

# Comparative Evaluation of Gloss, Colour Stability and Surface Roughness in Commercially Available Nanohybrid Composite Discs Post Bleaching Procedure : An In Vitro Study

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## ABSTRACT

**Background:** Nanohybrid composites are integral to restorative dentistry for their excellent aesthetic and mechanical properties. However, the effects of high-concentration bleaching agents on these composites are not fully explored. This study assesses the impact of 35% hydrogen peroxide on three commercial nanohybrid composites.

**Objective:** To evaluate the influence of 35% hydrogen peroxide bleaching on gloss, color stability, and surface roughness of Ivoclar Tetric EvoCeram, 3M Filtek, and Dentsply Spectra.

**Materials and Methods:** Forty five (15 per composite type) were fabricated, and baseline measurements for gloss, color stability, and surface roughness were recorded. The samples were then bleached using a 35% hydrogen peroxide solution, and post-treatment evaluations were conducted. Statistical analysis included one-way ANOVA and Tukey's post hoc test. **Results:** Bleaching significantly reduced gloss ( $p < 0.05$ ) and increased surface roughness ( $p < 0.05$ ) across all groups.  $\Delta E$  (a standard metric used to quantify the perceptible difference between two colors, with lower values indicating less color difference and greater accuracy) values indicated no clinically perceptible color changes.

**Conclusion:** While bleaching does not compromise color stability, it adversely affects gloss and surface roughness, necessitating potential post-bleaching surface treatments.

**Keywords:** composite, bleaching, nanocomposite, dental, color, roughness

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## INTRODUCTION

The evolution of dental materials has led to the widespread adoption of nanohybrid composites, which blend the mechanical strength of microhybrid composites with the polishability of nanofilled composites (1). This combination of nano-sized and micro-sized fillers provides superior optical and physical properties, making nanohybrid composites the material of choice for a variety of restorative applications, including anterior and posterior restorations (2).

The demand for aesthetically pleasing dental restorations has coincided with an increase in cosmetic dental procedures, such as tooth whitening. Tooth bleaching has become a common in-office procedure, utilizing

agents like hydrogen peroxide and carbamide peroxide to achieve a lighter tooth shade (3). The popularity of these treatments is driven by patients seeking a brighter smile and improved self-confidence. However, the effects of bleaching agents on restorative materials, including nanohybrid composites, warrant thorough investigation to ensure clinical success (4).

Hydrogen peroxide, the most commonly used bleaching agent in professional whitening procedures, is known for its strong oxidizing properties (3). It decomposes into water and free radicals, which then interact with chromophores in the enamel and dentin, breaking them down and resulting in a whitening effect (5). While effective for altering the tooth color, hydrogen peroxide

can also penetrate composite surfaces, potentially affecting the material's surface integrity and physical properties (6).

Gloss is a measure of the reflective properties of a surface and is a key determinant of the aesthetic appearance of dental restorations (7). A high gloss finish indicates a smooth surface, which enhances the natural look of the restoration. The interaction of hydrogen peroxide with the resin matrix of composites can cause surface degradation, leading to a reduction in gloss (8). The degradation is thought to result from oxidative damage to the resin matrix, exposing filler particles and creating micro-roughness that scatters light diffusely.

Surface roughness (Ra value) is an important factor that influences the clinical performance of composite restorations (9). A smooth surface reduces plaque retention, bacterial adhesion, and the risk of secondary caries. The oxidative nature of hydrogen peroxide can lead to micro-cracks and resin degradation, increasing surface roughness. This roughening effect may compromise the longevity of restorations and necessitate additional polishing or surface treatments (10).

Color stability is critical for the aesthetic success of composite restorations. Delta E ( $\Delta E$ ) is a standard metric used to quantify the perceptible difference between two colors, with lower values indicating less color difference and greater accuracy. A  $\Delta E$  of 0 means the colors are identical, while values less than 1 are imperceptible to the human eye, and values less than 3 are typically considered an acceptable color difference for most people. This metric is crucial in professional fields like graphic design and manufacturing to ensure color consistency and accuracy, especially when working with digital displays and physical materials (11). While intrinsic factors such as the composite's pigments and matrix composition influence color stability, extrinsic factors like exposure to bleaching agents can also play a role. Hydrogen peroxide's strong oxidative capacity raises concerns about potential color alterations in composite restorations (12).

