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Original Article

Dentistry Section

Comparative Evaluation of Surface Roughness and Gloss of Nanohybrid Composite Resins after Tooth Brushing: An In-vitro Study

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ABSTRACT

Introduction: The clinical longevity and aesthetics of composite restorations depend on surface smoothness and gloss, properties influenced by filler characteristics and altered by routine tooth brushing. Comparative data on how contemporary nanohybrid composites resist toothbrush abrasion are limited.

Aim: To compare surface roughness and gloss before and after simulated tooth brushing among Ivoclar Tetric N-Ceram, Dentsply Spectrum, and 3M Filtek Z250.

Materials and Methods: The present in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics at Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India, from August 2024 to September 2024. Thirty standardised nanohybrid composite discs (n=10 per material) were fabricated using prefabricated moulds (10 mm diameter×2 mm thickness). The samples were divided into three groups of 10 samples each as Group A (n=10): Ivoclar Tetric N Ceram (Ivoclar Vivadent, Switzerland) Group B (n=10): Dentsply Spectrum (Dentsply, India), Group C (n=10): 3M Filtek Z250 (3M, India). Only defect-free specimens without voids, cracks, or surface irregularities were included. Specimens were finished and polished using the Shofu Super-Snap polishing system following the manufacturer's protocol. Baseline surface roughness (Ra, μm) was measured using a Mitutoyo SJ-310 profilometer, and gloss (GU) was assessed using a 60° glossmeter. Specimens were subjected to 20,000 brushing cycles in a motorised tooth brushing simulator under a constant load of 2 N, using a toothpaste-water slurry (1:2). Post-abrasion surface roughness and gloss measurements were recorded. Paired t-tests were used for intra-group comparisons, and One-way Analysis of Variance (ANOVA) with Tukey's post-hoc test was applied for intergroup comparisons. Statistical significance was set at $p<0.05$.

Results: All materials showed increased surface roughness and reduced gloss after simulated tooth brushing ($p<0.001$). Significant intergroup differences were observed in post-brushing roughness and gloss (ANOVA, $p<0.001$). Dentsply Spectrum exhibited significantly lower surface roughness than Ivoclar Tetric N Ceram and 3M Filtek Z250, while 3M Filtek Z250 showed significantly lower gloss values than Ivoclar Tetric N Ceram and Dentsply Spectrum. No significant differences were observed between Ivoclar Tetric N Ceram and 3M Filtek Z250 for roughness or between Ivoclar Tetric N Ceram and Dentsply Spectrum for gloss.

Conclusion: Simulated tooth brushing adversely affected the surface and optical properties of all tested nanohybrid composites. Dentsply Spectrum demonstrated superior resistance to surface roughening, whereas 3M Filtek Z250 showed lower gloss retention than Dentsply Spectrum and Ivoclar Tetric N-Ceram. These differences may influence material selection when long-term esthetic performance is a priority.

Keywords: Abrasive wear, Dental materials, Dental polishing, Innovation, Novel

INTRODUCTION

Composite resins have been a staple in dentistry due to their strength and aesthetic appeal [1]. Overtime, these materials have evolved significantly, leading to various classifications based on the composition of their filler particles [1]. These include microhybrid, nanohybrid, and microfilled composites, each with unique properties tailored for specific clinical applications [2]. Nanohybrid composites, in particular, have gained attention for their enhanced aesthetic qualities and polished surfaces, achieved through the incorporation of nanoscale fillers [3].

Nanohybrid composites combine nanofillers and microfillers to optimise material performance [4]. For instance, Ivoclar Tetric N Ceram (Ivoclar Vivadent, Switzerland) offers excellent handling properties, natural aesthetics, and high mechanical strength, making it ideal for anterior and posterior restorations [4,5]. Its nanoscale fillers enable restorations to mimic the enamel and dentin finish. Similarly, Dentsply Spectrum (Dentsply, India) balances strength and ease of use, offering superior abrasion resistance and minimal polymerisation shrinkage for long-lasting restorations [6]. Its polishability and resistance to wear make it suitable for areas under heavy masticatory forces. 3M Filtek Z250 (3M, India), developed using advanced nanotechnology, demonstrates high fracture toughness, superior handling, and sustained gloss retention, ensuring durability and aesthetics for anterior and posterior restorations [7].

