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DIMENSIONAL STABILITY OF LIGNIN INCORPORATED ALGINATE IMPRESSION MATERIAL ---AN IN VITRO PILOT STUDY

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ABSTRACT

The aim of this pilot study was to determine and compare the dimensional stability of alginate impression material impregnated in different concentrations (0.75%, 1.5% and 3%) of lignin alkali with unmodified alginate at a storage time of 0-hour, 1 hour and 24 hours. Unmodified alginate impression material served as control group. Experimental groups A,B and C contained alginate impression material modified with Lignin alkali powder in 0.75% w/w, 1.5% w/w & 3% w/w respectively. To determine the dimensional stability a stainless-steel ruled test block was fabricated, which consisted of three parts Ruled block (A-A), Mould (B-B) and a Riser (C-C). The mixed material was placed immediately onto the mould by means of a stainless-steel spatula. The filled mould was covered with a thin sheet of polyethylene followed by a glass slab (weighing 75± 5 grams). After setting the mould was separated from the test block and the specimen was pressed out of the mould with the help of the riser (C-C). Storage of all the specimens for 1 hour and 24 hours was done in an incubator at 25oC ± 1. Digital images of the all-selected specimens were taken at 0-hour, at 1-hour interval and 24 hours interval with the help of a Canon scanner. Middle horizontal line in each impression's scanned image was measured using the tools of a software program (Adobe reader). Data was analyzed using software SPSS version 20. The mean difference of dimensional stability between groups at each stage were analyzed by one way ANOVA, followed by Post hoc Tukey test for comparison within groups. Level of significance was set at p<0.05. A statistically significant difference was found between the dimensional stability values of experimental groups A, B, C and control group at 1 hour (p<0.001) and 24 hours (p<0.000). No significant difference was found between the dimensional stability values of experimental group A, B, C and control group at 0 hour (p<0.310). The use of lignin alkali to improve the dimensional stability in alginate impression holds capability and further clinical research is needed in this direction.

Key Words: *Alginate, Lignin alkali, Dimensional stability, Ruled test block, Storage time*

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INTRODUCTION

For the fabrication of a successful and well fitted prosthesis, prime importance is given to the dimensional accuracy of the impression.[1] An impression material should be preferably capable of replicating fine surface details and steady in dimensions over a longer time to let the operator to pour the impression with ease. Dimensional changes in an irreversible hydrocolloid impression material like alginate can occur due to syneresis (water loss/exudation) or imbibition (water absorption) that occurs over time and could be responsible for compromising the dimensional stability and detail reproduction.[2] Irreversible hydrocolloid is most commonly used impression material for the fabrication of prosthesis as well as treatment planning in dentistry.[2] The popularity of irreversible hydrocolloid is credited to its low cost to the dentist, hydrophilic nature, pleasant taste and simple manipulation as compared to other impression materials.[2] However, the main problem with irreversible hydrocolloid are the low tear strength and poor dimensional stability and hence the impression should be poured immediately with dental

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stone to minimize the dimensional changes.[2] The storage time of irreversible hydrocolloid before pouring is a an important factor in dimensional stability of the impression.[2] Alginate was first discovered in 1880's but its history of use developed in 1940's during World War II due to the shortage of raw materials for reversible hydrocolloid.[3–5]thermo-stability, sol-gel transformation and drug release

The effect of water quality and quantity has also been described in various studies. The excess or shortage of water can affect the mechanical properties of alginate. Similarly, water rich in calcium ions can improve the mechanical properties of alginate.[6] Addition of various disinfectants including sodium fluoride, povidone-iodine powder, and some other materials showed improved antimicrobial property of the material but did not show any statistically significant difference in the dimensional stability.[7–12] Statistical evaluation of multiple research showed that the dimensional stability of irreversible hydrocolloid impression materials is significantly affected by storage time.[13,14]

