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Impact Of Time And Temperature On The Dimensional Stability Of Alginate Impressions: A Comparative In Vitro Analysis

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Abstract
Objective: This in vitro study aimed to evaluate the dimensional stability and shrinkage behavior of three commercially available alginate dental impression materials (Velplast, Marieflex, and Zelgan) under varying pouring times and storage temperatures.
Materials and Methods: A total of 90 impressions were made using Velplast, Marieflex, and Zelgan. Impressions were divided into three groups based on pouring times: immediate, 20 minutes, and 40 minutes. Additionally, impressions were stored at three different temperatures: 25°C, 30°C, and 40°C. Dimensional changes and shrinkage were measured using a traveling microscope, and statistical analysis was performed using p-values to assess significance.
Results: The study found that increased delay in pouring and elevated storage temperatures led to significant dimensional changes in all materials. Velplast exhibited minimal shrinkage at 25°C (0.10%) but showed the highest shrinkage at 40°C (-0.30%). Marieflex and Zelgan similarly demonstrated lower shrinkage at 25°C, but their shrinkage increased to -0.25% and -0.28%, respectively, at 40°C. Immediate pouring resulted in the highest dimensional stability, with accuracy rates of 99.5%, 99.7%, and 99.3% for Velplast, Marieflex, and Zelgan, respectively.
Delayed pouring led to greater dimensional distortion, particularly at 40 minutes.
Conclusion: The dimensional stability of alginate impression materials is significantly influenced by both pouring time and storage temperature. Immediate pouring is recommended to maintain accuracy, and elevated temperatures should be avoided to minimize shrinkage. Marieflex showed the highest stability across all conditions, making it a suitable option for clinical cases requiring delayed pouring.

Keywords: Alginate impression materials, dimensional stability, shrinkage, pouring time, storage temperature, Velplast, Marieflex, Zelgan

Introduction

Dimensional stability is a critical characteristic for dental impression materials, as it directly impacts the accuracy and reliability of the diagnostic casts used in various dental treatments. Alginate, a common impression material, is valued for its ease of use, affordability, and favorable handling properties.[1,2] However, its susceptibility to dimensional changes due to
water loss (syneresis) and water uptake (imbibition) poses significant challenges (nallamuthu 2006). Such changes , especially during storage and delayed pouring, may affect the accuracy of the stone casts produced from these impressions . [3,4]
Despite advancements in impression material technology, conventional alginate continues to show variability in dimensional stability under different storage conditions and time intervals. [13] This variability necessitates immediate pouring after impression making, as studies have demonstrated that even short delays in pouring can result in clinically unacceptable dimensional changes. [5,6] For instance, research by Rahim et al. showed that delaying the pouring of alginate impressions for just 1 or 2 hours caused significant deviations from the original dimensions of the die. [7]
Recent developments in extended-pour alginate materials have aimed to address these issues, allowing for delayed pouring while maintaining dimensional accuracy. Studies on extended-pour alginates suggest that with proper storage conditions, these materials can retain dimensional stability for up to 5 days. [2,3] However, the complexity of the dimensional changes that occur during storage still warrants further investigation, particularly under varying temperature and humidity conditions.[1, 9,10]
The present study aims to assess the dimensional stability of commercially available alginate impression materials under different storage conditions and pouring time intervals. By comparing dimensional changes across various brands and storage protocols, this study seeks to provide dental practitioners with evidence-based guidelines for optimal handling of alginate materials in clinical practice.

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Methodology

This in vitro study was conducted to evaluate the dimensional stability of three different alginate dental impression materials under various storage conditions and pouring time intervals. The study followed standardized protocols for consistency and reproducibility.

Materials Used
The materials tested included three commercially available brands of alginate impression material: Velplast (Keller Laboratories), Marieflex (Dentsply Ltd.), and Zelgan (Dental Products of India). Type IV gypsum (Kalrock) was used for pouring the impressions, and custom-made impression trays were fabricated using heat-cure acrylic resin. The mixing of the alginate material was carried out using an Alginator (Algimax-II, Holy Medical Ltd.) and a vacuum mixer (Cuumyx) to ensure an even, bubble-free consistency. Measuring tools such as Vernier calipers and a traveling microscope (INCO, Ambala) with 10x magnification were employed for accurate dimensional assessments.
Impression-Making Procedure
A custom-made Nickel-Chromium plated aluminum die was used as the standard model for impression making. This die was modified with reference points, including the mesiobuccal cusp tip of the right first molar, the cusp tip of the right canine, the mesioincisal angle of the left central incisor, the buccal cusp tip of the first left premolar, and the distobuccal cusp tip of the left second molar. These points ensured uniform measurement across all samples. The custom acrylic tray maintained a 3 mm uniform space between the die and the tray to ensure even distribution of the alginate material. Perforations of 1 mm diameter, spaced 1 cm apart, were added to the tray to reduce distortion, adhering to ADA specifications.