Surface roughness and gloss are critical factors influencing the durability and aesthetics of composite restorations [8]. Increased surface roughness can lead to plaque accumulation, complicating oral hygiene and increasing the risk of restoration failure [9]. This may contribute to secondary caries and periodontal complications [10]. Conversely, gloss, an indicator of surface smoothness and light reflection, determines the restoration's aesthetic success [11]. A lack of gloss may result in staining and discolouration, compromising its natural appearance [12].

Tooth brushing is a common factor affecting the surface properties of composites [13]. Studies suggest that toothbrush abrasion significantly alters surface roughness and gloss over time [14,15]. For example, Yu P et al., demonstrated that simulated tooth brushing impacts composite gloss and roughness, emphasising the role of oral hygiene in restoration longevity [16]. Although nanohybrid composites are widely used, comparative data on how their filler technology influences long-term resistance to toothbrush-induced abrasion particularly in terms of simultaneous surface roughness and gloss retention remain limited. By evaluating these properties under standardised simulated oral-hygiene conditions, the present study offers novel insights into the durability profiles of three commonly used nanohybrid materials, aiding evidence-based selection for clinically demanding restorative situations. The present in-vitro study aims to assess the effect of simulated tooth brushing on the surface properties of three nanohybrid composite resins. The primary objective was to quantitatively compare changes in surface roughness and gloss of Ivoclar Tetric N Ceram, Dentsply Spectrum, and 3M Filtek Z250 before and after simulated tooth brushing, and to determine inter-material differences in post-abrasion performance.

The null hypothesis (H_0) states that there is no significant difference in surface roughness or gloss values among the three composite resins following simulated tooth brushing. The alternate hypothesis (H_1) states that at least one composite resin will exhibit significantly different surface roughness or gloss values after simulated tooth brushing.

Findings from the present study are expected to provide evidence-based insight into the clinical behaviour of these materials under wear conditions, guiding optimal composite selection for long-lasting aesthetic and functional restorations.

MATERIALS AND METHODS

The present in-vitro experimental study was conducted in the Department of Conservative Dentistry and Endodontics at Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India, from August to September 2024. The protocol was approved by the Institutional Ethical Committee (Approval No. SRB/SDC/ENDO-2303/24/323).

Sample size calculation: Sample size was calculated using G*Power software (version 3.1) based on surface roughness data reported by AlAli et al. (2021). In that study, baseline surface roughness (Ra) values of resin composites ranged from 0.14-0.22 μm and increased to 0.41-0.49 μm following simulated tooth brushing abrasion. A representative mean difference derived from these reported values was used to estimate the effect size. Assuming a significance level (α) of 0.05 and a statistical power of 80%, the minimum required sample size was calculated to be 8 specimens per group. To enhance statistical reliability and to account for potential specimen loss, 10 specimens were included in each group in the present study [14].

Groups and Specimen Allocation

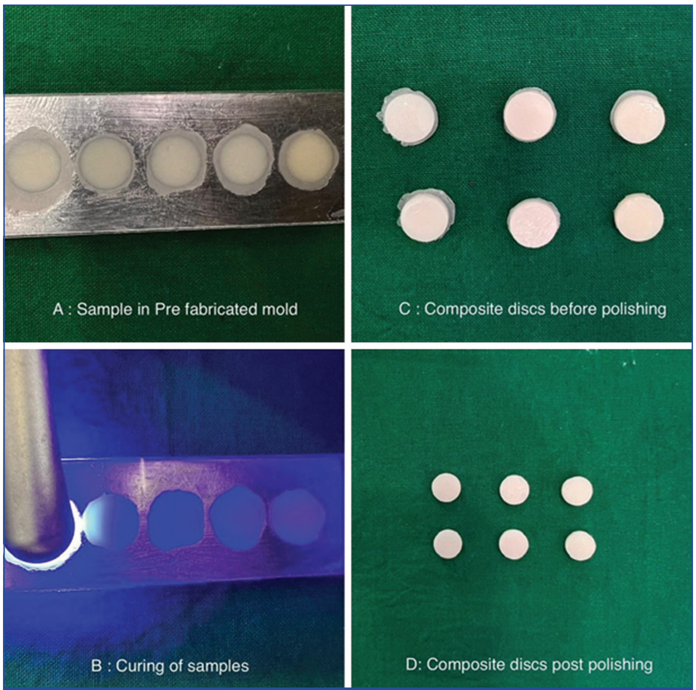
- **Group A (n=10):** Ivoclar Tetric N Ceram (Ivoclar Vivadent, Switzerland)
- **Group B (n=10):** Dentsply Spectrum (Dentsply, India)
- **Group C (n=10):** 3M Filtek Z250 (3M, India)

Inclusion criteria: Specimens fabricated as prefabricated nanohybrid composite discs (10 mm diameter×2 mm thickness), free from porosities, voids, cracks, discolouration or any surface defect; shade-matched resin composites belonging to the selected brands.

