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Comparative Evaluation of Surface Roughness and Microhardness of Composite After Curing Through Mylar Strip, Glycerin and Teflon (PTFE) Tape: An In Vitro Study.

Abstract:

Objective: The study aims to evaluate and compare the surface roughness and microhardness of composite resin cured using three different surface protectors:Mylar strip, Glycerin, and Teflon (PTFE) tape, and Air as a Control group.

Methods: 60 composite specimens were prepared and divided into four groups based on the curing method. Surface roughness was analyzed using a profilometer, while microhardness was assessed using a Vickers microhardness tester. Data were statistically analyzed using ANOVA and post-hoc tests.

Results: The PTFE tape group showed the highest microhardness values, followed by glycerin and Mylar. The glycerin group exhibited the smoothest surface (lowest roughness), while the Mylar group had the highest surface roughness. All intergroup differences were statistically significant ($p < 0.05$).

Conclusion: Both glycerin and PTFE tape are effective alternatives for controlling the oxygen-inhibited layer during composite curing. PTFE tape enhances microhardness, while glycerin results in smoother surfaces. Their appropriate clinical use may improve the mechanical and esthetic performance of composite restorations.

Key-words: Composite resin, surface roughness, microhardness, Mylar strip, glycerin, Teflon tape, PTFE Tape.

Introduction:

1.1 Background:

Composite resin is widely used in restorative dentistry due to its superior esthetics, excellent adhesion to tooth structure, and ability to conserve healthy tooth tissue[1-2]. However, composite restorations' longevity and clinical performance are significantly influenced by their surface roughness and micro hardness. Surface roughness affects plaque accumulation, staining susceptibility, and wear resistance[3-4], whereas micro hardness determines the material's resistance to mechanical forces and durability in the oral environment [5-6].

One of the critical steps in composite restoration is the curing process, which directly impacts the final physical and mechanical properties of the material [7]. To achieve a smooth and well-polished surface, various surface protectors, such as Mylar strips, glycerin, and Teflon (PTFE) tape, are used during curing. Each of these materials influences the oxygen inhibition layer and the degree of polymerization, thereby affecting the final surface texture and hardness of the composite.[8–10]

1.2 Surface Roughness and Its Clinical Implications:

The smoothness of a composite restoration plays a crucial role in maintaining oral hygiene. A rough surface facilitates

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bacterial adhesion, leading to an increased risk of secondary caries and periodontal disease[3,11]. Additionally, surface roughness impacts the esthetic properties of the composite, making it more prone to discoloration and staining over time[12]. Achieving a smooth surface with minimal roughness is, therefore, essential for the longevity and success of composite restorations [4,13].

1.3 Microhardness and Composite Strength:

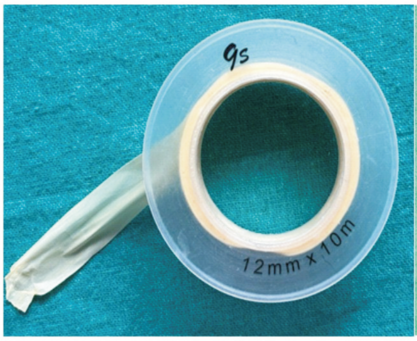
Microhardness is a key indicator of the polymerization efficiency of a composite material. A higher microhardness value correlates with better wear resistance, reduced material degradation, and improved mechanical strength[5,6]. The polymerization process is influenced by factors such as light intensity, exposure time, and the presence of an oxygen inhibition layer. Surface protectors like Mylar strips, glycerin, and Teflon tape can influence the curing process by either preventing or allowing oxygen to interact with the composite surface, thereby affecting the final hardness [9,10,14].

1.4 Effect of Surface Protectors on Composite Properties:

Glycerin: The use of glycerin as an oxygen barrier has been proposed to enhance polymerization by eliminating the oxygen inhibition layer, thus improving microhardness and surface smoothness [16,17].

Mylar Strip: Mylar strips are commonly used to shape and contour composite restorations, providing a smooth and glossy finish. However, composites cured under Mylar strips may exhibit a lower degree of polymerization due to limited light penetration and oxygen inhibition effects [15].

Teflon (PTFE) Tape: Teflon tape, traditionally used as a matrix material in dental procedures, has recently gained attention due to its non-stick properties and minimal interaction with composite resins. Its effect on the surface roughness and microhardness of composites remains under-researched [18,19]. (fig. 1).



