Original Article

Surface Detail Reproduction and Dimensional Stability of Contemporary Irreversible Hydrocolloid Alternatives after Immediate and Delayed Pouring

Abstract

Purpose: To overcome the poor dimensional stability of irreversible hydrocolloids, alternative materials were introduced. The dimensional changes of these alternatives after delayed pouring are not well studied and documented in the literature. The purpose of the study is to evaluate and compare the surface detail reproduction and dimensional stability of two irreversible hydrocolloid alternatives with an extended-pour irreversible hydrocolloid at different time intervals. **Materials and Methods:** All testing were performed according to the ANSI/ADA specification number 18 for surface detail reproduction and specification number 19 for dimensional change. The test materials used in this study were newer irreversible hydrocolloid alternatives such as AlgiNot FS, Algin-X Ultra FS, and Kromopan 100 which is an extended pour irreversible hydrocolloid as control. The surface detail reproduction was evaluated using stereomicroscope. The dimensional change after storage period of 1 h, 24 h, and 120 h was assessed and compared between the test materials and control. The data were analyzed using one-way ANOVA and *post hoc* Bonferroni test. **Results:** Statistically significant results ($P < 0.001$) were seen when mean scores of the tested materials were compared with respect to reproduction of 22 µm line from the metal block. Kromopan 100 showed statistically significant differences between different time intervals ($P < 0.001$) and exhibited more dimensional change. Algin-X Ultra FS proved to be more accurate and dimensionally stable. **Conclusions:** Newer irreversible hydrocolloid alternative impression materials were more accurate in surface detail reproduction and exhibited minimal dimensional change after storage period of 1 h, 24 h, and 120 h than extended-pour irreversible hydrocolloid impression material.

Keywords: *Dimensional stability, impression materials, irreversible hydrocolloid alternatives*

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Introduction

Surface detail reproduction and dimensional stability of an impression are paramount to the overall success of prosthodontic treatment.[1] Ideally, an impression material should be stable in dimension over time to allow the operator to pour the impression at convenience. Irreversible hydrocolloids are the conventionally used impression materials by dental clinicians. The storage time before pouring is a significant factor in the dimensional stability of irreversible hydrocolloids and the accuracy of the resulting stone casts.[2-5]

Irreversible hydrocolloid impression materials were originally developed during World War II, due to the scarcity of raw materials for reversible hydrocolloids.[6] Irreversible hydrocolloids are basically water-based materials that are cost-effective and can be easily manipulated by following the manufacturer's directions.[2,7] This makes them an indispensable part of dental practice. The popularity of irreversible hydrocolloids is attributed to their low cost, hydrophilic nature, and ease of manipulation as compared to other impression materials.[4,7-11]

Despite being widely used and accepted, irreversible hydrocolloids are not stable impression materials for storage. The greatest disadvantage of irreversible hydrocolloids is their low dimensional stability.[4,5,7,11-13] Water absorption (imbibition) and water exudation (syneresis) that occurs over time may result in the production of inaccurate casts, and it is generally recommended that irreversible hydrocolloid impressions should be poured immediately[3-5,8-11,14-19] or within few minutes after removal from

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the mouth.[20-22] Nevertheless, immediate pouring of an impression may not always be possible, especially when it has to be sent to a dental laboratory.

A number of new generation "extended-pour" irreversible hydrocolloids are available in the market that claim to maintain dimensional stability and accuracy with delayed pouring times of up to 100 h when stored as recommended by the manufacturer. These extended-pour irreversible hydrocolloids are designed such that the operator has the option of delaying the pouring time of impressions under specified storage conditions. A recent investigation showed that the storage of these impressions for up to 100 h resulted in minimum dimensional change.[23-25] However, repouring of the impression is not advised in extended-pour irreversible hydrocolloids and they are considered to be inferior to elastomeric impression materials in regard to surface detail reproduction and dimensional stability.

