

Comparative Clinical and Microbiological Evaluation of Chlorhexidine Mouthwash on PMMA Versus Polyamide Dentures: Randomized Parallel-Group Clinical Trial

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Abstract

Objectives: To evaluate the clinical, microbiological, and material effects of 0.12% chlorhexidine (CHX) mouthwash on polymethyl methacrylate (PMMA) and polyamide removable dentures in edentulous patients.

Methods: A randomized, controlled, parallel-group clinical trial was conducted on 40 edentulous patients aged 50–75 years, allocated into PMMA ($n = 20$) and polyamide ($n = 20$) denture groups. Participants were instructed to use 0.12% CHX mouthwash twice daily for 14 days. Clinical parameters, including Plaque Index (PI) and Gingival Index (GI), microbiological outcomes including *Candida albicans* and total bacterial counts, material properties including surface roughness and Vickers hardness, and patient-reported outcomes were assessed. Statistical analysis was performed at a significance level of $P < 0.05$.

Results: Both groups demonstrated significant reductions in PI and GI following CHX use ($P < 0.001$), with greater reductions observed in the PMMA group compared with the polyamide group. Microbial load reduction was higher in PMMA dentures. Surface analysis revealed minimal changes in PMMA dentures, whereas polyamide dentures exhibited increased surface roughness and reduced hardness. Polyamide dentures were associated with higher patient-reported comfort but more frequent adverse effects.

Conclusions: CHX use may improve gingival health and reduce microbial colonization in denture wearers. However, material-dependent differences suggest that PMMA dentures may exhibit greater resistance to biofilm formation and material degradation, whereas polyamide dentures may provide improved comfort with increased susceptibility to surface alterations. These findings should be interpreted cautiously because of the small sample size and short follow-up period.

Keywords: Chlorhexidine, denture complete, denture cleansers, dental plaque, denture base resins, polyamides, prosthodontics

Introduction

Removable prosthodontic appliances have remained an essential treatment modality to edentulous patients, in part because of their ease of access, low costs and satisfactory esthetic results. Traditional acrylic prostheses, which are made out of polymethyl methacrylate (PMMA), are the most popular that indicate their mechanical stability, biocompatibility, and clinical flexibility.¹ In comparison, the use of flexible polyamide (nylon-based) dentures has been receiving increasing attention over the last few decades as a possible alternative, which is more adaptable, more comfortable to patients, and better integrated with the mucosa of the mouth.² Nevertheless, regardless of these benefits, both the materials offer a perfect substratum on which microbial adhesion and biofilm formation can occur and both factors can precondition the development of gingival inflammation and denture.³ The use of chlorhexidine gluconate (CHX) is one of the most widely used antiseptic mouthwashes in dentistry that has been described as having a broad spectrum of antibacterial, antifungal and antiviral effects.⁴ Its efficacy has always been proven in the processes of controlling the development of oral biofilm, especially in denture users who are in a high risk of developing a microbial colonization.⁵ Nonetheless, CHX has side effects like mucosal irritation, extrinsic staining, and a change in the surface properties of restorative and prosthodontic materials, which limit the long-term clinical usage of CHX.⁶

The latter effects are particularly critical when it comes to removable dentures because PMMA and polyamide vary significantly in hydrophilicity, porosity, and surface roughness and that these factors could affect microbial retention and the extent of chemical degradation caused by CHX.⁷ Past in vitro studies have captured the varying susceptibility of denture base polymers to biofilm growth, and disinfectants effects.⁸ PMMA, which has a relatively smoother surface and lower water absorption, seems to resist adherence of microorganisms, whereas polyamide resins are more hydrophobic and porous, which creates favorable conditions for microbial colonization and mechanical alteration.⁹ However, a major gap in the literature still exists, as very few randomized clinical trials have provided a comprehensive comparison of the impact of CHX on the state of gingival health, microbial biofilm, and material properties between these two prosthodontic substrates. In this regard, the current research was planned to give a clinical, microbiological, and material assessment of 0.12% CHX mouthwash among the edentulous patients wearing PMMA or polyamide dentures. This trial will determine whether the efficacy and safety profile of CHX is affected by the denture material option by combining patient-reported outcomes measurements with the biological and mechanical measurements. Finally, the results can be used to inform the creation of material-specific hygiene guidelines and lead to the long-term care of denture users, which is supported by evidence-based recommendations.