(A)

(B)

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Fig. 1 Visual of barrier material use (A) PTFE Tape, (B) Glycerin, (C) Mylar Strip.

1. Methodology:

2.1 Study Design

This is an in vitro experimental study designed to evaluate and compare the surface roughness and microhardness of composite resin cured using three different surface protectors: Mylar strip, glycerin, and Teflon (PTFE) tape.

2.2Sample Preparation

A. Selection of Composite Material

A commercially available nanohybrid/light-cured bulk fill composite resin (Tetric® N-Ceram Bulk Fill IVA) was selected for the study due to its wide clinical applicability and superior mechanical properties.

B. Fabrication of Specimens

A cylindrical mold (diameter: 6 mm, thickness: 2 mm) was used to prepare 60 composite specimens. The mold was placed on a glass slide, and the composite resin was carefully packed into it in a single increment. A plastic instrument was used to contour the surface to ensure uniform thickness and avoid air bubbles.

C. Grouping of Samples

The specimens were randomly divided into four experimental groups (n = 15 per group) based on the curing surface protector used:

- Group 1 Air Group- The Specimen was cured in air without any surface protector.
- Group 2 Mylar Strip – A Mylar strip was placed over the composite surface before light curing.
- Group 3 Glycerin Group – After initial curing, a thin layer of glycerin was applied to the composite surface and light-cured again to remove the oxygen inhibition layer.
- Group 4 Teflon (PTFE) Tape Group – A layer of Teflon tape was used as a surface barrier during light curing.

D. Light Curing Protocol

An LED light-curing unit (WoodpeckeriLED MAX, 385–515 nm) was used for polymerization.

The curing light was placed at a fixed distance of 1 mm from the composite surface using a positioning jig to ensure consistent light exposure. The specimens were cured for 20 seconds at a1000 mW/cm² intensity(according to the manufacturer's instructions).

2.3Surface Roughness Analysis

A. Instrumentation

Surface roughness (Ra value, measured in micrometers [µm]) was analyzed using a profilometer (Mitutoyo SJ-410) Fig.2.The profilometer was calibrated before each measurement.

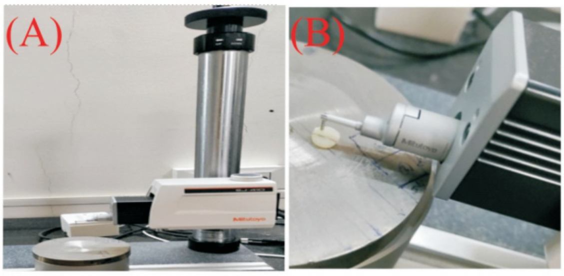

Fig. 2 (A, B) Surface Roughness tester Mitutoyo SJ-410.

B. Measurement Procedure:

Each specimen was placed on the profilometer stage.The stylus tip was moved across a central region of 4 mm length under a constant force.Three readings were taken at different points on the specimen surface, and the mean Ra value was recorded for each sample.

2.4Microhardness Testing:

1. Instrumentation:

Microhardness was evaluated using an electronic Vickers Microhardness Tester (HUATEC SRT-6200 Roughness Tester), 1-micron approx. At 40×. (Fig. 3)

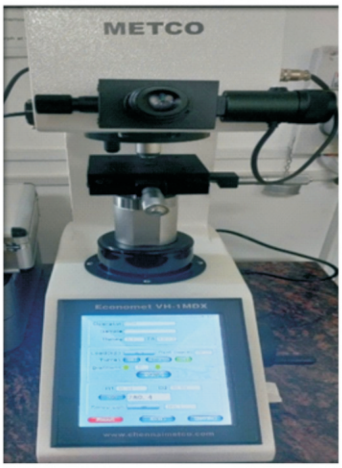

Fig.3 Vickers Microhardness Tester (HUATEC SRT-6200 Roughness Tester).