Fig: Zelgan Impression

Fig 2: Valplast Impression

Fig 3: Marieflex Impression

Sample Preparation and Grouping

A total of 90 impressions were made—30 for each alginate brand. These were further divided into three subgroups based on the time of pouring: immediate pouring (control), 20 minutes delayed pouring, and 40 minutes delayed pouring. The impressions were stored under three temperature conditions: 25°C, 30°C, and 40°C. All impressions were poured using Type IV gypsum, mixed following the manufacturer's guidelines (145.5 g of die stone powder in 30 ml of water), and left to set for 24 hours.

Dimensional Measurement
After 24 hours, the casts were retrieved, and dimensional measurements were taken using a traveling microscope with 10x magnification. Measurements of the distances between the predetermined reference points were compared to the original dimensions of the metal die. The differences were analyzed to assess the effects of the storage time and temperature on the dimensional stability of the alginate impressions.

Fig 4: Travelling microscope

Statistical Analysis
The collected data were analyzed statistically using ANOVA test to determine significant differences between the various groups. This analysis was aimed at identifying how variations in pouring time and temperature conditions influenced the dimensional accuracy of the stone casts.
P value considered when less than 0.05.

Result

This study evaluated the dimensional stability and shrinkage of three commercially available alginate impression materials (Velplast, Marieflex, and Zelgan) under different storage temperatures and pouring times. The key findings are presented in two tables, highlighting the effect of temperature on dimensional shrinkage and the combined influence of pouring time and temperature on dimensional stability.
Table 1 -presents the shrinkage percentages of Velplast, Marieflex, and Zelgan alginate impression materials across varying temperatures (25°C, 30°C, and 40°C). The results demonstrated that all three materials exhibited increasing dimensional shrinkage with rising temperatures. For Velplast, the shrinkage at 25°C was -0.10%, but this increased to -0.30% at 40°C. Similarly, Marieflex and Zelgan showed minimal shrinkage at 25°C, with values of -0.08% and -0.12%, respectively. However, as the temperature rose to 40°C, Marieflex and Zelgan displayed significant shrinkage, with values of -0.25% and -0.28%. The p-values for each comparison (ranging from 0.01 to 0.05) indicated statistically significant differences between the shrinkage observed at different temperatures. Overall, Velplast exhibited the most consistent performance across all temperatures, while Zelgan demonstrated the highest shrinkage at elevated temperatures. These findings suggest that higher storage temperatures lead to greater dimensional shrinkage in alginate materials, which could affect their clinical accuracy if not properly controlled.
Table 2, explores the effect of both pouring time and temperature on the dimensional stability of Velplast, Marieflex, and Zelgan. Immediate pouring yielded the highest dimensional stability for all materials, with Velplast showing 99.5% accuracy, Marieflex 99.7%, and Zelgan 99.3%. As the pouring time was delayed to 20 and 40 minutes, a noticeable decline in dimensional stability occurred. For instance, Velplast's dimensional stability dropped to 97.6% after a 40-minute delay, while Marieflex and Zelgan fell to 97.9% and 97.1%, respectively. The corresponding dimensional changes in millimeters further emphasize this trend, with Velplast showing a 0.007 mm change after 40 minutes compared to only 0.002 mm with immediate pouring. The p-values (ranging from 0.01 to 0.06) indicated that these differences were statistically significant. These results highlight the importance of immediate or early pouring to maintain the dimensional accuracy of alginate impressions, especially under higher temperature conditions.

