RESEARCH PAPER

Effect Of Hydroethanolic Solution Preservation On The Dimensional Stability Of Alginate Impression

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ABSTRACT
Introduction: Alginate remains the most widely used impression material in dentistry due to its ease of use and affordability. However, its major limitation is poor dimensional stability, particularly under tropical climatic conditions. This study aimed to evaluate the effect of a 50% hydroethanolic solution compared to tap water on the preservation of alginate impressions.
Methods: Standardized impressions were prepared using calcium alginate mixed with water at controlled temperature. Iron cylinders of known diameters (9.78 mm and 4.70 mm) were inserted into the impression tray. After setting, impressions were preserved either in tap water or in a 50% hydroethanolic solution. Plaster casts were poured at defined intervals (0 h, 24 h, 48 h, 72 h, and 96 h), and cylinder diameters were measured using digital calipers. Dimensional variations (ΔD) were analyzed statistically.
Results: Impressions stored in tap water showed significant dimensional changes within 24 hours, with progressive distortion beyond 48 hours and severe instability by 72 hours ($\Delta D = 0.70$ mm). In contrast, impressions preserved in hydroethanolic solution maintained dimensional stability up to 96 hours, with deviations remaining below 1 mm ($\Delta D = 0.28$ mm at 72 h; $\Delta D = 0.79$ mm at 96 h). Statistical analysis confirmed significant differences between the two preservation media ($p < 0.05$).
Conclusion: Tap water preservation limits alginate stability to less than 24 hours, consistent with previous studies. The hydroethanolic solution significantly extends stability to 96 hours, explained by ethanol substitution of water molecules within the calcium alginate matrix. This method offers a practical, low-cost solution for clinicians in tropical regions, enabling reliable impressions even when immediate pouring is not feasible. Careful control of preparation and preservation conditions remains essential to maximize clinical outcomes

Keywords: Alginate, dimensional stability, hydroethanolic solution, impression material, tropical dentistry.

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INTRODUCTION

The precision of a dental impression is the cornerstone of prosthetic success, serving as the foundation upon which every restoration is constructed. Often overlooked, the dental impression is the silent architect of prosthetic treatment, dictating accuracy, longevity, and clinical outcomes. An impression is defined as the negative reproduction of the morphology of the dental arch elements [1]. It provides essential diagnostic and technical information for prosthesis fabrication, making impression taking a decisive stage in the prosthetic chain, where the accuracy of the record largely determines the success of treatment [2].

A high-quality impression is characterized by faithful reproduction of surface details and reliable preservation over time [3]. The preservation of the impression is critical, as it ensures its effective clinical utility. The fidelity of an impression is primarily determined by its *dimensional stability*, defined as the linear variation in length of the impression material mass after setting, as a function of time [2,4]. Dimensional stability reflects the ability of a material to retain its original dimensions once removed from the oral cavity, thereby ensuring conformity with the patient's oral structures while maintaining surface texture integrity [5]. These properties are among the most sought-after in dental prosthetics.

Impression materials are generally classified into two categories: rigid, non-elastic materials (such as plaster, zinc oxide paste, and thermoplastic compounds) and elastic materials (including hydrocolloids and elastomers) [6]. Their dimensional stability varies considerably. Zinc oxide pastes, plasters, and elastomers can maintain stability for more than 96 hours, whereas alginate impressions retain stability for only 45 minutes to 1 hour, particularly under tropical climatic conditions [7–9]. Despite this limitation, alginates remain the most widely used impression material in Cameroon due to their affordability, ease of manipulation, and accessibility with remarkable impact on patients'