Methods

Design of Study and Study Population

This trial was a prospective, randomized, controlled parallel-group clinical trial. Randomization was performed using a computer-generated sequence, with allocation concealed using sealed opaque envelopes. Outcome assessors were blinded to group assignment, whereas participant blinding was not feasible due to the nature of the intervention.

This study was carried out in the Department of Prosthodontics, Gilgamesh University, Baghdad, Iraq, between August 2025 to December 2025. Fully edentulous participants between 50–75 years of age were recruited and participants were randomly divided into two parallel groups consisting of 20 in each group. The conventional polymethyl methacrylate (PMMA) dentures were given to Group A, while flexible polyamide dentures were given to Group B.

Ethical approval was obtained from the Scientific Committee at the Gilgamesh University (NO. 19B, 2025). All experiments were conducted in compliance with the ethical standards of a committee of the institution and/or national research and the Helsinki Declaration and updated versions.

Participants had to meet the eligibility criteria which included good health in general, were without systemic diseases that might impinge oral mucosa and lacked any history of antibiotic or antifungal therapy in the three months before the study. The exclusion criteria were oral mucosal abnormalities, chlorhexidine hypersensitivity, lack of oral hygiene or reluctance to adhere to the study protocol. The Institutional Review Board approved the study protocol and informed consent was signed by all the participants. The study reporting followed CONSORT guidelines for randomized clinical trials.

Intervention Protocol

Every subject was informed to apply 0.12% chlorhexidine gluconate (CHX) oral mouth rinse twice a day (mornings and evenings) for 14 consecutive days. The subjects were instructed not to rinse the water after every 30 seconds of rinsing. The subjects continued with their normal dental care routine, but were forced to discontinue all antimicrobial products during the study period.

Clinical Assessments

The researchers measured clinical parameters of the starting of the study (T0) and observed the parameters when CHX was used by the patients during 14 days (T1). A trained examiner, who was not informed about the assignment of the treatment groups according to Löe and Silness (1963), assessed the Gingival Index (GI) and Plaque Index (PI) assessment.¹⁰ To determine IL-6 and TNF- α inflammatory cytokines using ELISA, the researchers got samples of GCF taken on denture-bearing mucosa. The paper employed questionnaires to record patient-reported outcomes that comprised of comfort ratings and taste acceptability and adverse effects such as mucosal irritation and denture staining.

Microbiological Analysis

T0 and T1 Biofilm samples were taken on the corresponding fitting surfaces of dentures with sterile swabs. Selective media cultivation of the samples was conducted to determine the number of *Candida albicans* colonies and the total bacterial population measure. Microbial isolates were identified by routine microbiological methods which were identified using routine microbiological methods.¹¹

Material Surface Analysis

The researchers conducted laboratory experiments on PMMA and polyamide resin specimens that are used as the denture base materials in order to determine the effects of CHX. Profilometer was used to determine surface roughness (Ra) and microhardness was determined using a Vickers hardness tester prior to and following exposure to CHX. This test gave the possibility to compare material susceptibility to chemical changes caused by CHX. Trial registration: Not registered. The study was not prospectively registered; however, all procedures followed CONSORT 2010 guidelines. A CONSORT flow diagram is provided in Figure 1.

