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Comparative Evaluation of Effect of Altered Pouring Time on The Dimensional Accuracy of Alginate Replacement Materials: An In-vitro Study

Dr. Tripti[1], Dr. Veena Hegde[2], Dr. Nayana Prabhu[3], Dr. Pradeep S[4], Dr. Kavishma[5], Dr. Vaishnavi[6], Dr. Disha Prabhu[7]

[1]Former Post Graduate Student, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India
[2]Professor, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India (Corresponding Author)
[3]Associate Professor, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India
[4]Professor and Head, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India
[5]Senior Lecturer, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India
[6]Senior Lecturer, Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India
[7]Tutor, Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India

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KEYWORDS

Alginate; Dimensional stability; Extended storage

ABSTRACT:

Aims: The present study aimed to evaluate and compare the dimensional accuracy of alginate replacement material with a traditional PVS impression material at different pouring intervals.

Methods and Material: In this in-vitro study, sample size estimation was done using G*power software (version 3.1.9.2), at 95% confidence interval. A total of 40 impressions samples were made. Stainless steel dies were used to make impressions in accordance with ADA specification 19 using Alginate alternate PVS, Xantasil (Material A, Test group n=20) and conventional light body PVS, Express XT (Material B, Control group n=20). This 20 Impressions in each group were further divided into 4 groups (n=5) and poured after one hour(α), 24 hours (β), seven days (γ) and fourteen days (δ) time intervals. After obtaining the casts following the respective storage times, dimensional changes were measured using a Toolmaker's travelling microscope (α=0.05). Statistical analysis was performed using Paired T-test with post hoc Dunnett to compare the dimensional accuracy at different time intervals.

Results: The dimensional stability of impressions and accuracy of casts was least when poured at 14 days, the changes in both materials at all given time intervals was clinically insignificant (less than 0.5%).There was no significant difference in both impression materials at all pouring intervals (Paired T-test with post hoc Dunnett; p>0.001).

Conclusions: The results indicate that Xantasil can be used as a substitute to conventional polyvinyl siloxane material. Statistical significance of delayed pouring of xantasil up to 14 days was comparable to conventional PVS.

Introduction

Although diagnosis, treatment planning and fabrication procedures are undoubtedly the cornerstones that govern the success or failure of a prosthesis; the process begins with impression making. Irreversible hydrocolloid especially alginate with its fast setting time, easy manipulation, pleasant taste and relatively low cost; remains the most widely used impression material for the fabrication of diagnostic casts. However, lack of dimensional stability, poor tear strength and detail reproduction have made

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way to introduction of other materials.[1,2,3,4] Alginate replacement materials for extended storage have recently been promoted with claims that the materials maintain their dimensional stability for up to 100 hours.[3] Every alginate application can make use of these components. These materials essentially assert that they are constructed of improved PVS, which has made them far less expensive than standard PVS despite having nearly identical properties.[5] Polyvinylsiloxanes (PVS) are addition silicone elastomeric impression materials that exhibit excellent tear strength, elastic recovery and superior dimensional stability allows extended storage time and obtain multiple casts from the same impression. However, the inherent hydrophobicity with prolonged setting time and substantially high cost has given rise to some limitations in the use of these materials.[6,7,8] Limited literature from previous studies have supported manufacturer claims of dimensional accuracy over delayed and multiple pour conditions to a certain extent. Even though extended-storage alginate materials were used in recent studies, the comparison was made with regular alginate rather than PVS material.[3,9] Therefore The purpose of this study was to evaluate the accuracy of alginate alternatives compared to that of PVS materials when impressions were stored for different time intervals. Null hypothesis: There is significant difference among the selected impression materials.

Methods and Methodology

This in vitro study was conducted at the Department of Prosthodontics and Crown and Bridge, Manipal College of Dental Sciences, Manipal. The Kasturba Hospital Institutional Ethical Committee Clearance was obtained for the study with the ethical clearance number 820/2018.
Sample size estimation was done using G*power software (version 3.1.9.2), at 95% confidence interval.

