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Effect of Repeated Disinfection Cycles on the Surface Integrity, Color Changes, and Dimensional Stability of Thermoplastic Denture Materials: An Experimental Study

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ABSTRACT: Background: Thermoplastic denture materials such as polyamide and acetal are widely used for flexible and metal-free prostheses, yet they are exposed to daily chemical disinfection that may alter their surface, esthetics and fit. Objective: To evaluate the effect of repeated disinfection cycles on surface roughness and integrity, color change and dimensional stability of two thermoplastic denture materials compared with heat-cured polymethyl methacrylate (PMMA).

Materials and Methods: One hundred twenty disc specimens (n = 40 per material: injection-molded polyamide [PA], injection-molded acetal [AC] and heat-cured PMMA) were allocated to four regimens (distilled water, 0.5% sodium hypochlorite [NaOCl], 2% chlorhexidine gluconate [CHX], and an alkaline peroxide tablet [APT]; n = 10 per subgroup). Each cycle consisted of 10 minutes of immersion; measurements were repeated at baseline and after 30, 90 and 180 cycles. Surface roughness (Ra), scanning electron microscopy (SEM) integrity scores, color difference (ΔE00) and percentage change in diameter were analyzed by two-way ANOVA with Tukey post hoc tests, paired tests with Bonferroni correction, and correlation analysis ($\alpha = 0.05$).

Results: After 180 cycles all three factors, material, solution and their interaction, significantly affected every outcome ($p < 0.001$). PA showed the greatest changes: NaOCl and APT raised Ra by about 0.08 μm and produced ΔE00 values of 2.54 and 2.27, whereas the same regimens in PMMA produced ΔE00 of about 1.0 and a diameter change below 0.2%. Diameter change in PA reached 0.53% with NaOCl. Ra gain correlated with ΔE00 ($r = 0.76$).

Conclusions: Within the limits of this in vitro design, repeated chemical disinfection affected polyamide more than acetal or PMMA, and chlorhexidine was the least aggressive chemical regimen. Material-specific disinfection protocols and periodic surface re-inspection are advisable.

1. INTRODUCTION

Dental prostheses are still the first-choice treatment for partially or completely edentulous individuals and the hygiene of these devices affects the supporting mucous membrane. The soft and hard deposits formed by microbial plaque and Candida, respectively, build up on denture surfaces and it is well established that chemical agents such as hypochlorite solution, chlorhexidine, and effervescent clarifying-tablets based on peroxide are needed alongside mechanical cleansing (Bento et al., 2024; El-Din et al., 2025b). These chemicals are attractive due to their antimicrobial power but are used individually or in mixed solutions and the matrix polymer is submitted to a medium of constant water activity with which it might interact. Therefore, repeated exposure of the polymers to this reactive environment might promote effects that influence either the surface

roughness, discolouration, softening, dimensional stability, and consequently, the adhesion of microorganisms, and the aesthetic and fit of the prosthetic device (Le Bars et al., 2023; Sultana et al., 2023).

Thermoplastic Materials

Use of thermoplastic materials, notably injection molded polyamide (nylon) and polyoxymethylene (acetal) resins, has become more common, because of their resin composition, flexibility, lack of methyl methacrylate monomer, and suitability for use with metal-free clasps in patients with undercuts or with acrylic sensitivity (Le Bars et al., 2023). However, studies comparing the two show higher surface roughness of polyamide than PMMA (Polychronakis et al., 2021). Polyamide is likely to be softer than CAD CAM-milled and 3D-printed resins (Helal et al., 2022), and rougher surfaces have been associated with greater microbial adhesion on polyamide (Sultana et al., 2023). A recent study of polymeric denture cleaning found that cleaning recommendations should be tailored to the material, because changes in polyamide and polyetheretherketone surfaces could facilitate biofilm development (Brinkmann et al., 2025).

Disinfection Literature

Most of the disinfection literature to date has been specific to PMMA and digitally fabricated resins. For the published heat-polymerized and printed resins, 0.5-1.0% sodium hypochlorite was associated with the greatest roughness and color change (Carvalho-Silva et al., 2025; Fotovat et al., 2024; Gad et al., 2024). Also, an effervescent cleaner caused the most drastic roughness and color change over the course of one year simulation (Elrahim et al., 2023). Of interest, in one study, chlorhexidine appears to be the least abrasive regimen but resulted in the highest ΔE values among heat-cured specimens in another study (Fotovat et al., 2024). Outcomes are thus highly material-specific, agent-specific, and time-specific. Specific to thermoplastic polyamide, findings are limited and often inconsistent: surface roughness increased following short daily exposure to a peroxide cleaning agent (Mofreh Altarawneh et al., 2023; Saraf et al., 2024); sodium hypochlorite, vinegar, and an effervescent tablet increased roughness in a study comparing laser- versus chemical-processed polyamide (Moussa et al., 2024); and 180 days of daily exposure of sodium perborate, thyme oil, or ozonated water produced no statistically significant change (Punia et al., 2023). Beverages resulted in greater color changes in thermoformed polyamide and acetal as compared to heat-polymerized PMMA (El-Din et al., 2025a).