Exclusion criteria: Discs with visible defects, irregular dimensions, polymerisation errors, or compromised surface integrity after finishing/polishing; any specimens contaminated or damaged during handling.

Study Procedure

Specimen fabrication and curing: Composite discs were fabricated using a stainless-steel mould (10 mm×2 mm). The composite resin was placed incrementally and light cured through using an Light-Emitting Diode (LED) curing unit set to 800 mW/cm² intensity for 40 seconds per increment, consistent with protocols in composite polymerisation studies [Table/Fig-1] [17].



[Table/Fig-1]: a) Composite samples loaded in prefabricated mould; b) Polymerisation of the composite samples using standardised curing protocol; c) Composite discs before polishing; d) Composite discs post polishing.

After curing, all specimens were finished and polished using the Shofu Super-Snap disc system, following the manufacturer's protocol for disk sequence, speed, and pressure.

Baseline Measurements: Gloss and Surface Roughness [Table/Fig-2]

- **Gloss:** A 3NH glossmeter measured gloss at a standard 60° incidence angle. Three consecutive readings were taken per specimen and averaged to yield mean Gloss Units (GU).
- **Surface Roughness (Ra):** A Mitutoyo SJ-310 stylus profilometer was used. Each specimen was scanned three times in different orientations; the arithmetic mean Ra value in micrometers (μm) was computed.

[Table/Fig-2]: A 3NH glossmeter and Mitutoyo stylus profilometer.

Simulated Tooth brushing Abrasion Protocol: Specimens were subjected to 20,000 brushing cycles using a custom-built tooth brushing simulator to approximate long-term manual tooth brushing effects, in accordance with commonly employed in-vitro abrasion protocols. A brushing force of approximately 2 N was applied, which lies within the range of manual tooth brushing forces reported in clinical force-measurement studies and has been commonly used in in-vitro abrasion protocols to simulate routine oral hygiene conditions [13]. A standardised toothpaste-distilled water slurry (1:2 ratio) was used throughout the simulation, consistent with previously published in-vitro abrasion methodologies. Brushing was performed under controlled laboratory conditions, and the toothpaste slurry was periodically renewed to maintain consistent abrasivity throughout the simulation [18]. A total of 20,000 brushing cycles were applied, representing approximately six months of twice-daily brushing [Table/Fig-3] [19]. These controlled parameters enhance reproducibility and closely simulate oral hygiene-related abrasive challenges.

[Table/Fig-3]: Samples loaded onto toothbrush simulator.

After the brushing regimen, post-abrasion surface roughness (Ra) and gloss (GU) values were measured again using the same instruments and protocols as baseline.

Examiner calibration and reliability

Surface roughness and gloss measurements were performed by a single trained examiner. Prior to data collection, the examiner underwent calibration by performing repeated measurements on five randomly selected specimens at two time points, 24 hours apart. Intra-examiner reliability was assessed using the Intraclass Correlation Coefficient (ICC), which exceeded 0.90 for both surface roughness and gloss measurements, indicating excellent repeatability. As all measurements were conducted by the same calibrated examiner, inter-examiner reliability assessment was not applicable.