Alginate alternatives have been developed to overcome the drawback of less storage time of conventional irreversible hydrocolloids. These are basically addition cure polyvinyl siloxane (PVS) which are less expensive silicones and can be stored for longer time before pouring. The introduction of these newer alternatives has provided an additional choice of impression material for a variety of clinical applications in fixed partial dentures, removable partial dentures, orthodontic appliances, night guards, and sleep apnea appliances. According to the manufacturers of products such as AlgiNot FS (Kerr Corp., Romulus, MI) and Position Penta Quick (3M ESPE, St. Paul, MN), the pouring of impressions can be delayed without any significant distortion in the resultant casts. The manufacturers also claim that the accuracy of impressions may be unaltered even after repouring of casts. Recent studies have reported that these two irreversible hydrocolloid alternatives were more accurate with regard to the surface detail reproduction and they were dimensionally stable over an extended period.[26-29] However, the number of laboratory and clinical investigations on these materials is much lower than the number of studies on traditional irreversible hydrocolloids.

The purpose of this study was to evaluate and compare the surface detail reproduction and dimensional stability of two irreversible hydrocolloid alternatives with an extended-pour irreversible hydrocolloid impression material as control, at different time intervals. The null hypothesis was that there would be no significant difference between the two irreversible hydrocolloid alternatives and extended-pour irreversible hydrocolloid impression material with regard to the surface detail reproduction and dimensional stability.

Materials and Methods

The testing apparatus consists of a ruled metal block and ring mold. The dimensions of the apparatus were set according to the ANSI/ADA specification 18,[30-33] and all the impressions were made on the metal block. Three longitudinal lines X, Y, and Z were engraved onto the surface of the metal block with widths of 50 ± 8 µm, 20 ± 4 µm, and 75 ± 8 µm, respectively. These longitudinal lines were intersected by two transverse cross lines cd and c'd'; the distance between them was 25 mm. Exact measurement of each of the engraved longitudinal line was made before the commencement of testing, and widths were found to be 55 µm, 22 µm, and 77 µm.

Evaluation of surface detail reproduction

The metal block and ring were placed in a thermostatistically controlled water bath at a temperature of 32°C (±2°C) for 30 min to simulate the oral temperature before making the impression. For Kromopan 100, the powder was mixed with distilled water according to the manufacturer's recommended ratio. The ring mold was placed onto the metal block, and mixed impression material was applied directly onto the lined surface of the metal block. A glass slab was pressed slowly onto the impression material. Care was taken not to incorporate air in between the impression material and the glass slab. The assembly was immediately transferred to a water bath at 32°C ± 2°C. A 1 kg weight was placed on top of it to maintain a uniform force until the material was set. The ring mold was then separated from the metal block and the impression was retrieved and then examined immediately.

For AlgiNot FS and Algin X ultra FS, the mixed impression material was injected onto the lined surface using auto mixing tips and a dispensing gun loaded with the impression material cartridge, and the procedure was carried out in a similar manner.

Further, for the quantification of the surface detail reproduction, the specimens were examined immediately under the stereomicroscope (Labomed, USA) with eyepiece magnification of 10×, zoom magnification of 0.8. The impression material specimens that visually reproduce the 22 µm (Y line) of the steel die in its entirety were included for the microscopic measurements. The microscope eyepiece lens had a calibrated scale with readings in the nanometer scale (nm) which allowed for precise measurements of the samples. The readings obtained under the microscope were converted to the millimeter scale (mm) using the following formula:

$$\text{Numberof units} = \frac{\text{mm}}{\text{Eyepiece magnification} \times \text{zoom magnification}}$$

Evaluation of dimensional stability

The impression material specimens of each test material were made in a similar manner as described previously for surface detail reproduction for determining the dimensional change. The impression specimens were pressed out of the mold using the riser. These specimens were stored at room temperature for 1 h, 24 h, and 120 h for the assessment of dimensional change over the storage period. Kromopan 100 specimens were stored in sealed plastic zipper pouches whereas AlgiNot FS and Algin X ultra FS specimens were stored in open containers and maintained at room temperature until they were observed.

To determine the dimensional stability, the distance between the cross lines cd and c'd' on the ruled metal block was measured using a stereomicroscope at 10× eyepiece magnification and 0.8 zoom magnification and recorded as reading "A". The distance between the cross lines cd and c'd' reproduced in the impression specimens was measured at 1 h, 24 h, and 120 h of all specimens and recorded as reading "B". The measurements were made with the aid of the edges of the cross lines and performed each time in the same way, i.e. by measuring the same distance using the same reference point. The dimensional change was then calculated using the formula outlined in the ANSI/ADA specification number 19.[34]

Dimensional change %= (A–B)/A × 100.