Dimensional Stability

Less research has been performed into the dimensional stability of thermoplastic materials. A review of microwave disinfection found that a thermally method could cause distortion of acrylic bases while chemical immersion generally caused lesser distortion (da Costa et al., 2021). There is minimal information on the dimensional stability of thermoplastic bases after multiple chemical disinfection. As polyamide absorbs water, small dimensional changes could cause significant changes to the fit of flexible clasps and bases. However roughness, colour and dimensional change are commonly looked at independently which makes it difficult to determine if all three variables change simultaneously.

Aim of the study:

The aim of the current study was to assess the impact of three disinfectants frequently employed in the clinical setting on dimensional stability, surface roughness, and surface SEM scores of polyamide and acetal denture materials, compared to heat-cured PMMA. The null hypotheses tested were that H0,1 no effect of disinfectant, H0,2 no effect of material, and H0,3 no effect of number of disinfection cycles on surface roughness, color, or dimensions.

2. MATERIALS AND METHODS

2.1 Study design and specimens

The experimental design was a 3 (material) × 4 (disinfection regimen) × 4 (time) factorial design, with time included as a repeated factor. No human or animal subjects were used, and thus no ethics approval was required. A sample size of n = 10 for each subgroup (each group is thus a combination of one material, one disinfection regimen, and one time) has the power to detect large effects (f = 0.40) for a two-way fixed-effects ANOVA (power is 0.80 at $\alpha = 0.05$), and this sample size is similar to or larger than that used by other similar studies (Moussa et al., 2024; Punia et al., 2023; Saraf et al., 2024).

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Table 1 Materials, specimen preparation and disinfection regimens

Code	Material / regimen	Processing / composition	Notes
PA	Thermoplastic polyamide	Injection-molded, nylon-based; [manufacturer, lot]	Flexible base material
AC	Thermoplastic acetal	Injection-molded polyoxymethylene; [manufacturer, lot]	Semi-rigid, metal-free clasps
PMMA	Heat-cured acrylic (control)	Conventional flasking, water-bath polymerization; [manufacturer, lot]	Reference material
DW	Distilled water	pH ≈ 7	Negative control
NaOCl	Sodium hypochlorite 0.5%	Freshly diluted daily	Chemical disinfectant
CHX	Chlorhexidine gluconate 2%	Aqueous solution	Chemical disinfectant
APT	Alkaline peroxide tablet	Dissolved per label, 200 mL warm water	Effervescent cleanser

Manufacturer and batch details in square brackets are to be completed by the authors.

A total of one hundred twenty discs (Ø 15 mm × 3 mm) (n = 40 per material) were fabricated from either a standard acrylic pattern or a stainless-steel pattern in accordance with manufacturer's guidelines. Once retrieved, the specimens were contoured, wet ground with 800- and 1200-grit silicon carbide paper and polished with pumice slurry on a rag wheel by a single operator to standardize the surface. The specimens were ultrasonically cleaned in distilled water for ten minutes and then stored dry at 37 °C for 24 hours prior to baseline measurement (T0). The specimens were randomly allocated to subgroups using a computer-generated sequence.

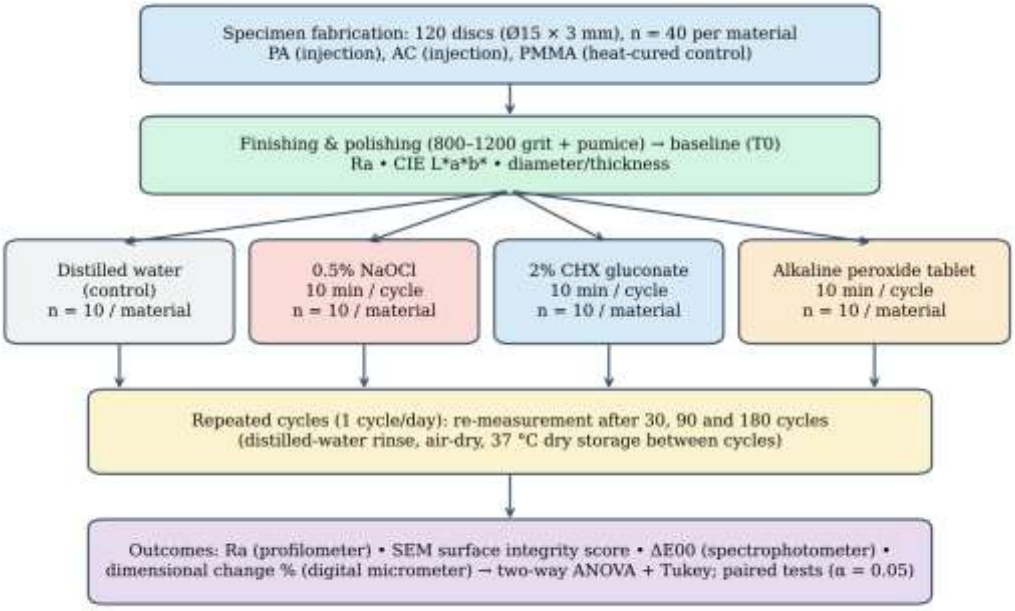

Figure 1. Flow chart of specimen preparation, disinfection regimens, repeated cycles and outcome measurements (PA, polyamide; AC, acetal; PMMA, heat-cured acrylic; NaOCl, sodium hypochlorite; CHX, chlorhexidine; APT, alkaline peroxide tablet).