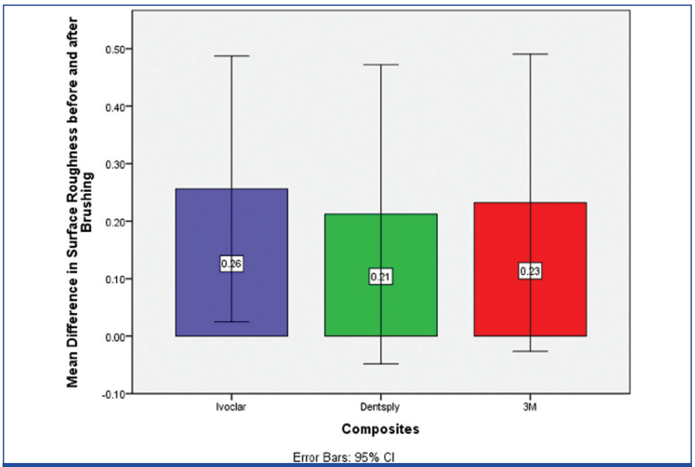
STATISTICAL ANALYSIS

Data analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics, Version 29. Normality of data distribution was verified using the Shapiro-Wilk test. Intergroup comparisons (among the three composites) were carried out using one-way ANOVA followed by post-hoc Tukey's test for pairwise comparisons. Intra-group comparisons (pre vs post-brushing within each material) were analysed using paired t-tests. A p-value <0.05 was set as the threshold for statistical significance.

RESULTS

The intragroup analysis demonstrated that all three nanohybrid composite resins exhibited a statistically significant increase in surface roughness and a significant reduction in gloss following simulated toothbrushing (p<0.001 for all groups) [Table/Fig-4,5]. Intergroup comparison of post-brushing surface roughness using one-way ANOVA revealed a statistically significant difference among the materials (p<0.001) [Table/Fig-6]. Post hoc Tukey HSD analysis showed that Dentsply Spectrum exhibited significantly lower surface roughness compared to Ivoclar Tetric N Ceram (p=0.0098) and 3M Filtek Z250 (p<0.001), while no significant difference was observed between Ivoclar Tetric N Ceram and 3M Filtek Z250 (p=0.5590) [Table/Fig-7a].

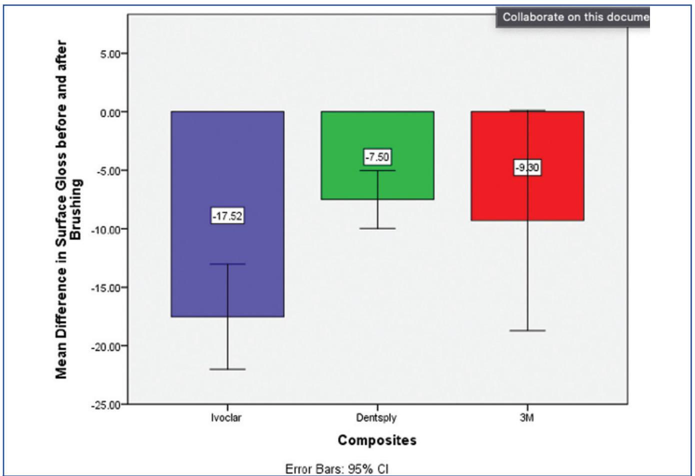
Similarly, intergroup comparison of post-brushing gloss values demonstrated a significant difference among the three composites (p<0.001) [Table/Fig-6]. Post hoc Tukey HSD analysis revealed that 3M Filtek Z250 exhibited significantly lower gloss values compared to both Ivoclar Tetric N Ceram (p<0.001) and Dentsply Spectrum (p<0.001), whereas no statistically significant difference was found between Ivoclar Tetric N Ceram and Dentsply Spectrum (p=0.9368) [Table/Fig-7b]. Overall, these findings indicate that although all tested composites were adversely affected by simulated toothbrushing, the magnitude of surface roughness increase and gloss loss was dependent on the composite material.



[Table/Fig-4a]: Mean difference in surface roughness before and after tooth brushing.

Group	Pre-treatment Mean±SD (μm)	Post-treatment Mean±SD (μm)	Paired t-test (t value)	p-value
Group A	0.389±0.288	1.257±0.409	8.686	0.0000114
Group B	0.073±0.019	0.533±0.080	17.757	0.0000000259
Group C	0.641±0.388	1.407±1.389	3.124	0.001518

[Table/Fig-4b]: Intragroup comparison of surface roughness (Ra, μm) before and after simulated tooth brushing.
Values are expressed as mean±standard deviation (SD). paired t-test. A p-value <0.05 was considered statistically significant. Ra: Surface roughness; SD: Standard deviation.



[Table/Fig-5a]: Mean difference in surface gloss before and after tooth brushing.

