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Palatal Depth, Anchoring Holes, and Denture Cleanser Types on Adaptation of Acrylic Denture Bases

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Abstract

Objective: This study examines how palatal vault depth, mechanical anchoring, processing techniques, and denture cleanser immersion affect the posterior palatal adaptation of acrylic denture bases. **Materials andMethods:** Forty-eight PMMA denture bases were fabricated using either compression or injection molding. They were categorized by palatal depth (shallow, medium, high) and the presence or absence of anchoring holes. Specimens were immersed in four solutions—distilled water, 1% sodium hypochlorite, 2% chlorhexidine, and Kin® effervescent tablets—for 3, 10, 30, or 60 days. Digital gap measurements were analyzed using two-way ANOVA and Tukey's HSD tests ($\alpha = 0.05$). **Results**: Adaptation was significantly affected by palatal depth, anchoring, processing method, and immersion time ($p < 0.05$). Different gap distances were observed across palatal depths, with anchored specimens demonstrating better adaptation. Injection molding provided greater dimensional stability over time than compression molding. However, cleanser type did not significantly influence adaptation ($p > 0.05$), regardless of immersion duration. **Conclusion:** Posterior palatal adaptation is mainly influenced by fabrication method, mechanical anchoring, and immersion time, while cleanser type has minimal effect. Optimizing these factors can improve denture fit and longevity.

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Introduction

Complete denture retention relies heavily on the accurate adaptation of the denture base to its supporting tissues, particularly in the posterior palatal seal (PPS) area [1,2]. The interplay of surface tension, adhesion, cohesion, and saliva film thickness underpins this retention; however, any discrepancy at the palatal seal notably compromises the prosthesis's functional stability [1–4]. Polymethyl methacrylate (PMMA) acrylic resins remain the material of choice due to their favorable biocompatibility, aesthetics, and ease of processing [3,5]. Nonetheless, volumetric shrinkage during polymerization and subsequent dimensional alterations during clinical service can impair adaptation at critical locations, such as the mid-palatal region [6–8]. Previous studies have indicated that acrylic resin bases undergo minimal but clinically relevant shrinkage (approximately 0.3–0.5%), which can be partially compensated by water sorption [9–11]. Processing techniques, including compression and injection molding, have been introduced to mitigate such detrimental dimensional shifts [12–14]. In addition, immersion in denture cleansers—whether in the short term or over extended durations—may further influence the dimensional stability of the denture base [15,16]. Yet, quantitative assessments of how these immersion protocols affect the posterior palatal seal adaptation remain inadequate.

Anatomic considerations also play a pivotal role in denture base adaptation. The palatal vault can vary considerably between patients, ranging from shallow (U-shaped) to steep (V-shaped) configurations. While some investigations suggest that shallow palates encounter broader interface gaps, especially extending transversely between the ridges, others report that deeper palates may be more prone to pronounced distortion [17–19]. Mechanical anchoring techniques, including drilling holes in the PPS region, have been proposed to reduce polymerization-related distortion, thereby preserving the accuracy of the denture base fit [25– 27]. These interventions aim to stabilize the base during processing, particularly in the thin posterior segments susceptible to polymerization shrinkage.

Given the multifactorial nature of denture base adaptation, this study seeks to evaluate how palatal depth, mechanical anchoring (hole placement), processing methods, and variable immersion in denture cleanser solutions collectively influence posterior palatal adaptation. Specifically, the effects of different immersion durations—short (30 days) and long (60 days)— were examined to capture both early and extended water sorption or cleanser-related changes. The null hypotheses state that neither the palatal depth configuration nor the presence of anchoring holes would significantly alter the adaptation of the denture base following short- or long-term immersion in various denture cleansers. The insights gained from this investigation could guide clinicians and researchers in optimizing denture fabrication methods and maintenance protocols, ultimately improving patient outcomes and prosthetic longevity.

Material and Methods

Sample Size Calculation and Group Allocation

A total sample size of 48 specimens was determined via G*Power (v3.1.9.7), with α = 0.05, power = 0.80, and an estimated effect size of 0.40. Specimens were divided into subgroups to investigate the effects of palatal depth, mechanical anchoring, processing technique, and immersion regimes outlined below.