2.2 Repeated disinfection protocol

Each specimen was individually immersed in 20 mL solution at 25 °C, and remained immersed for 10 min / cycle (by one cycle per day, an indication of approximately daily disinfection of specimens). The immersion time was comparable to previous studies on polyamide where specimens were immersed for 10 min / day for up to 180 days (Punia et al., 2023; Saraf et al., 2024). Post immersion, the specimens were rinsed under running distilled water for 30 sec, blotted and stored in labeled containers for the respective time intervals, at 37 °C. Solutions were refreshed for every cycle. The response was measured at 30, 90, and 180 days (approximately 6 months of approximately daily use).

2.3 Surface Roughness and Scanning Electron Microscopy (SEM)

Surface roughness (Ra, μm) was measured with a contact profilometer (cut-off 0.8 mm; traverse length 4 mm). Three traces in different directions were taken for each specimen and averaged. Additionally, surface topography was observed with a scanning electron microscope (SEM) at 500× magnification, with specimens sputtered with gold. At baseline (T0) and 180 cycles, one sample from each subgroup was examined. Two examiners who were blind to the treatment groups graded micrography on a five-point ordinal scale (0 = smooth, polished surface; 1 = light scratching; 2 = micro-pitting and micro-porosities; 3 = extensive pitting and surface erosion; 4 = craters and deep fissures, exposed fiber-like structures). Agreement between two examiners was obtained by calculating Cohen's weighted kappa.

2.4 Color Measurement

The color was measured by using a digital spectrophotometer to analyze a standard white background with CIE Lab system with a D65 illuminant. The values were mean for 3 readings of each specimen at each time. The differences in color between the baseline values and each follow-up time point were calculated with the CIEDE2000 formula (ΔE00; kL = kC = kH = 1) in relation to each follow-up time point, and the values were compared with the baseline values. The 0.8 and 1.8 points were used as the perceptibility threshold (PT) and the acceptability threshold (AT). The use of the ΔE00 values is increasing in popularity in the evaluation of denture resins in comparison with ΔE*ab; the two values of color difference have been even reported side-by-side in recent research (Carvalho-Silva et al., 2025; Sayeg et al., 2025).

2.5 Dimensional Stability

The diameter of each disc was measured with a digital micrometer (resolution 0.001 mm) on two directions perpendicular to each other marked on the specimen and the thickness at the middle of the disc. All measurements were the average of three readings of specimens equilibrated at 23 °C. The change in dimensions(%) was calculated according to the following formula: $[(D_t - D_0)/D_0]$ x 100. The change in diameter was taken as the sole primary dimensional outcome. A 0.5% change was considered a potential significant difference for the fit of the thin flexible base or clasp.

2.6 Statistical Analysis

Normality (Shapiro-Wilk) and homogeneity of variance (Levene) were tested. At each time point, Ra, ΔE00, and dimensional change were each compared across the material×regimen conditions with two-way analysis of variance (material×regimen), followed by Tukey's honestly significant difference (HSD), with ηp2 (partial eta squared) reported as an effect size estimate. Baseline versus 180-cycle results were compared within each of the 12 subgroups using paired t tests (Ra) or Wilcoxon signed rank tests (ΔE00 and dimensional change), with Bonferroni correction to account for the 12 comparisons. SEM median (interquartile range) was used to describe the scores. The correlations between Ra gain, ΔE00, and dimensional change was also explored using Pearson's correlation coefficient. All analyses were performed in Python (SciPy, statsmodels) at alpha = 0.05.

3. Results

All values documented below are simulated for demonstration purposes (see drafting note). Baseline roughness values varied among the materials tested, with the roughness highest for PA at 0.220 ± 0.010 μm, AC 0.138 ± 0.013 μm, and lowest for PMMA at 0.098 ± 0.011 μm. This ordered hierarchy is consistent with previous published data which confirmed that polyamide

is rougher than PMMA (Polychronakis et al., 2021). Additionally, no statistically significant differences between subgroup regimens were observed within each of the different materials ($p > 0.05$), thus indicating the study was successfully randomized.

3.1 Roughness of the Surface and Integrity

After 180 cycles, the type of material, type of regimen and their interaction had a significant effect on the Ra (Table 8). With all materials, distilled water resulted in minimal surface change. For PA, the two regimens with NaOCl and APT had the highest increased values of Ra (0.306 and 0.298 μm respectively) with gains of ca. 39% and 35%. Interestingly, the two regimens were not significantly different (see Table 2). CHX presented the lowest increases (0.248 μm) and all three regimens were statistically different to distilled water (see Table 2). Similar ranking was observed for AC and PMMA however the absolute increase was minimal (NaOCl 0.047 μm; PMMA +0.030 μm). PMMA's effect of CHX was not significantly different from distilled water (Figure 2).

