Original Article

Comparative Evaluation of Dimensional Stability and Compression Resistance of Different Types of Interocclusal Record Materials - An In Vitro Study

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Abstract

Background: Accurate interocclusal records are essential for the successful fabrication of prosthodontic restorations. This study compares the dimensional stability and compressive resistance of three common interocclusal recording materials to determine their suitability for various clinical applications.

Methods: An in vitro study was conducted at the Department of Prosthodontics, Saraswati Dental College & Hospital, Lucknow, in collaboration with the Central Institute for Plastics Engineering and Technology. Thirty samples (ten each of Polyvinylsiloxane, Zinc Oxide Eugenol paste, and Alu Wax) were evaluated for dimensional stability at 1, 24, and 48 hours, and for compressive resistance at 100 gm² and 1000 gm² using a Universal Testing Machine.

Results: Polyvinylsiloxane exhibited superior dimensional stability at all tested intervals compared to Zinc Oxide Eugenol paste and Alu Wax. In terms of compressive resistance, Alu Wax demonstrated the highest resistance at both tested loads, significantly outperforming the other materials. Zinc Oxide Eugenol paste showed the least favorable results in both tests.

Conclusion: The study highlights the importance of material selection in fixed prosthodontics. Polyvinylsiloxane, with its excellent dimensional stability, is ideal for situations requiring precise registration over extended periods. Alu Wax, due to its high compressive resistance, may be preferable under conditions of high mechanical stress. The findings suggest that traditional materials like Zinc Oxide Eugenol may not provide the same level of reliability as newer, more advanced materials.

Keywords: Interocclusal Recording Materials, Dimensional Stability, Compressive Resistance, Polyvinylsiloxane, Zinc Oxide Eugenol, Alu Wax, Prosthodontics

INTRODUCTION –

Interocclusal record materials are pivotal in the field of restorative dentistry and prosthodontics, as they provide an accurate registration of the positional relationship between the dental arches of patients. These materials are critical for procedures such as the fabrication of prostheses, diagnosis and planning of

treatment, and the assessment of occlusal relationships [1]. The efficacy of these materials significantly impacts the clinical outcomes in terms of fit, function, and longevity of dental restorations [2].

Dimensional stability refers to the ability of interocclusal record materials to maintain their form after being removed from a patient's mouth and before being used to articulate stone models. This property is crucial as changes in dimensions can lead to inaccuracies in mounting casts, ultimately affecting the occlusion of dental prostheses [3]. On the other hand, compression resistance denotes the material's ability to withstand occlusal forces during the recording phase and to resist deformation under load. This is essential for ensuring that the interocclusal records do not distort during handling, leading to erroneous registrations of the interarch relationships [4].

Various materials are currently used for interocclusal records, including wax, zinc oxide eugenol pastes, silicones, and polyether materials. Each material comes with its specific set of properties and limitations. For instance, waxes are easy to manipulate and inexpensive but often lack dimensional stability; they can distort due to temperature changes and are susceptible to deformation under pressure. Silicone-based materials offer better dimensional stability but can vary in their flow and rigidity, affecting their ability to register precise details [5,6]. Hence, there is an ongoing need to evaluate these materials to determine which provides the best combination of dimensional stability and compression resistance.

By understanding the properties of various interocclusal record materials, clinicians can make informed choices about the most appropriate material based on specific clinical situations, thereby improving the accuracy of their work and the overall treatment outcomes for patients [7]. Additionally, the findings of this study could guide manufacturers in improving the formulation of these materials to better meet clinical needs. This in vitro study aims to perform a comparative evaluation of the dimensional stability and compression resistance of different types of interocclusal record materials. The goal is to identify which materials provide the most reliable and accurate registrations under a variety of conditions simulating clinical use.

Materials and Methods:

This in vitro study was conducted at the Department of Prosthodontics and Crown & Bridge, Saraswati Dental College and Hospital, Lucknow, with sample testing completed at the Central Institute of Petrochemicals Engineering & Technology, Lucknow, Uttar Pradesh. The primary objective was to evaluate the dimensional stability and compressive resistance of three different types of commercially available interocclusal recording materials.