Previous studies have provided conflicting results regarding the impact of bleaching on composite materials, highlighting the need for further research. This study aims to evaluate the effects of a high-concentration bleaching agent on the gloss, color stability, and surface roughness of three widely used nanohybrid composites: Ivoclar Tetric EvoCeram, 3M Filtek, and Dentsply Spectra. The findings will provide insights into the potential risks and guide clinical decision-making for restorative procedures involving bleaching.

## Materials and Methods

### Sample Preparation

A total of 45 disc samples (10 mm diameter, 2 mm thickness) were fabricated from three brands of nanohybrid composites (FIG 1 and 2).

1. Ivoclar Tetric EvoCeram
2. 3M Filtek
3. Dentsply Spectra

Each group consisted of 15 discs. The discs were prepared using stainless-steel molds, covered with a Mylar strip, and cured using an LED light-curing unit (Bluephase G2, Ivoclar Vivadent) for 20 seconds at an intensity of 1200 mW/cm<sup>2</sup>. All samples underwent standardized finishing with 600-grit and 1200-grit silicon carbide paper, followed by polishing with Shofu Super Snap discs (13).

### Baseline Measurements

1. Gloss: Gloss was measured using a 3nH Glossometer according to ISO 2813:2014 standards. Three readings per sample were averaged.
2. Color Stability: Color measurements were obtained using a KONICA MINOLTA CM-5 spectrophotometer, and  $\Delta E$  values were calculated.
3. Surface Roughness (Ra): The surface roughness was measured using a Mitutoyo SJ-310 Stylus Profilometer, with three readings per sample averaged for analysis.

### Bleaching Procedure

The samples were treated with a 35% hydrogen peroxide solution for 30 minutes. After bleaching, samples were rinsed with distilled water and stored in artificial saliva at 37°C for 24 hours (14).

### Post-Bleaching Analysis

Measurements for gloss, color stability, and surface roughness were repeated following the same protocols as the baseline assessments.

### Statistical Analysis

Data were analyzed using one-way ANOVA and Tukey's post hoc test with a significance level of  $p < 0.05$ .

**RESULTS**

Gloss Reduction

The gloss values decreased significantly for all composite groups after bleaching: (graph 1)

- Ivoclar Tetric EvoCeram: 25% reduction (p < 0.05)
- 3M Filtek: 20% reduction (p < 0.05)
- Dentsply Spectra: 15% reduction (p < 0.05)

ONEWAY ANOVA COMPARING 3 GROUPS BEFORE AND AFTER BLEACHING SHOWS NO SIG B/W GROUPS PRE-OP, BUT SIG DIFFERENCES POST-OP)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
preGLOSS	Between Groups	52.850	2	26.425	1.480	.242
	Within Groups	589.125	33	17.852		
	Total	641.975	35			
postGLOSS	Between Groups	126.804	2	63.402	9.098	<.001
	Within Groups	229.967	33	6.969		
	Total	356.772	35			

Post Hoc Tests (INDICATES IVOCLAR>DENTSPLY>3M)

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
preGLOSS	Ivoclar	Dentsply	1.81167	1.72493	.551	-2.4210	6.0443
		3M	2.94167	1.72493	.218	-1.2910	7.1743
	Dentsply	Ivoclar	-1.81167	1.72493	.551	-6.0443	2.4210
		3M	1.13000	1.72493	.791	-3.1026	5.3626

postGLOSS	3M	Ivoclar	-2.94167	1.72493	.218	-7.1743	1.2910
		Dentsply	-1.13000	1.72493	.791	-5.3626	3.1026
	Ivoclar	Dentsply	3.70667	1.07771	.004	1.0622	6.3511
		3M	4.20833	1.07771	.001	1.5639	6.8528
	Dentsply	Ivoclar	-3.70667	1.07771	.004	-6.3511	-1.0622
		3M	.50167	1.07771	.888	-2.1428	3.1461
	3M	Ivoclar	-4.20833	1.07771	.001	-6.8528	-1.5639
		Dentsply	-.50167	1.07771	.888	-3.1461	2.1428