Fabrication of Master Die

Two stainless steel master dies were fabricated using a 3 axis CNC milling machine at MIT, Manipal in accordance with the revised ADA specification no 19 for non-aqueous elastomeric dental impression material and ISO 4823 for non-aqueous elastomeric dental impression material.[10,11,12] Three vertical lines – x, y and z of width 50µm were scribed atop the mould surface using an Electro discharge machine.[3] Line y passed through the center of the circular mould while lines x and z parallel to and 2.5mm from it on either side.[3,11] Two parallel horizontal lines 'cd' and c'd' each being 12.5 mm from the centre were scribed at right angles to lines x, y and z to produce points A, B, A' and B' having effective length AB = A'B'= 25mm.[3] [Figure 1] A master impression mold was fabricated to seat on top of the master die and contain the impression material while it sets.[3,11] [Figure 1]

Sample Selection and Fabrication

The alginate impression materials used in this study included one conventional polyvinyl siloxane material Express XT (Regular body, 3M, Minnesota United States) and extended-storage alginate material Xantasil (Heraeus Kulzer, Mitsui Chemicals Group, Armonk NY).[3] The auto mixing gun was loaded with a cartridge each of base and catalyst of the commercially available alginate replacement material and conventional polyvinylsiloxane.[3] Total of 40 casts were obtained from 40 impressions devoid of voids, surface irregularities or defects. These samples were divided into 2 groups of 20 impressions each made from Alginate alternate PVS, Xantasil (Material A, Test group n=20) and conventional light body PVS, Express XT (Material B, Control group n=20). These 20 Impressions were further divided into 4 groups (n=5). The first five samples were poured after one hour (α), and served as a control and remaining were poured after 24 hours (β), seven days (γ) and fourteen days (δ) time intervals. The mold and die were cleaned with alcohol to remove any debris before making impression.[13,14] The material was dispensed with master mould secured onto the master die.[3]A cover slip was placed over the mould to contain the impression material and held down with a 500gm standard weight to remove any excess material.[3][Figure 1] The impressions were allowed to set for 10 minutes following which they were retrieved from the impression mould and all excess material was trimmed using a BP blade.[3,14] [Figure 1] A total of 40 impressions were made following the same procedure. Impressions were considered to be satisfactory if all scribed lines were reproduced continuously for the full length and there were no other visible defects such as porosity.[3,14] [Figure 1] The retrieved impressions were poured after 1 hour. A wax mould resembling the master impression mould was fabricated to make retrieval of casts easier.[3] Initially 5 impressions of each material were poured in type IV gypsum (Kalrock, Kalabhai Karson Pvt Ltd, Mumbai, India) to serve as the control.[11] Adequate proportions (W/P ratio = 23:100) of die stone powder (25gm) and water (5.7ml) were taken in a rubber bowl, spatulated and placed on the dental laboratory vibrator (Lab vibrator, TBS India, Telematic Biomedical Services, India) to remove air bubbles, before pouring

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the cast.[14] The remaining impressions were stored as per manufacturer's instructions.[3,15] Five impressions of each material were used for fabrication of casts at the given time intervals– 1 day, 7 days and 14 days after impression making. The casts were allowed to set for 1 hour before retrieval and inspection for any surface irregularities/ defects.[3,10,14]

Test for Dimensional Accuracy

A Toolmakers travelling microscope (Mitutoyo TM series, Mitutoyo America Corporation, USA) was used for detailed evaluation of dimensions of the casts in comparison to the master die.[16] [Figure 1] Under the microscope at 25x, magnification lines x, y, z, cd and c'd' were clearly visible.[3,16] Points A, B, A' and B' were marked on the cast with a pencil. All observations were recorded by a single examiner.[16] Two measurements, correct up to 0.005mm were noted for each sample: Noted Two measurements for each sample were correct upto.[16]

a.Linear distance between points A and B i.e. distance between lines cd and c'd' on intersecting line x

b.Linear distance between points A' and B' i.e. distance between lines c d and c'd' on intersecting line z

An average of both readings was considered for each sample.[14,16]

Statistical Analysis

Liner dimensional changes were tabulated and standard deviation calculated. The data was analyzed using Paired T-test with post hoc Dunnett to evaluate and compare the dimensional accuracy of immediate and delayed poured casts at 95% confidence interval. The significance level was set at $P \leq 0.05$. Statistical analysis was performed using Statistical Package for Social Science (IBM,SPSS Inc. version 2.0).

