An In-Vitro Evaluation of Impact of Water Hardness on Tear Strength of Alginate Impression Material

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Abstract

Introduction: Traditionally, irreversible hydrocolloid (alginate) has been the material of choice for diagnostic impressions because it is inexpensive, hydrophilic, reasonably dimensionally accurate and easy to manipulate. Tearing in alginate impression can lead to inaccuracy of the gypsum model that forms the bases for prosthesis. This study was attempted to analyze the impact of water collected from different sources in relation to its hardness on the tear strength of commercially available alginate material and if water is an important factor in the tear strength of alginate. Additionally, authors also planned to assess the water hardness that would provide optimum tear strength to the alginate material.

Materials and Method: Ten samples of alginate in each group with water from different sources (tap water, mineral water, saline, distilled water) were taken. A Plexiglas mold was prepared, manipulated samples were poured in the mold, once set the samples were tested on Universal Testing Machine for ultimate tensile strength.

Results: The statistical result indicates that the alginate mixed with distilled water (10 samples each) shows better tensile strength followed by tap water, mineral water and saline. By comparing the mean tensile strength of the four groups, ANOVA showed significantly different tensile strength among the groups. The mean tensile strength of Group II was the highest followed by Group I, Group IV and Group III.

Conclusion: Maximum tear strength is indicated by the samples manipulated with the water having minimum dissolved salts i.e. distilled water.

Keywords: Alginate; Tap water; Mineral water; Saline, Distilled water; Digital universal Testing Machine

Introduction

Currently, hydrocolloid impression materials and synthetic elastomeric polymer impression material are amongst the foremost commonly used materials to record impression for various procedures in dentistry.[1] Irreversible hydrocolloid impression material is assumed as one of the groups often mentioned as “elastic impression materials”. Alginate impression material is routinely used for the aim of duplicating hard intra oral tissues and soft intra oral tissues.[2] When impressions are recorded for patients that have proper contact areas demonstrate that all impressions were to tear, due to reduced tear strength of irreversible hydrocolloid, accompanied by its reduced bulk in these areas.[3] Hence, there is critical clinical value for tearing of alginate highly dependent on its thickness. Factors affecting strength are W/P ratio, mixing time, time of removal of impression. Impression should resist tearing when tensile stress is applied during impression removal and cast separation from set impression. Impression material is most susceptible to tearing in interproximal areas and gingival crevices. Hence, it is necessary for impression materials to have optimum tear strength at the removal time. Another variable examined in tear strength testing, is the tearing rate, i.e. speed at which the impression material is removed from the mouth. Clinically, speed at which impression is removed from the oral cavity and the cast will affect tear strength of the impression material. [4, 5, 6] Tear strength is the measure of how much a material can withstand the tearing effect. Tearing of any impression material can result in inaccuracy of the initial cast. Tear strength is crucial to acknowledge when an impression involves mechanical undercut and/or lacks bulk to withstand tearing. [7, 8, 9] Many commerciality available irreversible hydrocolloid impression materials use

diatomaceous earth as filler in order to increase rigidity of the final mix and a binder such as CaSO4.2H2O. Numerous descriptions of tear strength have been studied and hypothesized that the 25% reduction of water required for mixing Tare-Free Alginate material would be resulting in greater tear resistance.[10-12] Various studies have shown that the alginates are not dimensionally stable and do not have good tear strength to be used as impression material for the prosthodontics cases. To overcome these deficiencies, during the last couple of years, various manufacturers have come out with improved alginates which have better properties and increased tear strength supposedly similar to that of elastomers.[13-16] Furthermore, not just the quantity of water being used but also the quality of water has an impact on the setting and set alginate properties. Additionally, in spite of the point that alginate manufacturers highly advice distilled water without other ions, which might impact the setting time and properties, tap water is the most commonly used water in day-to-day dental practice. [17-19] Because of different concentrations of ions in tap water being used in dental clinics, there is a chance of increase or decrease in the setting time or properties of alginate. Very few systematic studies have been done to evaluate the impact of different type of water (hardness) that is used to manipulate alginate powder on its tear strength.20-23 So the present study was based on evaluating the impact of water collected from different sources such as Tap water, Distilled water, Mineral water, Saline in relation to its hardness on the tear strength of commercially available alginate material.