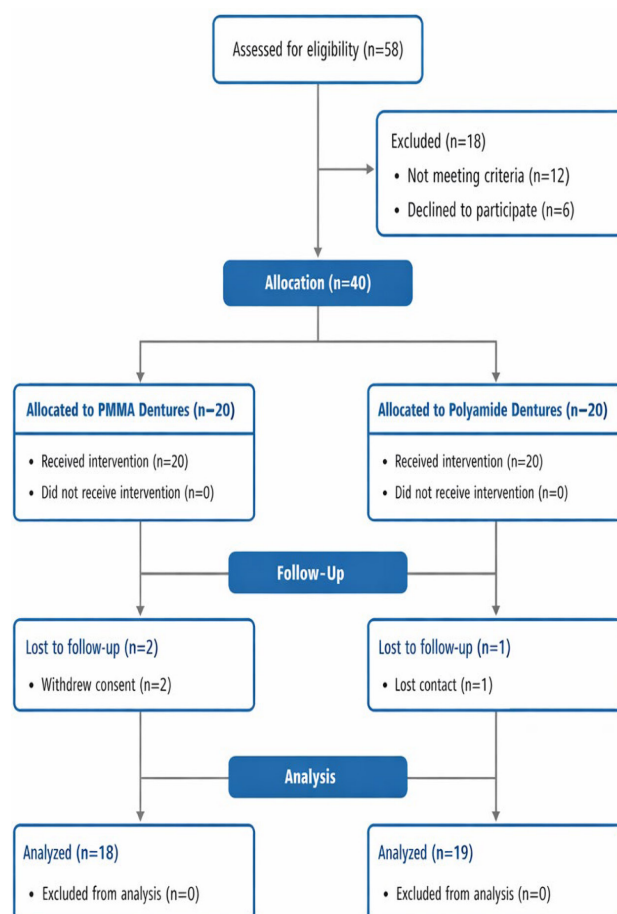


Fig. 1 CONSORT flow diagram of participant progress through the trial.

Statistical Analysis

The SPSS version 25 (IBM Corp., Armonk, NY, USA) was used to analyze the data. The Shapiro Wilk test was used to test normality. Data were normally distributed unless otherwise stated. Paired t-tests were used to determine intra-group differences (T0 vs. T1) whereas the independent t-tests or Mann-Whitney U tests were applied to determine between-group differences. A repeated-measures ANOVA was used in order to take into consideration repeated observations. The effect sizes and 95% confidence intervals (CI) were computed and multiple comparisons were corrected using Bonferroni adjustment for multiple comparisons. *P*-value less than 0.05 was regarded to be statistically significant. It is also worth noting that there was no a priori power analysis conducted in order to establish the best sample size. The absence of an a priori sample size calculation represents a methodological limitation. Therefore, a post hoc power analysis was considered to support the interpretation of findings. The post hoc power analysis indicated an estimated power of approximately 0.72, suggesting moderate statistical reliability.

Results

Clinical Parameters

Baseline (T0) No statistically significant differences existed in the PMMA (Group A) and polyamide (Group B) denture groups in Plaque Index (PI) or Gingival Index (GI) ($P > 0.05$) (Table 1, Figures 2 and 3). The PI and GI dropped significantly

(paired t-test $P < 0.001$) after 14 days of chlorhexidine (CHX) rinsing (T1) in both groups. Nevertheless, the amount of reduction was higher in the PMMA group than it was in the polyamide group (PI: mean reduction 1.4 vs. 1.1, ($P = 0.012$; 95% CI: -1.8 to -1.0); GI: mean reduction 1.3 vs. 1.0, $P = 0.018$; 95% CI: -1.6 to -1.0 vs. -1.3 to -0.7). The analysis of the effect size showed a moderate clinical effect (Cohen $d = 0.52$ PI and 0.49 GI).

Despite the fact that IL-6 and TNF- α samples in gingival crevicular fluid were collected, the data were incomplete and therefore excluded from the final statistical analysis to avoid biased interpretation.

Microbiological Findings

There were also significant reductions in total bacteria load and *Candida albicans* colony-forming units (CFUs) in both groups according to quantitative culture of denture biofilm samples after the use of CHX ($P < 0.001$) (Table 2). Mean CFU change was 78.5 percent in PMMA dentures as compared to 62.3 percent in polyamide dentures. Both the two reductions were found to be statistically significant, but inter-group comparison of superior microbial suppression was found to be in PMMA group ($P = 0.021$).

Surface Characteristics of Materials

Profilometric measurement indicated changes in surface roughness of PMMA samples were insignificant because of exposure to CHX ($\Delta R_a = +0.03 \mu m$) but polyamide samples

Table 1. **Clinical outcomes (Plaque Index and Gingival Index) at baseline (T0) and 14 days (T1) of mouthwash of chlorhexidine in PMMA and polyamide dentures (intra and inter-group evaluations)**

Parameter	PMMA baseline	PMMA Post-CHX	Polyamide baseline	Polyamide Post-CHX
Plaque index	2.3 $\pm$ 0.4	0.9 $\pm$ 0.2*	2.4 $\pm$ 0.5	1.3 $\pm$ 0.3*
Gingival index	2.1 $\pm$ 0.3	0.8 $\pm$ 0.2*	2.2 $\pm$ 0.4	1.2 $\pm$ 0.3*

Values are expressed as mean $\pm$ SD. *indicates a significant difference compared with baseline (paired t-test, $P < 0.05$). Between-group comparisons were performed using independent t-test.