Ethical clearance for the study was granted by the institutional ethical committee under reference SDC&H/IHEC/2019/VIDS/25, ensuring compliance with research standards and ethical guidelines.

The materials assessed in this study included Polyvinylsiloxane Bite Registration Material (Coltene Whaledent Jet Bite), Zinc Oxide Eugenol Paste (DPI Impression Paste), and Zinc Oxide Alu Wax Bite (Maarc Bite Registration Wax). Each material was chosen for its prevalence and potential utility in clinical dental settings.

Key equipment used in the testing of these materials included:

A Universal Testing Machine (INSTRON, PTC/083/ME), which was crucial for evaluating compressive resistance.

A Digital Vernier Caliper (Mitutoyo Digital Caliper) provided precise measurements of dimensional changes.

A Thermostat Controlled Water Bath Unit simulated oral temperature conditions, crucial for realistic testing environments.

The methodology of the study was meticulously structured to ensure reliable results. It began with the fabrication of a metal master die, constructed according to American Dental Association specification no.19. This die helped standardize the dimensions of the specimens. Thirty samples, ten for each material, were then prepared according to manufacturers' instructions and adapted to fit the metal master die.

The evaluation process consisted of two main assessments:

Dimensional Stability: This was measured at several time intervals using the digital vernier caliper. The goal was to detect any changes from the initial dimensions that might indicate material instability.

Compressive Resistance: Each sample underwent testing under specific forces applied through the universal testing machine to assess their resistance to deformation.

Finally, the data collected from these tests were subjected to rigorous statistical analysis. This analysis aimed to thoroughly evaluate the performance of each material under conditions that simulate actual clinical usage, thereby providing insights into their practical applicability and effectiveness in dental treatments. This comprehensive approach ensures that the study's findings are robust and can significantly contribute to the selection and use of interocclusal recording materials in clinical settings.

Results:

Dimensional Stability

1 Hour Evaluation:

The study found no statistically significant differences in dimensional stability among the tested materials at the 1-hour mark. The mean dimensional stability values were as follows: Polyvinyl Siloxane at 24.6350, Zinc Oxide Eugenol (ZOE) at 24.4960, and Alu Wax at 24.6230, with a P-value of 0.584, according to the ANOVA test.

24 Hours Evaluation:

After 24 hours, significant differences emerged, with Polyvinyl Siloxane demonstrating higher stability than both ZOE and Alu Wax. The respective mean values were Polyvinyl Siloxane at 24.5810, ZOE at 24.3370, and Alu Wax at 24.3440. The statistical analysis yielded a P-value of 0.024, indicating significant differences with Polyvinyl Siloxane exhibiting greater stability than the other materials, as highlighted by the post-hoc comparisons.

48 Hours Evaluation:

The trends observed at 24 hours continued through the 48-hour evaluation, with Polyvinyl Siloxane maintaining superior dimensional stability. The means recorded were Polyvinyl Siloxane at 24.5440, ZOE at 24.4110, and Alu Wax at 24.2160. The findings were statistically significant, as reflected by a P-value of 0.002 in the ANOVA test, confirming Polyvinyl Siloxane's superior performance over the other materials. (Table 1)

Compression Resistance

At 100 gm^2 Load:

Significant variances were observed in compression resistance among the materials when subjected to a 100 gm^2 load. Alu Wax showed the highest resistance, with a mean of 250.8268, followed by ZOE at 151.1550, and Polyvinyl Siloxane at 103.7148. The differences were statistically significant with a P-value of less than 0.0001, where Alu Wax was notably more resistant than both ZOE and Polyvinyl Siloxane.