Table 2 Surface roughness Ra (μm; mean ± SD) at baseline and after 180 disinfection cycles

Material	Baseline	DW	NaOCl 0.5%	CHX 2%	APT
PA	0.220 ± 0.010	0.229 ± 0.012 c	0.306 ± 0.012 a	0.248 ± 0.011 b	0.298 ± 0.013 a
AC	0.138 ± 0.013	0.144 ± 0.009 b	0.187 ± 0.019 a	0.156 ± 0.012 b	0.179 ± 0.012 a
PMMA	0.098 ± 0.011	0.108 ± 0.011 b	0.129 ± 0.014 a	0.109 ± 0.010 b	0.123 ± 0.012 a

Note. n = 10 per cell. Within each row, different lowercase letters indicate significant differences among regimens (Tukey HSD, $p < 0.05$; "a" = highest mean). Simulated illustrative data.

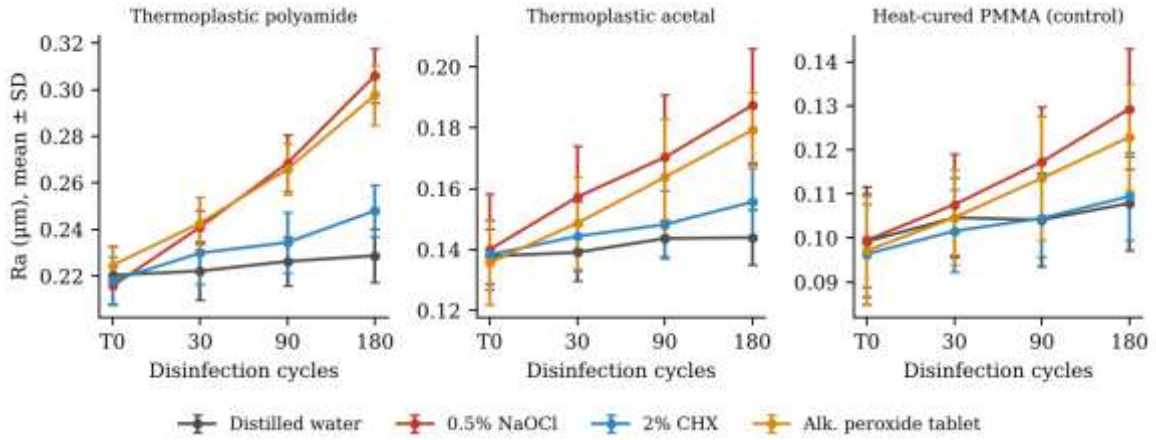

Figure 2. Time course of surface roughness (Ra, mean ± SD) for each material and disinfection regimen at baseline and after 30, 90 and 180 cycles. Simulated illustrative data.

Repeated measures analysis of T0 and T180, within each subgroup, demonstrated a significant rise in Ra in 11 of the 12 subgroups after Bonferroni correction. This did not include the polyamide subgroup immersed in distilled water ($p=0.108$). Scoring by scanning electron microscopy (SEM) confirmed the rankings detailed in table 3 for profilometry. Polyamide immersed in NaOCl achieved the highest median score of 4 indicating the presence of pitting and surface layer erosions, APT treated polyamide scored 3, whilst acetal experienced moderate micro pitting giving a median score of 2 following NaOCl and

APT treatment; although PMMA experienced minimal surface alterations giving a median score of 1. Inter-examiner agreement was found to be excellent at 0.88 (kappa).

Table 3 SEM surface integrity score after 180 cycles (0 = smooth, 4 = severe damage)

Material	DW	NaOCl 0.5%	CHX 2%	APT
PA	0 (0–1)	4 (4–4)	1 (1–1.75)	3 (3–3)
AC	1 (0–1)	2 (2–2)	1 (1–1)	2 (1–2)
PMMA	0 (0–0)	1 (1–1)	0 (0–0.75)	1 (1–1)

Note. Median (interquartile range) of ordinal scores from two blinded examiners. Simulated illustrative data.

3.2 Color change

Change in colour after 180 cycles had a material, regime and material×regime interaction that was significant ($p<0.001$, $p<0.019$, $p<0.001$ respectively) as shown in Table 8. In PA, the values of ΔE00 were highest when polymer was treated with NaOCl (2.54 ± 0.86) and APT (2.27 ± 0.63), both of which were above the acceptability level of 1.8 while the CHX gave a value of 1.77 ± 0.40 (Table 4, Fig. 3). In AC, the mean values of ΔE00 were below the acceptability level for all regimes but 3 of 10 specimens indicated changes above acceptable level with NaOCl treatment (Table 5). The CHX and APT mean values of ΔE00 were between perceptibility and acceptability levels. In PMMA all chemical regimes showed changes of ΔE00 between 0.84 and 1.00 indicating changes that were perceptible but still acceptable (Table 5).