Materials and Methods

This in-vitro study was abstracted, planned and conducted in Rama Dental College and Hospital, Kanpur. Testing was conducted in Department of mechanical engineering in Indian Institute of Technology Kanpur. Before real execution, outline of study was prepared and discussed with institutional committee. Following the approval (02/EC/RDCHRC/2021-2022/053), sampling and testing was initiated. Total 40 alginate samples were made and divided in ten alginate specimens using each type of water source i.e. tap water, distilled water, saline and mineral water (Fig. 1) as Group I, Group II. Group III, Group IV respectively. Manipulation of alginate was initiated by adding measured quantity of water to premeasured powder and mixing them. Setting time was controlled by varying water temperature, and not the consistency of mix. Mixing time was 45 seconds. The mixed material was placed in the rectangular groove of the Plexiglas mold (Fig. 2). The cover of the mold was applied with finger pressure and secured to the base. Plexiglas belongs to group of materials called engineering plastics. It is a transparent thermoplastic used widely such as glass substitute often for aquariums etc. Any excess material from the edges of the specimen was trimmed using a B.P. blade.1Total working time from manipulation of the alginate impression material and removal of the test specimen from the mold was within 3 minutes.[8] All specimen had equal thickness and weight. The ultimate tensile strength was tested using a digital Universal Testing Machine (Fig. 3). Before the test began, the fixture was adjusted so that the specimen was neither in compression nor tension. The specimens were loaded in tension until failure with a crosshead speed of 10 mm/min.[7] On applying certain pressure and tension the alginate impression material specimen that was loaded in the machine broke due to tension. The digital universal testing machine gave all the readings in kg, which were converted into megapascals and the tear strength was evaluated using the formula

Tear strength = ultimate tensile strength/ (10 mm x 0.1 mm). [1]

Statistical Methodology:

The final results were calculated using statistical tests to obtain p values, mean, standard error. The collected data were summarized as Mean +/- SE (standard error of the mean). Groups were compared by one factor analysis of variance (ANOVA) and the significance of mean difference between the groups was done by Tukey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. A two-tailed (α=2) $P<0.05$ was considered statistically significant. All the measured data and points were copied and sent for statistical evaluation using statistical software Statistical Package for Social Science version 22 (IBM Inv., Armonk, New York, USA).

Figure 1: Water sample (left to right): Distilled Water, Saline, Mineral water, Tap water

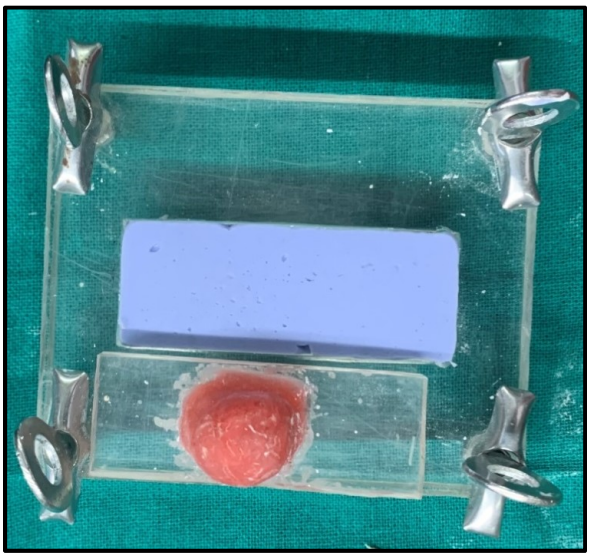

Figure 2: Plexiglas mold with Lid and Alginate sample

Figure 3: Digital Universal Testing Machine (UTM) with alginate sample failure

Results

The observed tensile strength (MPa) was then further summarized (Mean +/- SE) in Table 1. The tensile strength in Group I, Group II, Group III and Group IV ranged from 0.186-0.303, 0.039-0.127, 0.107-0.205 and 0.430-0.610 respectively with mean (+/- SE) 0.252 +/- 0.012, 0.084 +/- 009, 0.158+/- 0.010 and 0.532 +/- 0.022 respectively and median 0.269, 0.083, 0.162 and 0.560 respectively. The mean tensile strength of Group II was the highest followed by Group I, Group IV and Group III (Table 1).