At 1000 gm^2 Load:

The compression resistance test at 1000 gm² further reinforced the previous findings, with Alu Wax again showing the highest resistance, recorded at 1087.18. This was compared to 1049.82 for ZOE and 998.06 for Polyvinyl Siloxane. The P-value remained below 0.0001, indicating a significant difference, with Alu Wax maintaining the highest resistance followed by ZOE and then Polyvinyl Siloxane. (Table 2)

Table 1: Dimensional Stability across time intervals

Table 2: Compression Resistance at Different Loads

Discussion

This study's findings on the dimensional stability and compressive resistance of interocclusal recording materials are pivotal for clinical decisions in prosthodontics. The superior performance of Polyvinylsiloxane in terms of dimensional stability aligns with previous research which suggests that addition silicones provide excellent accuracy due to their material properties, such as minimal shrinkage and deformation post-set [9]. These characteristics make them particularly suitable for procedures where precision in the maxillomandibular relationship is critical.

In contrast, Alu Wax demonstrated the highest compressive resistance. This result is consistent with the known properties of waxes, which, despite their poor dimensional stability, often exhibit high resistance to compression when enhanced with fillers such as aluminum particles [10]. This makes them useful in specific clinical scenarios where load resistance is more critical than dimensional fidelity over time.

The observed performance of Zinc Oxide Eugenol (ZOE) paste in this study, which showed less favorable results in both tests, reflects the material's inherent limitations. ZOE's tendency to undergo dimensional changes due to dehydration and setting contraction is well-documented [11]. Such characteristics underscore the challenges of using traditional materials like ZOE in fixed prosthodontics, where precision is paramount.

Comparatively, studies have shown that materials like Polyvinylsiloxane are less affected by ambient conditions and handling errors, which can significantly impact the accuracy of interocclusal records [12]. Additionally, the ease of use and the ability to verify details visually make silicone-based materials preferred choices in modern dental practices [13].

Further, the study's outcomes support the findings of Michalakis et al., who highlighted the less favorable flow properties of ZOE compared to silicone-based materials, affecting the material's ability to record fine occlusal details accurately [14]. Similarly, the favorable properties of Polyvinylsiloxane are highlighted by Balthazar et al., who noted its stability under various environmental conditions [15].

This study also echoes the recommendations of Tejo et al., advocating for the timely use of materials based on their setting characteristics to minimize errors [16]. Such strategic application of material properties can optimize outcomes in fixed prosthodontic treatments. Ultimately, this study not only confirms the findings of previous researchers but also contributes new insights into the comparative benefits of these materials under simulated clinical conditions. Clinicians must consider these properties when selecting a material to ensure that the chosen medium best suits the specific needs of the treatment scenario.

Conclusion

The present in vitro study offers a comprehensive evaluation of the

dimensional stability and compressive resistance of three widely used interocclusal recording materials: Polyvinylsiloxane, Zinc Oxide Eugenol (ZOE) paste, and Alu Wax. The findings highlight the importance of selecting the right material based on specific clinical needs to optimize prosthodontic treatment outcomes.

Polyvinylsiloxane demonstrated superior dimensional stability over the time intervals tested, confirming its suitability for scenarios where precise registration of the maxillomandibular relationship is crucial. Its minimal dimensional change and resistance to environmental factors make it a reliable choice in fixed prosthodontics, particularly when delayed pouring of casts is anticipated.

Alu Wax, while showing the highest compressive resistance, exhibited less dimensional stability, suggesting its use may be more appropriate in situations where high compression forces are expected but less precision in dimensional fidelity can be tolerated.

Zinc Oxide Eugenol, despite its traditional popularity, displayed limitations in both dimensional stability and compressive strength. Its performance indicates that while it may still be useful in certain contexts, newer materials like Polyvinylsiloxane offer significant advantages in terms of accuracy and stability.

This study not only supports existing literature but also enriches our understanding, suggesting a shift towards more advanced materials that can reliably capture and maintain critical dental relationships over time. Future research should continue to explore and validate these findings across diverse clinical environments to further refine material selection and application strategies in fixed prosthodontics.

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