Lignin, being a polymeric material and one of the most abundant polymers found in plants is obtained from wood as a by-product from pulp and paper industry. Lignin formed as a result of kraft pulping is called lignin alkali (LA) or kraft lignin (KL). Lignin is highly complex in nature having effective mechanical, chemical and biological properties. Lignin-alginate aerogels are also used for scaffolds and tissue engineering.[15] Lignin-alginate films showed enhanced physio-mechanical properties to be used as a packaging or coating material.[16] Lignin not only has improved the mechanical properties of fiber boards but also has enhanced its dimensional stability and water sorption.[17]which improves the self-bonding capacity of wood fibers by lignin enzymatic cross-linking, mimics the natural process of lignification in living plants and trees. An interesting pathway to promote these interactions could be the addition of lignin to the system. The characterization of E. globulus KL after enzymatic treatment showed a decrease of phenolic groups as well as the aromatic protons without loss of aromaticity. There was also an extensive oxidative polymerization of the biomolecule. In the manufacture of self-bonded MDF, the synergy generated by the added lignin and laccase provided promising results. Thus, whenever laccase was present in the treatment, MDF showed an increase in mechanical and dimensional stability for increasing amounts of lignin. In a pilot scale, this method produced MDF that meets the requirements of the European standards for both thickness swell (TS Chemical modification of wood with lignin alkali combined with heat treatment has increased the leaching resistance, decreased moisture and water uptake resulting in improved dimensional stability of modified wood. Lignin is considered to be a natural raw material that can alter or substitute other materials due to its distinct chemical structure and large quantity in nature. Lignin alkali is also found to make a material repellent to water and distortion.[18]

The incorporation of lignin alkali into alginate impression material was proposed in this pilot study to improve the dimensional stability of alginate impression material at different time intervals. The null hypothesis tested was that the addition of lignin alkali in different concentrations (0.75%, 1.5% and 3%) to alginate impression material have no effect on the dimensional stability of alginate impression material over a time period of 0-hour, 1 hour and 24 hours.

MATERIALS AND METHODS

The study was conducted at Department of Science of Dental Materials, Sardar Begum Dental College and Hospital after the approval from the Ethical Committee and Advance Studies and Research Committee of Gandhara University, Peshawar, Pakistan.

In this in-vitro experimental pilot study, commercially available alginate (Neocolloid, Zhermack,Italy) and lignin alkali (Bomei,China) were used for the preparation of specimens. A stainless- steel ruled test block (Fig 1) was locally fabricated according to ANSI/ADA specification No.19 for testing the dimensional stability. The ruled test block consisted of three parts[19,20], i.e., a Ruled block (A-A), Mould (B-B) for carrying the impression material and a Riser (C-C) for removing the impression material from the mould. The ruled block had three horizontal reference lines X, Y, Z (25, 50, 75µm in width, 25 mm in length and a distance of 2.5mm between each line). Two vertical lines cd and cd' is bisecting the horizontal lines to mark the measuring point for distances.

Analytical balance (SARTORIUS, Germany) was used for proportioning of the lignin alkali powder and alginate powder. For experimental groups A, B and C Lignin alkali was mixed with alginate powder in 0.75% w/w, 1.5% w/w, & 3% w/w respectively (Table 1) through geometric dilution method with mortar and pestle.[21]

For control group five grams of alginate powder as supplied was manually mixed with 10ml of distilled water according to the manufacturer's instructions. For experimental groups A, B and C the modified alginate powder (Table 1) was mixed manually as done for the control group. A total of 60 specimens were prepared using the stainless-steel ruled test block with 15 specimens in each group. Mould was placed on ruled block. The mixed material was immediately placed into the mould by means of a stainless-steel spatula. The filled mould was covered with a thin sheet of polyethylene followed by a glass slab (weighing 75± 5 grams). A 500g weight was placed over it to standardize the pressure and allow the outflow of excess material.22 After setting of alginate the mould was separated from the ruled test block and the specimen was pressed out of the mould with the help of the riser.23 The prepared specimens of each group were then covered with a damp gauze. The storage of specimens for one hour and 24 hours was done in an incubator (Laboratory Electro thermal Thermostatic Incubator, China) at 25oC±1.19 The specimens that integrated all the areas of measurement i.e., the lines continuously recorded for the full length of 25mm (Fig 2) between cross lines were selected for further analysis. Any specimen with air bubbles or voids incorporation in the area of measurement were put in the exclusion criteria.

The control and experimental groups were than further divided accordingly to the storage times of 0-hour, 1 hour and 24 hour and are tabulated in Table 2.