Results

According to the results of one-way ANOVA, significant differences were found between the test materials and control in surface detail reproduction ($P < 0.001$) [Table 1 and Figure 1].

The results of the *post hoc* Bonferroni test showed a mean score higher in AlgiNot FS samples ($P = 0.011$) and Algin X Ultra FS ($P < 0.001$) when compared with Kromopan. However, no statistically significant differences were found between AlgiNot FS and Algin X Ultra FS ($P = 0.069$) [Table 2].

After calculating the percentage linear dimensional change, repeated ANOVA results showed statistically significant differences in the dimensional change of Kromopan samples at 1 h, 24 h, and 120 h ($P < 0.001$). The *post hoc* Bonferroni analysis results showed statistically significant differences between 1 h and 24 h ($P = 0.010$), 1 h and 120 h ($P = 0.001$), and also between 24 h and 120 h ($P = 0.044$) with mean value higher at 120 h [Table 3 and Figure 2].

A comparison of the dimensional change in AlgiNot samples by applying repeated ANOVA showed statistically insignificant results at different time intervals ($P = 0.064$). The *post hoc* Bonferroni analysis results for the AlgiNot group at 1 h, 24 h, and 120 h also showed statistically insignificant differences [Table 4 and Figure 3].

Repeated ANOVA for the comparison of dimensional changes in Algin X Ultra samples showed statistically insignificant results at different time intervals ($P = 0.064$). The *post hoc* Bonferroni analysis results for Algin X Ultra samples at 1 h, 24 h, and 120 h showed statistically insignificant differences [Table 5 and Figure 4].

Discussion

The conventional irreversible hydrocolloid is basically a linear polymer of a sodium salt of anhydro-β-D-mannuronic acid. When alginic acid reacts with a calcium salt, it produces an insoluble elastic gel called calcium alginate. When mixed with water, the alginate material first forms a sol. The following chemical reaction forms a gel to create the set impression material.[14] The major constituent of set hydrocolloid impression materials is water, which is a crucial factor in dimensional stability. Irreversible hydrocolloid impression contains almost 70% of water.[17] Because of this high water content, it is subjected to syneresis or loss of water. With time, the water is expelled from the interstitial spaces between chains. Therefore, the macroscopic result is

Table 1: Comparison of mean score using one-way ANOVA test for surface detail reproduction

Test materials	*n*	Mean±SD	95% CI for mean		*F*	*P*
			Lower bound	Upper bound		
Kromopan	60	24.67383±0.313061	24.59296	24.75471	13.310	<0.001
AlgiNot	60	24.78750±0.165646	24.74471	24.83029		
Algin X Ultra	60	24.87443±0.106831	24.84684	24.90203		
Total	180	24.77859±0.227802	24.74508	24.81209		

CI: Confidence interval; SD: Standard deviation

Table 2: Group comparison using *post hoc* Bonferroni tests for surface detail reproduction

Group (I)	Group (J)	Mean difference (I-J)	*P*	95% CI	
				Lower bound	Upper bound
Kromopan	AlgiNot	0.113667*	0.011	−0.20584	−0.02150
	Algin X Ultra	−0.200600*	<0.001	−0.29277	−0.10843
AlgiNot	Kromopan	0.113667*	0.011	0.02150	0.20584
	Algin X Ultra	−0.086933	0.069	−0.17910	0.00524
Algin X Ultra	Kromopan	0.200600*	<0.001	0.10843	0.29277
	AlgiNot	0.086933	0.069	−0.00524	0.17910

CI: Confidence interval, *P<0.05 is statistically significant the shrinkage of the impression. Furthermore, the material is capable of absorbing water through imbibition, which results in the expansion of the impression. A study was conducted by Garg *et al*. to evaluate syneresis and imbibition in four commercially available irreversible hydrocolloid impression materials at different time intervals of 10, 20, and 30 min and found different rates of imbibition and syneresis at different time intervals.[35]

Irreversible hydrocolloid alternatives were first introduced in 1984 to overcome the drawbacks of irreversible hydrocolloid impression materials.[36,37] They are less expensive silicone materials having better physical properties compared to irreversible hydrocolloids. The present study was conducted to compare such irreversible hydrocolloid alternatives with one extended-pour irreversible hydrocolloid as control, with regard to the surface detail reproduction and dimensional change.