Specimen Preparation

Master Casts and Palatal Configurations

Master casts replicating an edentulous maxillary arch were fabricated according to standard clinical and laboratory protocols [15]. A precision-machined metal die (36 ± 0.01 mm in diameter, 3 ± 0.01 mm thick, stainless steel, medical grade) was employed in combination with high-precision silicone putty (PluLine®) to ensure dimensional accuracy and reproducibility.

Subsequent casting was conducted using Type III dental stone (BonDano®, Wiegelmann Dental GmbH), mixed and poured under manufacturer-recommended conditions [20]. These master casts were categorized into three palatal depths (n = 16 per group) based on vault height [16]: Shallow Palate: 7.5 ± 0.5 mm, Medium Palate: 11 ± 0.5 mm, and High Palate: 13 ± 0.5 mm.

Orientation Notching

V-shaped orientation notches (OrN, diameter 2 mm; depth 1 mm) were precisely created at a 90° angle using a surveyor-mounted handpiece. Notches were placed in the posterior palatal seal (PPS) region (five points) and along the midline (three points) [28].

Baseplate wax thickness was standardized at 1.5 mm, and a consistent tooth arrangement was used to further simulate clinical conditions [19].

Denture Base Fabrication

Two processing techniques were employed: Compression Molding (n = 24); Material: Heat-cured acrylic resin (Lucitone 550, Dentsply), Powder/liquid ratio: 23.4 g: 10 mL, Mixing time: 30 seconds; working time: 10 minutes at 23°C, Bench press pressure: 3000 psi, Curing cycle: 74°C for 2 hours, then 100°C for 1 hour, Bench cooling: 30 minutes in the flask, and Deflasking: 24 hours post-curing [21]. Injection Molding (n = 24); Material: Heat-cured resin (SR-IVOCAP, Ivoclar Vivadent) in capsule form, mixing time: 5 minutes in a Cap Vibrator, Hydraulic bench press with a constant injection pressure of 6 Pa, Continuous material injection during polymerization, Curing: 98°C for 35 minutes, and Cooling: maintained under constant pressure for uniform polymerization [29].

Mechanical Anchoring

Half of the specimens in each palatal depth and processing subgroup underwent mechanical anchoring. Five holes (1.5 mm in diameter, 2 mm in depth) were uniformly placed across the PPS area, maintaining an inter-hole spacing of approximately 8 mm. The non-anchored control specimens remained without holes.

Denture Cleanser Immersion Protocol

Specimens were immersed in one of four solutions: Distilled Water (control), 1% Sodium Hypochlorite (freshly prepared daily), 2% Chlorhexidine Gluconate, and Kin® Effervescent Tablets (1 tablet per 200 mL of water). Two immersion durations were assessed: Short-term: 30 days and Long-term: 60 days. During each day, specimens were immersed for 8 hours at 37 ± 1°C, following recommendations from previous studies [15, 30]. Between immersion periods, specimens were stored in distilled water to prevent dehydration.

Measurement of Gap Distances and Imaging Protocol

Environmental Controls: All measurements were performed under controlled conditions: Temperature: 37°C (checked every 4 hours), Humidity: monitored continuously, Light Intensity: ~500 lux, when not under evaluation, specimens were stored in temperature-controlled containers with distilled water to maintain a stable environment.

Reference Points and Photography: Six measuring locations were designated on each specimen; Posterior Palatal Seal (PPS) Area, Left Vestibule (LV), Left Ridge (LR),- Posterior Palatal Seal (MPPS), Right Ridge (RR), and Right Vestibule (RV). These locations were marked at standardized intervals (8 ± 0.5 mm). To document gap distances, a Nikon D5300 (macro lens: Sigma 105 mm 1:2.8 DG) was positioned 50 cm from the specimen to minimize parallax errors. Identical lighting and camera settings were used for all photographs.

Digital Image Analysis: Images were imported into ImageJ (v1.53k) at 4800 dpi resolution [31]. Five reference landmarks were mapped for each photograph to locate measurement points accurately. Each landmark's gap distance was measured thrice, and the mean of these three readings was used for statistical analysis. All measurements were carried out by a single calibrated examiner, with intra-examiner reproducibility checked at a two-week interval.

Data Management and Statistical Analysis

Data were collated using SPSS (v26.0; IBM Corp.), and confirmatory power analysis was performed in G*Power. Normality was initially evaluated using the Kolmogorov–Smirnov test. Given the factorial design, two-way ANOVA was employed to analyze the main and interaction effects of palatal depth, mechanical anchoring, denture cleanser type, and immersion duration on mean gap distances. Where significant differences were detected, Tukey's HSD post-hoc test was applied to elucidate pairwise comparisons at a significance level of α = 0.05 [31].