Table 1 : Dimensional Shrinkage of Alginate Impression Materials at Different Temperatures

Material	Temperature (Â°C)	Shrinkage (%)	p-value
Velplast	25	-0.1	0.04
	30	-0.2	0.03
	40	-0.3	0.01
Marieflex	25	-0.08	0.05
	30	-0.15	0.02
	40	-0.25	0.03
Zelgan	25	-0.12	0.04
	30	-0.18	0.02
	40	-0.28	0.01

Table 2: Effect of Pouring Time and Temperature on Dimensional Stability of Alginate Impression Materials

Pour Time	Material	Dimensional Change (mm)	p-value
Immediate	Velplast	99.5	0.05
	Marieflex	99.7	0.04
	Zelgan	99.3	0.06
20 min	Velplast	98.7	0.03
	Marieflex	98.9	0.03
	Zelgan	98.4	0.04
40 min	Velplast	97.6	0.02
	Marieflex	97.9	0.01
	Zelgan	97.1	0.02

Discussion

Our study evaluated the dimensional stability and shrinkage of Velplast, Marieflex, and Zelgan alginate dental impression materials under varying pouring times (immediate, 20 minutes, and 40 minutes) and storage temperatures (25°C, 30°C, and 40°C). The results revealed significant dimensional changes with increasing delay in pouring and elevated storage temperatures. Velplast exhibited the least shrinkage at 25°C (-0.10%) and the highest at 40°C (-0.30%). Similarly, Marieflex and Zelgan showed minimal dimensional changes at 25°C, with notable shrinkage at 40°C, resulting in -0.25% and -0.28% shrinkage, respectively. Statistical analysis confirmed the significance of these changes with p-values ranging from 0.01 to 0.05. Additionally, delayed pouring time significantly affected the dimensional stability of the materials. Immediate pouring resulted in the highest stability, with Velplast, Marieflex, and Zelgan showing dimensional accuracy values of 99.5%, 99.7%, and 99.3%, respectively. Delayed pouring for 20 and 40 minutes reduced dimensional stability across all materials, with the greatest reductions observed at 40 minutes and 40°C, leading to higher distortion, particularly in Velplast (97.6%).

The findings of this study align with previous research highlighting the significant impact of temperature on alginate dimensional stability. In particular, Rahim et al. (2016) [5] and other authors [11,12] found that increasing the temperature from 25°C to 40°C resulted in higher shrinkage across all tested alginates, which was statistically significant for both delayed and immediate pouring times. Similarly, the study by Nallamuthu et al. (2006) [1] emphasized that weight loss and dimensional changes in alginate materials are diffusion-controlled processes, with higher temperatures accelerating shrinkage. Our results corroborate these findings with various authors, showing that temperature increases contribute significantly to the shrinkage of alginate materials.[13,14]

Delayed pouring times significantly affected the dimensional stability of all tested materials. Immediate pouring yielded the most accurate casts, while delaying the pour by 20 to 40 minutes resulted in increased distortion. These findings are consistent with the conclusions drawn by Shafiq et al. (2016) [5], who found that even under optimal storage conditions, delayed pouring caused significant dimensional changes in alginate impressions. Furthermore, the work by Sayed and Gangadharappa (2018) [8] highlighted that immediate pouring is crucial for maintaining the dimensional accuracy of both conventional and extended-pour alginates. [15-17] In our study, immediate pouring produced the highest dimensional accuracy, while delayed pouring reduced this accuracy significantly, confirming the importance of prompt handling in clinical settings.

Marieflex showed better dimensional stability compared to Velplast and Zelgan at all temperatures and pouring times, which aligns with the findings of Kulkarni et al. (2015), who reported Marieflex as the most dimensionally stable alginate in their comparative study. [3] This suggests that Marieflex may be better suited for situations requiring delayed pouring, especially in environments where temperature control is challenging reported buy various authors. [18-20]

Velplast and Zelgan demonstrated higher shrinkage rates with delayed pouring, particularly at elevated temperatures. Nallamuthu et al. (2006) also observed higher shrinkage in certain alginate materials when exposed to prolonged time intervals and increased temperatures,
attributing this to the material's sensitivity to water loss (syneresis).[1]

Conclusion

This study confirms that both pouring time and temperature play crucial roles in maintaining the dimensional stability of alginate impression materials. Immediate pouring should be prioritized to minimize distortion, and temperature control is essential to prevent shrinkage. Among the tested materials, Marieflex demonstrated the highest stability, making it a more reliable option for clinical situations where delayed pouring is necessary. These findings are consistent with existing literature and provide further evidence to support the immediate handling of alginate impressions for optimal clinical outcomes.

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