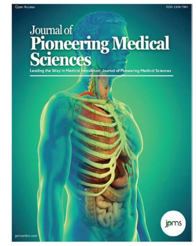

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Dimensional Accuracy of Impression Using Conventional Putty-wash Compared to Modified Putty-wash Technique

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Abstract **Background:** Impression material accuracy is crucial for the fabrication of indirect restorations because distortion during the impression process can affect the final dental prosthesis. However, the impression technique is essential for ensuring a proper fit for the prosthesis. Among various impression materials, this impression creates a dimensionally stable "negative" mold, which serves as the basis for developing a cast for the dental structure. **Purpose:** To evaluate and compare the dimensional accuracy of conventional and modified putty-wash techniques on measurements of the finish line on a scanned model using superimposition. The study aimed to evaluate if the impression made using the modified putty-wash technique can produce a more accurate cast than that made using the conventional putty-wash technique. **Methods:** This study used a master model fabricated from the original typodont containing two crown abutment preparations (molar and premolar). 95 impressions were made using upper plastic trays and divided into three groups. Group 1 consisted of 25 impressions using the two-step conventional putty-wash technique. Group 2 also had 25 impressions and was made using the modified putty-wash technique with baseplate pink wax, utility wax and light body. Group 3 included 45 impressions using the modified putty-wash technique. **Results:** The dimensional accuracy of the resulting casts was affected owing to a statistically significant difference between the modified and conventional putty-wash techniques. **Conclusion:** This study aimed to develop a more precise technique utilizing utility wax and hard pink baseplate wax as an alternative to the conventional putty-wash method. This approach enhances ease of handling for clinicians while offering cost-effectiveness and repeatability, as utility wax can be softened and reused. In contrast, putty material cannot be reused due to its susceptibility to deformation.

Key Words Accuracy of the Impression, Impression, Dental Prosthesis, Putty-Wash Technique

INTRODUCTION

The accuracy of the impression material is crucial for the fabrication of indirect restorations because distortion during the impression process can affect the final dental prosthesis. However, the impression technique is essential for ensuring a proper fit for prosthesis [1]. Among various impression materials, this impression creates a "negative" mold that is dimensionally stable, which serves as the base for developing a cast for the dental structure. Various materials are available to make an impression. Moreover, choosing the most suitable material is crucial. The choice of material must allow for accurate reproduction of static and oral structures. The impact and accuracy of the final dental restorations (crowns or bridges) significantly depend on the choice of impression materials and techniques used during impression-making. An essential factor in achieving precise impressions is the accurate reproduction of the preparation margins-the defined boundaries of the tooth structure. Ensuring clarity and integrity in these margins is critical for the success of indirect restorations [2].

Mouth replicas can be produced using impression materials that meticulously capture teeth and surrounding oral structures, allowing dental work to be completed without a patient. These materials create an accurate and detailed 3D representation of the mouth [3]. Irreversible hydrocolloid impression is one of the most common daily procedures. Additionally, alginate is another commonly used dental material, the fundamental results of an alginate impression can form the original "idea" regarding the patient's oral health [4]. The best results in fixed prosthodontics are usually achieved using conventional impression techniques involving materials such as polyether or polyvinylsiloxane. This approach involves stone casting to create indirect restorations. However, other options besides traditional treatment approaches are available [5]. However, the introduction of CAD/CAM technology has significantly improved the accuracy and reproducibility of the results [6].

Digital impression techniques offer numerous benefits. Moreover, different approaches have been employed to create impression-free models that may be advantageous over traditional plaster models. Intraoral scanners were developed to obtain digital dental models directly from patients without requiring dental impressions [7], potentially shortening the time between patient assessment and a complete diagnosis. Direct intraoral scanning is cost-effective despite the laboratory time required. Newer devices have yielded progressively faster scanning speeds and higher detail quality. Numerous studies have highlighted the ease of data communication during digital scanning and patient comfort during impression-taking [8].

