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ORIGINAL RESEARCH

A Study on Imbibition and Syneresis in Four Commercially Available Irreversible Hydrocolloid (Alginate) Impression Materials

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ABSTRACT

Purpose: To evaluate imbibition and syneresis in four commercially available irreversible hydrocolloid (alginate) impression materials at different time intervals (10, 20 and 30 minutes).

Materials and methods: Eighty samples of four commercially available irreversible hydrocolloid (alginate) impression materials Algitex (DPI, Mumbai), Plastalgin (Septodont, Cedex, France), Zelgan 2002 (Dentsply), Finndent (Pyrex Polykem) were made. Twenty samples each of four irreversible hydrocolloid (alginate) impression materials were grouped into four groups (I, II, III and IV). Measured quantity of alginate powder and liquid was used to make samples. The samples were evaluated for imbibition and syneresis at different time intervals (i.e.10, 20, and 30 minutes) by weighing on electronic analytic balance. The data were analyzed using the one-way ANOVA, post hoc test and t-test.

Results: The statistical data revealed that imbibition within four groups of irreversible hydrocolloid (alginate) impression materials were not significant. Regarding syneresis there was insignificant difference between the four groups but within the group itself they showed significant difference between them depending upon the time interval. It was observed that Group I showed significant difference in syneresis at time interval of 10 to 20 minutes. Group II showed significant difference in syneresis at time interval of 10 to 30 minutes.

Conclusion: This study demonstrated that four groups of irreversible hydrocolloid (alginate) impression materials showed different rates of imbibition and syneresis at time interval of 10, 20 and 30 minutes depending upon molecular weight, calcium concentration and environmental conditions.

Keywords: Irreversible hydrocolloid, Imbibition, Syneresis, Impression material.

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INTRODUCTION

Impression making and pouring are critical steps in the process of producing successful crowns and bridges in oral rehabilitation. Impression materials should reproduce hard and soft tissues around prepared and adjacent teeth in order to obtain biologically, mechanically, functionally and esthetically acceptable restorations. There are several elastic impression materials available for dental use: Synthetic elastomeric materials including polysulfide, condensation silicone, addition silicone, polyether and hydrocolloids. Alginate (hydrocolloid) is polysaccharide consisting of alternating segments of (1-4) linked α-L-guluronic acid and β-d-mannuronic acid. It is a popular material in the last years because of its easy mixing and low cost when compared to other impression materials. It is used most commonly in making dental casts for diagnosis, treatment and fabrication of prostheses.[1]

Although some professionals have been using alginate in clinical practice for definitive impressions, problems with dimensional stability and unsatisfactory detail reproduction are some of the limitations to its use. Alginate impression materials have been largely disregarded for precise fixed prosthetic rehabilitation in spite of their many advantages such as ease of use, low cost and hydrophilic nature. Part of the reason is the clinical disadvantage due to their relative lack of dimensional stability and detail reproduction when compared with other elastomers.

Unfortunately gain (imbibition) or loss of water (syneresis) in the impression material is accompanied by dimensional changes and detail reproduction of clinical significance.[2] In past, researches had been carried out on various properties of alginate impression material and most of them included the influence of storage and environment conditions. However, none of these investigations enlightened the role of water content and water fluctuations in the impression materials which may occur during manipulation and in turn lead to dimensional instability and inaccurate surface detail.

So considering these facts during impression making and pouring the present study aims to measure the water gain (imbibition) and water loss (syneresis) in the four commercially available irreversible hydrocolloid (alginate) impression materials.

MATERIALS AND METHODS

The materials used in the present study primarily comprised the four commercially available irreversible hydrocolloid (alginate) impression materials (Fig. 1). They were Algitex (DPI, Mumbai), Plastalgin (Septodont, Cedex, France), Zelgan 2002 (Dentsply) and Finndent (Pyrex Polykem) (Table 1).