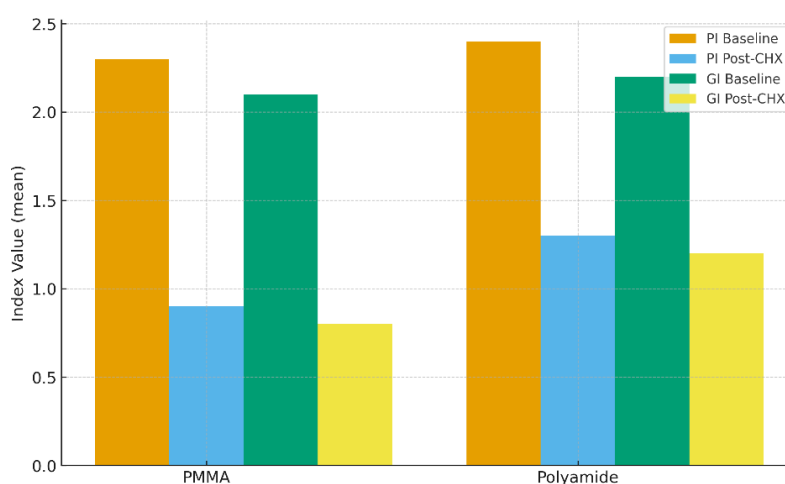


Fig. 2 **Clinical parameters (Plaque Index and Gingival Index) before and after chlorhexidine application in PMMA and polyamide denture groups. The mean values of Plaque Index (PI) and Gingival Index (GI) at the 14 days of chlorhexidine use. The results indicated that both groups had great decreases, but PMMA dentures had better improvements ($P < 0.05$).**

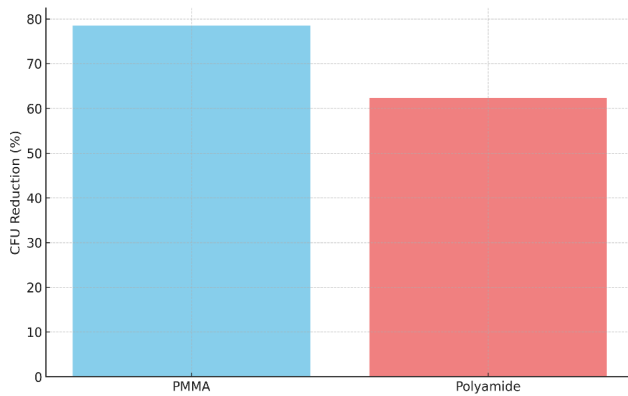


Fig. 3 Comparative changes in plaque index and gingival index following chlorhexidine use. Bar graph of mean $\pm$ SD values of PI and GI in Group A (PMMA) and Group B (Polyamide) before and after treatment with chlorhexidine. Standard deviations are referred to as error bars. There were also notable decreases in the two groups, but PMMA had greater change magnitude ($P < 0.05$).

Table 2. Microbiological analysis: Mean bacterial load and *Candida albicans* colony-forming units (CFUs) at baseline and post-treatment, expressed as absolute values and percentage reduction

Parameter	PMMA (Group A)	Polyamide (Group B)	P-value
Bacterial load reduction (%)	78.5%	62.3%	0.021
<i>Candida albicans</i> CFU reduction (%)	78.5%	62.3%	<0.05

CFU, Colony-Forming Units; CHX, Chlorhexidine. Data represent percentage reduction from baseline between-group comparisons were analyzed using independent t-test. Statistical significance was set at $P < 0.05$.

showed a high level of change ($\Delta Ra = +0.12 \mu m$; $P < 0.01$) (Figure 4). The testing of microhardness revealed that the samples of PMMA were stable, but polyamide exhibited a weak, though statistically significant, loss of Vickers hardness ($P = 0.032$; 95% CI: -5.4 to -0.6). These results indicate that polyamide dentures are more prone to changes due to chemical degradation (Table 3).