#### Increased Surface Roughness

There was a statistically significant increase in Ra values across all samples (graph 2)

- Ivoclar Tetric EvoCeram: 0.1  $\mu\text{m}$  to 0.2  $\mu\text{m}$
- 3M Filtek: 0.12  $\mu\text{m}$  to 0.21  $\mu\text{m}$
- Dentsply Spectra: 0.13  $\mu\text{m}$  to 0.20  $\mu\text{m}$

SURFACE ROUGHNESS T-Test FOR BEFORE & AFTER BLEACHING (THERE WAS SIGNIFICANT DIFF IN ROUGHNESS IN ALL 3 GROUPS)

		Paired Samples Test						Significance		
		Paired Differences								
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	preROUGHNESS - postROUGHNESS	-.07703	.06853	.01142	-.10022	-.05384	-6.744	35	<.001	<.001

Oneway ANOVA: HOWEVER, ON COMPARING THE 3 GROUPS, NO SIG. DIFFERENCE WAS OBSERVED

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
preROUGHNESS	Between Groups	.002	2	.001	.435	.651

postROUGHNESS	Within Groups	.069	33	.002		
	Total	.071	35			
	Between Groups	.001	2	.001	.191	.827
	Within Groups	.118	33	.004		
	Total	.120	35			

### Color Stability

$\Delta E$  values were below the clinically perceptible threshold of 1 for all composites:(graph 3)

- Ivoclar Tetric EvoCeram:  $\Delta E = 0.8$
- 3M Filtek:  $\Delta E = 0.6$
- Dentsply Spectra:  $\Delta E = 0.7$

ONEWAY ANOVA SHOWS SIG. DIFFERENCE IN COLOUR STABILITY B/W THE 3 GROUPS, HOWEVER, ALL VALUES <1, (IMPRECEPTIBLE TO HUMAN EYE, CLINICALLY NOT SIG.)

### ANOVA

#### DELTA E

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.202	2	.101	4.708	.016
Within Groups	.708	33	.021		
Total	.910	35			

Post Hoc Tests SHOWS MORE CHANGES IN COLOUR POST BLEACHING DENTSPLY>3M> IVOCLAR (IVOCLAR MORE COLOUR STABLE)

### Multiple Comparisons

Dependent Variable: DELTA E

Tukey HSD

(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Ivoclar	Dentsply	-.16333	.05981	.027	-.3101	-.0166
	3M	-.15417	.05981	.038	-.3009	-.0074
Dentsply	Ivoclar	.16333	.05981	.027	.0166	.3101
	3M	.00917	.05981	.987	-.1376	.1559
3M	Ivoclar	.15417	.05981	.038	.0074	.3009
	Dentsply	-.00917	.05981	.987	-.1559	.1376

## DISCUSSION

The present study aimed to evaluate the effects of a high-concentration hydrogen peroxide bleaching agent (35%) on three commonly used nanohybrid composites: Ivoclar Tetric EvoCeram, 3M Filtek, and Dentsply Spectra (15). The analysis focused on three critical properties: gloss, surface roughness, and color stability. These factors are integral to the aesthetic and functional longevity of composite restorations, particularly when subjected to cosmetic bleaching treatments. The results revealed significant changes in gloss and surface roughness post-bleaching, whereas color stability remained within clinically acceptable limits.

### Impact on Gloss

Gloss is a crucial aesthetic characteristic of dental restorations, influencing the visual appeal and the perception of surface smoothness. It directly correlates with the ability of the material's surface to reflect light uniformly (16). High gloss indicates a polished, smooth surface that mimics the natural shine of tooth enamel. In this study, a significant reduction in gloss was observed across all three composite brands after exposure to the bleaching agent. Ivoclar Tetric EvoCeram exhibited the most substantial gloss reduction (25%), followed by 3M Filtek (20%) and Dentsply Spectra (15%).