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satisfaction [10]. Like all impression materials, the properties of alginates are influenced by the preservation medium, with hydro-ethanolic solutions being of particular interest.
Beyond their practical limitations, alginates also present a scientific challenge in prosthetic dentistry. Their hydrophilic nature makes them highly sensitive to environmental factors such as humidity and temperature, which accelerate dimensional changes and compromise accuracy [11]. In tropical regions, where climatic conditions are consistently hot and humid, these effects are exacerbated, reducing the clinical reliability of impressions if not processed within a narrow time frame. This underscores the importance of identifying preservation strategies that can extend the usability of alginate impressions without compromising their fidelity.
Furthermore, the choice of preservation medium plays a decisive role in maintaining impression quality. Hydro-ethanolic solutions have been proposed as a potential stabilizing environment, capable of *reducing microbial contamination* while *limiting dimensional changes* [12]. However, empirical data on their effectiveness under tropical conditions remain scarce. Establishing evidence-based guidelines for the maximum processing time of alginate impressions preserved in such media is therefore essential, both to improve clinical practice and to ensure reliable prosthetic outcomes in resource-limited settings.
Accordingly, the present study aims to determine, under tropical climatic conditions (hot and humid), the maximum processing time that ensures optimal dimensional stability of alginate impressions when preserved in a hydro-ethanolic solution.

MATERIALS AND METHODS

This experimental clinical study was carried out at the dental prosthetic laboratory of the Yaoundé University Teaching Hospital between January 2024 on dental models with cylinders attached to the models. We measured linearly the dimensional variations of the impressions with calcium alginate stored in tap water, subsequently the tap water was replaced by a hydroethanolic solution as the preservation solvent.
Equipment and Materials
The experimental setup comprised a digital balance for weighing reagents, a graduated cylinder for measuring liquids, a bowl and alginate spatula for mixing, and water dispensers to standardize solvent volumes. An iron cylinder and electronic digital calipers were employed for impression taking and dimensional measurements. A thermometer was used to monitor ambient and solvent temperatures throughout the procedure.
The impression material consisted of calcium alginate powder, prepared with distilled water at controlled temperature. A 50% hydro-ethanolic solution was used as the preservation medium for impressions after pouring.

Methodology
The study was designed to evaluate the dimensional stability of calcium alginate impressions under two preservation conditions: tap water and hydro-ethanolic solution.
Preparation of impressions: In a bowl, 18 g of calcium alginate was mixed with 54 mL of water at 10 °C. The mixture was homogenized for 45 seconds using an alginate spatula. The paste was then placed into a standardized impression tray (Figure 1). Two iron cylinders of known diameters (9.78 mm and 4.70 mm) were inserted vertically into the paste (Figure 2).

Setting and preservation: After a setting time of 1 minute 40 seconds, the cylinders were carefully removed. The impressions were initially preserved in tap water, and subsequently in a 50% hydro-ethanolic solution.
Reproduction and measurement: At defined time intervals in hours (0 h, 24 h, 48 h, 72 h, and 96 h), plaster casts were poured into the impressions to reproduce the cylinders. The diameters of the reproduced cylinders were measured using electronic calipers (Figure 3), ensuring accuracy to the nearest 0.01 mm.
Dimensional variation analysis: Linear dimensional changes were calculated by comparing the measured diameters of reproduced cylinders with the original reference diameters. The percentage variation was recorded for each preservation condition and time interval.

Figure 1: Impression tray

Figure 1 illustrates the device used for taking the impressions, allowing standardization of experimental conditions and reproducibility of measurements.