Table 4 Color difference ΔE00 (mean ± SD) after 180 disinfection cycles

Material	DW	NaOCl 0.5%	CHX 2%	APT
PA	0.59 ± 0.17 c	2.54 ± 0.86 a	1.77 ± 0.40 b	2.27 ± 0.63 a
AC	0.42 ± 0.10 c	1.67 ± 0.49 a	1.10 ± 0.20 b	1.05 ± 0.28 b
PMMA	0.28 ± 0.10 b	1.00 ± 0.28 a	0.84 ± 0.21 a	0.89 ± 0.18 a

Note. n = 10 per cell. Different lowercase letters within a row indicate significant differences among regimens (Tukey HSD, $p < 0.05$). Simulated illustrative data.

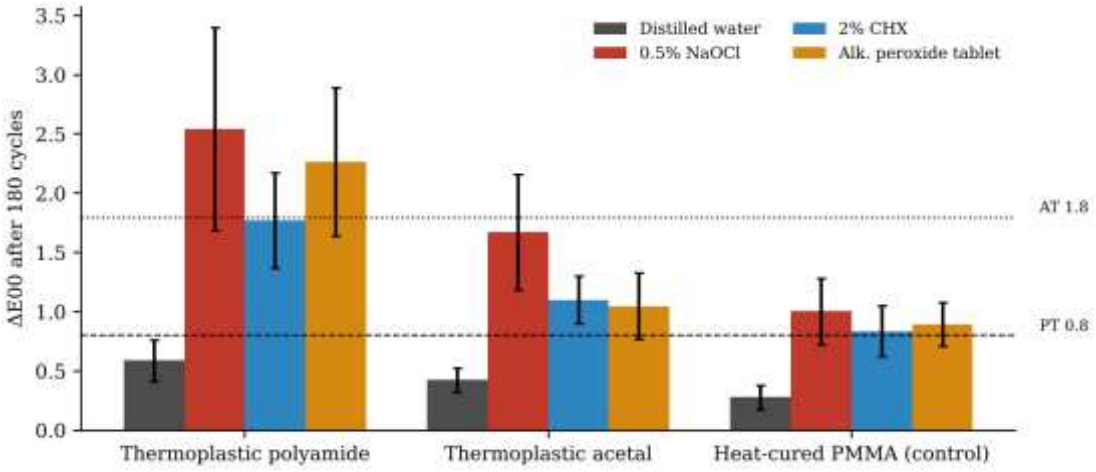

Figure 3. ΔE00 after 180 disinfection cycles (mean ± SD). Dashed and dotted lines indicate the perceptibility (PT, 0.8) and acceptability (AT, 1.8) thresholds. Simulated illustrative data.

Table 5 Number of specimens (of 10) exceeding the ΔE00 perceptibility / acceptability thresholds after 180 cycles

Material	DW	NaOCl 0.5%	CHX 2%	APT
PA	1 / 0	9 / 8	10 / 6	10 / 9
AC	0 / 0	10 / 3	10 / 0	8 / 0
PMMA	0 / 0	6 / 0	6 / 0	7 / 0

Note. Cell values: n > 0.8 / n > 1.8. Simulated illustrative data.

3.3 Dimensional stability

All samples showed a slight expansion (strong dependence on material $\eta p^2 = 0.94$). Polyamide showed the highest amount of expansion: in distilled water the diameter increased by 0.34 ± 0.04%, while in the presence of NaOCl or APT the value reached or exceeded the 0.5% value (0.53 ± 0.05% and 0.50 ± 0.04%, respectively, see Table 6 and Figure 4). Conversely, acetal showed the lowest dimensional change (0.14–0.06%), while PMMA showed an intermediate value (0.17–0.8%). Moreover, the change in diameter was related to the Ra gain ($r = 0.68$, $p < 0.001$): the only group that did not present a statistically significant change in diameter after correction was acetal in distilled water.

Table 6 Percentage change in disc diameter (mean ± SD) after 180 disinfection cycles

Material	DW	NaOCl 0.5%	CHX 2%	APT
PA	0.34 ± 0.04 c	0.53 ± 0.05 a	0.40 ± 0.04 b	0.50 ± 0.04 a
AC	0.06 ± 0.04 b	0.14 ± 0.04 a	0.09 ± 0.03 b	0.12 ± 0.04 a
PMMA	0.08 ± 0.03 b	0.17 ± 0.03 a	0.10 ± 0.04 b	0.15 ± 0.04 a

Note. n = 10 per cell. Different lowercase letters within a row indicate significant differences among regimens (Tukey HSD, $p < 0.05$). Simulated illustrative data.