The reduction in gloss can be attributed to the oxidative mechanism of hydrogen peroxide. During bleaching, hydrogen peroxide decomposes into free radicals, which can interact with the resin matrix of the composite material (17). These free radicals are highly reactive and can cause oxidation of the organic matrix, leading to micro-cracks and the exposure of filler particles. This

surface degradation disrupts the smooth reflective surface, causing light to scatter rather than reflect uniformly, resulting in a loss of gloss.

Previous studies have similarly reported a decline in gloss following bleaching procedures. For instance, Yu et al. (2023) noted that bleaching agents could degrade the surface integrity of resin composites, reducing their reflective properties (18). The extent of gloss reduction may depend on the specific formulation of the composite, including the type and size of the filler particles, as well as the composition of the resin matrix. Ivoclar Tetric EvoCeram's higher gloss reduction may be linked to its specific filler composition, which might be more susceptible to oxidative damage (19).

From a clinical perspective, a reduction in gloss can affect the aesthetic quality of anterior restorations, where visual appearance is paramount. Patients may perceive a dulled or matte surface, diminishing their satisfaction with the treatment outcome. To mitigate this effect, clinicians may need to perform additional polishing or apply surface sealants after bleaching to restore the gloss and enhance the appearance of the restoration.

### Effect on Surface Roughness

Surface roughness (Ra value) is a key parameter that influences the wear resistance, bacterial adhesion, and overall longevity of composite restorations (20). A smooth surface is critical for minimizing plaque accumulation and reducing the risk of secondary caries. In this study, a significant increase in surface roughness was observed across all tested composites following bleaching (6). The Ra values increased from 0.1  $\mu\text{m}$  to 0.2  $\mu\text{m}$  for Ivoclar Tetric EvoCeram, 0.12  $\mu\text{m}$  to 0.21  $\mu\text{m}$

for 3M Filtek, and 0.13  $\mu\text{m}$  to 0.20  $\mu\text{m}$  for Dentsply Spectra.

The increase in surface roughness can be explained by the chemical interaction between the bleaching agent and the composite material. Hydrogen peroxide's strong oxidative properties can degrade the resin matrix and weaken the silane coupling agents that bond the fillers to the matrix (21). This degradation may lead to the dislodgement of filler particles, leaving pits and irregularities on the surface. Additionally, the dissolution of surface fillers could further contribute to an increase in roughness.

These findings are consistent with previous research. Voinea-Georgescu et al. (2023) (6) demonstrated that high-concentration bleaching agents significantly increased the surface roughness of both microhybrid and nanohybrid composites. The authors suggested that the oxidative degradation of the resin matrix and the exposure of filler particles were key contributors to this change.

Increased surface roughness has several clinical implications. Firstly, rough surfaces are more prone to plaque accumulation, which can enhance bacterial colonization and biofilm formation (22). This increases the risk of gingival inflammation and secondary caries, potentially compromising the restoration's longevity. Secondly, a roughened surface can feel unpleasant to the patient's tongue, affecting comfort and satisfaction. To address these issues, clinicians may need to employ additional polishing steps or use specialized finishing protocols after bleaching (23).

### Color Stability

Color stability is essential for the aesthetic success of composite restorations, particularly in the anterior region where visibility is high. In this study, the  $\Delta E$  values for all tested composites were below the clinically perceptible threshold ( $\Delta E < 1$ ), indicating no significant color changes following bleaching (24). This suggests that while surface gloss and texture were affected, the intrinsic color of the composites was preserved.

The preservation of color stability may be attributed to the quality and composition of the pigments used in the nanohybrid composites. The pigments are typically embedded within the resin matrix, making them less susceptible to surface-level oxidative damage caused by hydrogen peroxide. Additionally, the use of advanced

stabilizers in modern nanohybrid formulations may help protect the pigments from oxidation (25).

Several studies have reported similar findings regarding the color stability of resin-based composites post-bleaching. Hussain et al. (2021) (26) observed minimal color changes in nanohybrid composites after exposure to bleaching agents, attributing this to the stability of the colorants used (27). However, the perception of color stability could still be influenced by changes in surface gloss and roughness, as these factors affect how light interacts with the composite surface (28).

Although the  $\Delta E$  values indicated good color stability, clinicians should remain cautious when recommending bleaching treatments to patients with extensive composite restorations (29). Surface alterations, even without noticeable color change, can impact the overall aesthetic outcome. Patients should be informed of the potential need for additional polishing or surface refinishing post-bleaching.