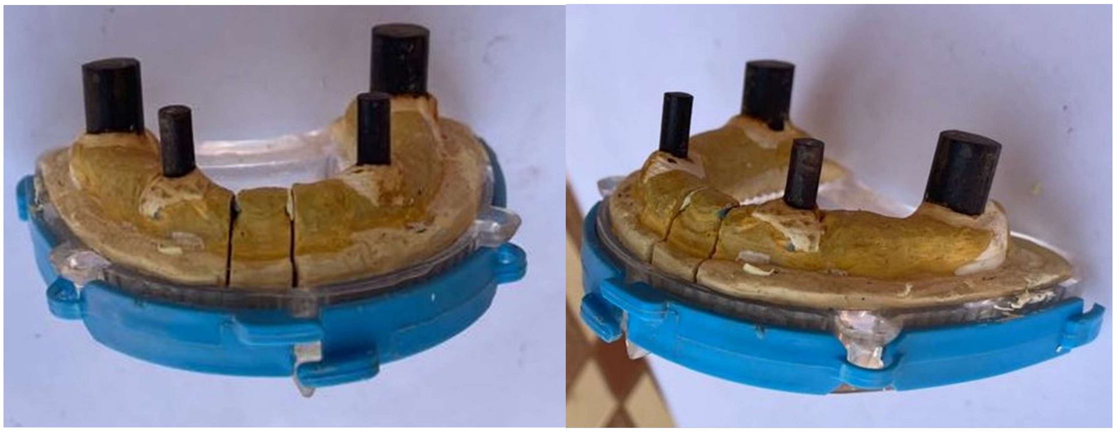


Figure 2: Iron cylinders

Figure 2 shows the metal cylinders used as a dimensional reference, ensuring the accuracy and reliability of the measurements carried out during the study.

Figure 3: Digital caliper

Figure 3 shows the measuring instrument used for evaluating cylinder diameters, ensuring accurate and reproducible measurement of dimensional variations.

RESULTS

The data collected after measuring cylinders for each sample and within a given time interval are recorded in the tables below:

The baseline diameters of the reference cylinders were **9.78 mm** (Cylinder 1) and **4.70 mm** (Cylinder 2). At time 0, the reproduced impressions showed mean diameters of **9.80 mm** and **4.78 mm**, respectively, indicating minimal deviation from the original reference values (ΔX = +0.02 mm for Cylinder 1 and +0.08 mm for Cylinder 2). This confirms that the alginate mixture initially provided a faithful reproduction of the reference morphology.

At **24 hours**, however, measurable variations were observed. Cylinder 1 diameters ranged between **9.69–9.99 mm**, while Cylinder 2 diameters ranged between **4.90–5.13 mm**. These fluctuations reflect the onset of dimensional instability, likely due to **syneresis** (loss of water) and **imbibition** (absorption of water) inherent to alginate hydrocolloids. The variability across samples suggests that alginate impressions preserved in tap water cannot reliably maintain dimensional fidelity beyond the first few hours.

By **48 hours and beyond (72 h, 96 h)**, the dataset shows missing or unstable values, indicating that impressions were no longer clinically usable. This aligns with established literature reporting that alginate impressions retain dimensional stability for only **45–60 minutes under ambient conditions**, and up to **1 hour in tropical climates** .

Conclusion :

Alginate impressions show initial accuracy, reproducing reference dimensions faithfully at baseline. Within 24 hours, early instability emerges, compromising dimensional fidelity. Clinically, tap water preservation is unsuitable beyond 1 hour, especially in tropical climates. These findings highlight the need for alternative media such as hydro-alcoholic solutions to extend usability (Table 1).

Table 1: Variation in dimensional stability of alginate impressions with tap water as a preservation solvent.

Simple alginate sample	**Cylinder diameter (mm) at 0 o'clock**		**Cylinder diameter (mm) at 24 hours**		**Cylinder diameter (mm) at 48 hours**		**Cylinder diameter (mm) at 72 hours**	
	Cylinder 1 (9.78mm)	**Cylinder 2 (4.70mm)**	**Cylinder 1 (9.78mm)**	**Cylinder 2 (4.70mm)**	**Cylinder 1 (9.78mm)**	**Cylinder 2 (4.70mm)**	**Cylinder 1 (9.78mm)**	**Cylinder 2 (4.70mm)**
1	9.79	4.80	9.77-9.88	5.03-5.11	/	/	/	/
2	9.80	4.75	9.69-9.78	5.03-5.09	/	/	/	/
3	9.81	4.77	9.76-9.87	5.07-5.10	/	/	/	/
4	9.79	4.80	9.79-9.88	5.05-5.12	/	/	/	/
5	9.81	4.76	9.79-9.85	4.94-5.11	/	/	/	/
6	9.80	4.75	9.77-9.89	5.03-5.09	/	/	/	/
7	9.79	4.77	9.78-9.99	4.92-5.12	/	/	/	/
8	9.80	4.76	9.80-9.98	5.05-5.10	/	/	/	/
9	9.79	4.80	9.77-9.87	5.03-5.13	/	/	/	/
10	9.81	4.80	9.78-9.98	5.07-5.10	/	/	/	/
11	9.79	4.78	9.84-9.80	5.04-5.11	/	/	/	/
12	9.80	4.80	9.78-9.80	5.03-5.10	/	/	/	/
13	9.81	4.80	9.85-9.95	5.03-5.09	/	/	/	/
14	9.79	4.76	9.78-9.85	4.90-5.08	/	/	/	/
15	9.79	4.75	9.79-9.98	5.05-5.09	/	/	/	/
16	9.80	4.77	9.75-9.89	5.03-5.12	/	/	/	/
X	**9.80**	**4.78**	/	/	/	/	/	/
ΔX	**0.02**	**0.08**	/	/	/	/	/	/