Nonetheless, several studies have highlighted that digital impressions yield more accurate results than traditional impressions due to direct digital scanning of teeth does not undergo secondary reactions compared to dental stones. However, conventional impressions using elastomeric impression material and stone models undergo dimensional changes owing to silicon shrinkage [9]. Conversely, impressions must achieve a high degree of accuracy, closely replicating the teeth being modeled. To prevent dimensional alterations, it is essential to implement proper storage protocols that safeguard impression integrity [7]. Insufficient handling and delays can lead to undesirable shape alterations [10]. Over the years, advancements in impression materials have significantly improved prosthetic dentistry. The most commonly utilized materials include reversible hydrocolloids, alginates, polysulfides and condensed silicone. Additionally, polysiloxane (PVA), polyvinylsiloxane (PVC), polyethers and polyethylene (PE) are recognized for their distinct properties. Within elastomer dentistry, polyvinylsiloxane (PVS) and polyethers (PE) remain the preferred materials for prosthetic impressions, owing to their superior clinical performance and minimal dimensional variation [11]. The ideal impression material must meet stringent clinical and laboratory standards, demonstrating exceptional dimensional stability and accuracy. These mechanical properties are crucial in ensuring optimal elastic recovery, thereby preserving the integrity of the impression [12]. Its superior mechanical and physical properties, ease of manipulation, dimensional stability and exceptional elastic recovery make it the preferred choice among dental professionals [13]. Moreover, PVS facilitates convenient impression pouring, allowing the operator to perform a second pour when necessary. Additionally, its auto-mix system minimizes the risk of defects such as voids, bubbles and pull defects, ensuring superior dimensional accuracy in impressions [14].

The hydrophilicity of polyether is one of its defining characteristics [15]. These materials naturally attract and integrate with water and moisture, ensuring seamless adaptation to humid environments. This property is crucial for achieving precise impressions, as it allows the material to accurately capture the intricate details of the patient's dental anatomy, faithfully reproducing its delicate nuances [16].

An accurate final cast enables precise dental restoration, with dimensional stability ensuring repeatable pours. However, prolonged storage reduces accuracy. To mitigate this, impression materials must exhibit minimal polymerization shrinkage and maintain long-term stability, as studies confirm peak accuracy occurs immediately post-polymerization but gradually declines over time.

PVS materials exhibit exceptional dimensional stability, allowing impressions to be poured within two weeks of creation [17]. However, over time, the water content in PVES and other elastomeric impression materials evaporates, leading to shrinkage upon extraction. Accuracy may be influenced by the material's chemical properties and the type of disinfectant used, potentially resulting in water imbibition. The immersion method, involving submersion in disinfectants for approximately 30 minutes, enables hydrophilic elastomeric impression materials to absorb significant amounts of water [18].

Despite meticulous execution, some degree of distortion is inevitable during impression-making in prosthesis fabrication. Therefore, the selected impression technique plays a critical role in determining the accuracy and fit of the final restoration. The accuracy of dental impressions is significantly influenced by the selected impression material and technique. Several methods for PVS materials accommodate varying viscosities, including the one-step dual-viscosity, one-step single-viscosity and two-step putty-wash techniques [19]. However, in the one-step approach, putty material may displace the wash from critical areas such as the finish line, potentially compromising precision despite its efficiency [20]. Selecting an appropriate technique is essential for achieving an accurate fixed partial denture. Both one-step and two-step methods are viable but maintaining a uniform, consistent wash space remains crucial for optimal impression accuracy.

Most studies strongly recommend the two-step technique, as it ensures a uniform wash space, facilitating proper polymerization of the light-body framework material. The clinical success of fixed prostheses relies heavily on the precision of both the impression material and the procedural accuracy. Elastomeric impression materials benefit from putty, which serves as a tray for the wash material. However, light-body materials exhibit superior detail reproduction and flowability, enabling an accurate impression with minimal dimensional variation between the vertical and horizontal expansion of the prepared abutment [21].