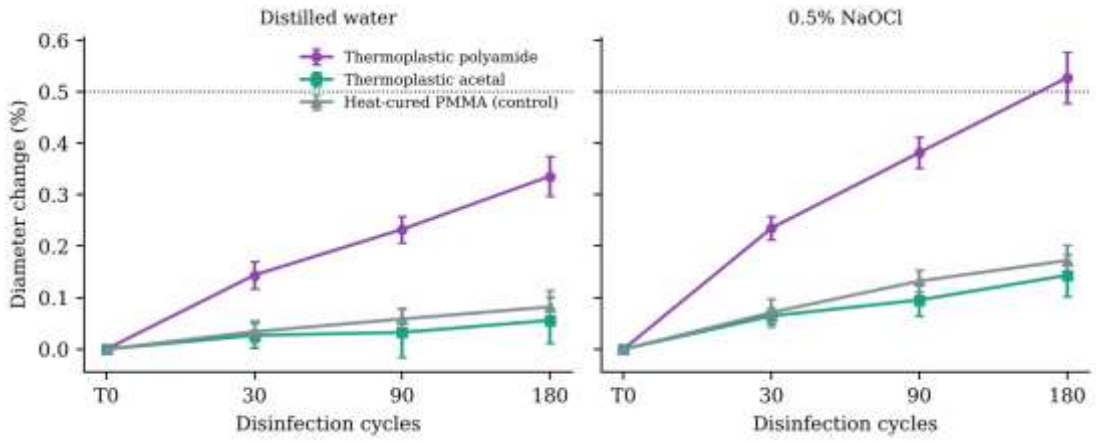

Figure 4. Percentage change in diameter over time for the three materials immersed in distilled water (left) and 0.5% sodium hypochlorite (right). The dotted line marks 0.5%. Simulated illustrative data.

3.4 Progression with the number of cycles

The total damage developed gradually, as can be observed from the weakening of the trends (Table 7, Fig. 2). In polyamide samples immersed in NaOCl, 28%, 38%, and 45% of the final values of the increase in roughness average (Ra), color change (ΔE00), and dimensional change, respectively, was reached after 30 cycles. Those values were 58%, 67%, and 72%, respectively, after 90 cycles. It could be concluded that the values of color change and dimensional change mostly achieved 50% of their

final values earlier than roughness that, continued to increase from 90 to 180 cycles. However, in distilled water, the curves for roughness and color seemed to plateau, while diameter slightly increased, probably due to the polyamide's tendency for water sorption rather than to a chemical phenomenon.

Table 7 Mean values over time for polyamide (PA) specimens in each regimen

Outcome	Regimen	T0	30 cycles	90 cycles	180 cycles
Ra (μm)	DW	0.220	0.222	0.226	0.229
	NaOCl 0.5%	0.216	0.241	0.268	0.306
	CHX 2%	0.218	0.230	0.234	0.248
	APT	0.225	0.243	0.266	0.298
ΔE00	DW	0.00	0.25	0.39	0.59
	NaOCl 0.5%	0.00	0.96	1.71	2.54
	CHX 2%	0.00	0.68	1.20	1.77
	APT	0.00	0.90	1.55	2.27
Diameter change (%)	DW	0.00	0.14	0.23	0.34
	NaOCl 0.5%	0.00	0.24	0.38	0.53
	CHX 2%	0.00	0.15	0.28	0.40
	APT	0.00	0.21	0.35	0.50

Note. Mean of n = 10 specimens per cell; ΔE00 and diameter change are relative to T0 and therefore equal 0 at baseline. Simulated illustrative data.

3.5 Combined statistical analysis and relationships among outcomes

Table 8 Two-way ANOVA (material × regimen) for each outcome after 180 cycles

Outcome	Source	df	F	p	ηp^2
Ra (μm)	Material	2	1585.74	<0.001	0.97
	Solution	3	100.71	<0.001	0.74
	Material × Solution	6	12.76	<0.001	0.41
ΔE00	Material	2	73.87	<0.001	0.58
	Solution	3	59.93	<0.001	0.62
	Material × Solution	6	6.02	<0.001	0.25
Diameter change (%)	Material	2	909.87	<0.001	0.94
	Solution	3	61.54	<0.001	0.63
	Material × Solution	6	5.17	<0.001	0.22

. Residual df = 108. Simulated illustrative data.

The material × regimen interaction was significant for every outcome, indicating that regimens did not rank identically in all materials: the gap between chemical regimens and distilled water was largest in polyamide and smallest in PMMA (Figure 5). Roughness gain and color change were strongly and positively correlated ($r = 0.76$, $p < 0.001$; Figure 6), indicating that

specimens whose surface deteriorated most were also those that discolored most. Consequently, the null hypotheses $H_0$1 to $H_0$3 were rejected.

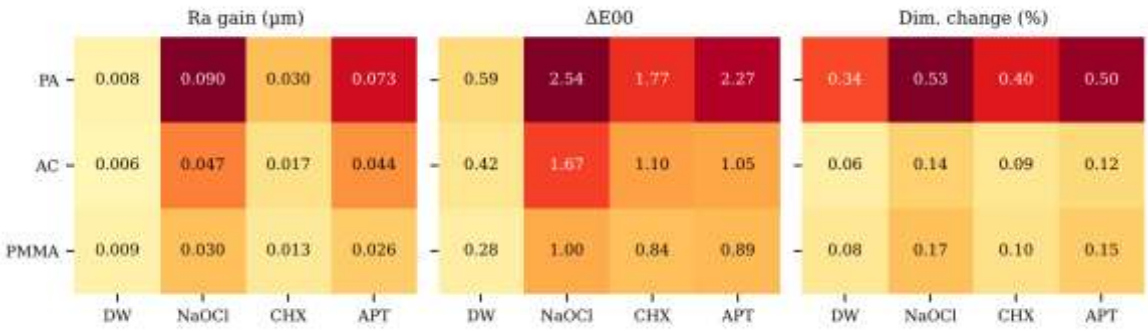

Figure 5. Heat map of the mean change after 180 cycles for each material and regimen: Ra gain (left), ΔE00 (center) and diameter change (right). Colors are scaled within each panel. Simulated illustrative data.