Table 1 shows significant variability in the dimensions of the impressions after just 24 hours, marked by the appearance of ranges of values for the measured diameters.

At **baseline (0 h)**, the reproduced cylinder diameters (mean 9.81 mm and 4.75 mm) were very close to the reference values (9.78 mm and 4.70 mm), confirming **initial accuracy** of alginate impressions.

By **24 h**, both cylinders showed measurable expansion (mean 9.90 mm and 4.87 mm), with deviations of +0.12 mm and +0.17 mm. This indicates the onset of **early dimensional instability**, consistent with alginate's tendency toward imbibition.

At **48 h**, deviations increased further (mean 9.95 mm and 4.99 mm), with changes of +0.17 mm and +0.29 mm, confirming progressive distortion.

At **72 h**, the diameters reached 10.09 mm and 5.08 mm, corresponding to deviations of +0.31 mm and +0.33 mm. These exceed the clinically acceptable threshold of ±0.1 mm, rendering impressions unreliable for prosthetic fabrication.

By **96 h**, instability was pronounced, with mean diameters of 10.60 mm and 5.55 mm, deviations of +0.82 mm and +0.85 mm. This demonstrates **severe dimensional distortion**, confirming that alginate impressions preserved in tap water are unsuitable for delayed processing.

Conclusions

Alginate impressions reproduce reference dimensions faithfully at baseline, confirming their initial accuracy. Within 24–48 hours, progressive dimensional changes emerge, compromising fidelity and clinical reliability. By 72 hours, deviations exceed acceptable thresholds, rendering impressions unsuitable for prosthetic use. At 96 hours, severe distortion occurs, underscoring the need for alternative preservation media such as hydro-alcoholic solutions (Table 2).

Table 2: Variation in dimensional stability of alginate impressions with 50% hydroethanolic solution as preservation medium.

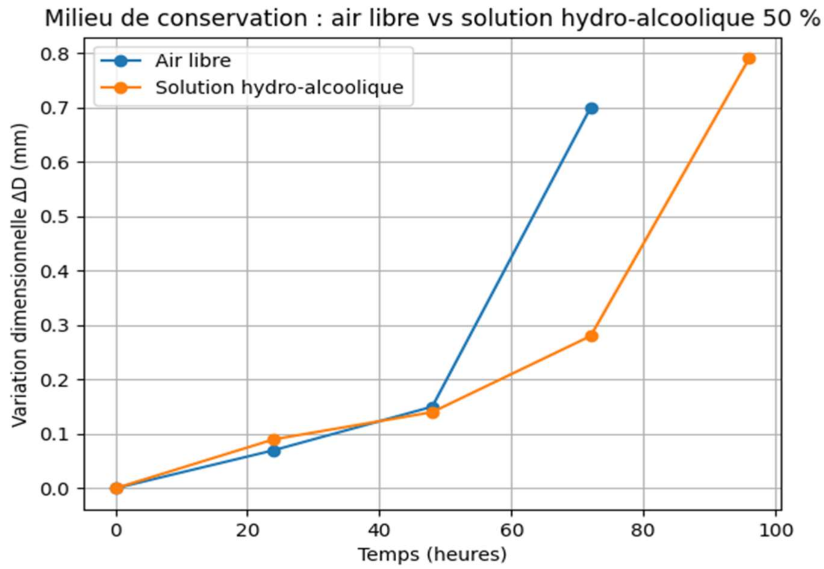
samples	**Cylinder diameter (mm) at 0 o'clock**	**Cylinder diameter (mm) at 24 hours**	**Cylinder diameter (mm) at 48 hours**	**Cylinder diameter (mm) at 72 hours**	**Cylinder diameter (mm) at 96 hours**

