Original Article

Accuracy of Some Elastic Impression Materials Used in Prosthetic Dentistry

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Abstract

Objective: Elastic impression materials considered favourable decision in fixed and removable prosthesis due to ease of use and accuracy. High price tag is the main drawback. The purpose of this study was to evaluate surface detail reproduction and dimensional stability of newly introduced 3M Preliminary Penta™ VPS in comparison to other elastic impression.

Methods: Alginate, alginate replacement and 3M light body were tested for surface detail reproduction and dimensional stability. Ten samples were prepared for each using a stainless-steel die that was created according to ADA specification No. 18 and 19. Surface detail was assessed directly after setting while dimensional stability was evaluated immediately and 24hr after. The data were analysed using a paired sample t-test.

Results: All the samples were able to record 75µm line for surface detail. Surface record of 3M imprint™ 4 Preliminary Penta™ VPS showed a similar result to light body. While alginate failed to reproduce 50µm and 20µm lines. Regards to dimensional stability, light body resisted change with respect to time. In contrast, alginate revealed a significant effect ($p<0.05$) on dimensional stability for the same storage period while not a major effect was observed for alginate replacement.

Conclusions: Within the limitations of this study, it can be concluded that light body underwent less dimensional change than alginate and alginate replacement. It also revealed a better replication of details. Alginate replacement was more stable during the storage period with better surface detail record than alginate.

Keywords: *Alginate, 3M light body, 3M imprint™ 4 Preliminary Penta, Elastomeric.*

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Introduction

Impression materials are used for registration of hard and soft oral structures for fabrication of definite dental prosthesis, therefore, a precise replica is necessary to form an ideal cast[1]. Hydrocolloids considered as a first elastic material to be used in the dental field, they include reversible (agar-agar), irreversible (alginate) hydrocolloids and synthetic elastomers (polysulfides, polyethers, silicones)[2].

Alginate is the most frequently used irreversible hydrocolloid due to elastic state. They are frequently used for prosthodontic and orthodontic purposes[3] to make preliminary impressions for provisional crown and bridge, study model, sports mouth guard, bleaching trays and removable prosthesis[4]. It was developed by the US Navy as a replacement of Agar during the second world war[5] due to a shortage of raw materials for making reversible hydrocolloid[6].

The wide popularity of alginate is due to the faster reaction at a higher temperature and elastic property that allows it to be withdrawn over the undercut and also low wetting angle makes the material hydrophilic in nature that facilitate accurate impression in the presence of saliva or blood[7]. Despite these good mentioned properties, alginate restrict its use in some cases such as inadequate capturing of the margins will result in misfit prosthesis[8]. Moreover, marginal tearing of the impression is most commonly seen when making an impression for deep undercut this is related it is viscosity[9]. Additionally, removal of impression prior to the complete set of the material may also cause marginal tearing[10].

Pouring time is also a very critical point when dealing with alginate. The impression should be poured within 15 minutes because the material will undergo dimensional change due to high water content (85%) which puts it at high risk of expansion associated with imbibition or shrinkage due moisture loss[1,11]. In a study by Walker et al[12], a significant difference in dimensional change was noticed after 30 minutes of storage. Other studies also showed that alginate is stable when poured immediately but the dimensional stability will diminish with time[13].

The shortcomings of irreversible hydrocolloid enabled the researchers to develop a new impression material that somewhat satisfies the requirements for ideal impression material. In 1950s, elastomeric impression materials, first in the form of polysulfide and later silicone was introduced[14]. Elastomeric impression material considered to have better dimensional stability and they don't require to be poured immediately after impression taking; they are used in cases where the precise replication of the prepared tooth is required like crowns and inlay/ onlay[15].

According to the polymerization method of silicone impression material, they are classified into addition reaction silicone (Vinyl Poly Siloxanes-VPS) and condensation curing silicone (polysilixone)[16]. The earlier one is characterized by excellent dimensional accuracy and long-term dimensional stability[16] and pouring can even be delayed for one week[17]. The later one is characterized by high hydrophobicity which makes an impression in a wet environment difficult, also dimensional instability is another issue[14,18].

A study by Eames et al[19] tested thirty-four elastomeric impression materials for accuracy and dimensional stability at 30 min and one day after. Additional silicon revealed the least change over the tested period. Clancy et al[20] studied additional silicon over 4 weeks, their findings concurred with the previous study. Others have tested VPS under dry, moist and wet conditions; results revealed non-significant effects on the dimensional accuracy[21].