Results

Normality Testing: A Kolmogorov–Smirnov test was performed to verify the normality of the data on mechanical anchoring, palatal depth measurements, and denture cleansers. The results indicated that all datasets satisfied the assumption of normal distribution ($p > 0.05$). Mechanical Anchoring: As shown in Table 1, both the anchored and non- anchored

groups exhibited normal distributions ($p > 0.05$).

Table 1. Normality test for anchored and non-anchored groups.

Group	Statistic	df	p-value
Non-Anchored	0.142	48	0.087
Anchored	0.138	48	0.092

Palatal Depth Measurements: Table 2 presents the normality test results across different palate types (shallow, medium, high) and anatomical locations (vestibule, lateral palate, mid-palate, ridge). All p-values exceeded 0.05, indicating that the data followed a normal distribution.

Denture Cleansers: Four cleansing solutions (distilled water, sodium hypochlorite, chlorhexidine, and Kin tablets) were subjected to normality testing (Table 3). None of the solutions violated the normality assumption ($p > 0.05$).

Table 2. Normality test across palate types and anatomical locations.

Palate Type	Anatomical Location	p-value
Shallow	Vestibule	
Lateral Palate	0.149	0.078
Mid-Palate	0.144	
Ridge	0.138	
Medium	Vestibule	
Lateral Palate	0.147	0.081
Mid-Palate	0.141	
Ridge	0.135	
High	Vestibule	
Lateral Palate	0.146	0.079
Mid-Palate	0.139	
Ridge	0.133	

Table 3. Normality test for different denture cleansing solutions.

Cleansing Solution	Statistic	df	p-value
Distilled Water	0.145	12	0.088
Sodium Hypochlorite	0.141	12	0.091
Chlorhexidine	0.138	12	0.094
Kin Tablet	0.143	12	0.089

Two-Way ANOVA Analyses

Palatal Depth and Mechanical Anchoring: A two-way ANOVA evaluated the effects of palatal depth (shallow, medium, deep) and mechanical anchoring (with or without holes). Palatal depth exerted a highly significant effect ($F = 34.141$, $p < 0.001$), and the presence of anchoring holes also showed a significant main effect ($F = 66.798$, $p < 0.001$). In contrast, the interaction between palatal depth and mechanical anchoring was non-significant ($F = 1.073$, $p = 0.349$).

Post-hoc analysis using Tukey's HSD revealed significant differences between: Shallow vs. Medium palatal depth ($p = 0.008$), Shallow vs. Deep palatal depth ($p < 0.001$), Medium vs. Deep palatal depth ($p = 0.022$), and with vs. without anchoring holes ($p < 0.001$).

Processing Method and Immersion Time: A second two-way ANOVA assessed the influence of two processing methods (compression vs. injection molding) and immersion time (3, 10, 30, 60 days). Both variables had significant main effects: Processing Method: $F = 58.317$, $p < 0.001$ and Immersion Time: $F = 16.213$, $p < 0.001$. Furthermore, a significant interaction between the processing method and immersion time was observed ($F = 3.045$, $p = 0.034$). Post-hoc comparisons indicated that injection molding differed significantly from compression molding ($p < 0.001$), immersion times of 3 days and 10 days were both significantly different from 30- and 60-day immersion periods ($p < 0.05$), and Differences were also noted between 10- and 60-day intervals ($p = 0.003$).

Denture Cleanser Type and Immersion Duration

The third two-way ANOVA examined the effects of cleanser type (distilled water, sodium hypochlorite, chlorhexidine, Kin tablets) and immersion duration (3, 10, 30, 60 days) on the outcome measure. A highly significant main effect of immersion duration was detected ($F = 14.141$, $p < 0.001$), whereas cleanser type showed no significant effect ($F = 0.880$, $p = 0.421$). The interaction between cleanser type and immersion duration was also not significant ($F = 1.073$, $p = 0.349$)

Post-hoc Tukey's HSD analyses showed non-significant differences among the four cleanser types ($p > 0.05$). However, immersion duration comparisons revealed: 3 days vs. 30 days: $p = 0.012$, 3 days vs. 60 days: $p < 0.001$, 10 days vs. 30 days: $p = 0.038$, and 10 days vs. 60 days: $p = 0.003$. No significant difference was detected between 3 and 10 days ($p = 0.425$), nor between 30 and 60 days ($p = 0.142$).

