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# THE PREVALENCE OF SURFACE ROUGHNESS AND STAINING IN INTERIM RESTORATIONS FABRICATED WITH DIFFERENT ACRYLIC RESINS

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## ABSTRACT

**Background:** Interim (provisional) restorations must maintain acceptable surface smoothness and colour stability for function and aesthetics during the provisional period. Different acrylic resins vary in polymer chemistry and processing, which may affect surface roughness and susceptibility to staining.

**Objective:** To compare surface roughness and staining prevalence of interim restorations fabricated with (1) conventional heat-cured polymethyl methacrylate (PMMA), (2) auto polymerizing (chemically cured) PMMA, and (3) CAD/CAM-milled PMMA-based blocks.

**Methods:** A laboratory-based comparative study using standardized crown specimens (n = 20 per group) prepared from the three acrylic resin types. Baseline surface roughness (Ra, µm) was measured with a profilometer after finishing and polishing. Specimens then underwent thermocycling and a 7-day staining challenge (coffee). Post-challenge Ra and colour changes (ΔE00) were recorded. Surface topography was examined with SEM for a subset. Statistical comparisons used ANOVA (or Kruskal–Wallis as appropriate) with $\alpha = 0.05$.

**Results:** CAD/CAM-milled specimens showed the lowest baseline Ra and the smallest mean colour change after staining; auto polymerizing PMMA had the highest Ra and most pronounced staining. Thermocycling and staining increased Ra in all groups, but increases were significantly larger in chemically cured PMMA ($p < 0.05$).

**Conclusions:** Material and processing significantly influence surface roughness and staining of provisional restorations. CAD/CAM-milled PMMA blocks may provide superior surface properties compared with conventional laboratory or chairside auto polymerizing resins.

**Key Words:** Interim restorations, Provisional crowns, Surface roughness, Staining resistance, Polymethyl methacrylate, Auto polymerizing acrylic resin

## INTRODUCTION

A crucial part of fixed prosthodontic processes are interim restorations. While definitive restorations are being made, they safeguard prepared teeth, preserve occlusal connections, offer aesthetics, and make soft tissue care easier.[1] The physical and visual stability of provisional restorations is therapeutically significant since they stay in the oral environment for varying lengths of time, ranging from a few days to many months. Surface roughness and color stability are two important surface characteristics that influence patient satisfaction and biological compatibility of temporary prosthesis.[2]

Surface roughness influences plaque accumulation, gingival response, wear of opposing dentition, and the apparent luster of the restoration.[3] The roughness parameter Ra (arithmetical mean deviation of the profile) is commonly used to quantify surface texture; values above commonly cited thresholds (often around 0.2 µm for plaque retention) have been associated with increased biofilm accumulation.[1]

Different acrylic resins and fabrication techniques produce different surface topographies: laboratory-processed heat-cured polymethyl methacrylate (PMMA) typically undergoes controlled polymerization with lower residual monomer and more homogeneous polymer networks, whereas auto polymerizing (chemically cured) PMMA used chairside may have higher residual monomer and porosity if polymerization is incomplete.[2] More recently, CAD/CAM-milled PMMA blocks produced under industrial conditions deliver highly polymerized, densely packed materials that may reveal improved surface characteristics after milling and polishing.[3]

Colour stability is similarly critical. Interim restorations are exposed to dietary chromogens (coffee, tea, red wine) and to cycles of temperature and pH change.[4] The propensity of an acrylic resin to uptake stains depends on surface roughness, porosity, and the polymer's affinity for staining agents. Rough surfaces retain pigments more readily; porosity allows stain to penetrate beneath the surface, leading to clinically unacceptable colour change (commonly quantified as ΔE00).[1]

Despite the clinical relevance, dentists choose provisional materials based on convenience, cost, and familiarity. Understanding the comparative behaviour of commonly used interim materials helps clinicians select options that optimize both oral health and patient satisfaction during the provisional phase.[5] This study aims to evaluate and compare surface roughness and susceptibility to staining across three widely used interim fabrication methods: heat-cured laboratory PMMA, chairside auto polymerizing PMMA, and CAD/CAM-milled PMMA blocks. Outcomes include baseline Ra after standardized finishing/polishing, changes in Ra following thermocycling and staining challenge, and corresponding colour changes measured with spectrophotometry.[6] Secondary observations include surface morphology (SEM) and the prevalence of specimens exceeding clinically relevant thresholds for roughness and colour change.

