ORIGINAL ARTICLE

Assessment of Viscosity of Alginate Impression Materials Mixed at Different Water Temperatures

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ABSTRACT

Background: Alginate impression materials are widely used in dentistry, and viscosity influences their flow and accuracy. Water temperature may affect the rheological properties of alginate.

Objective: The objective of this study was to assess the viscosity of alginate impression materials using a viscometer at varying water temperatures (7°C, 25°C, and 50°C) .

Method: Three types of alginate were mixed with water at three different temperatures, and viscosity was measured using a viscometer.

Results: A clear correlation between temperature and viscosity was observed. Higher temperatures resulted in lower viscosity, improving material flow and detail reproduction.

Conclusion: The viscosity of alginate impression materials was significantly affected by water temperature ($p < 0.05$), with observable variations in viscosity noted across different temperature conditions.

Keywords: *Alginate; Impression Materials; Dental Impression; Viscosity*

Introduction

Alginate impression materials are widely used in dental practice because of their affordability, ease of manipulation, and ability to accurately reproduce oral structures for diagnostic and restorative procedures [2,7,9]. Despite the introduction of newer elastomeric impression materials, alginate remains a preferred choice for preliminary impressions due to its cost-effectiveness and satisfactory clinical performance [2,9].

Viscosity, defined as the internal resistance of a material to flow, plays a crucial role in the handling and performance of alginate impression materials7. The viscosity of alginate affects its flowability, adaptation to oral tissues, ability to record fine surface details, and overall impression accuracy [7,9]. During setting, alginate undergoes a sol-to-gel transformation in which soluble alginate reacts with calcium ions to form a cross-linked gel network, resulting in progressive changes in viscosity until complete gelation occurs[7].

Several factors influence the viscosity and setting characteristics of alginate impression materials, including the powder-to-water ratio, mixing technique, particle size, storage conditions, and water temperature[3,6,7]. Variations in these factors may affect working time, setting time, dimensional stability, tear strength, and surface detail reproduction, ultimately influencing the quality of the final dental cast[4,5,11,12].

Among these variables, water temperature is one of the most practical factors that can be controlled by clinicians during impression making[3,6]. Previous studies have demonstrated that increasing water temperature accelerates the chemical reaction of alginate, resulting in reduced working and setting times, whereas lower temperatures prolong the setting process and increase manipulation time[3,6]. Satterthwaite et al. reported that temperature significantly influences the working time and tear strength of alginate impression materials, highlighting its importance in clinical applications[3].

The physical properties of alginate impressions are closely related to their dimensional stability and resistance to distortion. Dimensional stability is a critical determinant of impression accuracy and directly affects the precision of the resulting dental cast and prosthetic restoration1. Naumovski and Kapushevska demonstrated that maintaining dimensional stability is essential for achieving clinically acceptable impression accuracy and minimizing distortion during impression procedures1. Delayed pouring, improper storage, and variations in handling procedures can adversely affect impression accuracy and the dimensional stability of the resulting casts [4,8,11,12]. Studies evaluating contemporary alginate materials have emphasized the importance of maintaining optimal manipulation conditions to preserve dimensional accuracy and surface detail reproduction[8,11,12].

Although previous investigations have examined the effects of water temperature on setting time and selected mechanical properties of alginate impression materials [3,6], limited information is available regarding its direct influence on viscosity. Since viscosity plays a critical role in impression accuracy, understanding the relationship between water temperature and alginate viscosity may help clinicians optimize impression-making procedures and improve clinical outcomes [3,7,9].

Therefore, the aim of this study was to evaluate the effect of varying water temperatures on the viscosity of alginate impression materials. The findings of this study may provide evidence-based recommendations regarding optimal mixing conditions and contribute to improved handling characteristics, impression accuracy, and reliability of alginate impressions in clinical practice[1,3,4,8].

Materials and Methods

This experimental in vitro study was conducted at the University College of Medicine and Dentistry, University of Lahore, and the University of Engineering and Technology using a controlled experimental sampling technique. Three commercially available alginate impression materials were evaluated: fast-set alginate(Hydrogum, Zhermack, Italy), normal-set alginate (Neocolloid, Zhermack, Italy), and chromatic-change alginate (Tropicalgin, Zhermack, Italy). All materials were proportioned and mixed according to the manufacturers' instructions using distilled water to eliminate the influence of mineral contaminants. To ensure standardization and minimize variability, all samples were mixed manually for 45 seconds, which lies within the recommended mixing time range (30–60 seconds) reported in previous studies and is consistent with guidelines from the International Organization for Standardization for alginate impression materials. Environmental conditions were controlled and continuously monitored using a calibrated digital thermo-hygrometer to ensure room temperature of 23 ± 2°C and relative humidity of 50 ± 10% during all experimental procedures. Water temperatures were standardized at 7°C, 25°C, and 50°C and maintained using a calibrated water bath and digital thermometer to ensure consistency throughout the experiment.