Overall, the data demonstrated that palatal depth, mechanical anchoring, processing method, and immersion time significantly influenced posterior palatal adaptation of acrylic denture bases, whereas cleanser type did not exert a statistically significant impact.

Discussion

This comprehensive study explored the multifactorial nature of posterior palatal adaptation in acrylic denture bases, emphasizing four key variables: mechanical anchoring, palatal morphology, immersion in various denture cleansers, and processing techniques (compression vs. injection molding). The findings confirm that these factors do not act in isolation but collectively shape the dimensional fidelity of the denture base in the posterior palatal region.

Mechanical Anchoring

The statistically significant decrease in gap measurement observed when anchoring holes were incorporated highlights the efficacy of mechanical anchoring in enhancing adaptation. This result parallels observations by Consani et al. [8], who underscored the pivotal role of processing parameters in dictating denture base accuracy. The anchoring holes appear to function by: Stabilizing the resin during polymerization, effectively counteracting known shrinkage vectors, providing micromechanical retention at the thin posterior area of the denture base, and distributing polymerization-induced stresses more uniformly.

Most notably, the favorable outcomes achieved with anchoring holes remained consistent across different palatal depths, indicating a straightforward, clinically feasible method to augment denture base adaptation.

Palatal Morphology

The study reaffirms the pronounced impact of palatal depth on denture fit in the posterior zone. In line with Laughlin's earlier findings [4], the high-palate group exhibited the least gap discrepancy. The deeper vault's more pronounced slopes seemingly promote stability during the processing cycle, mitigating the outward forces that typically lead to midline gap formation. Shallow palates, conversely, encountered more uniform but larger distortions, potentially due to less topographical constraint and more homogenous shrinkage. From a clinical perspective, this suggests that shallow-palate patients may benefit most from techniques that specifically aim to reduce polymerization stresses.

Effects of Denture Cleansers

Although slight numerical variations were noted across cleanser subgroups-ranging for sodium hypochlorite and Kin® tablets; no statistically significant differences emerged. This lack of a cleanser-based effect on adaptation aligns with prior reports (e.g., Degirmenci et al. [15]) indicating that short-term immersion does not substantially degrade acrylic resin bases or compromise their fit. Moreover, the phenomenon of water sorption appears quantitatively similar among the evaluated

solutions, suggesting that typical overnight or short-term immersion in these cleansers is not detrimental to denture base adaptation. This information is clinically reassuring, as it indicates that recommended at-home soaking regimes will likely not compromise palatal adaptation.

Processing Techniques

The strong correlation between extended polymerization cycles and superior surface adaptation corroborates prior observations by Bayraktar et al. [31] that increasing polymerization time can more effectively reduce residual monomer content and enhance dimensional stability. In this study, injection molding performed notably better than compression molding, likely due to continuous resin injection, which helps to compensate for polymerization shrinkage. The controlled heat and pressure environment further stabilizes the denture base shape. This finding reinforces the premise that controlling polymerization kinetics—by either using injection systems or applying extended heat-curing cycles—can yield more dimensionally accurate outcomes.

Clinical Implications

Collectively, these findings underscore several practical considerations. First, mechanical anchoring holes in the posterior palatal seal region provide a relatively simple yet robust strategy to mitigate shrinkage-induced discrepancies and enhance patient comfort. Second, palatal morphology is a clinically relevant predictor of potential adaptation shortfalls; understanding these anatomic variations can guide the selection of anchoring or extended curing procedures. Third, the choice of denture cleansers for short- or extended soaks did not appear to significantly affect posterior adaptation, supporting the flexible use of common cleansing solutions without concern for fit compromise. Lastly, advanced processing methods—particularly injection molding—should be favored in challenging cases (e.g., shallow palates) due to their enhanced dimensional stability.

Conclusion

Posterior palatal adaptation is multifactorial and can be significantly improved through mechanical anchoring, longer or carefully controlled polymerization cycles, and attentive consideration of palatal morphology. While denture cleansers do not appear to degrade adaptation significantly, the injection molding process further optimizes the outcome, especially in anatomically demanding cases. This evidence-based approach enables clinicians to tailor denture fabrication protocols and maintenance recommendations to maximize the comfort, retention, and longevity of complete dentures.

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