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Research Paper

Comparative Evaluation of the Wear Resistance of Nano-hybrid Resin Composites after Simulated Toothbrushing

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Abstract
Background: *Wear resistance is an important mechanical property that determines the longevity and clinical success composite restorations. Continuous exposure to toothbrushing and dentifrice abrasion may cause loss of restorative material, increased surface roughness, plaque accumulation and deterioration of esthetics. Recent advances in nano-hybrid resin composites have improved filler technology and resin matrix composition, thereby enhancing their resistance to abrasive wear. However, comparative evidence regarding the wear resistance of recently introduced nano-hybrid composites remains limited.*
Aim: *To compare the wear resistance of Restorite Nanohybrid (Prime), Fusion Universal (Prevest DenPro Limited) and Tetric N-Ceram (Ivoclar) following simulated toothbrushing.*
Materials and Methods: *Thirty-six disc-shaped specimens (5 mm × 3 mm) were prepared from three nano-hybrid resin composites (n=12). Specimens were finished, polished and stored in distilled water at 37°C for 14 days. Initial weight was recorded before subjecting the specimens to 100,000 cycles of simulated toothbrushing under a 200 g load using a dentifrice slurry. Final weight was measured after brushing. Data were analyzed using paired t-test, one-way ANOVA and Tukey's post hoc test (α=0.05).*
Results: *All composites demonstrated measurable wear after simulated toothbrushing. Tetric N-Ceram exhibited the least weight loss, followed closely by Fusion Universal with no statistically significant difference between them (P>0.05). Prime Restorite Nano Hybrid demonstrated significantly greater weight loss than both materials (P<0.05).*
Conclusion: *Tetric N-Ceram and Fusion Universal exhibited comparable wear resistance and significantly outperformed Restorite Nano Hybrid. The superior wear resistance observed in Tetric N-Ceram and Fusion Universal may contribute to improved long-term clinical durability in stress-bearing restorations.*

Keywords: *Nano-hybrid composite, Wear resistance, Toothbrushing abrasion, Surface roughness, Resin composite, Fusion Universal, Tetric N-Ceram.*

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I. Introduction

Resin-based composite restorations have become the material of choice for direct esthetic restorations owing to their excellent esthetics, adhesive bonding capability and continuous improvements in mechanical properties. Contemporary nano-hybrid composites combine nanosized fillers with conventional filler particles to achieve improved polishability, fracture toughness, wear resistance and long-term clinical performance, making them suitable for both anterior and posterior restorations.[1] Despite significant advancements in composite technology, restorative materials are constantly subjected to complex mechanical and chemical challenges. Occlusal loading, dietary habits and daily toothbrushing contribute to gradual material degradation. Among these factors, toothbrushing abrasion represents one of the most common causes of surface deterioration because restorative materials are exposed to repeated mechanical contact with toothbrush bristles and abrasive dentifrice particles throughout their service life.[2] Wear of composites is defined as the progressive loss of restorative material resulting from mechanical interaction with opposing surfaces or abrasive agents. Excessive wear adversely affects anatomical form, marginal adaptation, occlusal stability and esthetics, eventually compromising restoration longevity. Increased wear also produces rougher restoration surfaces that facilitate plaque accumulation, bacterial colonization and extrinsic staining, thereby increasing the risk of secondary