Introduction of alginate replacement as a lower cost material, in contrast to more expensive additional silicon opened a new opportunity for dental clinicians. They are clean, accurate since the material is premixed and the ratio is automatically correct[22], dust free, easier impression making due to thixotropic nature, and most importantly pouring can be delayed and even multiple pouring can be done with the same impression[23].

This research was conducted to evaluate the dimensional accuracy and detail reproduction of the newly developed silicone impression material by 3M imprint™ 4 Preliminary Penta™ VPS and compare it with alginate impression material and regular set 3M light body.

Materials and methods

In this study, 30 samples were prepared in total for the three impression materials (Alginate, 3M imprint™ 4 Preliminary Penta™ VPS and 3M light body). Surface detail reproduction and dimensional stability tests were conducted for each using a stainless-steel die that was constructed according to ADA specification No. 18 and 19. The apparatus (Figure 1) consists of three parallel lines 25mm in length horizontally and two vertical ones that bisects the three parallel lines. The parallel lines have a width 50µm, 20 µm and 75 µm from the top respectively.

Before each material being placed onto the die, the ruled surface was cleaned with alcohol and the metal ring was lubricated with petroleum jelly to aid in separation when the material sets.

For alginate, the powder was mixed with distilled water according to manufacturer's instruction using alginate auto-mixer. After amalgamation, the mixture was placed onto the metal ring conditioned in a thermostatically controlled water bath at 35±1 ºC and a glass slab was placed over the stainless-steel die and loaded with 1kg mass. The sample was removed 3 minutes after the stated setting time by the manufacturer. This was according to ISO 1563:1990 for dental alginate impression material and ADA specification No. 18 for alginate impression material[24,25]. In regard to the other two, the materials were loaded onto the apparatus and were transferred to a water bath at 32±2ºC. The work was done without the use of latex gloves[26]. The impression was separated from the die following three minutes after the minimum time recommends by the manufacturer for removal of impression from the mouth. The testing procedure was followed according to ADA No.19 for elastomeric impression material[27]. The images for the sample of each impression material is shown in Figure 2.

All the samples were prepared under uniform atmospheric pressure conditioned at 23.0±1.0ºC and 50±5% relative humidity according to ADA specification No.18 and 19[25,27].

In regard to detail reproduction, the samples were examined immediately after separation from the die under daylight and recorded whether 20 µm, 50µm and 75 µm lines are completely reproduced over the full length of 25mm distance between the cross line[24,27]. The surfaces were assessed according to the ranking system established by Owen[28] which are:

Score 1: Line reproduced clearly and sharply over entire length between the marks.

Score 2: Line clear over more than 50% of length, or line indistinct over less than 50% of length, the line appears to be reproduced well over the entire length, but not sharply.

Score 3: Line clear over less than 50% of length, or line indistinct over more than 50% of length, or line visible over entire length but blemished not sharp.

Score 4: Line is not reproduced over entire length; rough, blemished, pitted.

Only the samples that satisfy the requirements for Owen's score 1 were used for dimensional stability[29]. For a dimensional change, the ingots were observed directly after removal from the die under Maozua digital microscope at 8x magnification. The distance between the cross lines D_1 and D_2 were measured using the software provided and after 24 hours on the same sample[27]. During the waiting period, the samples were kept in a standard laboratory condition which were 23 ºC ±1 ºC and 50± 5% humidity. The percentage of dimensional change was calculated using the formula: (A-B)/A x 100[27]. Where 'A' is the distance between D_1-D_2 on the metal block and 'B' is the distance between the cross lines on the impression.

Statistical analysis

Shiparo-wilk test used to check normality of the data. Statistical package of social science (SPSS), version 23 and Microsoft Excel were used for data analysis. Paired sample t-test was used to compare means from the same group at different time. p value ≤ 0.05 was considered to be statistically significant.

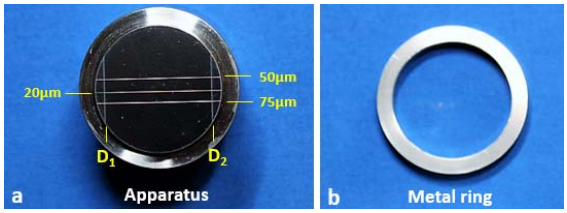

Figure 1: a) Stainless steel die for measurement of dimensional stability and surface detail reproduction. b) Metal ring to cover the die.