Results

Table 1 and table 2 shows linear dimensions of control group, Material B (PVS Express XT) and test group, Material A (Xantasil). Mean and standard deviation values of the dimensional accuracy at immediate and delayed time intervals are presented in Table 3.

There was no significant difference ($p > 0.05$) in mean value of Material A Xantasil or Materal B Express XT samples, when tested at different time intervals.[Table 1,2] Maximum variation in dimensional stability for alginate alternatives(test group) was observed for casts fabricated on day 14 after impression making. Maximum variation in dimensional stability for traditional polyvinylsiloxanes (control group) was observed for casts fabricated on day seven after impression making. As the p-value > 0.05, no significant difference was established between test and control materials when tested at different time intervals. [Figure 1, Table. 3] Paired T test with post hoc Dunnett was used to compare the dimensional changes of delayed impressions (1, 7 and 14 days) to that of immediately poured impressions. As indicated by the Paired T-test with post hoc Dunnett, the highest value of dimensional change was observed for alginate alternatives for casts fabricated on day 14 after impression making. [Table 4, Graph 1]

Table 1: Study data for test material

Material	Time of impression pouring (Sample group)	Sample	Average dimensions (mm)
Material A (Test) Alginate alternate VPS	1 hour (α)	1	25.070
		2	24.835
		3	24.715
		4	25.195
		5	25.070
	1 day (β)	1	25.090
		2	25.175
		3	25.000
		4	25.205
		5	25.330
	7 days (γ)	1	25.185
		2	25.005
		3	25.145

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		4	25.455
		5	25.035
	14 days (δ)	1	25.105
		2	25.040
		3	25.235
		4	24.960
		5	25.250

Table 2: Study data for control material

Material	Time of impression pouring (Sample group)	Sample	Average dimensions (mm)
Material B (Control) Conventional polyvinylsiloxane	1 hour (α)	1	24.755
		2	24.835
		3	24.650
		4	24.905
		5	25.070
	1 day (β)	1	25.015
		2	25.295
		3	25.040
		4	25.080
		5	25.020
	7 days (γ)	1	25.205
		2	25.185
		3	25.030
		4	25.270
		5	24.930
	14 days (δ)	1	25.690
		2	24.890
		3	25.340
		4	25.200
		5	25.035

Table 3: Comparison of dimensional change when poured immediately & atdelayed intervals

Sample group		Mean	Std. Deviation	Difference	P value*
1 hour (α)	Material A	24.843000	.1584535	-0.134	
	Material B	24.977000	.1959783		0.128
1 day (β)	Material A	25.090000	.1174202	-0.07	0.396
	Material B	25.160000	.1241471		
7 days (γ)	Material A	25.124000	.1397050	-0.041	
	Material B	25.165000	.1784657		0.559

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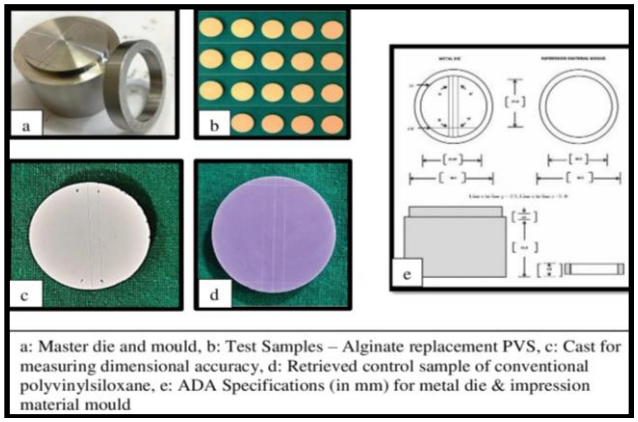
14 days(δ)	Material A	25.231000	.3074980	0.113	0.477
	Material B	25.118000	.1248299		