Fig. 1: Impression materials

Table 1: Irreversible hydrocolloid (alginate) impression materials

Brand name	*Name and address of the manufacturers*
Plastalgin	Septodont, 58, Rue du pont de cretail, 94107 saint-maur-des-fosses. Cedex, France
Algitex	Dental products of India, 9 Wallace street, Mumbai-400001
Zelgan 2002	Dentsply India Pvt Limited, Plot no. 9, Udyog Vihar, Phase -1, Gurgaon, Haryana
Finndent	Pyrex Polykem, 114/1-Sai Kirpa, 7-Civil lines, Roorkee-247667, Uttarakhand, India

A total of 80 samples (Fig. 2) were made from four commercially available irreversible hydrocolloid (alginate) impression materials (Table 2).

- *Group I:* Consists of 20 samples prepared from Algitex irreversible hydrocolloid (alginate) impression material.

Fig. 2: Samples retrieved

Table 2: Grouping of samples

Sl. no. of groups	*Samples*
I	20
II	20
III	20
IV	20
Total	80

Serial number depicts group, i.e. serial I depicts group I

- *Group II:* Consists of 20 samples prepared from Plastalgin irreversible hydrocolloid (alginate) impression material.
- *Group III:* Consists of 20 samples prepared from Zelgan 2002 irreversible hydrocolloid (alginate) impression material.
- *Group IV:* Consists of 20 samples prepared from Finndent irreversible hydrocolloid (alginate) impression material.

The measured quantity of alginate powder was shifted into premeasured water in clean rubber bowl. Alginate powder was incorporated into the water by careful mixing with a plaster spatula. Mixing was carried out for 45 seconds to 1 minute depending upon brand and type of alginate. Alginate impression material was allowed to set for 5 minutes. Preweighted beaker along with final set alginate was weighted on electronic weighing balance. Weight of beaker was subtracted from the final set alginate. Samples were removed from the beaker after the complete set of alginate. Similarly the samples of different groups of impression materials were prepared.

After the preparation of samples, they were tested using the electronic analytic balance (Fig. 3). The different values of imbibition were obtained and results were formulated.

Next, the same samples were evaluated for syneresis at different time intervals (i.e. 10, 20 and 30 minutes) and results were formulated.

RESULTS

The statistical data revealed that mean values of imbibition for Group I was greater than Group II, III, IV (Group I > II >III >IV) but they showed insignificant difference between them (Table 3).

The statistical data for syneresis revealed that Group I showed higher mean values than Groups II, III and IV at time intervals of 10, 20 and 30 minutes but they showed insignificant difference between them (Table 4).

With multiple comparison (post hoc test) and paired t- test it was observed that syneresis values within the four groups itself at different time intervals (i.e.10, 20 and 30 minutes) showed significant difference between them. Group I showed significant difference in syneresis values at time interval of 10 to 20 minutes. Group II showed significant difference in syneresis values at time interval of 10 to 30 minutes respectively.

DISCUSSION

Historically, impression materials have been chosen by comparing their tear strength, working and setting time, color, odor, dimensional accuracy and surface detail

Table 3: Groupwise descriptive statistics—imbibition

Groups	N	Mean	Std. deviation	Std. error
Algitex (I)	20	16.200	0.2121	0.0949
Plastalgin (II)	20	16.140	0.1140	0.0510
Zelgan (III)	20	16.060	0.1817	0.0812
Finndent (IV)	20	15.960	0.2074	0.0927
Total	80	16.090	0.1917	0.0429

Fig. 3: Electronic analytic balance

reproduction. Selection criteria are now focused on ease of manipulation, including the availability of mechanical and automix mixing systems as well as on the wettability, dimensional stability and accuracy of the materials. Accuracy is the ability to reproduce true measured value and dimensional stability is the ability to maintain accuracy across time. Impression materials should be accurate and remain dimensionally stable until cast in a gypsum product. The processes that influence dimensional stability of alginate is expansion due to water absorption (imbibition) and shrinkage due to evaporation of water (syneresis).[3] Imbibition process depends on storage condition and syneresis is affected by proprietary constituents of the alginate. The dimensional accuracy of casts produced from alginates also is influenced by factors other than syneresis, evaporation, imbibition and proprietary constituents. Slight differences in accuracy were noted among different brands measured by either a quantitative or qualitative evaluation method. However, no single product seemed to noticeably outperform the others, all appeared to be comparable with reported values and were considered to be within clinically acceptable limits for accuracy.