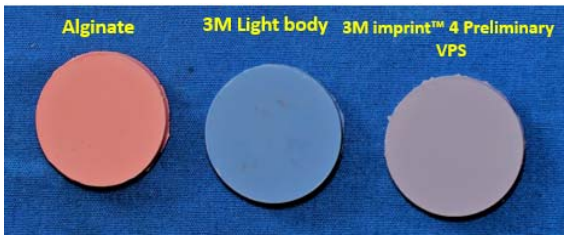

Figure 2: Photographic representation of the three impression materials used.

Results

The three impression materials were compared for their surface detail reproduction and dimensional stability.

Surface detail reproduction

The results for this test showed that all the materials were able to record the 75µm line with Owen's score 1 requirements. While for 50 µm satisfied Owen's score 1 for all the samples in both light body and alginate replacement (Figure 3). However, alginate revealed Owen's score 2 and 3 for 40% and 60% tested samples respectively. Light body and alginate replacement fulfilled Owen's scored 1 (20µm) for 80% and 60% of samples accordingly. While all the tested samples for Alginate manifest Owen's score 4 for the 20 µm line (Figure 4).

Dimensional stability

Based on the results obtained from paired sample t-test, it showed that the mean value for alginate immediately after removal from the die was 25.01mm and after 24 hrs the value reduced to 21.37mm for dimensional stability of the samples. This showed a significant mean reduction by 15% ($p<0.05$; $t=68.66$). For alginate replacement, it revealed a minor significant difference of 0.11% between the means before (24.90mm) and after (24.87mm) the given time. While the light body was the most dimensionally stable material, with no significant difference ($P>0.05$; $t=-0.61$) even after one day (Table 1 and Figure 5).

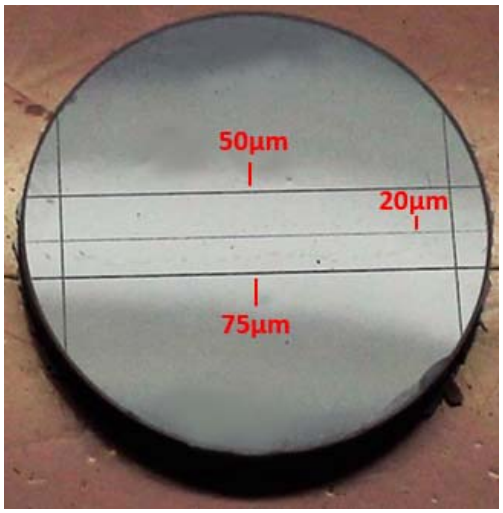

Figure 3: 3M imprint™ 4 Preliminary Penta™ VPS showing Owen's score 1 for all the lines.

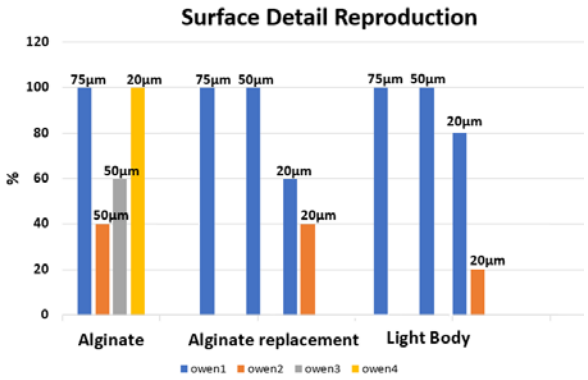

Figure 4: Summary of surface detail reproduction for the three-material tested.

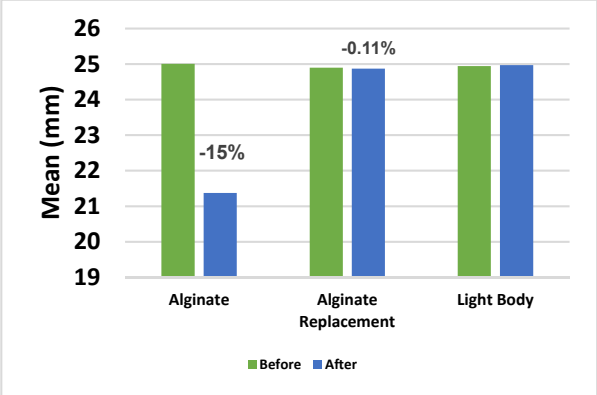

Figure 5: Illustrates the effect of time on dimensional stability

Discussion

There is a countless number of impression materials used in dental practice to capture oral cavity structures, the decision will be based on the type of treatment provided and clinician's preference[30]. The common method to test impression material for surface detail and dimensional stability is using ADA specification 18 & 19 apparatus. It is important to point out that this method does not completely replicate the clinical situations the material goes through during impression making.