Objectives

This study systematically evaluates and compares the accuracy of various impression techniques based on master cast measurements. The null hypothesis asserts that no statistically significant difference exists between the modified and conventional putty-wash techniques, indicating no effect on the dimensional accuracy of the resulting casts. Conversely, the alternative hypothesis posits that utility wax achieves superior dimensional accuracy compared to the putty-wash technique, specifically at eight designated points along the finish line.

METHODS

This study used a master model fabricated from the original upper typodont containing two crown abutment preparations: The first right molar and the second tooth was the first left premolar (Figure 1). This study aims to measure the accuracy of different impression techniques on a master model by examining the differences between the conventional and modified putty-wash techniques.

For all groups, a total of 50 impressions were made using a resin-printed model fabricated from a scanned typodont containing two full-coverage crown abutment preparations. These impressions were distributed to assess the accuracy of 6 points on each prepped tooth on the finish line using a Meshmixer application (V3.5). Next, the impressions were divided into three groups randomly using upper plastic trays #3 (size medium) to compare the conventional putty-wash technique to that of the modified putty-wash. Therefore, two groups were assigned:

- **For Group I**, 25 impressions were made by a calibrated operator using the two-step conventional putty-wash technique with a plastic stock tray. By using the VPS putty impression material, two scoops of base and catalyst were equally dispensed, mixed and applied following the manufacturer's instructions on a plastic tray. The model was previously sprayed with handpiece lubricant to prevent material tearing. The prepped tooth was covered by a section of nylon sheet to act as a spacer, providing a space to prevent the light body from washing out. After 5 minutes of setting time, the putty impression was removed. Moreover, the nylon sheets were removed to prepare for the next step. The light body was dispensed on the tray and the model
- **For Group II**, A total of 25 impressions were made by the same calibrated operator using a modified putty-wash technique with baseplate pink wax, utility wax strips (Coltene Whaledent) and light body material (Zhermack Elite HD+). To make the tray bulkier, multiple layers of baseplate wax were applied to the plastic tray (Figure 2). The wax was fused with four utility wax strips arranged in a U-shape, then softened with a torch for 2-3 seconds. These strips were blended because the baseplate wax was too hard and couldn’t capture fine occlusal details. Utility wax performed better in capturing these details. Finally, the light body material was applied before seating the impression tray

The master cast was scanned for reference backup. However, out of the 50 sample size, 25 impressions made with the conventional technique were digitally scanned by (Zirkonzahn S600 ARTI) a calibrated scanner each time. Next, the scanned pictures of each group was superimposed on the master cast to obtain the difference in numbers between the master cast and impressions using Meshmixer (v3.5).

Result of Putty Wash Techniques on Tooth Dimensions

This study examined the effects of two impression techniques, Putty Wash and Modified Putty Wash-Utility Wax, on various tooth dimension measurements (buccal, palatal, mesial and distal depths) of two different teeth (#16 and #24) (Figure 3).