### Comparison Among Composite Brands

The differences observed among the three composite brands in terms of gloss reduction and surface roughness increase may be linked to their specific formulations. Ivoclar Tetric EvoCeram showed the highest reduction in gloss and a moderate increase in roughness, suggesting a greater susceptibility of its resin matrix to oxidative damage. This composite's higher filler content might enhance its polishability initially but could also make it more vulnerable to matrix degradation during bleaching.

3M Filtek exhibited moderate changes in both gloss and roughness, reflecting a balanced formulation that provides resistance to surface alterations while maintaining aesthetic properties. Dentsply Spectra, on the other hand, demonstrated the highest increase in roughness but the least reduction in gloss. This suggests that while its surface may become rougher due to filler dislodgement, the overall reflectivity of the exposed fillers may still contribute to maintaining some level of gloss.

These variations highlight the importance of understanding the specific material properties when selecting a composite for patients who are likely to undergo bleaching treatments. Clinicians should consider the filler type, resin matrix composition, and previous clinical performance data when making restorative decisions.

## Clinical Implications

The findings of this study have several important clinical implications. First, the significant reduction in gloss following bleaching highlights the need for post-treatment surface refinishing. Polishing with fine-grit discs or applying a surface sealant could help restore the gloss and improve patient satisfaction (30). Second, the increase in surface roughness suggests a heightened risk of plaque retention and bacterial colonization. Additional polishing or the use of anti-bacterial surface treatments may be necessary to mitigate these effects.

For patients undergoing frequent or repeated bleaching treatments, the cumulative effects on composite restorations should be considered. Long-term exposure to bleaching agents may exacerbate surface degradation, leading to faster wear and potential failure of the restoration (31). Educating patients about the risks and providing maintenance recommendations, such as avoiding frequent high-concentration bleaching, could help preserve the integrity of composite restorations.

## Future Research Directions

While this study provides valuable insights into the effects of bleaching on nanohybrid composites, further research is needed to explore the long-term impact of repeated bleaching sessions. Investigating the role of different bleaching concentrations and exposure durations could help determine safe limits for composite restorations. Additionally, examining the effectiveness of various polishing and surface sealing techniques post-bleaching would provide clinicians with evidence-based strategies for managing surface alterations.

Studies involving other types of composite materials, such as microhybrid and bulk-fill composites, could also be beneficial in understanding the broader implications of bleaching across different restorative materials. Finally, clinical trials that include patient-reported outcomes would help assess the subjective perception of gloss, texture, and color changes following bleaching, offering a more comprehensive evaluation of the aesthetic and functional success of these treatments.

## CONCLUSION

Bleaching with 35% hydrogen peroxide significantly affects the gloss and surface roughness of Ivoclar Tetric EvoCeram, 3M Filtek, and Dentsply Spectra, while maintaining good color stability. These findings underscore the importance of post-bleaching surface

treatments to restore gloss and reduce roughness, enhancing the overall longevity and aesthetic quality of composite restorations.