Imbibition has direct influence on dimensional stability of impression. Because of the difficulty encountered in mixing the impression materials, some of them produce the impression surfaces with numerous voids. One possible theory to explain this is that material may be very sensitive to moisture in air because of its high concentration of surfactant. In the present study four groups of irreversible hydrocolloid (alginate) impression materials were evaluated for imbibition and syneresis. The imbibition should be checked by weighing the specimens 5 minutes after mixing the alginate powder and liquid. The results indicated that the imbibition values were insignificant among the four irreversible hydrocolloid (alginate) impression materials. This may be influenced by calcium concentration or the surrounding environment. An increase in the calcium concentration reduces the degree of swelling.[4]

The presence of divalent metallic cation was found to induce shrinkage, and believed to be caused by the formation of additional cross-linking junctions in the gel. Water in an alginate gel is either free or bound. The free water is trapped among the filler particles and is susceptible to increase or decrease as a result of evaporation or imbibition. The amount of water lost through evaporation may be regained through imbibition. Water loss depends upon diffusion kinetics, decrease in entropy and change in Gibbs free energy. Furthermore, complex osmotic pressure and gradient changes existing between the gel, sol and environment are specific for different alginate materials depending upon ingredients.[5]

Table 4: Groupwise descriptive statistics—syneresis

	Groups	N	Mean	Std. deviation	Std. error
Syneresis 10 mins	Algitex	20	16.1800	0.21679	0.09695
	Plastalgin	20	16.0200	0.08367	0.03742
	Zelgan	20	15.9400	0.19494	0.08718
	Finndent	20	15.8400	0.20736	0.09274
	Total	80	15.9950	0.21145	0.04728
Syneresis 20 mins	Algitex	20	16.1000	0.21213	0.09487
	Plastalgin	20	16.0000	0.10000	0.04472
	Zelgan	20	15.8800	0.14832	0.06633
	Finndent	20	15.8000	0.23452	0.10488
	Total	80	15.9450	0.20384	0.04558
Syneresis 30 mins	Algitex	20	16.0800	0.21679	0.09695
	Plastalgin	20	15.9400	0.11402	0.05099
	Zelgan	20	15.8600	0.15166	0.06782
	Finndent	20	15.7800	0.21679	0.09695
	Total	80	15.9150	0.20072	0.04488

Regarding syneresis all the four brands of irreversible hydrocolloid (alginate) impression materials showed insignificant difference but within the groups they showed significant difference between them at different time intervals. It was found that Group I showed significant difference in syneresis values at time interval of 10 to 20 minutes. Group II showed significant difference in syneresis values at time interval of 10 to 30 minutes. It may be attributed to the fact that in Groups I and II impression materials have higher ratio of calcium to sodium, which lose water more rapidly than do alginates with a lower ratio of calcium to sodium, even though they exhibit greater dimensional stability. Syneresis is strongly related to the amount of calcium present in the gel. It was observed that improved dimensional stability of alginates that contain higher ratios of filler to alginic polymer and lower weight molecular polymer chains. Previous studies demonstrated a relation between the alginate molecular weight, the flexibility of the elastic segment and the degree of syneresis. The more flexible and elastic segments allowed rapid relaxation, further facilitating the contraction and high degree of syneresis.[6]

Different mechanisms could be responsible for the collapse of alginate gel, such as competition between alginate gelation and phase separation in the biopolymer mixture or an overassociation of alginate chains at high calcium concentration favored by presence of gelatin.[7]

Limitations of study: The impression materials used does not simulate the oral environment, the irreversible hydrocolloid (alginate) impression materials used in this study were nonchromatic. The chromatic impression material may show different rate of imbibition and syneresis depending upon the brand of the alginate and period of time interval.

CONCLUSION

It can be concluded that water content and water fluctuations in the impression material greatly affects dimensional stability and accuracy of dental casts. Imbibition and syneresis in four groups of irreversible hydrocolloid impression materials showed different values at time intervals of 10, 20 and 30 minutes depending upon the composition, molecular weight, calcium concentration, storage and environmental conditions.

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