Group	Pre-treatment Mean±SD (GU)	Post-treatment Mean±SD (GU)	Paired t-test (t value)	p-value
Group A	57.60±2.40	41.07±1.56	15.362	0.0000000397
Group B	48.93±1.05	41.79±2.11	6.876	0.0000001330
Group C	43.83±3.06	36.27±2.67	15.362	0.0000000917

[Table/Fig-5b]: Intragroup comparison of Gloss (GU) before and after simulated tooth brushing.
Values are expressed as mean±standard deviation (SD). paired t-test. A p-value <0.05 was considered statistically significant.GU: Gloss units; SD: Standard deviation.

Parameters	Intergroup Comparison	Post-treatment Mean±SD	ANOVA (F value)	p-value
Surface Roughness (Ra, μm)	Group A	1.257±0.409	9.698	p<0.001
	Group B	0.5330±0.0803		
	Group C	1.407±1.389		
Gloss (GU)	Group A	41.07±1.56	15.697	p<0.001
	Group B	41.79±2.11		
	Group C	36.27±2.67		

[Table/Fig-6]: Intergroup comparison of surface roughness and gloss after simulated tooth brushing.
Values are expressed as mean±standard deviation (SD). One-way analysis of variance (ANOVA). A p-value <0.05 was considered statistically significant. Ra: Surface roughness; GU: Gloss units; SD: Standard deviation; ANOVA - Analysis of variance.

Surface Roughness comparison	p-value	Significance
Group A vs Group B	0.0098	Significant
Group A vs Group C	0.5590	Not significant
Group B vs Group C	0.0007	Significant

[Table/Fig-7a]: Post-hoc Tukey HSD multiple comparison analysis for post-brushing surface roughness (Ra, μm).
Post-hoc multiple comparison analysis was performed using Tukey's honestly significant difference (HSD) test following one-way analysis of variance (ANOVA) to identify pairwise differences in post-brushing surface roughness among the three composite resin groups; A p-value <0.05 was considered statistically significant: Ra: Surface roughness; HSD: Honestly significant difference; ANOVA: Analysis of variance

Gloss comparison	p-value	Significance
Group A vs Group B	0.9368	Not significant
Group A vs Group C	0.0001	Significant
Group B vs Group C	0.0002	Significant

[Table/Fig-7b]: Post-hoc Tukey HSD multiple comparison analysis for post-brushing Gloss (GU).
Post-hoc multiple comparison analysis was performed using Tukey's honestly significant difference (HSD) test following One-way analysis of variance (ANOVA) to identify pairwise differences in post-brushing gloss values among the three composite resin groups; A p-value <0.05 was considered statistically significant; GU: Gloss units; HSD: Honestly significant difference; ANOVA: Analysis of variance

DISCUSSION

The aim of the present study was to assess and compare the effect of simulated toothbrush abrasion on the surface roughness and gloss of three nanohybrid composite resins. Consistent with previous research indicating that mechanical abrasion gradually alters resin surfaces through matrix loss and filler protrusion, all materials demonstrated increased roughness and reduced gloss following brushing. In the present study, no statistically significant intergroup differences in post-brushing surface roughness were observed, indicating comparable resistance to surface wear among the tested nanohybrid composites. Similar patterns of minimal inter-material differences in roughness following mechanical finishing or abrasive challenges have been reported in previous in-vitro studies, suggesting that composites with comparable filler-matrix architectures may respond similarly to surface wear mechanisms [19,20].

Surface roughness is strongly influenced by filler size, morphology, silanisation, and spatial distribution within the composite network [21]. Nanohybrid composites incorporate a mixture of nanometric and micrometric fillers designed to enhance polishability and mechanical behaviour [22]. Such hybridisation promotes better filler packing, reduced inter-particle spacing, and improved matrix-filler bonding, contributing to smoother post-polish surfaces and improved resistance to mechanical abrasion. The present findings are consistent with those reported by Yu P et al., and Soliman HAN et al., who observed that nanohybrid composites subjected to brushing exhibited minimal inter-material differences in surface roughness, which was attributed to uniform filler architecture promoting consistent micro-abrasive wear [16,23].

Gloss, a key determinant of the optical success of restorations, is closely related to surface flatness, refractive index compatibility between filler and matrix, and the composite's ability to reflect light uniformly [24]. Ardu S et al., emphasised that gloss is more sensitive to surface micro-defects than roughness, making it a more critical indicator of aesthetic longevity [25]. In the present study, Dentsply Spectrum demonstrated greater gloss preservation than Ivoclar. Similar outcomes have been reported by Lassila L et al., who observed that optimised nanofiller blends, when uniformly distributed, maintain surface reflectivity to a higher degree after brushing abrasion [26]. These findings reinforce that filler structure, silane coupling, and filler-resin bonding integrity strongly influence gloss survival under abrasive stress.