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## FIGURES AND GRAPHS

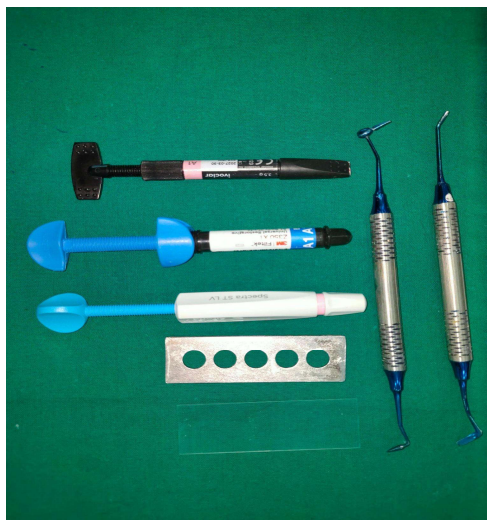


FIG 1 : Three Nanohybrid Composites

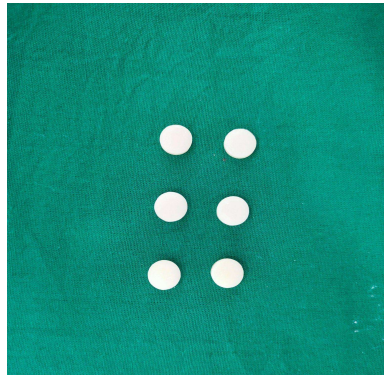
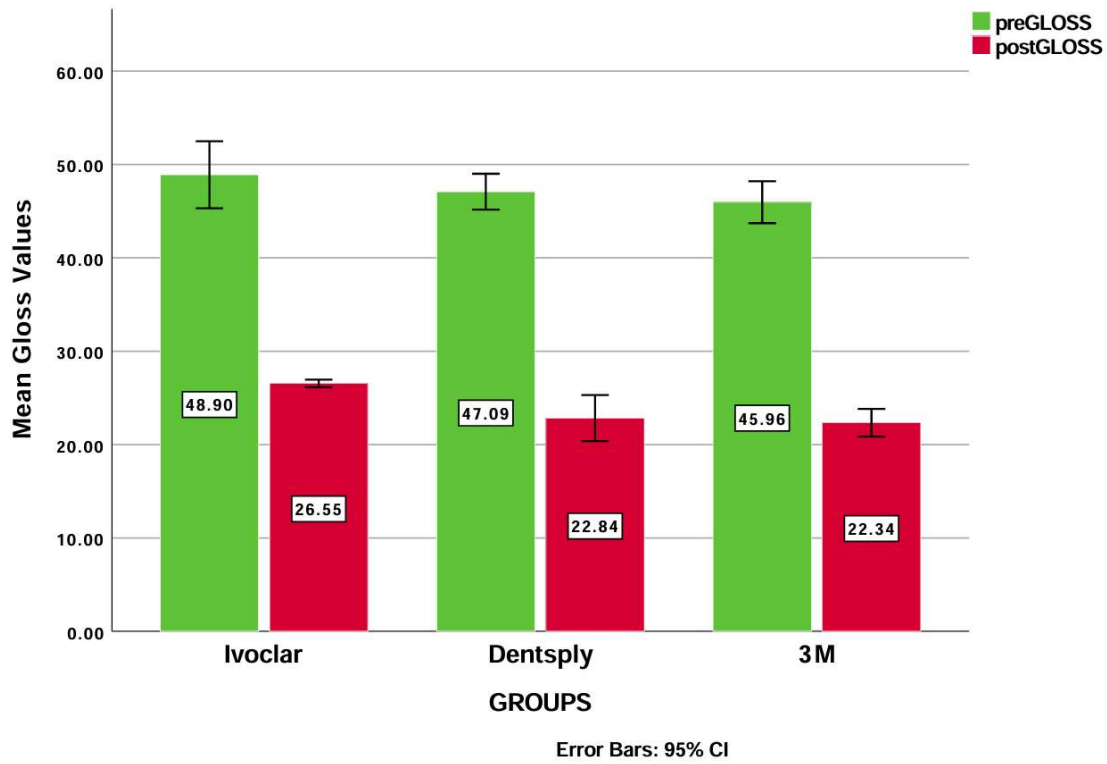