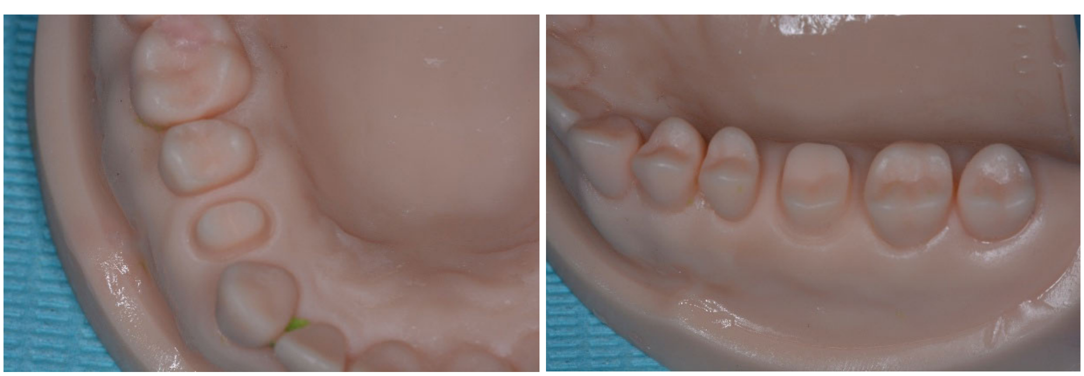

Figure 1: Printed master cast

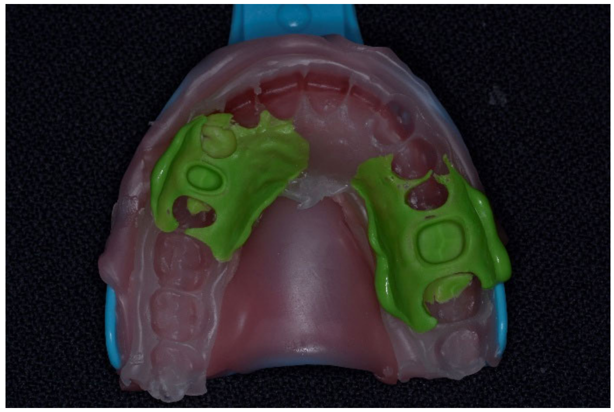

Figure 2: Modified putty-wash technique

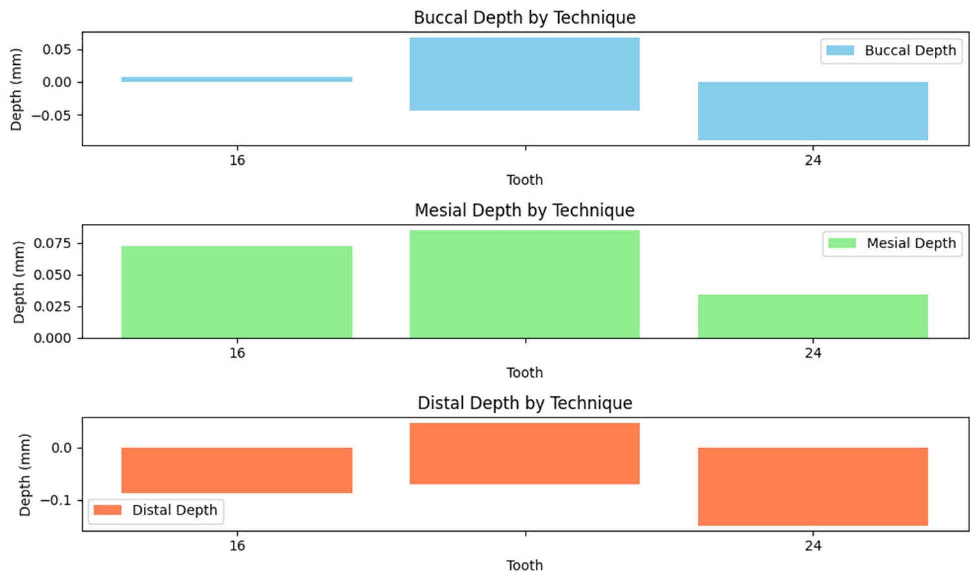

Figure 3: Explain the difference between the two techniques among tooth #16, #24

Key Findings: Tooth #16:

- The Modified Putty Wash-Utility Wax exhibited enhanced Distal Depth than the Putty Wash
- No significant differences were found in Buccal Depth, Palatal Depth or Distal Depth between the techniques

Tooth #24:

- The Modified Putty Wash-Utility Wax exhibited enhanced Mesial Depth than the putty wash
- No significant differences were found for any other measurements

DISCUSSION

The data represent the results of a General Linear Model (GLM) analysis conducted using two different dental techniques: putty wash and modified putty wash–utility wax. The analysis was performed separately for two different tooth numbers: 16 and 24.