Sample size was calculated using OpenEpi software based on one-way ANOVA for three independent groups. With a significance level of 0.05, power of 80%, and a medium effect size (Cohen's f = 0.25), the required sample size was estimated at 18–21 specimens per group. To ensure adequate power and account for experimental variability, the sample size was set at 20 specimens per group for each condition.

Immediately after mixing, viscosity was measured using a rotational spindle viscometer (HFBTE, Model NDJ-8S) under controlled laboratory conditions. Measurements were recorded two minutes after the initiation of mixing to ensure consistency within the working phase of the material. The viscometer was operated using spindle number 64 at a speed of 0.1 rpm, and viscosity values were recorded in centipoise (cP). Multiple readings were obtained for each material and temperature combination, and mean values were calculated. Statistical analysis was performed using one-way ANOVA to evaluate the effect of temperature on viscosity among the tested groups.

Although detail reproduction was assessed using a stainless-steel die in accordance with ISO 1563 standards to maintain clinical relevance, the primary outcome of this study was viscosity, as it directly influences flowability, handling characteristics, and adaptation of alginate impression materials.

Figure 1: *Viscometer NDJ 8-S*

Table 1: *Distribution of Samples According to Alginate Type (Fast Set, Normal Set, and Chromatic-Change) and Water Temperature for Viscosity Testing*

Test Performed	Fast Set			Normal Set			Chromatic-Change			Total
	7°C	25°C	50°C	7°C	25°C	50°C	7°C	25°C	50°C	
Viscosity (n)	20	20	20	20	20	20	20	20	20	**180**

Results:

The study revealed a clear inverse relationship between water temperature and viscosity for all three alginate types. At 7°C, the highest viscosities were observed: normal-set (120 ± 10 cP), fast-set (110 ± 8 cP), and chromatic-change (105 ± 9 cP). At 25°C, viscosities decreased to 85 ± 7 cP for normal-set, 75 ± 6 cP for fast-set, and 70 ± 5 cP for chromatic-change. At 50°C, viscosities dropped further to 60 ± 4 cP, 55 ± 4 cP, and 50 ± 3 cP, respectively. One-way ANOVA demonstrated statistically significant differences in viscosity among the tested groups at all temperature levels (7°C: $p = 0.007$, 25°C: $p < 0.001$, and 50°C: $p = 0.002$). These findings indicate that water temperature significantly affected the viscosity of all alginate types, with increasing temperature resulting in progressively lower viscosity values. Additionally, significant differences were observed among the alginate types across the tested temperature conditions.

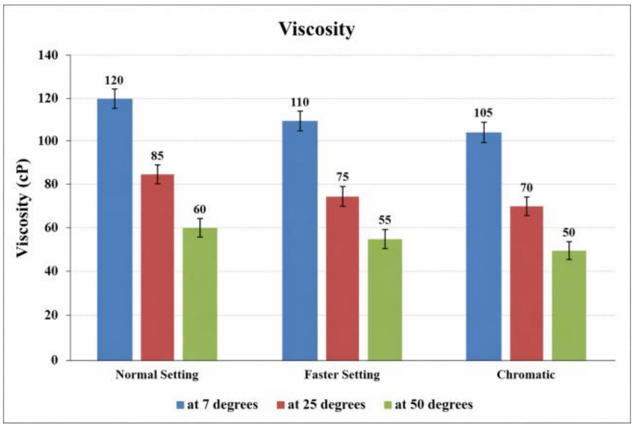

Figure 2: *Overall comparison of viscosity among three types of alginates at different temperatures*
p-values were generated through one-way ANOVA

Table 2: *Comparison of Mean Viscosity of Different Alginate Impression Materials Mixed at Different Water Temperatures*

Water Temperature	Alginate Type	n	Mean Viscosity (cP)	SD	F-value	p-value
7°C	Normal-set	20	120.86	10.49	6.15	0.007*
	Fast-set	20	110.47	8.93		
	Chromatic-change	20	105.57	9.53		
25°C	Normal-set	20	85.75	7.29	12.48	<0.001*
	Fast-set	20	75.70	6.18		
	Chromatic-change	20	70.92	5.91		
50°C	Normal-set	20	60.52	4.87	8.57	0.002*
	Fast-set	20	55.98	4.98		
	Chromatic-change	20	50.86	3.43		

**Statistically significant at p < 0.05.*

Despite these changes in viscosity, all three alginate types successfully reproduced the 50 µm and 75 µm lines at all temperatures. Samples mixed at 50°C, which exhibited lower viscosity, showed smoother line margins and fewer voids under microscopic evaluation. In contrast, high-viscosity samples mixed at 7°C occasionally demonstrated incomplete flow into the finer 50 µm line but maintained good stability upon removal.