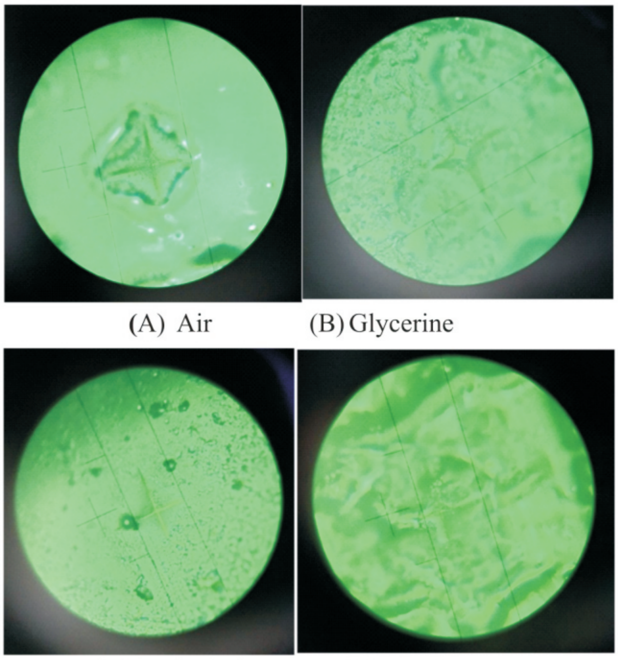

Fig. 4 Microscopic image of composite sample under Vickers Microhardness Tester (HUATEC SRT-6200 Roughness Tester). (A) Air, (B) Glycerine, (C) Mylar Strip, (D) Teflon (PTFE) Tape.

2. Measurement Procedure:

Each specimen was dried and positioned on the testing platform. A Vickers diamond indenter was appliedwith 20g for 10s. Three notches were made in the middle of the composite resin block, at different points, keeping the same distance of 1 mm adjacent to the sample's margin. The indentation was measured using a high-magnification optical microscope, and the average Vickers Hardness Number (VHN) was calculated (Fig. 4).

1. Statistical Analysis:

The collected data were recorded and analysedusing IBM SPSS software, version 22. Descriptive statistics (mean and standard deviation) were used for each group.

One-way ANOVA was performed to compare the surface roughness and microhardness values between the three groups.Post-hoc Tukey's test was used for pairwise comparisons.The significance level was set at $p < 0.05$.

2. Results:

The mean microhardness values of the composite samples differed significantly among the four groups. PTFE Tape demonstrated the highest mean microhardness of 72.25 ± 2.18, indicating the most effective surface polymerization and hardness.The Glycerine group (50.74 ± 7.36) and Air group (50.48 ± 3.27) showed comparable intermediate values.Mylar Strip exhibited the lowest microhardness at 47.24 ± 1.21, suggesting a greater influence of the oxygen-inhibited layer.A statistically significant difference was observed among the groups (**p = 0.001**), indicating that the type of surface barrier or matrix used during curing significantly affected the composite material's microhardness. The PTFE Tape group's notably higher hardness suggests superior polymerization at the surface level compared to the other groups.(Table 1)

Pairwise comparisons confirmed the superiority of PTFE Tape: PTFE Tape vs Glycerine: p = 0.001, PTFE Tape vs Mylar Strip: p = 0.000, PTFE Tape vs Air: p = 0.001, No significant differences were found between Glycerine, Mylar Strip, and Air (p > 0.05), indicating comparable microhardness within these groups.(Table 2)

The surface roughness values showed numerical variation across the groups,Glycerine showing the highest surface roughness (5.38 ± 2.39), suggesting a rougher, less polished surface.Mylar Strip (2.72 ± 1.49) and Air (2.64 ± 0.65) showed lower roughness values, indicating smoother surfaces.PTFE Tape showed a mean roughness of 3.54 ± 0.29, slightly higher than Mylar and Air, but with very low standard deviation, suggesting consistent performance.However, ANOVA analysis revealed that these differences were not statistically significant (P = 0.153), indicating that the method of curing had no significant impact on surface roughness.(Table 3)

One-way ANOVA revealed a significant difference in microhardness among the groups. The **between-group variance (4.874)** was notably higher than the **within-group variance (2.108)**, confirming that the type of OIL control method significantly influenced the microhardness of the composite resin.(Table 4)

Table 1 Comparison of Mean Microhardness Values of Composite Resin Using Different Oxygen-Inhibition Layer (OIL) Control Methods.