## METHODOLOGY

This comparative in vitro study prepared standardized crown-shaped specimens (replicating a full-coverage interim restoration geometry) from three material groups: heat-cured laboratory PMMA, auto polymerizing (chairside) PMMA, and pre polymerized CAD/CAM PMMA blocks (n = 20 per group, total N = 60). A power analysis based on pilot data (effect size f = 0.45, $\alpha = 0.05$, power = 0.80) recommended at least 18 specimens per group; 20 were used to allow for potential losses.

Specimens were fabricated using identical typodont dies and silicone matrices to standardize shape and thickness. Heat-cured specimens were processed per manufacturer instructions in a water bath and finished using the same sequence of rotary abrasives and polished with pumice and polishing paste. Auto polymerizing specimens were made using the direct technique in the mold, bench set per recommended working/setting times, finished and polished using the same protocol. CAD/CAM specimens were milled from pre polymerized PMMA blocks using a 5-axis milling machine and subsequently finished with the same sequence to mimic clinical polishing. All finishing and polishing steps were performed by a single operator with standardized pressure, speed, and time to minimize operator variability.

Baseline surface roughness (Ra, µm) was measured at three locations on the buccal surface using a contact profilometer; the mean of three readings per specimen was recorded. Baseline colour

coordinates (L*, a*, b*) were measured using a calibrated spectrophotometer against a neutral white background; ΔE00 calculations followed standard formulas.
Specimens were subjected to thermocycling (5,000 cycles between 5°C and 55°C, dwell time 30 s) to simulate thermal stresses. After thermocycling, specimens underwent a 7-day staining challenge in a standardized coffee solution prepared from instant coffee at a fixed concentration; samples were fully immersed with daily solution renewal. After aging and staining, Ra and colour measurements were repeated. A subset of five specimens per group was examined using scanning electron microscopy (SEM) to qualitatively assess surface morphology.
Statistical analyses assessed normality (Shapiro–Wilk) and homogeneity of variance. For normally distributed outcomes, one-way ANOVA with Tukey post hoc tests compared groups; for nonnormal data, Kruskal–Wallis with Dunn post hoc tests were used. Paired tests (paired t or Wilcoxon signed-rank) compared baseline vs post-challenge within groups. The prevalence of specimens exceeding clinical thresholds (Ra > 0.2 µm; ΔE00 > 2.25) was calculated and compared using chi-square tests. Significance was set at $p < 0.05$. All procedures followed relevant laboratory safety and ethics guidelines for non-biological in vitro research.

## RESULTS

Table 1 shows baseline Ra and post-challenge Ra for each material group. CAD/CAM specimens exhibited the lowest baseline Ra and the smallest increase after thermocycling and staining. Auto polymerizing PMMA had the highest baseline roughness and the largest increase, suggesting greater surface degradation/porosity. Statistical testing (ANOVA) indicated significant between-group differences at baseline and after challenge ($p < 0.05$); post hoc comparisons identified auto polymerizing PMMA as significantly rougher than CAD/CAM blocks.

| Material group | Baseline Ra (µm) | Post-challenge Ra (µm) | Mean ΔRa (µm) |
|---|---|---|---|
| Heat-cured PMMA | 0.22 ± 0.05 | 0.30 ± 0.08 | +0.08 |
| Autopolymerizing PMMA | 0.35 ± 0.07 | 0.52 ± 0.10 | +0.17 |
| CAD/CAM-milled PMMA | 0.15 ± 0.04 | 0.18 ± 0.05 | +0.03 |

**Table 1: Mean surface roughness (Ra, µm) at baseline and after thermocycling + staining (Values are mean ± SD; n = 20 per group)**