caries and periodontal inflammation.[3,4] The wear behavior of resin composites is influenced by multiple material-related factors, including filler loading, filler particle size, filler morphology, filler-matrix bonding, resin matrix composition and degree of polymerization. Nano-hybrid composites generally possess higher filler loading with improved filler distribution, resulting in better resistance to matrix degradation and filler particle dislodgement during abrasion.[5] Recent investigations have demonstrated that filler morphology and the quality of the silane coupling agent significantly influence resistance to toothbrush abrasion. Composites with higher filler loading and stronger filler-matrix adhesion exhibit lower material loss and maintain smoother surfaces after simulated aging procedures.[6] Modern resin composites incorporate highly cross-linked monomer systems such as Bis-GMA, UDMA and Bis-EMA along with nanofillers composed of silica, zirconia or mixed ceramic particles. These modifications have substantially improved the mechanical behavior of restorative composites, particularly their resistance to abrasion and fatigue under cyclic loading.[7] Surface degradation resulting from toothbrushing is clinically important because rough restorative surfaces not only compromise esthetics but also increase biofilm retention. Previous studies have reported that surface roughness values exceeding 0.2 μm favor bacterial adhesion and plaque accumulation, emphasizing the importance of selecting restorative materials capable of maintaining smooth surfaces following long-term brushing simulation.[8] Tetric N-Ceram (Ivoclar) is a widely investigated nano-hybrid composite containing highly dispersed nano-fillers and optimized photoinitiator technology, providing excellent mechanical properties and wear resistance. Fusion Universal (Prevest DenPro Limited) is a recently introduced universal nano-hybrid composite formulated with a highly filled resin matrix intended to provide enhanced strength, polish retention and abrasion resistance. Restorite Nanohybrid (Prime Dental Pvt Limited) is another nano-hybrid restorative composite reinforced with zirconia fillers; however, independent evidence regarding its wear performance remains scarce.[9] Although several studies have evaluated the wear behavior of established resin composites, direct comparison among recently introduced nano-hybrid restorative materials is limited. Moreover, there is little published evidence comparing Fusion Universal and Restorite Nanohybrid with a well-established reference material such as Tetric N-Ceram under standardized simulated toothbrushing conditions.[10] Therefore, the present in-vitro study was undertaken to compare the wear resistance of Restorite Nanohybrid, Fusion Universal and Tetric N-Ceram after simulated toothbrushing by evaluating weight loss.

II. Materials and Methodology

The present in-vitro experimental study was conducted to evaluate and compare the wear resistance of three commercially available nano-hybrid resin composites following simulated toothbrushing. The materials evaluated were Restorite Nanohybrid (Prime Dental Pvt Limited), Fusion Universal (Prevest DenPro Limited, India) and Tetric N-Ceram (Ivoclar, Schaan, Liechtenstein)**.** A total of 36 disc-shaped specimens (5 mm in diameter and 3 mm in thickness) were prepared using a custom-made stainless-steel split mould, with 12 specimens allocated to each group. The sample size was determined using G*Power software (Version 3.1.9.7) with an effect size of 0.50, a significance level of 5%, and a study power of 80%, resulting in a minimum requirement of 10 specimens per group. To compensate for possible specimen loss, 12 specimens were included in each group. The mould was placed on a Mylar strip over a glass slide, and the composite material was packed into the mould in a single increment to minimize void formation. Another Mylar strip and glass slide were placed over the mould, and gentle pressure was applied to obtain a flat and standardized surface. Polymerization was performed using a calibrated LED light-curing unit (3M, XL 1500) with an output intensity of approximately 1000-1200 mW/cm² according to the manufacturers' instructions. Each specimen was cured for 30 seconds from the top surface, removed from the mould, and cured for an additional 30 seconds from the opposite surface to ensure complete polymerization. Following specimen fabrication, all samples were finished and polished using the Sof-Lex™ polishing disc system (3M ESPE, USA) in a sequential order of coarse, medium, fine and superfine discs under continuous water irrigation. Each polishing step was performed for 15 seconds by a single operator to eliminate operator-related variability. The specimens were then ultrasonically cleaned (Codyson CD-4821) in distilled water for 10 minutes to remove any polishing debris and stored individually in distilled water at 37°C for 2 weeks. Samples were weighed everyday for 2weeks until it gave constant weight reading for 5 consecutive days. Baseline weight of each specimen was recorded using a calibrated analytical electronic balance (SartoriusR 2002, Sartorius Werke A.G., Goettingten, Germany) with an accuracy of 0.0001 g and the mean of three consecutive measurements was considered the initial weight. Abrasion test was done using a computer-controlled toothbrushing simulator. Each specimen was securely mounted in the specimen holder and subjected to 100,000 brushing strokes by fixing brush to special mechanical device that maintained its long axis parallel to acrylic bases. A soft nylon-bristled toothbrush (Colgate Gentle Enamel Ultra Soft, Colgate-Palmolive India) was used under a constant load of 200 g with a reciprocating stroke length of 38 mm at a frequency of approximately 350–380 strokes per minute. A dentifrice slurry prepared by mixing toothpaste (Colgate Strong Cream, Colgate-Palmolive India) and distilled water in a 1:2 ratio was used throughout the experiment, and the slurry was continuously stirred to prevent settling of abrasive particles.

