The space of 3 mm between the tissue surface of the die and custom acrylic tray and 1mm diameter of perforations with 1cm spacing between two perforations were followed as per the ADA specifications for the use of alginate material to avoid any influence on dimensional accuracy of the impression and thereby on the cast obtained by pouring the impressions.

Specially designed metal stand used in this study ensured same orientation of custom acrylic tray over metal die (fixed over the metal cube) and also maintained a uniform space of 3 mm between the metal die and the inner surface of the custom acrylic tray and also the same load was applied while making all alginate impressions. An acrylic box frame (BF) was fabricated using auto polymerizing acrylic resin. A wax pattern of frame was prepared by boxing the custom tray. The key extensions of the custom tray was used for proper orientation of the box frame over the impression made using custom acrylic tray while pouring the stone cast.

Impressions were made using the metal apparatus that was fabricated to standardize the impression procedure [Table/Fig-5]. Each group consisted of total of 30 samples and each brand of 10 samples. Distilled water was used in this study so as to eliminate the effect of minerals on the property of alginate. The water powder ratio for Velplast was 20ml of water and 55gms of powder, Marieflex & Zelgan 22ml of water and 57gm of powder was used according to the manufacturer's recommendations. Impression materials were mixed using alginator with mixing time of 10 seconds as per the mixing protocol for the alginator.

Impression was poured with type IV gypsum product (Die Stone) under specific environmental conditions and storage time as per the protocol.As per the manufacturer recommendation 145.5 gm of die stone powder was mixed in 30 ml of water.The utility of specially designed metal stand with the custom acrylic tray and box frame has been proved in the study to provide uniform space of 3 mm for material, and making of the stone cast to perfection.

The following points were selected to measure the distance between each of the samples using travelling microscope with 10x magnifications after 24 hours of cast retrieval for evaluating the effect of variations in temperature i.e. 25^{0}C, 30^{0}C and 40^{0}C on dimensional accuracy.

A-E = Across the arch in transverse plane (posterior region)

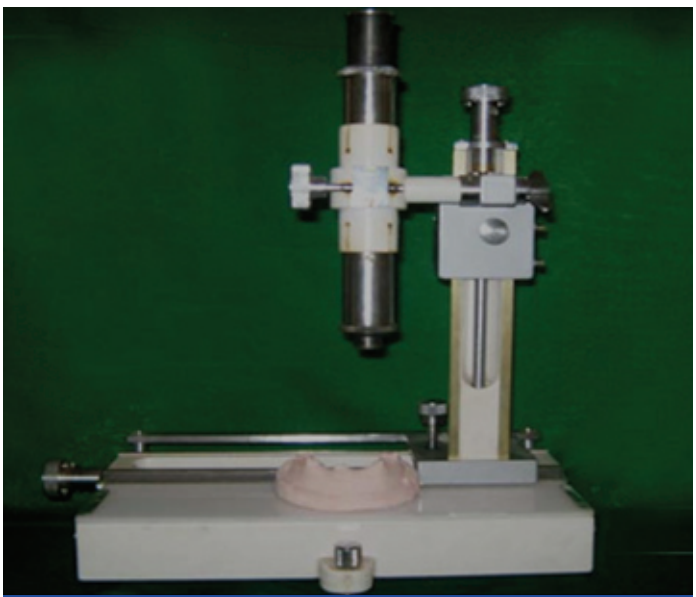
B-D = Across the arch in transverse plane (anterior region)

A-C = Diagonal (Antero posterior)

C-E = Diagonal (Antero posterior)

A-B = Sagittal plane on the right side (Antero posterior)

D-E = Sagittal plane on left side (Antero posterior)



[Table/Fig-4]: Showing the travelling microscope with cast for recording measurements

[Table/Fig-5]: Showing the impression procedure

The measurements were calculated using following formula:

Total count = Main scale reading + Vernier scale reading x Least count

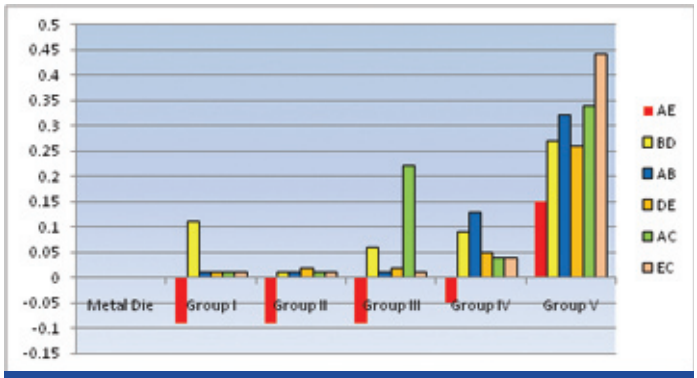
The least count for the travelling microscope used in this study was 0.01mm.The readings were then statistically analysed.

RESULTS

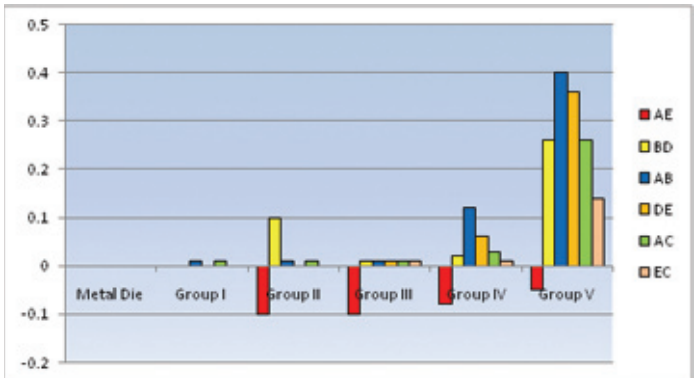
Careful evaluation of the casts obtained by pouring alginate impressions immediately showed accurate results even though insignificant difference was observed when impression was stored at varying degrees of temperature for 20 minutes [Table/Fig-6]. But the values obtained by storing the alginate impressions for 20 minutes at 30^{0}C were found to be nearly accurate than 40^{0}C. When the accuracy for the material were analysed the results obtained showed that material B showed more accuracy as compared to the materials A and C. Material C was considered to be the second best in order [Table/Fig-7,8]. This study can prove as a breakthrough for further evaluation of dimensional accuracy of alginate impression materials using other variables having potential to affect dimensional accuracy and dimensional stability of this popular impression material. Thus it can be summarized that there is definite correlation between time of pour and temperature of the room while pouring alginate impression on the dimensional accuracy of the stone casts.

DISCUSSION

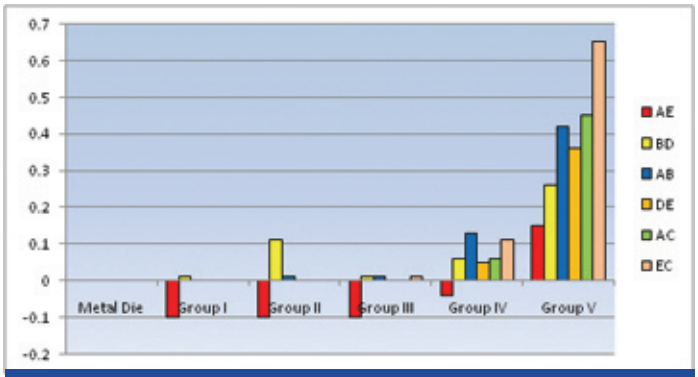
There are many rigid, thermoplastic or elastic materials available for recording impressions in dentistry. Amongst these, elastic materials are widely used because of elastic nature. The literature search in google scholar, Hinari, Pubmed, Cochrane data base, science direct using key words in abstract and title field was done. The literature was thoroughly reviewed to find the facts about the material. In the past many studies were performed to delineate properties of the materials [3-7]. The review of literature showed the scarcity of the published data on recently introduced material in India. The search revealed the few facts [8-12] about existing material in the world of dentistry but not exclusively in India. Only one published literature studied the recently introduced materials in Indian subcontinent [12]. The recent material claims dimensional stability because of improved techniques of production and sophisticated handling of material in terms of powder and liquid ratio, operating environment etc. In markets, every day new materials are introduced with a lot of claim in regard to superiority of material properties over the existing materials.