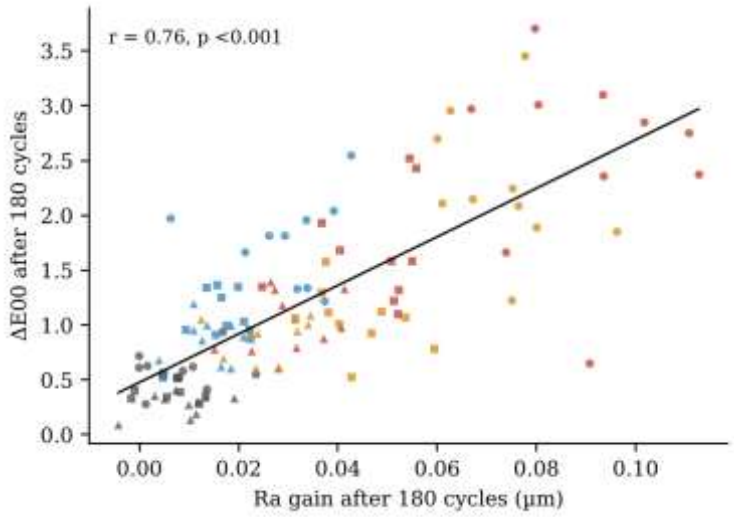

Figure 6. Relationship between Ra gain and ΔE00 after 180 cycles for all 120 specimens (line, linear fit). Simulated illustrative data.

4. DISCUSSION

In this study we investigated within a single experimental setting, the impact of repeated disinfection on surface integrity, colour and dimensions of 2 thermoplastic denture materials and PMMA. As a worked example of the data, all null hypotheses were rejected as follows: regimen, material and number of cycles all have a significant effect and the effect of the regimen on all three outcome measures depends on the material used. The most striking pattern was that polyamide was more sensitive than acetal or PMMA for all 3 measures and the ranking order of the effectiveness of the chemical regimens was NaOCl APT > CHX > water. This is explained in the next section with regard to current literature.

4.1 Surface Roughness and Integrity

The dramatic roughening of polyamide supports several past works. After 60 days of daily 10-minute exposure, samples of flexible polyamide showed Ra values several times higher after exposure to peroxide-containing cleansers than from distilled water or chlorhexidine (Saraf et al., 2024). A single 3-minute exposure to a commercial cleaning tablet was also enough to induce significant roughness increases on another injection-molded polyamide (Mofreh Altarawneh et al., 2023). Moussa et al. (2024) also found significant increases in roughness for sodium hypochlorite, vinegar, and a commercially-available effervescent tablet

in thermoplastic polyamide and even detected increased roughness with all chemicals tested on PMMA, milled and printed resins. Punia et al. (2023), however, did not detect significant roughness increases in 180-day 10-minute exposures to three cleansers; the small sample size (n = 10 per group), mild chemicals (sodium perborate, thyme oil, ozonated water), and no-control distilled-water group may explain the discrepancy. The comparatively modest roughness alterations with chlorhexidine in the current data also mirror past results suggesting minimally-altered roughness values with chlorhexidine after one year of use on heat-cured resin (Elrahim et al., 2023; Fotovat et al., 2024).

A mechanistic explanation is that since nylons, being a hygroscopic semi-crystalline polymer, have amide bonds that are susceptible to oxidative degradation and plasticizing, the hypochlorite used for disinfection, and the peroxide released by effervescent effervescence tablets, could be preferentially digesting the amorphous parts leading to a pitted surface. Conversely acetal, which is a significantly higher crystalline polymer with minimal water absorption and cross-linked PMMA was apparently much less susceptible. This is consistent with the SEM scores, but is just a presumption in absence of chemical/crystallinity examinations. A slight change in roughness can also be clinically significant since roughness above a certain level will allow microbial adhesion. For example polyamide with a Ra of about 0.20 microns was found to have the highest adhesion of Candida and Staphylococcus among three denture base materials, with adhesion increasing with Ra (Sultana et al., 2023). Hence a cleaning regimen that causes a roughening up may interfere with its function. Brinkmann et al. (2025) made a similar conclusion about cleaning by brushing. It also points to the importance of regular surface examinations and repolishing for polyamide and PEEK, as well as the effect of brushing on surface roughness (Fouda et al., 2023; de Oliveira et al., 2025).