Toothbrushes were replaced after every 50,000 cycles to maintain consistent brushing efficiency. After completion of the brushing simulation, all specimens were thoroughly rinsed with distilled water, ultrasonically cleaned for 10 minutes, and dried before final evaluation. The final weight of each specimen was measured using the same analytical balance, and the percentage weight loss was calculated using the formula: Weight loss (%) = [(Initial weight − Final weight) / Initial weight] × 100**.** All data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 31.0. Normality of data distribution was assessed using the Shapiro–Wilk test. Intragroup comparisons between baseline and post-brushing measurements were performed using the paired t-test, whereas intergroup comparisons were carried out using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test for pairwise comparisons. A P value <0.05 was considered statistically significant.

III. Results

All the tested nano-hybrid resin composites exhibited measurable wear following simulated toothbrushing, as evidenced by a significant reduction in specimen weight after 100,000 brushing cycles ($p < 0.05$). The percentage weight loss differed significantly among the three materials (One-way ANOVA, $p < 0.001$). Tetric N-Ceram demonstrated the least weight loss (1.15 ± 0.11%), indicating the highest wear resistance, followed closely by Fusion Universal (1.19 ± 0.13%). No statistically significant difference was observed between Tetric N-Ceram and Fusion Universal ($p = 0.382$). In contrast, Restorite NanoHybrid exhibited the highest percentage weight loss (1.78 ± 0.18%), which was significantly greater than both Fusion Universal and Tetric N-Ceram ($p < 0.001$).

Table 1. Mean Initial Weight, Final Weight and Percentage Weight Loss after Simulated Toothbrushing

Group	Material	Initial Weight (g) Mean ± SD	Final Weight (g) Mean ± SD	Weight Loss (%) Mean ± SD	p-value*
I	Restorite NanoHybrid (Prime)	0.1348 ± 0.004	0.1324 ± 0.004	**1.78 ± 0.18**	<0.001
II	Fusion Universal (Prevest Denpro)	0.1342 ± 0.005	0.1326 ± 0.005	**1.19 ± 0.13**	<0.001
III	Tetric N-Ceram (Ivoclar)	0.1346 ± 0.004	0.1331± 0.004	**1.15 ± 0.11**	<0.001

*Paired t-test comparing initial and final weight.

Table 2. Intergroup Comparison of Percentage Weight Loss

Material	Weight Loss (%) Mean ± SD
Restorite NanoHybrid (Prime)	1.78 ± 0.18[a]
Fusion Universal (Prevest Denpro)	1.19 ± 0.13[b]
Tetric N-Ceram (Ivoclar)	1.15 ± 0.11[b]

One-way ANOVA: $F = 56.21$, **$p < 0.001$**

Different superscript letters indicate statistically significant differences (Tukey's post hoc test).

Table 3. Tukey's post hoc test

Comparison	Mean Difference	p-value
Restorite Nanohybrid vs Fusion Universal	0.59	<0.001
Restorite Nanohybrid vs Tetric N-Ceram	0.63	<0.001
Fusion Universal vs Tetric N-Ceram	0.04	0.428 (NS)

IV. Discussion

The longevity and clinical success of posterior resin composite restorations are largely dependent on their ability to withstand abrasive wear under functional and oral hygiene conditions. Although occlusal loading contributes significantly to clinical wear, routine toothbrushing remains an important factor responsible for gradual material loss over time. The present study compared the wear resistance of three commercially available nano-hybrid resin composites after simulated toothbrushing and demonstrated significant differences among the tested materials. The findings revealed that Tetric N-Ceram exhibited the highest wear resistance, followed closely by Fusion Universal, while Restorite Nanohybrid demonstrated significantly greater wear and consequently the lowest wear resistance**.** The superior wear resistance observed in Tetric N-Ceram may be attributed to its optimized filler technology, high filler loading and highly cross-linked resin matrix. Contemporary nano-hybrid composites containing uniformly distributed nano-sized fillers exhibit improved stress distribution and greater resistance to abrasive wear, thereby maintaining their structural integrity under repeated brushing cycles. Similar observations have been reported by Ferracane JL, who emphasized that improvements in filler characteristics and resin chemistry have substantially enhanced the wear performance of modern resin composites.[11] Fusion Universal demonstrated wear resistance comparable to Tetric N-Ceram, with no statistically significant difference between the two materials. This finding suggests that the material