Sample number	Cylinder 1 (9.78mm)	Cylinder 2 (4.70mm)	Cylinder 1 (9.78mm)	Cylinder 2 (4.70mm)	Cylinder 1 (9.78mm)	Cylinder 2 (4.70mm)	Cylinder 1 (9.78mm)	Cylinder 2 (4.70mm)	Cylinder 1 (9.78mm)	Cylinder 2 (4.70mm)
1	9.81	4.76	9.92	4.87	9.93	5.01	10.11	5.09	10.59	5.20
2	9.80	4.75	9.90	4.85	9.96	4.98	10.05	5.06	10.50	5.50
3	9.84	4.74	9.93	4.85	9.94	4.99	10.08	5.05	10.67	5.60
4	9.80	4.77	9.91	4.87	9.94	4.97	10.07	5.07	10.61	5.54
5	9.81	4.76	9.93	4.91	9.94	4.98	10.08	5.05	10.60	5.53
6	9.80	4.75	9.93	4.86	9.94	4.97	10.06	5.08	10.60	5.52
7	9.83	4.77	9.89	4.87	9.93	4.98	10.08	5.14	10.60	5.60
8	9.84	4.76	9.87	4.85	9.95	4.98	10.06	5.10	10.60	5.54
9	9.80	4.74	9.91	4.88	9.96	4.96	10.18	5.13	10.45	5.53
10	9.81	4.74	9.94	4.85	9.95	5.02	10.10	5.12	10.62	5.52
11	9.83	4.76	9.88	4.87	9.97	5.00	10.09	5.08	10.66	5.55
12	9.80	4.74	9.89	4.88	9.94	5.01	10.08	5.09	10.63	5.55
13	9.81	4.74	9.90	4.88	9.96	4.96	10.06	5.09	10.59	5.56
14	9.84	4.76	9.91	4.85	9.98	5.01	10.11	5.06	10.66	5.58
15	9.81	4.75	9.92	4.85	9.91	4.97	10.11	5.05	10.63	5.59
16	9.80	4.77	9.88	4.86	9.95	4.98	10.09	5.04	10.64	5.55
X	**9.81**	**4.75**	**9.90**	**4.87**	**9.95**	**4.99**	**10.09**	**5.08**	**10.60**	**5.55**
ΔX	**0.03**	**0.05**	**0.12**	**0.17**	**0.17**	**0.29**	**0.31**	**0.33**	**0.82**	**0.85**

Dimensional Stability of Alginate Impressions: Open Air vs. Hydro-Alcoholic Preservation

The comparative analysis highlights the **critical influence of preservation conditions** on alginate dimensional stability. At baseline (H0), both groups showed perfect fidelity. By **24–48 hours**, dimensional changes were statistically significant in both conditions ($p < 0.05$), though deviations remained relatively small. At **72 hours**, impressions stored in open air exhibited severe distortion ($\Delta D = 0.70$ mm), while those preserved in hydro-alcoholic solution showed markedly lower variation ($\Delta D = 0.28$ mm, $p < 0.05$). This demonstrates the stabilizing effect of hydro-alcoholic preservation under tropical conditions.