For Tooth #16

The descriptive statistics showed the mean and standard deviation for the four dependent variables (BD, PD, MD and DD) for each technique, indicating that the effect of the dental technique on different dimensional measurements of the tooth was examined.

Box's Test of Equality of Covariance Matrices showed that the assumption of homogeneity of covariance matrices was violated for tooth #16 ($p<0.001$). Therefore, the variance-covariance structures were unequal across the two technique groups, breaking a critical GLM assumption.

The multivariate tests showed a significant effect of the intercept ($p<0.001$) across all multivariate test statistics (Pillai's trace, Wilks' lambda, Hotelling's Trace, Roy's largest root). Therefore, significant differences were observable in the combined dependent variable groups. However, the effect of the technique was not statistically significant ($p = 0.069$), suggesting that the different techniques did not have a significant multivariate effect on the dependent variables of tooth #16.

Levene's test of equality of error variances showed that the assumption of homogeneity of variance was met for most of the dependent variables (BD, PD and DD) but not for MD (p = 0.009). Therefore, the variance in the MD scores was unequal across the groups for tooth #16.

For Tooth #24

The descriptive statistics followed a similar pattern, providing the mean and standard deviation for the same four dependent variables across the two techniques.

Box's test revealed a significant result ($p<0.001$), indicating that the homogeneity of the covariance matrices assumption was violated for tooth #24. The violation of this assumption suggests that the GLM may not be the most appropriate analysis for this data, as it depends on the assumption being met. Alternative analyses, such as multivariate analysis of variance (MANOVA), are more suitable given the apparent differences in the variance-covariance structures between the two technique groups. These results are comparable. No significant effect of the interception ($p<0.001$) was observed across all multivariate test statistics, indicating significant differences between groups in the combined dependent variables. The effect of the technique was also not statistically significant (p = 0.087) for tooth #24, which aligns with the findings for tooth #16. Therefore, the different techniques did not have a significant multivariate effect on the dependent variables.

Levene's test of the equality of error variances showed that the assumption of homogeneity of variance was met for all dependent variables for tooth #24.

Based on the ANOVA results for teeth #16 and #24, the key points were as follows:

Tooth #16:

- The Corrected Model was statistically significant for BD (p = 0.080), MD (p = 0.062) and DD (p = 0.028), indicating that the technique explained a significant portion of the variance in the measurements
- The Intercept was statistically significant for PD ($p<0.001$) and DD ($p<0.001$), suggesting that the grand mean values for these measurements differed significantly from 0
- The Technique factor is statistically significant for DD (p = 0.028), with a moderate effect size (partial η^2 = 0.097)
- The estimated marginal means show the grand mean values for the different measurements: BD = 0.034, PD = 0.078, MD = -0.020, DD = 0.050

Tooth #24:

- The Corrected Model was statistically significant for MD (p = 0.014), indicating that the technique factor explained a significant portion of the variance in this measurement
- The Intercept was statistically significant for MD ($p<0.001$) and DD ($p<0.001$), suggesting that the grand mean values for these measurements differed significantly from 0
- The Technique factor is statistically significant for MD (p = 0.014), with a moderate effect size (partial η^2 = 0.119)
- The estimated marginal means show the grand mean values for the different measurements: BD = -0.066, PD = 0.023, MD = -0.110, DD = 0.083

Analyzing the accuracy of putty wash and modified putty wash–utility wax techniques using a General Linear Model (GLM) for teeth #16 and #24. Statistical tests revealed violations of covariance matrix assumptions, suggesting the need for alternative analyses. While the technique had a marginally significant effect on Distal Depth (DD) for tooth #16 and Mesial Depth (MD) for tooth #24, multivariate analysis indicated no overall significant impact. The findings suggest that impression technique effects may be location-dependent, influenced by anatomical and procedural factors (Table 1, 2).