Patient-Reported Outcomes

The polyamide group (mean VAS = 8.6 ± 0.7) had a better score than PMMA (7.8 ± 0.5) in patient comfort which is an indicator of high flexibility and adaptation ($P = 0.015$). On the other hand, polyamide users reported adverse effects of denture staining and taste change more often (35% vs. 10%, $\chi^2 = 4.62$, $P = 0.031$; 95% CI: 5.3 to 39.7). Table 4 Visual analogue scale (VAS) scores of comfort and frequency of adverse effects (staining, taste alteration) in PMMA and polyamide denture wearers (Figure 5). In Table 5, the overall clinical, microbiological, material-related and patient-reported results are summarized. The results of the chloride hexidine mouthwash effect on PMMA and polyamide dentures are graphically shown in Figure 6.

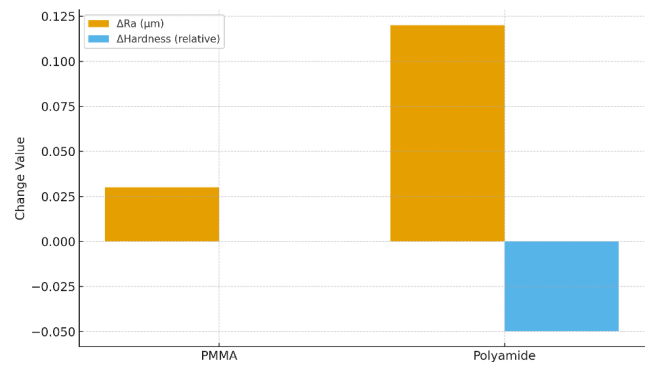


Fig. 4 Effects of denture material properties changed by chlorhexidine exposure. Comparative study of the roughness of the surface (Ra , μm) and the vickers hardness of PMMA and polyamide denture samples in the pre- and post-chlorhexidine (14 days) state. There were small changes in surface of PMMA dentures, but substantial changes in roughness and slight changes in hardness in polyamide dentures ($P < 0.05$).

Table 3. Comparison of clinical, microbiological and material effects of chlorhexidine mouthwash on PMMA and polyamide dentures

Parameter	PMMA dentures	Polyamide dentures
Surface roughness (Ra , μm)	+0.03 (stable)	+0.12 (increased)*
Vickers hardness	No significant change	Slight decrease ($P = 0.032$)

Ra = Surface Roughness; P less than 0.05, significant change. ΔRa = Change in surface roughness values were analyzed using independent t-test. *indicates significant difference ($P < 0.05$).

Table 4. Patient-reported outcomes

Parameter	PMMA dentures (n = 20)	Polyamide dentures (n = 20)
VAS comfort score (mean $\pm$ SD)	7.8 ± 0.5	8.6 ± 0.7
Denture staining (%)	10%	35%
Altered taste (%)	10%	35%

Note: Polyamide dentures were also related to higher levels of comfort, whereas the negative aspects, including staining and changes in taste, were more reported than PMMA dentures. P -values: Comfort ($P = 0.015$), Adverse effects ($\chi^2 = 4.62$, $P = 0.031$). Continuous variables were analyzed using independent t-test, while categorical variables (adverse effects) were analyzed using chi-square test, data are presented as mean $\pm$ SD or percentage.

Discussion

The present randomized clinical trial suggests that 0.12% chlorhexidine (CHX) may improve gingival health and reduce microbial colonization in both PMMA and polyamide denture wearers. However, the observed differences between materials indicate that denture substrate characteristics may influence both antimicrobial efficacy and material stability.

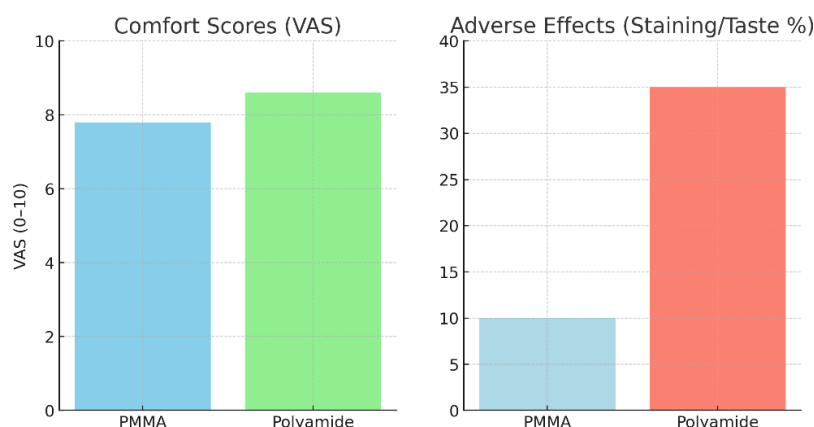


Fig. 5 Patient-reported outcomes in PMMA and polyamide denture groups. (A) Visual analogue scale mean discomfort during denture use of PMMA and polyamide denture wearers. (B) Adverse effects, such as staining and changes of taste, frequency of reported adverse effects. Polyamide dentures had a higher score in the comfort scale, but also a greater number of adverse effects ($P < 0.05$).