Comparing the mean tensile strength of four groups, ANOVA showed significantly different tensile strength among the groups (F=189.60, P<0.001) (Table 2), Further, comparing the difference in mean tensile strength between the groups, Tukey test showed significantly (P<0.001) different and lower tensile strength in both Group II (66.8%) and Group III (37.2%) while significantly (P<0.001) different higher in Group IV (52.6%) as compared to Group I. Furthermore, the mean tensile strength of both Group III (47.0%) and Group IV (84.2%) was also found significantly (P<0.01 or P<0.001) different and higher as compared to Group II (Table 3). Moreover, the mean tensile strength of Group IV (70.2%) was also found significantly (P<0.001) different and higher as compared to Group II (Table 3).

Table 1: Summary of tensile strength (Mpa) of four groups

Group	N	Min	Max	Mean	+/- SE	Median
Group I	10	0.186	0.303	0.252	0.012	0.269
Group II	10	0.430	0610	0.532	0.022	0.560
Group III	10	0.039	0.127	0.084	0.009	0.083
Group IV	10	0.107	0.205	0.158	0.010	0.162

Table 2: Comparison of mean tensile strength of four groups of ANOVA

Source of Variation (SV)	Sum of Square (SS)	Degree of Freedom (df)	Mean Square (MS)	F Value	P Value
Groups	1.153	3	0.384	189.60	<0.001
Residual	0.073	36	0.002		
Total	1.226	39	0.386		

Table 3: Comparison of Difference in mean tensile strength between groups by Tukey Test

Comparisons	Mean Difference	Q	P value	95% CI of difference
Group I vs. group II	0.17	11.83	P<0.001	0.1142 to 0.2228
Group I vs. group III	0.09	6.60	P<0.001	0.3339 to 0.1483
Group I vs. Group IV	-0.28	19.64	P<0.001	-0.3339 to -0.2253
Group II vs. Group III	-0.07	5.23	P<0.001	
Group II vs. Group IV	-0.45	31.47	P<0.001	
Group III vs. Group IV	-0.37	26.24	P<0.001	

Discussion

Vidhashree V and others stated that some water supplies contain large amount of minerals that can affect the accuracy and setting time of alginate. For obtaining the best results distilled or demineralized water can be used.[4] In the current study the samples were prepared to evaluate the tear strength of alginate using a Plexiglas mold. To evaluate the tear strength various machines can be used i.e. tensilo meter or universal testing machine. In the present study digital universal testing machine was used to get the accurate readings at specific speed and the machine was electro mechanically operated, so less chances of error were possible. Best water purifiers state that the hardness in the drinking water is created by naturally occurring substances like calcium (Ca) and magnesium (Mg).Total dissolved solids (TDS) are the amount of total mobile charged ions in water of a given volume which include minerals, salts, cations, anions and metals. In a study by Rasha MA and others it was stated that some water supplies contain large amounts of minerals that can adversely affect the accuracy and the setting time of alginate impression materials. However if concerned about mineral content of local water supplies distilled or demineralised water can be substituted to improve the strength of alginate impression material.[5] In the present study the results obtained were a lot similar to the previous studies. After testing all the mixed alginate samples on digital Universal Testing Machine reading obtained for the tear strength of all samples of alginate impression material were evaluated, the results indicates that the used distilled water with less dissolved salts showed better tear strength than other water sources with high concentration of dissolved salts. Hence hardness of water plays an important role in the tear strength of alginate. These inferences were comparable with the study conducted by Peutzfeldt and associates.[8] The outcome of results obtained was based on hardness of water. The maximum hardness value was of saline followed by mineral water, tap water and distilled water i.e. the maximum number of salts mixed in the fluids taken were as follows, saline > mineral water > tap water > distilled water. The results attained were significant statistically. Nonetheless, authors tried to included maximum parameters, more definite research involving a larger sample size and water samples from more sources is needed before conclusive and meaningful statement regarding effect on tear strength of alginate impression material using different water sources can be drawn.

Conclusion

Within the scope and limitations of this study authors stated that hardness of water i.e. total dissolved concentration of mineral salts play an important role on the final tear strength of alginate impression material. Maximum tear strength is indicated by the samples manipulated with the water having minimum dissolved salts i.e. distilled water. As compared to different water sources, distilled water when mixed with alginate impression material exhibited highest tear strength followed by tap water, mineral water and normal saline. The present study suggests the use of distilled water for obtaining best tear strength with alginate impression materials.

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