[Table/Fig-6]: Comparison of variations (shrinkage/expansion) amongst groups with metal die for material A (considering 'Zero' as base value of metal die)



[Table/Fig-7]: Comparison of variations (shrinkage/expansion) amongst groups with metal die for material B (considering 'Zero' as base value of metal die)
Differences in comparison with the measurements of Metal Die {(-) indicates shrinkage; (+) indicates expansion}



[Table/Fig-8]: Comparison of variations (shrinkage/expansion) amongst groups with metal die for material C (considering 'Zero' as base value of metal die).

In India,dental material market is fast growing as an excellent tourist destination for treatment because of lesser costs involved. Very few studies are available in the literature on the newly developing dental materials, which may lead to failure of treatment and will have an impact on growing health care market in India [12]. Lack of evidence based basic scientific knowledge on recently introduced materials created the necessity for basic invitro and invivo studies in regard to material properties. Keeping concerns over the mushrooming of dental manufacturers, their claims & scarce literature of newer emerging material properties created mandatory necessity for material comparison with existing old material and its concepts. Because of changing concepts it's very difficult for dentist to properly select material without evidence based literature. So, the study was planned to compare the properties of materials available in the market and comparison with existing literature so that it will provide fair idea about any improvements in relation to its accuracy and stability.

Impression materials should have ability to reproduce a true measured value and they should be dimensionally stable across time. But accuracy depends on evaporation of water and syneresis [2,13,14]. In an alginate gel water is either free or bound. Because of free water evaporation or imbibition by impression is susceptible to volumetric increase or decrease [14]. These properties primarily depend on storage conditions and syneresis is affected by constituents of the alginate [15]. Water loss in alginate depends on decrease in entropy, complex osmotic pressure, changes in Gibbs free energy, diffusion kinetics and gradient changes existing between the sol gel and environment also depends on ingredients [15].

Alginates with a lower ratio of calcium to sodium loose less water compared to alginates with a higher ratio of calcium to sodium and they exhibit greater dimensional stability [15]. Alginates containing higher ratios of filler to alginic polymer and lower-weight molecular polymer chains showed improved dimensional stability. Chromatic alginates are alkaline during initial mix but when sets it decreases to near neutrality [3-6]. Additives influence the dimensional stability which has not been examined to our knowledge but it may have a beneficial role.

Dimensional change of alginate is multifactorial and material specific. Dimensional stability of the impression material showed the greatest discrepancy from the standard model which was 0.005 inches and extended-pour alginate was 0.003 inches (approximately 75 μm) on the day one of pour. Generating the casts from the conventional alginate sooner is beneficial [7]. The amount of expansion or

shrinkage when carefully evaluated in the present study showed that the casts obtained by pouring alginate impressions immediately showed accurate results even though insignificant difference was observed when impression was stored at varying degrees of temperature for 20 minutes, but the values obtained by storing of alginate impressions for 20 minutes at 30^{0}C were found to be nearly accurate than the values obtained by storing of impression at 40^{0}C. A net contraction in the material usually follows the formation of the insoluble gel and the contraction may continue even if the impression is immersed in a liquid [15]. During shrinkage if impression material is bounded tightly with trays then material will be pulled toward the tray which causes an increase in tooth and arch widths. During imbibition it will distort by swelling.The shrinkage of material that took place towards the bulk of material is in accordance with the study by Wadhwa SS et al., [12].

The authors considered a greatest allowable deviation of 0.003 inches (75 μm) from the standard tooth model and arch width measurements for casts which are clinically acceptable. The range of 0.003 inches (i.e. between 27 and 83 μm) marginal discrepancy is clinically acceptable for cast and ceramic restorations [8,9]. The effect of variation in room temperature of 25^{0}C, 30^{0}C and 40^{0}C on the dimensional accuracy of the casts made after pouring alginate impressions made with all three brands,when compared with the measurements of the metal die, no significant difference observed with 25^{0}C. But at increase temperature of 30^{0}C and 40^{0}C, the expansion was observed which was statistically significant. [Table/Fig-6,7] show the number of specimens in each experimental group that met our standard of clinical acceptability. The marieflex alginate material met our standard.