Table 5. Summary of clinical, microbiological, material, and patient-reported outcomes

Parameter	PMMA dentures (Group A)	Polyamide dentures (Group B)	Key finding
Plaque index (PI)	Significant reduction (−1.4)	Significant reduction (−1.1)	Greater reduction in PMMA ($P = 0.012$)
Gingival index (GI)	Significant reduction (−1.3)	Significant reduction (−1.0)	Greater reduction in PMMA ($P = 0.018$)
Bacterial load/CFU	↓ 78.5%	↓ 62.3%	PMMA more effective ($P = 0.021$)
Surface roughness (Ra)	Stable (+0.03 μm)	Increased (+0.12 μm)	Polyamide more affected ($P < 0.01$)
Hardness (Vickers)	No significant change	Slight decrease ($P = 0.032$)	Polyamide weaker stability
Comfort (VAS score)	7.8 $\pm$ 0.5	8.6 $\pm$ 0.7	Polyamide more comfortable ($P = 0.015$)
Adverse effects	Staining/taste = 10%	Staining/taste = 35%	Higher in polyamide ($\chi^2 = 4.62$, $P = 0.031$)

Values represent mean changes or percentages. Statistical comparisons were performed using independent t-test and chi-square test where appropriate. Significance level was set at $P < 0.05$.

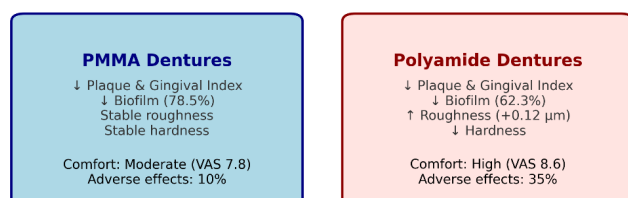


Fig. 6 Integrated summary of clinical, microbiological, and patient-centered. Graphical overview demonstrating the difference between the effects of chlorhexidine mouthwash on PMMA and polyamide dentures. PMMA showed more antimicrobial ability and the stability of material properties, whereas, polyamide offered better comfort but had greater chances to be affected by surface degradation and staining.

These findings are generally consistent with previous clinical and in vitro studies; however, the relatively short follow-up period limits the ability to assess long-term effects of CHX on denture materials. In addition, variations in surface chemistry, porosity, and water absorption between PMMA and polyamide may partially explain the differential response observed in this study. The study results are limited by the small participant number of 40 individuals because this small sample size prevents generalization to different population groups. A bigger participant sample from multiple research

sites is required for the study because this design approach generates findings that apply to broader populations.

Clinical Outcomes

The two denture groups showed major decreases in Plaque Index (PI) and Gingival Index (GI) after two weeks of using CHX rinse. The study results match earlier research which demonstrates that CHX effectively controls oral biofilm growth and enhances dental health for people who wear dentures.¹² The PMMA users obtained superior results because acrylic resins have a smoother surface than polyamide which makes it hard for microorganisms to establish attachment.¹³

The study of Gad et al., demonstrated that *Candida albicans* shows reduced attachment to PMMA surfaces when compared to flexible denture base materials which supports the results of this research.¹⁴

Microbiological Findings

The microbiological tests showed that CHX treatment decreased both bacterial numbers and *Candida albicans* populations in all samples but PMMA dentures had better results (78.5% vs. 62.3%). The study confirms previous research which shows that polyamide's water-resistant and porous structure properties enable bacteria to create biofilms. Research studies

showed that bacteria penetrate deeper into flexible denture materials which reduces the long-term effectiveness of CHX.⁵

Material Surface Properties

The surface analysis showed that PMMA samples kept their original state after CHX treatment but polyamide samples became rougher and their microhardness decreased. The study by Elhagali et al. demonstrated that polyamide dentures show higher chemical sensitivity.¹⁵ The study confirms that CHX damages nylon-based prostheses as shown by Yin et al. (2025).¹⁶ The oral environment changes create conditions that speed up staining processes and enable biofilm to reattach which threatens the long-term success of oral hygiene maintenance.

