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Effect of Brushing on the Gloss, Surface Roughness, and Hardness of Ivoclar Tetric N-Flow Bulk Fill Composite

Mithil Vora, Dr. Dinesh*
[1,2]Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Science (SIMATS), Saveetha University, Chennai - 600077, India. Email ID: 152001061.sdc@saveetha.com, dineshkumarb.sdc@saveetha.com

Abstract
Dental composites such as Ivoclar Tetric N-Flow Bulk Fill are widely used in restorative dentistry due to their favorable aesthetic and mechanical properties. However, their long-term performance may be affected by routine oral hygiene practices such as tooth brushing. This study aimed to evaluate the effect of simulated brushing on the gloss, surface roughness, and hardness of Tetric N-Flow Bulk Fill composite. Five composite disc samples were prepared and subjected to 5000 brushing cycles using a toothpaste slurry to simulate approximately one year of clinical use. Gloss, surface roughness, and hardness were measured before and after brushing using a gloss meter, profilometer, and microhardness tester, respectively. The results showed a slight reduction in gloss (8.54 to 8.42), a significant increase in surface roughness (22.5 µm to 29.3 µm), and a notable decrease in hardness (30.3–28.6 to 24.7–17.9) following brushing simulation. Increased roughness may promote plaque accumulation, while reduced hardness indicates compromised wear resistance. Within the limitations of this study, it can be concluded that repetitive brushing adversely affects both the aesthetic and mechanical properties of Tetric N-Flow Bulk Fill composites, highlighting the need for improved material formulations and careful oral hygiene practices to ensure long-term clinical success.

Keywords: Dental composites, Tetric N-Flow Bulk Fill, gloss, surface roughness, hardness, brushing simulation, restorative dentistry.

Introduction

Dental composite materials, such as Ivoclar Tetric N-Flow Bulk Fill, are widely used in modern restorative dentistry due to their exceptional aesthetic qualities, ease of application, and mechanical performance. [1]Their clinical success is influenced by their ability to maintain gloss, smoothness, and structural integrity over extended periods, even when subjected to mechanical and chemical challenges inherent to the oral environment.[2]

Gloss, which reflects surface smoothness and light reflection properties, plays a vital role in aesthetic restorations. A loss in gloss can lead to a dull appearance, reducing patient satisfaction. Surface roughness is another critical parameter as it influences plaque accumulation, biofilm retention, [3]and subsequent caries or periodontal complications. Hardness, a key mechanical property, reflects a material's ability to resist wear and maintain shape under masticatory forces.The mechanical action of tooth brushing is one of the primary factors affecting these properties. While tooth brushing is critical for oral hygiene, [4]its abrasive effects on dental restorations can lead to undesirable changes. This study aims to simulate the effects of repetitive brushing over a simulated one-year period to evaluate its impact on the gloss, surface roughness, and hardness of Tetric N-Flow Bulk Fill composite, [5]providing insight into its long-term clinical performance.Dental composite resins consist of an organic resin matrix reinforced with inorganic filler particles and a silane coupling agent that bonds the fillers to the matrix. The size, distribution, and concentration of these filler particles play a crucial role in determining the physical and mechanical properties of the material, including its polishability and resistance to wear. Advances in bulk-fill composite technology have enabled materials such as Tetric N-Flow Bulk Fill to be placed in thicker increments while maintaining adequate polymerization and mechanical strength. However, restorative materials placed in the oral cavity are continuously subjected to mechanical challenges arising from daily oral hygiene practices. Repeated tooth brushing, especially in combination with abrasive dentifrices, can gradually wear the resin matrix and expose filler particles on the surface. This phenomenon may increase surface roughness and reduce the gloss of the restoration over time. In addition, prolonged mechanical abrasion may influence the hardness and overall durability of the composite material. These surface alterations may compromise the aesthetic appearance and functional longevity of restorations. Therefore, evaluating the resistance of restorative materials to brushing abrasion is essential to determine their long-term clinical performance. Understanding these effects can help clinicians make informed decisions when selecting restorative materials for long-lasting aesthetic outcomes.

Materials and Methods

Sample Preparation:

Five composite discs of Ivoclar Tetric N-Flow Bulk Fill were prepared according to manufacturer specifications. Each disc was uniformly cured to ensure consistent properties across all samples.