The extended-pour irreversible hydrocolloids are newer materials that show promising dimensional stability up to 120 h. The studies performed by various authors such as Todd *et al*.[38] and Eriksson *et al*.[39] have shown Kromopan 100 as a stable material with less dimensional change for up to 48 h. Walker *et al*.[23] evaluated the dimensional change over time of two extended-pour irreversible hydrocolloid impression materials with conventional irreversible hydrocolloids. They showed that Alginmax and Kromopan 100 were dimensionally stable after storage for 100 h. However, recent

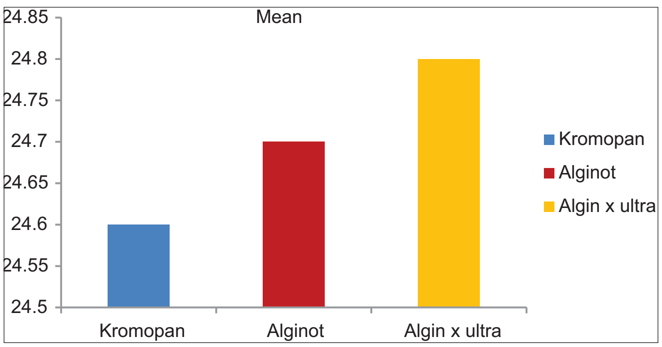

Figure 1: Surface detail reproduction

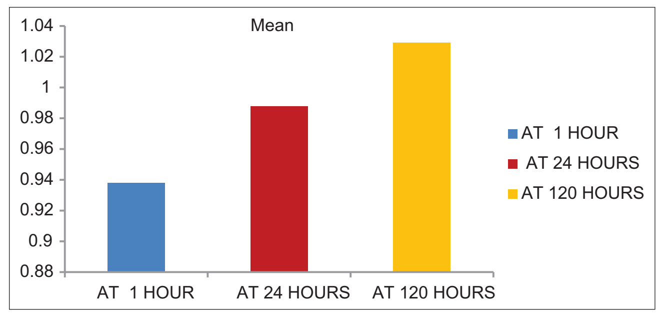

Figure 2: Dimensional stability of Kromopan

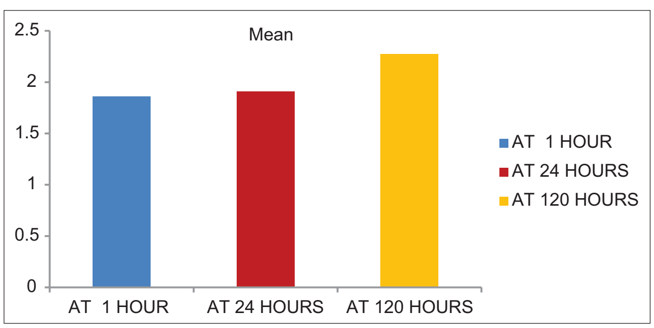

Figure 3: Dimensional stability of AlgiNot

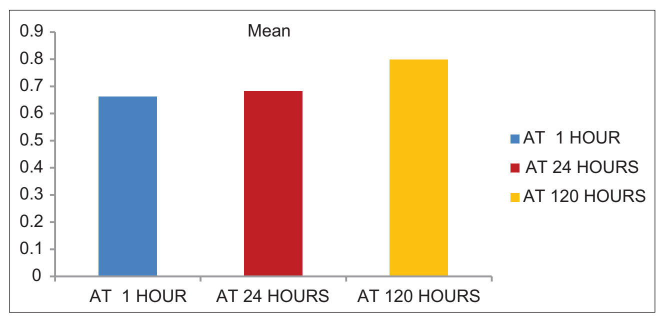

Figure 4: Dimensional stability of Algin X Ultra

Table 3: Comparison of dimensional stability in Kromopan samples using repeated ANOVA test after calculating the percentage linear dimensional change and *post hoc* Bonferroni tests for group comparison