Fig 2 : Composite discs



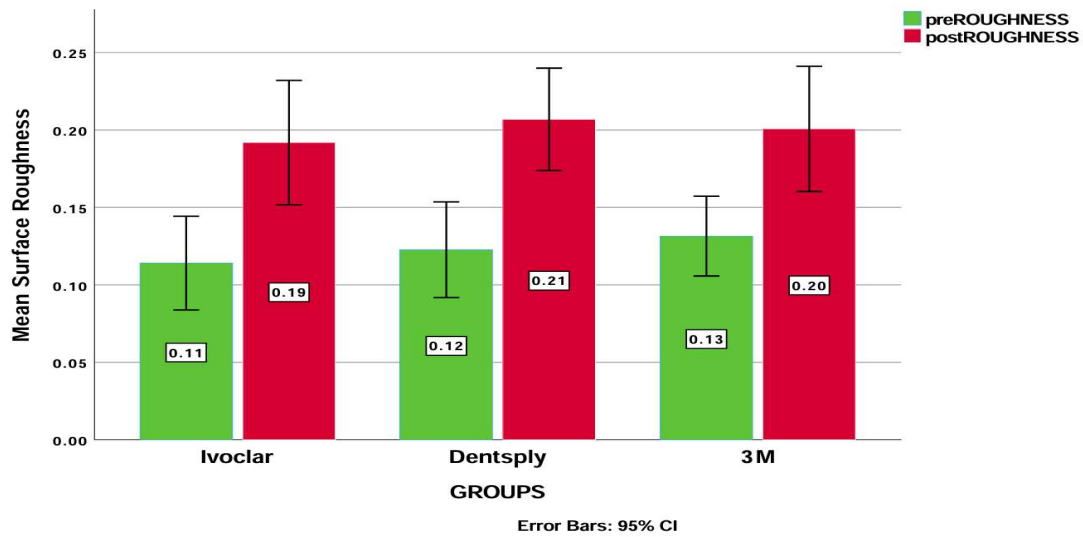
Fig 3 : Bleaching with a 35% hydrogen peroxide solution

### GGraph

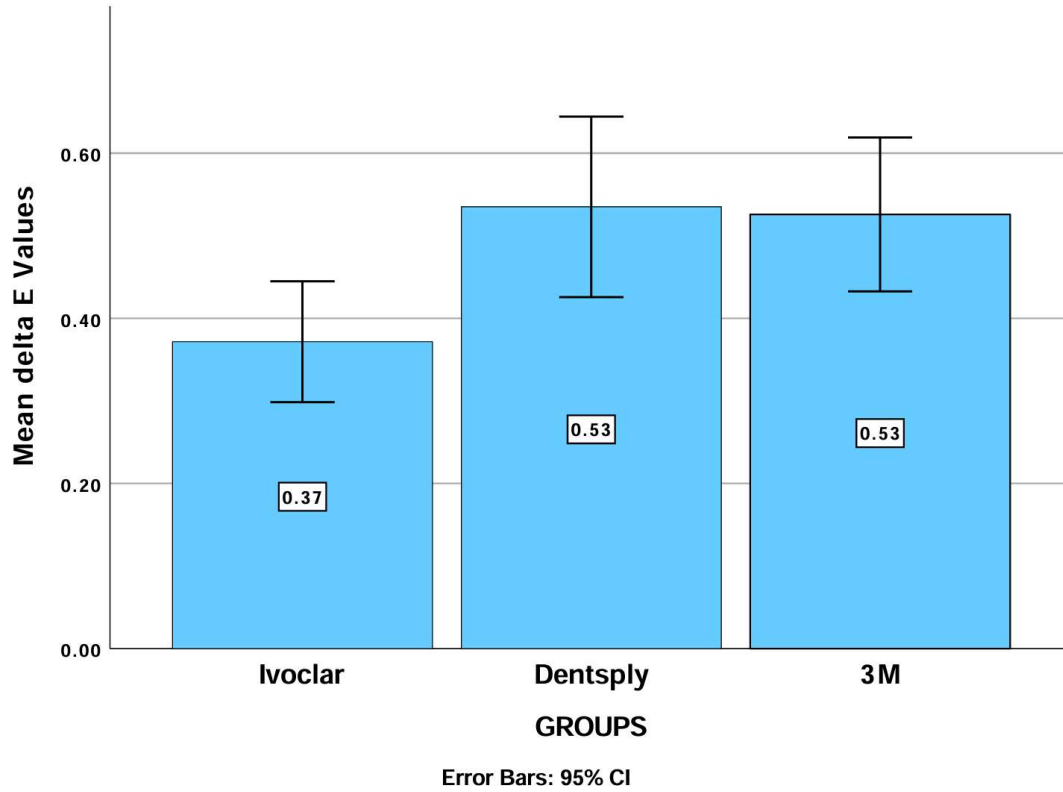


Graph 1 : Mean Gloss Values

### SURFACE ROUGHNESS



Graph 2 : Mean Surface Roughness



Graph 3 : Mean Delta E Values