By **96 hours**, open air samples were no longer measurable due to excessive distortion, whereas hydro-alcoholic preservation maintained impressions with $\Delta D = 0.79$ mm. Although instability was evident, the hydro-alcoholic medium significantly extended the usable lifespan of alginate impressions compared to open air storage (Figure 4).



At baseline (H0), both preservation conditions showed perfect dimensional fidelity, with no measurable variation from the reference cylinders. By **24 hours**, however, impressions stored in open air exhibited early instability ($\Delta X = 0.07$ mm), while those preserved in hydroethanolic solution showed slightly greater deviation ($\Delta X = 0.09$ mm), though both changes were statistically significant ($p < 0.05$).

At **48 hours**, dimensional changes continued to progress, with open air samples showing a mean deviation of 0.15 mm compared to 0.14 mm in hydroethanolic solution. Although both conditions remained unstable, the hydroethanolic medium demonstrated marginally better control of dimensional variation.

By **72 hours**, the difference became more pronounced: impressions in open air showed severe distortion ($\Delta X = 0.70$ mm), while those preserved in hydroethanolic solution exhibited significantly lower deviation ($\Delta X = 0.28$ mm, $p < 0.05$). This highlights the stabilizing effect of the hydroethanolic medium under tropical conditions.

At **96 hours**, open air samples were no longer measurable due to excessive distortion, whereas hydroethanolic preservation maintained impressions with a deviation of 0.79 mm. Although instability was evident, the hydroethanolic solution extended the usable lifespan of alginate impressions far beyond that of open air storage (Figure 4).

Fig 4. Dimensional Stability of Alginate Impressions: Open Air vs. Hydro-Alcoholic Preservation

Statistical analysis of the results

Time	**Open air**	**50% hydroethanolic solution**	**p-value**
H0	0.00	0.00	—
24/7	0.07	0.09	p < 0.05
H48	0.15	0.14	p < 0.05
H72	0.70	0.28	p < 0.05
H96	—	0.79	p < 0.05

Conclusion

Hydroethanolic preservation significantly reduced dimensional changes compared to open air, particularly after 96 hours, confirming its potential as an effective medium for extending the clinical usability of alginate impressions in tropical climates

DISCUSSION

The comparative analysis confirms that tap water preservation leads to rapid dimensional instability, with clinically significant distortions observed within 24 hours. This finding is consistent with earlier reports from Djeredou et al. (2001) in Côte d'Ivoire, who documented a maximum storage time of 45 minutes for alginate impressions [7,8.9], and with results obtained in Cameroon (2018), where impressions remained stable for only 1 hour [10]. Similarly, Zwista et al. (2022)

reported a maximum storage time of 20 minutes when alginate was modified with 2% trisodium phosphate [11]. These studies collectively highlight the inherent limitations of alginate hydrocolloids under conventional preservation conditions.

In contrast, the present study demonstrates that the use of a 50% hydro-ethanolic solution significantly extends dimensional stability up to 96 hours. This improvement can be explained by the substitution of water molecules (molecular mass 18 g/mol) with larger ethyl alcohol molecules (molecular mass 46 g/mol) within the calcium alginate matrix [11–13]. The slower diffusion and evaporation of ethanol compared to water reduces syneresis and imbibition, thereby delaying distortion. However, the ratio of 50/50 is critical, as higher concentrations of ethanol (>50%) have been shown to alter the structural integrity of calcium alginate, leading to reduced elasticity and compromised mechanical properties [14–16].

These findings suggest that hydro-ethanolic preservation offers a practical solution for extending the usability of alginate impressions in tropical climates, where high humidity accelerates dimensional changes. Clinically, this approach could bridge the gap between impression taking and laboratory processing, particularly in resource-limited settings where immediate pouring is not always feasible.

CONCLUSION

The use of hydro-ethanolic solution as a storage medium for alginate impressions provides a reliable extension of dimensional stability up to 96 hours, surpassing the limits reported in previous studies. This preservation method is simple, cost-effective, and adaptable to tropical conditions, making it a valuable innovation for dental practitioners in developing regions. Careful control of preparation and processing remains essential to maximize its benefits

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