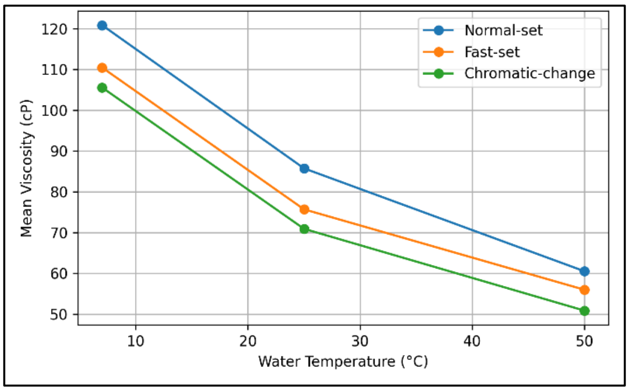

Figure 3: *Effects of Water Temperature on Alginate Viscosity*

Discussion:

This study demonstrates that water temperature has a significant influence on the viscosity and flow behaviour of alginate impression materials. The results showed statistically significant differences among the tested temperature groups ($p < 0.05$), confirming that both temperature and material type play an important role in modifying rheological properties.

Overall, an inverse relationship was observed between water temperature and viscosity. As water temperature increased, viscosity decreased, resulting in a more fluid consistency that enhanced the material's ability to flow into narrow grooves and fine anatomical details. This improved flowability at higher temperatures can be clinically advantageous in achieving better surface detail reproduction, particularly in complex dental structures. These findings are consistent with Craig and Powers (2002), who reported that increasing temperature reduces the viscosity of hydrocolloid materials and enhances their flow characteristics. Similarly, Patel et al. (2007) also demonstrated that warmer mixing conditions improve alginate flow and detail accuracy.

In contrast, lower water temperatures produced a marked increase in viscosity, resulting in a thicker and more cohesive mix. While this increased viscosity improved material body and stability, it restricted flow into fine surface details. The highest viscosity observed at 7°C suggests improved resistance to deformation, which may be beneficial during tray removal and in reducing distortion.

This observation aligns with Borsato et al. (2012), who reported that higher viscosity materials exhibit greater resistance to deformation and improved dimensional stability during clinical handling.

At the highest tested temperature (50°C), the alginate exhibited the lowest viscosity and highest flowability, allowing superior penetration into fine surface irregularities. However, this increased fluidity may also introduce clinical limitations.

As noted by Wang et al. (2017), low-viscosity alginate materials may be more prone to tearing, distortion, and reduced mechanical integrity during removal, which can compromise the accuracy of the final impression. Therefore, although elevated temperatures enhance flow, they may simultaneously reduce material strength, requiring careful clinical balance.

Among the materials tested, the normal-set alginate consistently demonstrated the highest viscosity across all temperature conditions. This indicates a stronger resistance to flow compared to the fast-set and other formulations. While this property may enhance stability and control during manipulation, it may also limit the ability to capture fine anatomical details, especially at elevated temperatures. Patel et al. (2007) similarly emphasized that formulation differences significantly influence the handling and rheological behaviour of alginate materials.

In clinical practice, these findings highlight the critical importance of controlling water temperature during alginate manipulation. Warmer temperatures may be preferred when improved detail reproduction is required, whereas cooler temperatures may be advantageous when greater stability and reduced deformation are prioritized. The statistically significant differences observed in this study confirm that water temperature is not merely a procedural variable but a key determinant of impression quality.

Conclusion:

Within the limitations of this in vitro study, water temperature significantly affects the viscosity of alginate impression materials. Higher temperatures reduce viscosity and improve flowability, enhancing fine detail reproduction, while lower temperatures increase viscosity and improve stability but limit flow. Alginate type also significantly influences rheological behavior, with normal-set alginate showing consistently higher viscosity. Overall, both temperature and material formulation play key roles in optimizing the clinical performance of alginate impressions.

Ethical Approval:

The study was approved by the Institutional Review Board of The University of Lahore.
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Data Availability: Data supporting the findings are available upon reasonable request.

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Conflict of interest: The authors declare that they have no conflict of interest.

Authors' Contribution:

DA: Conceptualization, methodology, data collection, and data analysis.
MSN: Methodology, literature review, manuscript writing and final approval of the manuscript.
YM: Conceptualization, literature review, data interpretation, and manuscript writing.
MUS: Data collection, methodology, and critical revision of the manuscript.
ZI: Supervision, study design, critical review, and final approval of the manuscript.

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