A dimensional stability test procedure was carried out for all the selected specimens. The digital images of the all specimens were taken at 0-hour, one hour interval and 24 hours interval with the help of a Canon Cano scan LiDe120 scanner. Middle horizontal line in each impression scanned image was measured using the tools of a software program (Adobe Acrobat Reader DC v.21). Before taking any measurement, each image was calibrated against the known length of the middle line of the die image.[19,20,22–24] Jeltrate Plus and Hydrogum 5

Data was analyzed using software SPSS v 20. Mean and standard deviation were estimated for each study group. To test the mean difference of dimensional stability between groups at each stage (0-hour, 1 hour and 24 hours storage), separately one-way ANOVA was performed with $p < 0.05$ as significance level. If the results were significant, then Post Hoc (Tukey test) was performed to know that the difference exists in between the groups.

RESULTS

The comparison of mean values among the different study groups are presented in Table 3. The results showed that there was no significant difference between the dimensional stability values of experimental group A, B, C and control group at 0 hour ($p<0.310$). A statistically significant difference was found between the dimensional stability values of experimental groups A, B, C and control group at 1 hour ($p<0.001$) and 24 hours ($p<0.000$). At 1-hour and 24-hour, the Post hoc Tukey test showed statistically significant difference in dimensional stability value as compared to control group (Table 4).

DISCUSSION

Dental impression is a true indicator of soft and hard tissue details in the oral cavity. In order to make a well fitted prosthesis, impression should be accurate and dimensionally stable. Because inaccuracy and dimensional instability can lead to an ill fitted prosthesis. Accuracy is the capacity to repeat a true measured value and dimensional stability is the capacity to keep up accuracy across time. The processes that impact alginate dimensional stability are expansion, shrinkage and syneresis. The initial two processes depend primarily on capacity conditions and syneresis are influenced by the restrictive constituents of

TABLE 1: AMOUNT OF LIGNIN IN GRAMS (WEIGHT%) IN CONTROL AND EXPERIMENTAL GROUPS

Groups	Amount of lignin alkali (grams) in 5 grams of powder	Wt.% of Lignin Alkali
Control group	0 +5 gram of alginate	0%
Experimental group A	0.0375g lignin+4.9625g alginate	0.75%
Experimental group B	0.075% lignin+4.925g alginate	1.5%
Experimental group C	0.15% lignin+4.85g alginate	3%

TABLE 2: DIFFERENT STORAGE TIME IN CONTROL AND EXPERIMENTAL GROUPS

Groups	Storage for 0-hour	Storage for 1 hour	Storage for 24 hours
Control group	5	5	5
Experimental group A (0.75% lignin)	5	5	5
Experimental group B (1.5% lignin)	5	5	5
Experimental group C (3% lignin)	5	5	5

TABLE 3: MEAN VALUES IN CONTROL AND EXPERIMENTAL GROUPS AT 0-HOUR, 1-HOUR AND 24-HOURS

Storage time		Sum of Squares	df	Mean Square	F	Significance
0 hour	Between Groups	.011	3	.004	1.295	.310
	Within groups	.045	16	.003		
	Total	.056	19			
1 hour	Between Groups	.873	3	.291	8.810	.001
	Within groups	.529	16	.033		
	Total	1.402	19			
24 hours	Between Groups	17.492	3	5.831	17.822	.000
	Within Groups	5.235	16	.327		
	Total	22.726	19			

TABLE 4: POST HOC TUKEY TEST SHOWING DIFFERENCE IN MEAN VALUES BETWEEN THE GROUPS AND WITHIN THE GROUPS AT 0-HOUR, 1-HOUR AND 24-HOURS

Dependant Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
0 hour	Control	Exp Group A	.05600	.03347	.369	-.0397	.1517
		Exp Group B	.04800	.03347	.497	-.0477	.1437
		Exp Group C	.05600	.03347	.369	-.0397	.1517
1 hour	Control	Exp Group A	.44800	.11496	.006	.1191	.7769
		Exp Group B	.44000	.11496	.007	.1111	.7689
		Exp Group C	.53600	.11496	.001	.2071	.8649
24 hour	Control	Exp Group A	1.48000	.36175	.004	.4450	2.5150
		Exp Group B	2.12800	.36175	.000	1.0930	3.1630
		Exp Group C	2.42400	.36175	.000	1.3890	3.4590