The two polymers, PMMA and polyamide, respond differently. This behavior can be attributed to the intrinsic properties of the materials themselves. PMMA generally exhibits lower water uptake and higher resistance to degradation which ensures that the surface remains undisturbed and biofilm formation is reduced. In contrast, polyamide with its higher hydrophilic character and higher porosity undergoes a larger surface transformation that promotes biofilm re-attachment while preserving sufficient antimicrobial activity of the material.

On the other hand, the higher durability of PMMA could allow for a prolonged bactericidal effect due to its smoother surface. This balance between bactericidal effectiveness and material durability is particularly relevant in a clinical context. While the high concentration of chlorhexidine led to a reduction in biofilm for both materials, there is a possibility that the reaction between the chlorhexidine and the polyamide could have a detrimental effect on the surface of the material, leading to a rapid re-colonisation.

Patient-Reported Outcomes

Polyamide dentures demonstrate material weakness but patients prefer them because of their flexible nature which provides better comfort and tissue adaptation.¹⁷ Polyamide group demonstrated a higher frequency of adverse effects of stain and taste change in relation to (Du et al., 2018) and other studies have conducted on CHX discoloration of flexible denture bases 2025.¹⁸ The paradox underscores the trade-off between an increased level of comfort and esthetic and functional stability in the long-run.

Clinical Implications

The research findings show that proper denture care needs personalized methods which depend on the type of denture material. The application of CHX for PMMA dentures is safe but its use with polyamide needs proper evaluation. Polyamide users can achieve effective biofilm control through ultrasonic cleaning and alternative disinfectants which minimize material degradation risks.¹⁹ Although IL-6 and TNF- α were collected, incomplete datasets prevented robust statistical analysis; therefore, these variables were excluded to avoid biased interpretation. The relatively short follow-up period (14 days) limits the ability to draw conclusions regarding long-term material degradation and sustained clinical outcomes.

Conclusion

Within the limitations of this study, chlorhexidine (CHX) use may improve gingival health and reduce microbial colonization in both PMMA and polyamide denture wearers. PMMA dentures may exhibit greater resistance to biofilm formation and material degradation, whereas polyamide dentures may offer improved patient comfort but could be more susceptible to surface changes and adverse effects.

These findings suggest that denture hygiene protocols may need to be tailored according to material type. However, the results should be interpreted with caution due to the relatively small sample size and short follow-up duration. Further long-term studies with larger cohorts are recommended.

Limitations

This study has certain limitations. The sample size ($n = 40$) is rather small; the intervention duration (14 days) could have limited the generalizability and ability to apply the findings in the long-term. Moreover, the lack of complete data regarding inflammatory markers (IL-6 and TNF- α) and the lack of a priori power analysis are also some methodological gaps. Lastly, some references include non-peer-reviewed sources, which decreases the overall quality of evidence. It is suggested that future research should include more cohorts, longer follow-up, and referencing.

Clinical Recommendations

1. Material-Specific Protocols: In the case of PMMA dentures, CHX may be safely used as an effective disinfectant without significant chances of affecting the material properties. In the case of polyamide dentures, the application of CHX must be reduced or combined with other forms of cleaning plans (e.g., the use of ultrasonic cleaner, non-oxidizing disinfectants) to reduce the degradation and discoloration of the denture surfaces.

2. Patient Counseling: Denture wearers and especially those who use polyamide prosthesis ought to be educated on the risk of staining and the altered taste with the continued use of CHX. The priority to be given should be in the balance between greater comfort and greater risk of undesirable effects.

3. Future Research: Cumulative effects of CHX on various bases of dentures should be studied using larger groups of patients over a period of time. Comparative studies comparing other disinfectants may aid in the implementation of safer and more effective hygienic measures depending on flexible denture bases. Another limitation lies in the heterogeneity of references, as some citations are derived from theses or book chapters rather than high-impact clinical journals. Future work should build upon stronger evidence from peer-reviewed prosthodontic and dental materials journals to reinforce external validity.

AI-assisted tools were used for language refinement and structural editing. All scientific content was reviewed and validated by the authors.

Conflicts of Interest

The authors have no conflicts of interest to declare for this study. ■

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