Time interval (h)	Mean±SD	*n*	*F*	*P*	*Post hoc* Bonferroni (*P*)		
1	0.9381±0.51760	25	13.632	<0.001	-	0.010	0.001
24	0.9877±0.52317	25			0.010	-	0.044
120	1.0291±0.50666	25			0.001	0.044	-

SD: Standard deviation

Table 4: Comparison of dimensional stability in AlgiNot samples using repeated ANOVA test after calculating the percentage linear dimensional change and *post hoc* Bonferroni tests for group comparison

Time interval (h)	Mean±SD	*n*	*F*	*P*	*Post hoc* Bonferroni (*P*)		
1	1.8610±1.49232	25	3.148	0.064	-	1.00	0.218
24	1.9115±1.38167	25			1.00	-	0.083
120	2.2742±1.48699	25			0.218	0.083	-

SD: Standard deviation

Table 5: Comparison of dimensional stability in Algin X Ultra samples using repeated ANOVA test after calculating the percentage linear dimensional change and *post hoc* Bonferroni tests for group comparison

Time interval (h)	Mean	*F*	*P*	*Post hoc* Bonferroni (*P*)		
1	0.6629	3.733	0.064	-	0.080	0.153
24	0.6826			0.080	-	0.259
120	0.7990			0.153	0.259	-

studies have shown that Alginplus, Hydrogum 5, and Cavex ColorChange were dimensionally stable for only 24 h at consistent temperature and humidity.[40,41]

In the present study after visual examination, all the three materials were able to reproduce 22 µm (Y line) to its entire length of 25 mm. When microscopically assessed, AlgiNot and Algin X Ultra were able to reproduce the Y line of the metal block more accurately than the control material Kromopan. Algin X Ultra FS was found to be most accurate in surface detail reproduction among the three materials. The results were similar to the study conducted by Ragain *et al*.,[42] which reported on the ability of PVS impression materials to consistently reproduce 20 µm wide lines.

At the time of comparison of dimensional changes, it was noted that Algin X Ultra FS and Alginot FS underwent minimal dimensional changes when stored for 120 h, and Kromopan 100 showed greater variability among the three materials. The study results indicate that the newer irreversible hydrocolloid alternative materials showed better dimensional stability in comparison to the extended-pour alginates when delayed pouring is considered.

Nassar *et al*.[26] and Patel *et al*.[27] have used AlgiNot and similar materials for a time-dependent comparison and found them recommendable for usage with regard to dimensional accuracy, surface detail reproduction, and gypsum compatibility.

The ADA specification number 18[30] and the ISO (International Organization for Standardization) 1563:1990[43] specify requirements for irreversible hydrocolloid impression materials used in dentistry; however, neither of them specifies any limit on dimensional changes. The ADA specification number 19[34] for elastomeric impression materials specifies that the dimensional change of a material should be <1.5% at 24 h. The dimensional changes of the test materials used in this study were within this limit.

One of the limitations of the study is that the impression material specimens were not subjected to any disinfectants, which could have an effect on the tested parameters. Only linear dimensional change was assessed in the study. Further investigations should be conducted to assess the behavior of these materials *in vivo*. Prospective research should investigate rheological behavior, elastic recovery, and other physical properties of these irreversible hydrocolloid alternative materials.

Conclusions

On the basis of the observations, statistical analysis, results, and limitations of this study, the following conclusions were drawn:

a. The newer generation irreversible hydrocolloid alternatives performed better with respect to the surface detail reproduction and dimensional change
b. Algin X Ultra was found to be most accurate in surface detail reproduction and was more dimensionally stable than the other materials
c. Irreversible hydrocolloid alternatives were more dimensionally stable up to 120 h when compared to extended-pour irreversible hydrocolloids
d. When the mean percentage dimensional change was compared at 1 h, 2 h, and 120 h, Kromopan showed maximum dimensional change whereas Algin X Ultra exhibited least.

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Conflicts of interest

There are no conflicts of interest.

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