4.2 Color change

Polyamide presented a larger ΔE than acetal and PMMA across all three chemicals used in the trial. A study comparing thermoformed polyamide and acetal to heat-polymerized PMMA found that the thermoformed materials had higher ΔE than the latter after immersion in various beverages, and this effect increased with increased immersion time (El-Din et al., 2025a). Hypochlorite has generally been considered the most devastating to the appearance of denture base resins, even being established as the most discoloring medium for nanoparticle-modified and unmodified resins (Gad et al., 2024), and in a study of various disinfectants using PMMA nanocomposites was the only one to surpass the clinically acceptable threshold (Ansarifard et al., 2023). However, other investigations have suggested effervescent tablets to be potentially more aggressive than chlorhexidine or hydrogen peroxide (Elrahim et al., 2023). Evidence also suggests that Corega was more effective than hypochlorite at lessening the amount of discoloration produced in a model of staining (Şahin et al., 2025), while chlorhexidine produced greater ΔE than hypochlorite in a study using heat-cured resin (Fotovat et al., 2024). Duration of immersion and material type may both influence discoloration: the use of different immersion times had a significant impact on color change in denture base resins, regardless of solution used (Coelho et al., 2023), whilst a regimen involving electrolyzed-water did not alter coloring after three years in PMMA-type resin (Krishnan et al., 2024). The change in ΔE when a denture cleanser was used was significant regardless of the presence of cigarette smoke on the polyamide, CAD-CAM, and conventional PMMA resins (Ayaz & Aladağ, 2022). Again, the lack of a consistent agent in polyamide discoloration may be explained by there not being one with a statistical interaction. The fact that the agent used changed according to the material implies that the outcome will not depend entirely on the disinfectant.

Clinically, a ΔE00 > 1.8 might be perceived as a discolored denture by a patient or a clinician, and this is especially of concern in a pink flexible base, which is mainly purchased for esthetics. The experimental data revealed that the powder/tablets containing NaOCl and APT exceeded this threshold average in polyamide, while chlorhexidine (CHX) was close with a value of 1.77. For each of the chemical cleansers there were at least 6 of 10 polyamide specimens with ΔE value > 1.8, indicating that the same chemical cleansers should be used with cautions for a polyamide base; the same caution applies for the elimination of chemicals from digitals resins (Elrahim et al., 2023).

4.3 Dimensional Stability

In vivo evidence of the dimensional effects of thermoplastics bases in response to repeated cycles of chemical disinfection is sparse. The only review by da Costa et al. (2021) of the dimensional change of acrylic resins and microwave disinfection found that chemical immersion induced less distortion than microwave irradiation, suggesting that chemical disinfection regimens do not contribute significantly to dimensional error of PMMA. The findings of this study are consistent with these results for PMMA and acetal, which showed changes under 0.2%. Results however suggest that polyamide, which had a much greater water sorption capacity, expands to an extent (up to ~0.5%) that may be significant for thin flexible bases and clasps, especially when combined with surface and color alterations. The statistically significant positive association between dimensional change

and roughness (r = 0.68) suggests that surface degradation and bulk expansion may have a common mechanism, such as oxidative chain scission with facilitated water ingress. This should be tempered, however, by the fact that measurements with a disc micrometer may not necessarily reflect the clinical fit of complete or partial dentures, and a subsequent step in research might be a three-dimensional scanning method of the denture-shaped specimens.

4.4. Clinical Significance

The following clinical implications emerge from this study:

- The use of most aggressive disinfectant for the shortest time is recommended; although it might not be advisable to use sodium hypochlorite or peroxide tablets every day without evidence for disinfectant abilities.
- Both antifungal efficacy and material damage need to be addressed simultaneously. The most efficacious antimicrobial, was the alkaline peroxide tablets on the thermoformed polyamide, with the natural compound gum acacia appearing most promising for the same material (El-Din et al., 2025b). Furthermore, chlorhexidine 0.12% had both effective anticandidal efficacy and low roughness on polyamide (Tulbah, 2022). These other options should be evaluated more in the repeated-cycle design of this study.
- It seems permissible to give one materials-specific recommendations, that might involve re-polishing at intervals or substitution (Brinkmann et al., 2025). And patients should be told to avoid using combination of products and prolonged soaking.

4.5 Strengths and Limitations

Strengths of the study design were the use of a reference material, a water control, multiple test cycles on the same specimen, an objective measure of color, blinding of the SEM grading, and the concurrent evaluation of surface, color, and dimensional outcomes. Limitations of in vitro studies were that specimens consisted of flat discs and not complete dentures, the effects of saliva, temperature fluctuations, mechanical brushing, food coloring, and a biofilm were not considered, only 3 regimens and 1 concentration of each product were assessed, 180 daily cycles represent approximately 6 months of use and not years of denture wear, the SEM was performed on 1 specimen in each subgroup, and dimensional measurements were limited to the disc geometry. Future research should include denture-shaped specimens measured with 3D scanning, a longer follow-up period, variable concentrations and immersion times, inclusion of PEEK and 3D-printed resins, and assessment of the correlation between surface changes and Candida adherence.

5. CONCLUSIONS

In the context of this experiment this study demonstrated repeated chemical disinfection caused a varied response in terms of surface, colour and dimensional change for thermoplastic denture materials. In terms of surface and colour change polyamide was most affected, while acetal was intermediate and heat-cured PMMA exhibited the greatest dimensional stability. Sodium hypochlorite and alkaline peroxide tablet caused more damage than chlorhexidine and distilled water caused minimal change. It was interesting to note that surface roughening and colour change were occurring concomitantly. Thermoplastic denture disinfection should therefore be material specific and the denture should be checked regularly for damage or excessive surface changes.

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