One of the ideal requirements for impression material is the elasticity and dimensional stability. Nowadays the elastomeric impression materials are most commonly used in dental practice, but their cost is the main drawback. In this study, accuracy of alginate replacement (3M Preliminary Penta™ VPS) was compared with other elastomeric impression materials since this is a newly developed and it has properties better than alginate and closely resembles other elastic impression materials with a lower price tag.

Table 1: Comparison of three tested impression material by paired t-test.

Material		Mean(mm)	SD	t	df	p-value
Alginate	Before	25.01	0.12	68.66	9	0.0001
	After	21.37	0.15			
Alginate Replacement	Before	24.90	0.14	5.58	9	0.0001
	After	24.87	0.14			
Light Body	Before	24.94	0.14	-0.61	9	0.559
	After	24.97	0.16			

The ability of a material to record fine details is a very critical point for the final prosthesis success. The results of this study showed that alginate was able to only record 75µm line successfully. While the other lines were not recorded sharply. Composition of alginate is one of the factors that play an important role in this equation; trisodium phosphate is used to slow down the chemical reaction between powder and water and any change in it is concentration dramatically affect the accuracy[31].

According to the standard set for detail reproduction by ADA specification No. 19 and ISO 4823:2000, elastomeric impression material should record the 20 µm width in two out of three specimens[27,32]. The light body fulfilled the requirements while alginate replacement could not meet the two out of three samples for the 20µm benchmark set for type III (light body) and type II (medium body), while it is detail reproduction resembles heavy body (type 1) and putty (type 0) consistency.

The conflict between the two silicon impression material could be the result of different hydrophilicity of the material that is related to the surface free energy of the unpolymerized material and it is ability to wet the impressed surface which plays a crucial role in detail reproduction[33,34]. The effect of different amount and size of filler particles and the extent of cross-linking agents could also be a possible explanation of the present results[35].

Based on the results for dimensional stability of the current study, the results showed that both 3M light body and 3M imprint™ 4 Preliminary Penta™ VPS was within the specification standard of maximum 0.5% liner dimensional change within 24 hrs according to the standard that is set ADA No.19[27]. It is critical to point out that 3M imprint revealed a statistically significant effect ($p<0.05$) during the storage period. Even though more than 24 hrs storage period was not recorded, but the results suggest with continuous storage for both elastomeric impressions, they would be susceptible to further change; this might exceed the 0.5% standard mark.

The good dimensional stability is due to its chemical structure made from polymethyl hydrogen siloxane copolymer with silane terminal group as a base material. While the accelerator contains vinyl-terminated polydimethylsiloxane, during mixing an addition reaction occurs between the silane and vinyl groups and a minimum hydrogen gas released which result in a minimum dimensional change[36,37]. Also the addition of palladium as hydrogen absorber consequently resulting in a better dimensionally stability of the impression[37.38].

In concern to alginate, the material was significantly influenced by the storage period. To this date, there is no standard protocol that concerns with dimensional stability of alginate. ADA specification No.19[27] considers a 0.5% change as a baseline for dimensionally stable material within the 24 hrs. If this guideline is used for evaluation of mean dimensional change, alginate does not follow the definition of dimensionally acceptable material because it had 15% shrinkage within the 24 hrs.

The potential explanation of this behaviour could be due to hydrophilic nature that makes the material unstable in environmental humidity and temperature[23] due to water evaporation(syneresis) causing shrinkage and associated water exudation onto the impression surface, leading to a perpetual contraction of the colloidal skeletal network even at 100% humidity[12] that puts it at a higher risk for dimensional change at a daily environment. In addition, alginate with high filler content in contrast to alginic polymer and lower-weight molecular polymer chains will have an influence on dimensional stability[39].

Conclusions

Within the limitations of this *in vitro* study, it can be concluded that the light body underwent less dimensional change than alginate and alginate replacement. It also revealed a better replication of details. Alginate replacement was more stable during the storage period and with better surface detail record than

alginate but not to the light body's standard. It can be concluded that alginate replacement can replace conventional alginate, heavy body and putty PVS. Because of the experiment cannot exactly mimic oral conditions the results of this experiment should be considered with caution.

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