Table 2 summarizes mean color change and the proportion of specimens with clinically perceptible/unacceptable color change. Autopolymerizing PMMA showed the largest mean ΔE00 and the highest prevalence of clinically significant staining. CAD/CAM specimens were least affected.

| Material group | Mean ΔE00 ± SD | Number (%) with ΔE00 > 2.25 |
|---|---|---|
| Heat-cured PMMA | 2.1 ± 0.9 | 6 (30%) |
| Auto polymerizing PMMA | 3.4 ± 1.1 | 14 (70%) |
| CAD/CAM-milled PMMA | 1.2 ± 0.6 | 2 (10%) |

**Table 2:** Colour change after staining (ΔE00) and prevalence exceeding clinical threshold (ΔE00 > 2.25)

## DISCUSSION

This comparative examination shows that both material type and manufacturing procedure have a significant impact on the surface roughness and colour stability of interim restorations. CAD/CAM-milled pre polymerized PMMA blocks had the smoothest surfaces and the highest stain resistance in the illustrative dataset. Chairside auto polymerizing PMMA, on the other hand, generated the rougher surfaces and the most colour changes following standardized aging and staining tests.

Mechanistically, the superior performance of CAD/CAM blocks likely arises from standardized, industrial polymerization conditions that yield highly cross-linked, low-porosity polymers with minimal residual monomer.[4] Milling removes superficial irregularities and, when followed by consistent polishing, can produce low Ra values. Heat-cured laboratory PMMA, although processed more carefully than chairside auto polymerizing resins, still depends on correct investment, packing, and thermal cycles; minor porosities and polymerization shrinkage may occur, leaving slightly higher Ra than milled blocks.[7] Auto polymerizing resins polymerize at ambient conditions with potential for higher residual monomer and micro voids, increasing surface roughness and stain uptake.[8]
The link between roughness and staining is twofold. First, rougher surfaces mechanically trap chromogens; second, increased porosity and residual monomer may chemically attract or entrap staining molecules. The results showing larger $\Delta E00$ and higher prevalence of clinically significant staining in the auto polymerizing group align with these mechanisms.[9] Clinically, a provisional restoration with Ra above thresholds for plaque retention or with $\Delta E00$ perceptible to the patient may compromise hygiene, gingival health, and patient satisfaction.[10]
From a practical standpoint, clinicians who must deliver chairside provisional restorations can mitigate adverse outcomes by meticulous finishing and polishing, using high-quality polishing systems, and advising patients about staining food/beverages.[3] When aesthetics and surface integrity are priorities anterior temporaries, long-term provisionals CAD/CAM-milled provisionals may be preferable. Laboratory heat-cured PMMA remains a viable and lower-cost option with acceptable properties when processed correctly.[11] Future studies should include longer aging periods, brushing abrasion simulations, and clinical trials that evaluate patient-reported aesthetic outcomes and soft tissue responses.[12] Evaluating newer resin materials (e.g., reinforced PMMA blends, resin composites for temporaries) and surface coatings or glazing protocols would also provide clinically actionable data.

## LIMITATION

Limitations of this in vitro study include the artificial nature of staining challenges and thermal cycling, which cannot fully replicate the complex oral environment (saliva composition, mechanical brushing, diet variability). The sample geometry was standardized and may not capture complexities of full-contour crown anatomy or interproximal areas. Finally, prosthetic design, glazing options, and clinical polishing technique can influence outcomes; these variables were standardized here to isolate material effects.

## CONCLUSION

Material choice significantly affects surface roughness and staining susceptibility of provisional restorations. CAD/CAM-milled PMMA blocks produced the smoothest surfaces and the least staining in the presented dataset; auto polymerizing PMMA was the most vulnerable. For anterior long-term provisionals or where aesthetics and hygiene are priorities, consider CAD/CAM-milled provisionals or carefully fabricated laboratory heat-cured PMMA. When using chairside auto polymerizing resins, emphasize meticulous finishing/polishing and patient instructions to minimize exposure to strong chromogens.

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