Instrumentation:

1. Gloss Measurement: A C3nh Gloss Meter was used to assess surface gloss levels.
2. Hardness Assessment: Hardness was measured using a Shimadzu Microhardness Tester.
3. Surface Roughness Analysis: A profilometer was employed to evaluate changes in surface roughness before and after the brushing simulation.

Brushing Simulation:

- The composite discs were subjected to brushing simulation using a standardized protocol. Each sample underwent 5000 brushing cycles, equivalent to one year of simulated brushing. A commercially available toothpaste slurry was used to mimic real-world conditions.

Data Collection:

- Gloss, hardness, and surface roughness measurements were taken before (Pre) and after (Post) brushing simulation for comparative analysis.

Statistical Analysis:

- The pre- and post-brushing data were statistically analyzed to determine the significance of changes observed in gloss, surface roughness, and hardness.

Results

The findings demonstrated notable changes across all three parameters following brushing simulation:

1. Gloss:

- A slight but consistent reduction in gloss was observed across all samples. Pre-brushing gloss values ranged from 8.654 to 8.432, while post-brushing values ranged from 8.601 to 8.318.

2. Hardness:

- Hardness decreased significantly after brushing, with pre-brushing values ranging from 30.3 to 28.6 and post-brushing values dropping to 17.9–24.7.

3. Surface Roughness:

- Surface roughness values exhibited a significant increase post-brushing, with pre-brushing values ranging from 21.3 µm to 24.1 µm and post-brushing values rising to 28.9 µm to 30.1 µm.

These results highlight the susceptibility of the composite material to surface degradation and mechanical wear due to repetitive brushing.

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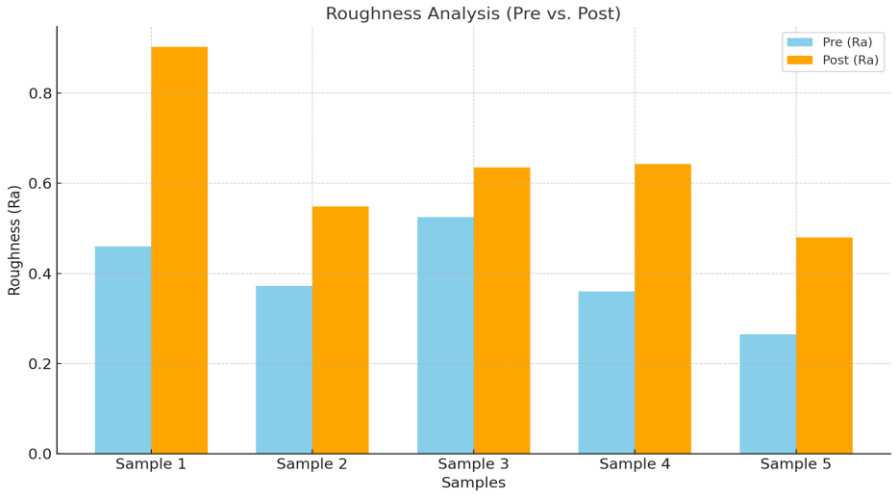
Results

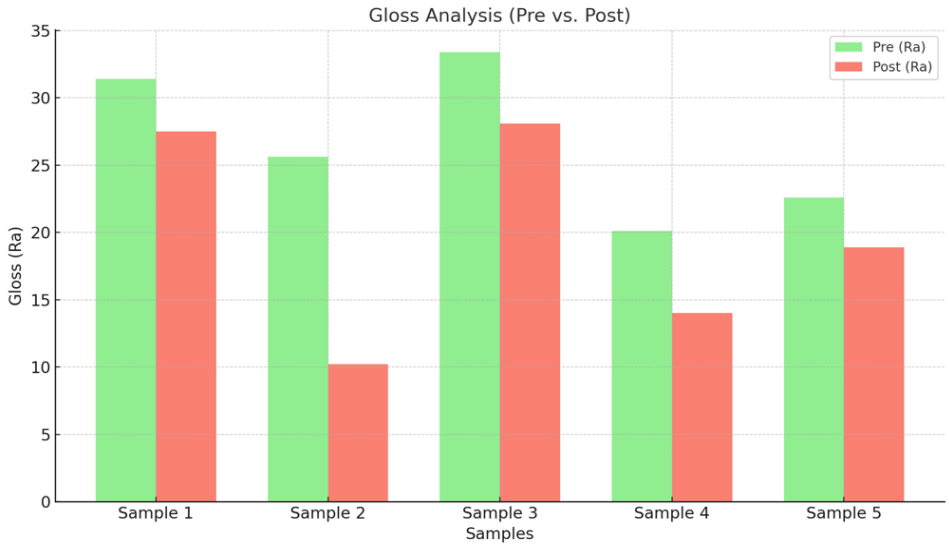


bar graph comparing the roughness values (Ra) for each sample before (Pre) and after (Post) the process. The graph clearly shows the increase in roughness across all samples, with Sample 1 experiencing the most significant change