The maximum allowable dimensional change for polysulfides is 0.40% and 0.60% for silicones [10].So, the authors considered 0.50% dimensional change in this study. The dimensional change in the present study ranged from –0.496% to 0.161% [Table/Fig-1,2]. Casts from the conventional alginate impression material should be generated within the two days. Careful precautions were followed in the study by customizing palatal vaults of stock trays with impression compound so that impression was of a uniform thickness. Excess material may undergo more dimensional change than other areas which contain a thin material [12].

Techniques involving the use of optical microscopes, which are capable of discerning as little as 1 μm and much more precise to measure dimensional discrepancies. During impression and preparation of cast random errors may arise from many sources like incorrect water powder ratio, improper size of the tray, movement during gelation, debonding of impression material from the tray, improper removal of the tray and prolonged contact with the gypsum product [12]. Gypsum products exhibit expansion during setting. Microstone has a maximum net expansion of 0.12%, may be because of negation effects of imbibition [12].

During gelation because of unequal pressure stress may occur and are relaxed after removal of the tray from the mouth which may result in a distorted impression [13]. The studies showed the distortion ranging from 100 to 500 μm during mandibular impression making [13,14]. The distortion is larger for both impression materials in our study. Furthermore, acrylic prostheses fabrication may introduce additional and possibly significant random errors. The study uses Alginator which will give easy consistent mixes, saves time and cleanup with smooth bubble free mixer [7]. Mechanical mixing would make impressions much easier to accomplish.

The study showed fabrication of dimensionally stable casts, occlusal splints, appliances and removable partial denture frameworks is possible with proper adequate storage within the limits (100% humidity). An alginate impression may expand, which indicates the processes other than dehydration, including polymerisation and imbibition.The storage of impressionfor a reasonable time could improve time of chair side procedures, which offers a potential advantage to the clinician [12]. It is also demonstrated as per the results of this study [Table/Fig-6] that the immediate-pour produced negligible amount of error in the casts which is insignificant clinically and also statistically than the storage methods. The delay in pouring of alginate impressions between 10-20 minutes produced an accurate cast than the stored alginate impressions for more than 20 minutes in humidor. But in contrast to our results, Wadhwa SS et al., showed storage of impression in a zip-lock plastic bag for upto 1 hour without any significant distortion [12]. It may be due to compositional variation as the material used in their study is different [12].

In this study, no significant differences in dimensional accuracy of the cast were observed which was obtained by pouring alginate impressions adhering to manufacturer's instructions, in regards to time and temperature. Prolonged storage of impressions for 40 minutes even at humidor leads to distortion of the casts obtained from almost all alginate impressions and differences werestatistically significant in regards to changes in dimensions of cast. The effect of variation in room temperature of on the dimensional accuracy of the casts when compared no significant difference observed with 25^{0}C. But at increased temperature of 30^{0}C and 40^{0}C, the expansion was observed which was statistically significant.

The dimensional accuracy of impression and master cast are multifactorial, it depends on manufacturer-composition, manipulative factors, environmental factors etc. Our study has not considered the manufacturer-compositions (viz. fillers) factors, etc [12] even though the study has been standardised and single experienced operator performed all procedures to prevent gross manipulative variations. But the study is carried out invitro; this may be one of the factor when compared to oral environment which contains saliva. Our study warrants multicentre same brand, multi-operator randomised blinded studies with large sample size along with compositional evaluation for each lot of material to check the variations if any.

CONCLUSION

The study showed immediate pouring of the cast is still recommended. Marieflex showed the best results in accuracy in comparison with other materials. During transport, maintenance of temperature and humidity play key role so that the least distortion make the successful prosthesis. The manipulation instructions with temperature of mixing water, environment & water powder ratio plays key role in minimizing the distortion. It is necessary to explore the topic further to evaluate the reason for the changes in dimensions of the casts obtained by pouring alginate impression at higher temperature.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Feb 19, 2015**
Date of Peer Review: **Apr 11, 2015**
Date of Acceptance: **Jun 23, 2015**
Date of Publishing: **Aug 01, 2015**