Group	Mean	Std. Deviation	P-value
Glycerine	50.744467	7.3558265	0.001 (sig)
Mylar Strip	47.244467	1.2075525	
Air	50.477800	3.2701039	
PTFE Tape	72.255533	2.1752156	

*p (≤0.05) Statistically significant

Table 2: Pairwise Comparison of Mean Microhardness Between Different OIL Control

(I) Group	(II) Group	Mean Difference	Std. Error	P-value
Glycerine	Mylar Strip	3.500	3.440	.744
Glycerine	Air	0.267	3.440	1.000
Glycerine	PTFE Tape	-21.511	3.440	.001
Mylar Strip	Air	-3.233	3.440	.785
Mylar Strip	PTFE Tape	-25.011	3.440	.000
Air	PTFE Tape	-21.778	3.440	.001

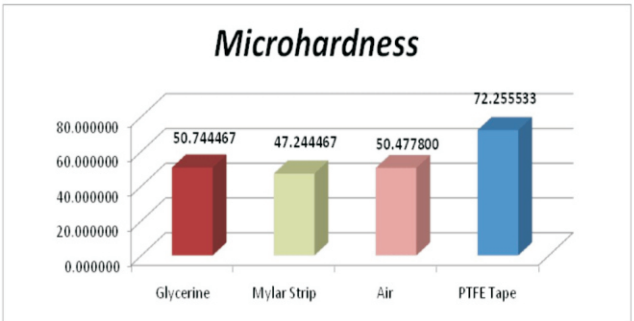

Fig. 5 Graphical Representation of Mean Microhardness

Table 3: Comparison of Mean Surface Roughness of Composite Resin Using Different Oxygen-Inhibition Layer (OIL) Control Methods

	SURFACE ROUGHNESS			
Group	Mean	Std. Deviation	F	Sig.
Glycerine	5.3802	2.38765	2.312	0.153 (insignificant)
Mylar Strip	2.7157	1.48910		
Air	2.6393	.65410		
PTFE Tape	3.5443	.29008		

*p (≤0.05) Statistically significant

Table 4 Inter Group Comparison Roughness of Composite With the topical application of Air Glycerin, Mylar Strip and PTFE tape group

	Sum of Squares	df	Mean Square
Between Groups	14.621	3	4.874
Within Groups	16.861	8	2.108
Total	31.481	11	

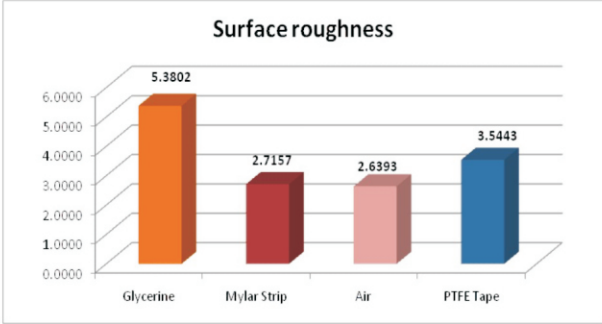

Fig. 6 Graphical Representation of Surface Roughness

1. Discussion:

The surface characteristics of resin composites, specifically surface roughness and microhardness, are critical to the restoration's clinical performance and longevity. These properties influence plaque accumulation, aesthetic stability, wear resistance, and ultimately the potential for secondary caries and periodontal complications. In the present study, surface roughness and microhardness were evaluated following final composite resincuring using different methods: Air, Mylar strip, glycerin gel, and Teflon (PTFE) tape. The results demonstrated that both surface roughness and microhardness were significantly affected by the choice of surface contact material during curing.

Microhardness is a crucial mechanical property of composite resins, directly reflecting the degree of monomer conversion and polymer cross-linking at the surface. Among the tested groups, PTFE Tape demonstrated the highest mean surface microhardness (72.25 ± 2.18), which was significantly greater than that of the Glycerine, Mylar, and Air groups. The difference in microhardness values among the groups was found to be statistically significant ($p = 0.001$), This finding suggests that PTFE Tape effectively prevents the diffusion of ambient oxygen to the composite surface during light polymerization, thereby enhancing the degree of conversion and improving polymer cross-linking at the surface suggesting that the OIL control method plays a pivotal role in influencing the final hardness of the composite surface.

While PTFE Tape has not been previously studied in the context of curing composite resins, its non-stick, chemically inert, and flexible sealing properties may explain its superior performance. Although no direct literature is available to compare, its barrier function is similar in principle to **Mylar strips**, which have been used clinically to isolate restorative material from oxygen exposure. However, in the present study, the Mylar Strip group exhibited the lowest microhardness (47.24 ± 1.21). Although Mylar strips have been widely used in clinical practice due to their ability to produce smooth surfaces, their performance in microhardness enhancement appears limited. The Mylar strip may not seal the surface effectively against ambient oxygen due to slight misfits or wrinkles, leading to suboptimal polymerization at the topmost layer. This observation is contraryto the findings of Strnad et al. (2015) and Park lee et al.(2011), who concluded that restorations cured under Mylar often possess the highest surface hardness,followed by glycerin and Air this can be due to Mylar strip block contact of restorative material with air and only the oxygen within composite leads to the OIL formation.[10,20]