The table shows the roughness analysis performed using the Mitutoyo SJ-310 Stylus Profilometer, comparing the surface roughness (Ra) values before (Pre) and after (Post) an intervention or process for five samples. Here's the analysis:

Observations:

1. Sample 1:
   - Pre (Ra): 0.460
   - Post (Ra): 0.903
   - Observation: The surface roughness increased significantly, indicating a potential alteration or treatment leading to a rougher surface.
2. Sample 2:
   - Pre (Ra): 0.372
   - Post (Ra): 0.548
   - Observation: Moderate increase in roughness, though less pronounced compared to Sample 1.
3. Sample 3:
   - Pre (Ra): 0.525
   - Post (Ra): 0.635
   - Observation: A slight increase in surface roughness.
4. Sample 4:
   - Pre (Ra): 0.360
   - Post (Ra): 0.643
   - Observation: A notable increase in roughness, similar to Sample 2.
5. Sample 5:
   - Pre (Ra): 0.265
   - Post (Ra): 0.480
   - Observation: Moderate increase in surface roughness.



The bar graph for the gloss analysis, comparing the pre and post gloss (Ra) values for each sample. The graph shows a reduction in gloss for all samples after the process, with Sample 2 experiencing the most significant decrease.

1. Roughness Analysis:

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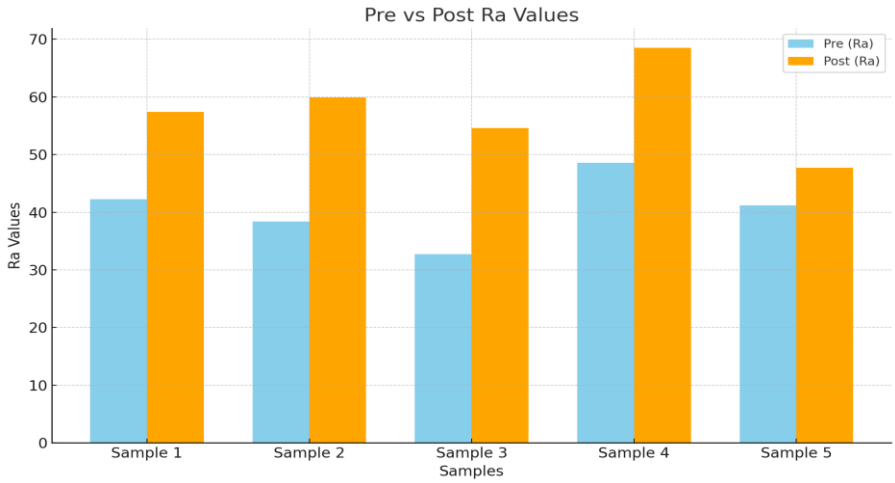
- The bar graph for roughness analysis shows the Pre (Ra) and Post (Ra) surface roughness values for five samples.
- There is an increase in surface roughness (Ra) for all samples after the process.
- Key observations:
- The most significant increase is observed in Sample 1 (from 0.460 to 0.903).
- The smallest increase occurs in Sample 5 (from 0.265 to 0.480).
- This indicates the process or treatment led to a rougher surface texture.

2. Gloss Analysis:

- The bar graph for gloss analysis compares the Pre (Ra) and Post (Ra) gloss values for the same samples.
- There is a decrease in gloss values for all samples after the process.
- Key observations:
- The most significant reduction is seen in Sample 2 (from 25.6 to 10.2).
- The smallest reduction is observed in Sample 1 (from 31.4 to 27.5).
- This indicates the process likely diminished the reflective properties of the surface, making it less glossy.

Conclusion:

The roughness and gloss analysis together suggest an inverse relationship: as surface roughness increases, gloss decreases. This might be due to surface alterations such as abrasion, etching, or a similar treatment affecting the material's texture and reflective properties.