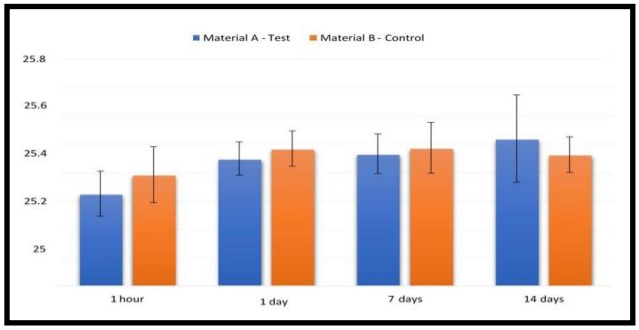
Table 4: Significance of mean differences at different time intervals

Sample Group	Mean Difference	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
β vs α	0.0640000	.931	0.408211	0.280211
γ vs α	0.0930000	.825	0.437211	0.251211
δ vs α	0.0247000	.190	0.591211	0.097211



a: Master die and mould, b: Test Samples – Alginate replacement PVS, c: Cast for measuring dimensional accuracy, d: Retrieved control sample of conventional polyvinylsiloxane, e: ADA Specifications (in mm) for metal die & impression material mould

Figure 1: Samples and procedure



Graph 1: Comparison of dimensional change when poured immediately & at delayed intervals

Discussion

Recording of impressions and production of cast are prec arious for efficacious fabrication of dental prosthesis. Impression materials should replicate intra ora l tissues as perfectly as possible to restore biological, mechanical, functional and esthetic prerequisites. Given that accurate casts accomplish various functions including patient education; diagnosis and treatment planning. Hence an exact unembellished impression is warranted for accuracy of models for ensuring appropriate treatment planning, fabrication of prosthetic appliance and successful rehabilitation.[15] Studies have found that the dimensional accuracy of casts constructed from alginate is time and material dependent. Ideally, when these materials are used, immediate pouring of the cast is advocated. However, results from certain modified products such as extended pour (Kromopan, Lascod; Triphasix, Parkell) or chromatic (Jeltrate, Dentsply) alginates suggest that delayed pouring – not later than 5 days, may be employed, when stable alginate is utilised and impression is correctly stored (Mitumoyo, Stackhouse).[15,16] Xantasil has been recognised as the most affordable substitute for alginate. It is a high-quality product that is accurate, easy to use, and stress-relieving for 10 to 15 minutes. It is economical, saves money, and accounts for 5% of practise overhead.[17] It can be used to study dental models, register them, get a bleaching trace, and get a first impression. The delivery method, which also features a precise component ratio that aids the clinician in mixing to clear up the problem, is of the highest quality.[17] According to study by Aathira et al 2020, they emphasize on all the advantages of the alternative impression material which would be a great preferred choice of clinicians. Hence clinicians come to know about the product well and incorporate it into their practice.[17] This research is required to convey the benefits of alternative materials and list the good features of alternatives effectively, enabling them to operate comfortably, quickly, and affordably. Additionally, this lessens the workload of the clinicians.[17] In the present study, polyvinyl siloxane-based alginate replacement material was used for evaluation of the effect of extended storage periods on dimensional accuracy. A wide array of permutations has been established for impression materials and their storage time before cast pouring. The time ranges from immediately to 13 weeks after retrieval from the mouth depending on the chemical composition of the material. It