The Glycerine group and Air-cured group presented intermediate values of microhardness (50.74 ± 7.36 and 50.48 ± 3.27, respectively), showing no statistically significant difference between them ($p = 1.000$). This suggests that while glycerine may form a viscous barrier, its effectiveness may be inconsistent due to operator variability in application thickness and completeness of coverage. Similar results were reported by Strnad et al. (2015) and Park lee et al.(2011), who observed that glycerine application did not significantly enhance surface hardness compared to air curing when standardized curing time and light intensity were used[10,20].

Surface roughness is another important parameter influencing the clinical performance of composite restorations. A smoother surface is associated with reduced plaque accumulation, decreased staining, and better esthetics. In this study, the Glycerine group showed the highest surface roughness (5.38 ± 2.39), while Air (2.64 ± 0.65) and Mylar Strip (2.72 ± 1.49) resulted in relatively smoother surfaces. PTFE Tape had a moderate roughness value of 3.54 ± 0.29.

Despite the numeric differences, ANOVA analysis revealed no statistically significant difference in surface roughness among the groups ($p = 0.153$). This suggests that while the choice of OIL control may influence surface texture to some extent, it is not the dominant factor. These results are consistent with the study by **da Costa et al. (2007)**, who found that surface roughness is more strongly affected by finishing/polishing techniques and filler morphology than by the curing atmosphere [21].

Interestingly, the Mylar Strip produced relatively smooth surfaces, consistent with its known ability to form a film over the composite during curing. However, as previously mentioned, this smoothness comes at the cost of reduced surface hardness, likely due to oxygen inhibition under the strip. Bollen et al. (1997) also noted that while smoothness may aid in initial plaque resistance, surface hardness remains a more important determinant for long-term durability [22].

Clinical Significance:

Achieving optimal surface properties of composite restorations is essential for ensuring their longevity, wear resistance, and resistance to plaque accumulation. The presence of an oxygen-inhibition layer can compromise surface hardness, leading to inferior mechanical performance.

This study highlights the clinical potential of PTFE (Teflon) tape as a novel and effective oxygen-inhibition control method. Unlike traditional approaches such as Mylar strips or glycerine gel, PTFE tape provided significantly higher surface microhardness without the need for additional finishing or polishing procedures. Its consistent performance and ease of application make it particularly beneficial in clinical situations where access for polishing is limited—such as in deep class V lesions, posterior restorations, or pediatric dentistry.

2. Study Limitations:

1. In vitro setup only:

The study was conducted under laboratory conditions, which may not fully replicate the complex oral environment—factors such as saliva, thermal fluctuations, occlusal stress, and biofilm formation were not accounted for.

2. Limited composite types:

Only one brand/formulation (Tetric bulk-fill) was evaluated. Results might differ with other composite types—such as nanohybrid, or microfilled resins.

3. Barrier application inconsistency:

Although efforts were made to standardize PTFE tape, glycerine, and Mylar placement, slight variations in thickness or positioning could have influenced outcomes, particularly surface roughness.

4. Single curing protocol:

A single curing time and light intensity were used. Different exposure times, light energies, or curing devices (e.g., halogen, polywave LED) were not tested and may affect performance.

5. Focus on surface properties only:

The study measured microhardness and surface roughness, but did not evaluate other clinically relevant outcomes—e.g., degree of conversion, bonding strength, marginal integrity, wear resistance, or mechanical strength.

6. No long-term aging tests

Samples were not subjected to thermocycling, mechanical fatigue, or water storage. Hence, long-term stability, degradation, and wear performance remain unknown.

7. Sample size and generalizability

Although statistical significance was achieved, the sample size was modest, and results may not generalize across all resin composites or clinical scenarios.

3. Conclusion

Within the limitations of this in vitro study, the following conclusions can be drawn:

PTFE tape was the most effective oxygen-inhibition control method, significantly enhancing surface microhardness without compromising surface roughness. Roughness differences were not statistically significant across groups, indicating greater influence from composite properties and finishing. Glycerine and air showed moderate effectiveness, while Mylar strip, despite yielding smoother surfaces, resulted in the lowest microhardness.

These findings support the incorporation of PTFE tape as a reliable barrier during composite curing, with the potential to improve the mechanical performance and longevity of esthetic restorations.

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