Table 1: Pairwise test for #16

Dependent variable		Sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Noncent. parameter	Observed power[b]
BD	Contrast	0.058	1	0.058	3.200	0.08	0.063	3.2	0.418
	Error	0.869	48	0.018					
PD	Contrast	0.002	1	0.002	0.419	0.52	0.009	0.419	0.097
	Error	0.227	48	0.005					
MD	Contrast	0.232	1	0.232	3.666	0.062	0.071	3.666	0.467
	Error	3.038	48	0.063					
DD	Contrast	0.027	1	0.027	5.161	0.028	0.097	5.161	0.605
	Error	0.249	48	0.005					

The table is based on the linearity of pairwise comparisons, a: Tooth number: 16, b: Computed using alpha = 0.05

Table 2: pairwise test for tooth #24

Dependent variable		Sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Noncent. parameter	Observed power[b]
BD	Contrast	0.024	1	0.024	0.276	0.602	0.006	0.276	0.081
	Error	4.219	48	0.088					
PD	Contrast	0.007	1	0.007	0.234	0.631	0.005	0.234	0.076
	Error	1.355	48	0.028					
MD	Contrast	0.077	1	0.077	6.461	0.014	0.119	6.461	0.702
	Error	0.571	48	0.012					
DD	Contrast	0.023	1	0.023	0.897	0.348	0.018	0.897	0.153
	Error	1.242	48	0.026					

The F-tests are based on the effect of the technique, a: Tooth number: 24, b: Computed using alpha = 0.05

For Tooth #16, the technique demonstrated a marginally significant effect on Buccal Depth (BD) and Mesial Depth (MD), alongside a significant effect on Distal Depth (DD). The effect sizes for these findings were moderate, indicating potential clinical relevance. The observed statistical power ranged from medium to moderately high, suggesting sufficient sensitivity to detect these effects. However, the technique did not significantly impact Palatal Depth (PD), as its effect size was negligible and statistical power remained low, limiting the reliability of detecting any potential effects.

For Tooth #24, the technique exhibited a significant effect exclusively on Mesial Depth (MD), characterized by a moderate effect size and high observed power. Conversely, Buccal Depth (BD), Palatal Depth (PD) and Distal Depth (DD) demonstrated non-significant effects, with negligible effect sizes and low observed power. The disparity in findings between the two teeth suggests that the technique's impact may be location-dependent within the oral cavity. Variables such as tooth anatomy, surrounding bone and soft tissue characteristics and technique application may influence these variations.

These findings underscore the necessity of evaluating new techniques across multiple tooth sites to comprehensively assess their efficacy and limitations. While the marginally significant results suggest potential clinical utility, the observed inconsistencies indicate the need for further research to establish the optimal applications and constraints of this approach.

CONCLUSIONS

The fabrication of dental fixed prostheses is highly dependent on the selection of impression materials and techniques to ensure the dimensional accuracy of full-coverage crowns on prepared teeth. Additionally, the success of partial and full-coverage prostheses is influenced by the clinician's expertise in impression-making, pouring techniques and material handling. While no significant difference was observed between the studied techniques, the modified putty-wash method is recommended for its cost-effectiveness and value as an educational tool in undergraduate training rather than for clinical application in patient care.

Limitations

- **Temperature Stability:** Maintaining a stable temperature was challenging, as fluctuations could affect the dimensional stability of utility wax
- **Material Stabilization:** Ensuring proper stabilization of the light-body material over the utility wax posed difficulties, impacting impression accuracy
- **Clinical Replication Limitations:** The in vitro setting may not fully replicate clinical conditions, where variables such as saliva, patient movement and oral environmental factors influence impression accuracy

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

Ethical Approval

The research proposal was approved by the regional research and ethics committee of King Abdulaziz University with an Ethical Approval number (168-11-23).

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