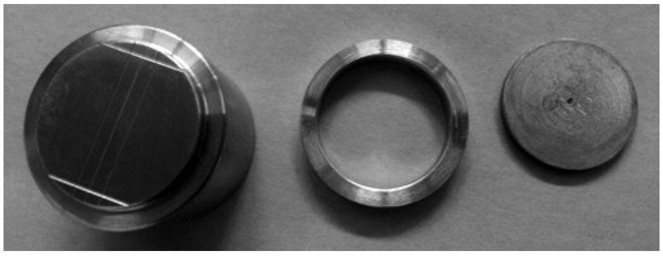

Fig 1: Stainless-Steel Ruled Test Block

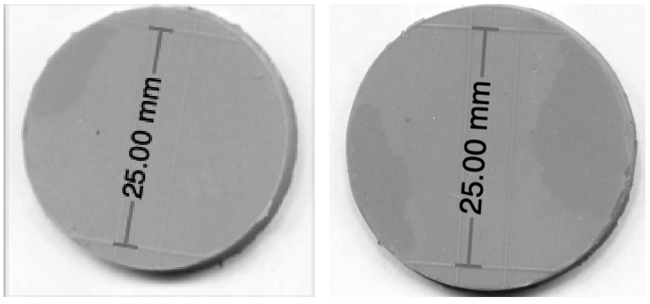

Fig 2: Prepared specimens of alginate impression material

the alginate.[25] Elastomeric impression material were introduced to overcome the low dimensional stability and tear strength of hydrocolloid impression materials but their use is limited in low socio economic regions due to their cost effectiveness.

In our study lignin alkali was added in different concentrations to improve the dimensional stability of conventional alginate at 0-hour, 1 hour and 24 hours storage times. Based on the results of our study there was no improvement in dimensional stability of irreversible hydrocolloid at 0 hour. Whereas, all the three experimental groups A, B and C showed statistically significant difference in the dimensional stability value at 1 hour and 24 hours storage as compared to control group. Therefore, the null hypothesis was partially rejected.

Lignin alkali used in this study is basically derived from a complex organic plant polymer "Lignin". The nature of lignin alkali is hydrophilic and it can be predicted that calcium ions from alginate can crosslink to the long chain's scaffolds of lignin, thereby may increase the stability of hydrogel. Water in the alginate gel is either free or bound. The free water is caught among the filler particles and is vulnerable to volumetric increments or diminishes because of dissipation or imbibition. As alkali lignin have calcium ions in their composition so possibility is that it crosslinks with the guluronic and mannuronic (G and M) units of alginate to make hydrogel surface more gelatin like, tight structured and less porous, thus reducing the available space for the entry or escape of water molecules making alginate more dimensional stable.[18,26]

In our pilot study it was observed that by increasing the lignin alkali in w/w % has increased the dimensional stability. This pilot study is in correspondence with Colleagues and Thomas [27] as they noticed improved dimensional stability with alginates that contain higher proportions of filler to alginic polymer. So, as the concentration of lignin alkali in this research is increased it showed improvement in dimensional stability. Although no standard specifically addresses alginate dimensional accuracy or stability as per ADA specification No. 19 for an elastomeric impression material to be delegated dimensionally stable after some time, the material should display close to 0.50 % maximum admissible dimensional change to be the standard in this investigation.[20] Based on the results of our study, all three groups having lignin (0.75%, 1.5% and 3%) showed improved dimensional stability values i.e., less than 0.50 % which are according to ADA specification no.19. From this discussion, we may expect that the dimensional stability of the two impression materials varies, the behavior of the two impression materials as to dimensional changes across different time may be subsequently, multifactorial and material specific. These variables incorporate syneresis, development of free water by means of evaporation and imbibition, proportions of calcium to sodium and filler to polymer and other restrictive constituents.[27]

CONCLUSION

Within the limits of this pilot study, it can be concluded that the use of lignin alkali to improve the dimensional stability in alginate impression holds capability and further clinical research is required in this direction.

LIMITATION

Although the study was conducted following the standard protocols for impression making. In-vivo results may vary because of the presence of oral fluids. Therefore, further studies are required to look at the use of this research for in-vivo use.

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