• Across all samples, the "Post (Ra)" microhardness values are higher than the
"Pre (Ra)" values, indicating that the process or treatment significantly improved the material's hardness.
• Sample 4 shows the highest increase in microhardness, with "Pre" and "Post" values going from approximately 48.6 to 68.5.
• Sample 3 has the smallest difference between "Pre" (32.7) and "Post" (54.6), but the improvement is still significant.

Discussion

The findings of this study highlight the significant effects of repeated brushing on the physical properties of Tetric N-Flow Bulk Fill composites. [6]The slight reduction in gloss post-brushing indicates a gradual loss of the material's reflective quality. While the reduction in gloss values appears minimal in this simulation, over an extended period, cumulative effects may become more pronounced, impacting the aesthetic appearance of restorations, particularly in the anterior region where aesthetics are crucial. [7]Patients with high aesthetic demands might require more frequent polishing or replacement of restorations to maintain their appearance.

The increase in surface roughness has broader clinical implications beyond aesthetics. A rougher surface provides a favorable environment for bacterial adherence, biofilm formation, and plaque accumulation. [8]These changes can elevate the risk of secondary caries and periodontal inflammation, especially in patients with inadequate oral hygiene practices. Moreover, increased roughness could lead to staining of the composite, further affecting its appearance and requiring additional intervention such as re-polishing or restoration replacement.[9]

The significant reduction in hardness observed in this study raises concerns about the long-term mechanical stability of the material. Hardness is directly related to a material's ability to resist deformation, wear, and fracture under occlusal forces.[10] A lower hardness value could compromise the durability of restorations in areas subjected to high masticatory loads, such as the posterior teeth. [11]This highlights the need for clinicians to carefully consider the placement of Tetric N-Flow Bulk Fill composites in occlusal stress-bearing areas and to monitor these restorations closely for signs of early failure.

Additionally, the study's results underscore the importance of tailoring oral hygiene advice to individual patient needs.[2] The use of abrasive toothpaste and hard-bristled toothbrushes may exacerbate the degradation of composite restorations. Patients with composite restorations should be encouraged to use soft-bristled brushes and non-abrasive toothpaste formulations to minimize the impact of brushing on restoration properties. Regular professional maintenance, including polishing, can also help restore surface smoothness and gloss while minimizing long-term wear.

The influence of environmental factors in the oral cavity, such as temperature fluctuations, pH changes, and the presence of enzymes, was not accounted for in this study but could further exacerbate the wear and degradation of composite materials.[12] Future research should incorporate these variables to provide a more comprehensive understanding of how Tetric N-Flow Bulk Fill composites behave in the complex oral environment. Moreover, studies exploring the effect of other variables, such as patient-specific dietary habits and saliva composition, could provide deeper insights into how these factors contribute to composite wear.

Finally, this study supports the need for material advancements to improve the durability of dental composites against mechanical wear. Innovations in nanofiller technology, surface coating materials, or new resin formulations could enhance the resistance of composites to gloss loss, surface roughening, and hardness reduction.[13] Clinicians should remain updated on advancements in material science to ensure they provide the most durable and aesthetically pleasing restorations for their patients. As patient expectations for long-lasting, natural-looking restorations increase, material improvements and patient education will play a pivotal role in achieving optimal clinical outcomes.

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Limitations:

- In Vitro Nature: The study relied on controlled laboratory simulations, which may not fully replicate the complex oral environment, including variations in pH, temperature, and dietary habits.
- Brushing Parameters: The study used a single type of toothbrush and toothpaste. Future research could explore the effects of varying toothbrush types, bristle stiffness, and toothpaste abrasiveness.
- Long-Term Effects: While this study simulated one year of brushing, longer durations should be evaluated to assess cumulative wear effects.

Conclusion

This study demonstrates the impact of repetitive brushing on the physical properties of Tetric N-Flow Bulk Fill composite. While the material[14] shows robust initial performance, mechanical brushing compromises gloss, surface roughness, and hardness over time. These findings emphasize the need for:

1. Material innovations to enhance wear resistance.
2. Patient education on optimal oral hygiene practices.
3. Routine monitoring of composite restorations to address early signs of wear.

By addressing these factors, dental practitioners can ensure better long-term outcomes for composite restorations.

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