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has been indicated that PVS impressions should be poured between 30 minutes and 21 days.[18] Alginate replacement VPS imprint material showed growth following initial 30-minute shrinkage in trials conducted by Walker et al. in 2010.[3] This behaviour may be connected to previously discovered variations in bound versus unbound water in extended-storage alginate materials with greater filler-polymer and Ca-Na ratios.[3,19] A measurement technique for dimensional change is not included in the ADA specification 18 for alginate imprint materials.[3,12,18,19] The protocol for dental elastomeric impression materials, as outlined in American National Standard Institute/American Dental Association Specification No. 19, was used to measure dimensional change over time (dimensional stability), in which the length of the middle horizontal line of the stainless steel die (Figure 1) is compared with the same line in the cast.[3,12,18,19] The two cross-points (marked X and X′) served as the measurement beginning and end points.[3,15] ADA Specification 19 for non-aqueous impression materials states that for a material to be considered as elastomeric, it must exhibit a 24-hour dimensional change no greater than 0.5% (Type I, III) and 1.0% (Type II).[11,12] Accordingly, Xantasil – the alginate substitute used in this study displayed a change <0.5%. Nevertheless, since elastic properties of permanent deformation and flow have not been investigated for alginate alternatives, it is hard to classify them appropriately in accordance with ADA/ANSI.[13,18] Previously, **Nassar et al** (2011) and **Torassian et al** (2010) compared the dimensional accuracy of irreversible hydrocolloid alternative impression materials with immediate and delayed pouring up to four hours and seven days respectively.[20,21] It was concluded that within the limitations of the studies, all alginate substitutes engaged demonstrated dimensional changes less than 0.5%. In the present study, this observation was corroborated and further extended to be valid for a period of up to 14 days.[20,21] **Martins et al** in 2019 conducted an evaluation of VPS impression type's dimensional alterations. After setting, the material shrank by 0.29%–0.15% and 0.32%–0.21% at 24 hours. After one week, the material shrank by 0.30%–0.23%.[22,23,24] The silicone was not observed to significantly shrink over time; it may be stored for a week without running the risk of clinically significant dimensional changes and is an effective and reasonably priced alternative to alginate.[22,23,24] The lack of standardisation of methodologies used in the research on the dimensional stability and accuracy of silicone-based impression materials was confirmed by **Naumovski et al** in a review of the literature in 2019, but all findings indicate that addition silicone is superior to condensation silicone in all parameters and to other elastomers.[23,24,25]

In a study, **S. Ahmad** in 2007 and later **Suprono** in 2012, evaluated the effect of immersiondisinfection on alginate, alginate alternative and addition cure silicone.[18,26] The results concluded that although both brands of alginate failed to meet the requirements of ISO 1563 for dimensional accuracy and surface detail reproduction, all alginate alternatives and addition silicone satisfied ISO 4823 for surface details by reproducing the 20µm line on the impression and 50µm on the resultant cast (best with type V stone).[18,26] Less than the required 1% of the linear dimensional change was observed.[18,25,26] However, it should be highlighted that the surface abrasion resistance of type III gypsum castings made from the alginate substitutes was negatively impacted by the immersion disinfection.[18,25,26] Limited literature is presently offered regarding "alginate replacement VPS" material. Although a wide range of parameters have been tested, nearly all the studies have compared this novel material to irreversible hydrocolloids. Considering its basic composition, this material should ideally be upheld to standards set by ADA/ANSI for elastomeric impression materials. Thus, future research can aim to compare these alginate substitutes to polyvinylsiloxane for all essential material characteristics. Thus the study proves against null hypothesis. In the present study, alginate replacement VPS Xantasil was evaluated for dimensional accuracy and stability when casts were fabricated immediately (at one hour) and at delayed (one day, seven days, fourteen days) time intervals. The results were compared to yardstick conventional polyvinylsiloxane for analysis.

The limitations of the present in vitro study include:

Only one alginate replacement PVS material was used in the study. The results obtained here may therefore not apply to the dimensional accuracy of other brands alginate substitutes. Environmental parameters of storing impressions such as temperature and humidity were not controlled. Impressions were stored according to manufacturer instructions in a plastic bag. This may affect the dimensional accuracy at delayed pouring times differently. Inherent variability of alginate substitute PVS impression material used in the study as it mainly composed of water. It would have been better to measure the same impression across time to reduce variability, instead of separate impression. To standardize the study to measure dimensional change, impression with voids were discarded; hence a future research can aim to study at effect of voids on dimensional stability. Ideally, the impression shrinkage is countered by gypsum

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expansion and could affect the dimensional accuracy of the cast obtained. However, this was ruled out as the objective of the present study was to make it as clinically significant as possible.

Clinical Implication

Since these materials are comparable in dimensional qualities to conventional PVS materials, they can be employed in impression making with delayed pouring economically.

Conclusion

Within the limitations of the present study, the following conclusions can be drawn:

1. The dimensional accuracy of alginate replacement VPS impression material is comparable to that of traditional polyvinylsiloxane.
2. Dimensional stability reduces with time with both immediate and delayed pouring until 14 days, statistically this difference is insignificant.

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