Conversely, Ivoclar exhibited greater gloss loss despite having initially high gloss values. Drummond JL attributed such differences to interfacial degradation at the filler-resin boundary and changes in surface energy, which disrupt light reflectance after mechanical wear [27]. Meanwhile, the gloss behaviour of 3M Filtek appeared comparable to Dentsply, which aligns with findings that resin composites with nanofiller-rich formulations tend to maintain optical uniformity and surface gloss more predictably than conventional hybrid systems, due to their optimised filler size and distribution influencing surface smoothness and light reflection [28].

Based on the findings of this study, the null and alternate hypotheses were addressed as follows. For surface roughness, no statistically significant intergroup differences were detected after simulated tooth brushing, indicating that all three nanohybrid composites exhibited comparable resistance to abrasion. Therefore, the null hypothesis (H_0) that no significant difference exists in post-abrasion roughness among the materials was accepted for this parameter. However, for gloss retention, a significant intergroup difference was observed, with Dentsply Spectrum demonstrating superior gloss preservation compared with Ivoclar. This outcome indicates that at least one composite material performed differently under simulated brushing conditions. Thus, the alternate hypothesis (H_1) was accepted for gloss, and the null hypothesis was rejected for this variable.

Clinically, gloss stability is especially important in anterior restorations where long-term aesthetic quality is relevant to patient satisfaction [29]. Composites that retain gloss more effectively may require fewer polishing recalls, reduce aesthetic failures, and offer sustained visual harmony with enamel surfaces [30]. As roughness differences were not significant across groups, all three materials may be considered acceptable with respect to plaque retention potential, periodontal impact, and overall mechanical response to routine brushing pressures [31]. In cases prioritising long-term aesthetic stability, Dentsply Spectrum may be preferred, whereas Ivoclar may still be selected when superior initial gloss is desired, such as when achieving immediate anterior cosmetic enhancement.

From a cost-effectiveness standpoint, materials capable of retaining gloss and surface smoothness over time can reduce the need for repolishing, shade correction, or premature restorative replacement. This may lower treatment cost over extended clinical periods. When two materials exhibit equivalent roughness behaviour but differ in gloss stability, the material with greater optical resilience such as Dentsply can offer improved clinical and economic value over time.

In-vitro simulation models, while standardised, do not fully replicate the complex oral environment. Future studies should include salivary interactions, pH cycling, bleaching agents, acidic dietary exposure, and thermocycling to mimic intraoral aging more closely. Long-term clinical trials, advanced imaging methods such as Atomic Force Microscopy (AFM), and spectrophotometric gloss-mapping could further elucidate material surface degradation pathways and inform optimised nanohybrid formulations.

Limitation(s)

The brushing simulation did not account for variations in toothpaste abrasiveness, brushing force, patient habits, or salivary buffering. Two-body abrasive wear was evaluated in isolation, excluding erosive and fatigue-related degradation mechanisms. Additionally, only surface roughness and gloss were assessed, while other relevant parameters such as microhardness, colour stability, and filler-matrix interface integrity were beyond this study's scope.

CONCLUSION(S)

The present study found that all three nanohybrid composites demonstrated comparable resistance to toothbrush-induced surface wear, as reflected by similar post-abrasion roughness. However, their optical stability under brushing stress varied, with Dentsply Spectrum showing the greatest gloss retention, followed by 3M Filtek, while Ivoclar exhibited the most noticeable gloss reduction. These findings indicate that although the tested composites perform similarly in terms of mechanical surface preservation, differences in gloss stability may influence long-term aesthetic outcomes. From a clinical perspective, Dentsply Spectrum may be considered a favourable choice in restorations where sustained gloss and long-term aesthetics are priorities, particularly in anterior regions. Ivoclar, despite offering high initial gloss, may be more prone to aesthetic changes over time. Future studies incorporating clinical conditions, intra-oral aging factors, and extended follow-up are recommended to further validate the aesthetic durability of nanohybrid composites.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 13, 2025
- Manual Googling: Feb 26, 2026
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