possesses adequate filler incorporation and matrix composition capable of resisting toothbrush abrasion effectively. Recent investigations have shown that advances in universal nano-hybrid composites have enabled mechanical properties comparable to those of well-established restorative materials. Ilie N reported that recently introduced universal resin composites exhibit excellent mechanical stability and resistance to material degradation owing to improvements in filler distribution and polymer network formation.[12] The comparable performance of Fusion Universal observed in the present study may therefore be related to these material characteristics. In contrast, Restorite Nanohybrid exhibited significantly greater weight loss than the other two composites, indicating inferior wear resistance. The higher wear observed may be associated with differences in filler characteristics, resin matrix composition or filler-matrix interaction, which influence the resistance of restorative materials to abrasive forces. According to Garoushi S and co-workers, resin composites with lower effective filler reinforcement or weaker filler-matrix bonding are more susceptible to progressive material loss during mechanical abrasion.[13] These observations are consistent with the greater wear recorded for Restorite Nanohybrid in the present investigation. Wear resistance is a multifactorial property influenced by filler loading, particle morphology, resin composition, degree of conversion and the quality of silanization. A highly filled composite generally exhibits improved resistance to material loss because the filler particles bear a greater proportion of the applied stresses while minimizing matrix abrasion. Lassila LVJ et al. demonstrated that increased filler loading and optimized particle size distribution significantly improve the resistance of restorative composites to abrasive wear.[14] The present findings agree with these observations, as the materials possessing superior wear resistance likely benefited from more efficient filler reinforcement. The brushing protocol employed in the present study consisted of 100,000 brushing cycles, which has been widely accepted as an effective laboratory method for simulating long-term clinical toothbrushing. Although laboratory simulations cannot completely reproduce the complex intraoral environment, they provide standardized and reproducible conditions for comparing restorative materials. Heintze SD reported that standardized in-vitro wear simulations remain reliable predictors of the relative clinical performance of restorative composites when identical testing conditions are maintained.[15] The findings of the present investigation are also consistent with previous studies demonstrating superior wear resistance of contemporary nano-hybrid composites compared with materials having less optimized filler systems. Roulet JF and colleagues observed that improvements in nano-filler technology substantially reduce material loss during abrasive wear testing, thereby enhancing restoration longevity.[16] Similar conclusions were reported by Cenci MS, who stated that improvements in filler architecture and resin chemistry have significantly contributed to the enhanced durability of modern posterior resin composites.[17] The comparable performance of Fusion Universal and Tetric N-Ceram observed in the present study suggests that recently introduced universal nano-hybrid composites may provide clinical performance similar to that of well-established restorative materials. This finding is clinically relevant because wear resistance is directly related to the maintenance of anatomical form, occlusal stability and restoration longevity. Opdam NJM emphasized that restorative materials demonstrating lower wear rates are associated with improved long-term clinical survival and reduced need for restoration replacement.[18] Within the limitations of this in-vitro study, both Fusion Universal and Tetric N-Ceram demonstrated excellent resistance to toothbrush-induced wear, whereas Restorite Nanohybrid showed significantly greater material loss. Although further long-term clinical studies are required to validate these laboratory findings, the results suggest that Fusion Universal performs comparably to the widely used Tetric N-Ceram and may therefore be considered a suitable restorative material for stress-bearing posterior restorations.

V. Conclusion

Within the limitations of this in-vitro study, all three nano-hybrid resin composites exhibited measurable wear following simulated toothbrushing. Tetric N-Ceram demonstrated the highest wear resistance, followed closely by Fusion Universal, with no statistically significant difference between the two materials. In contrast, Restorite Nanohybrid exhibited significantly greater material loss, indicating the lowest wear resistance among the tested composites. The findings suggest that both Tetric N-Ceram and Fusion Universal possess superior resistance to toothbrush-induced wear and may therefore be expected to provide improved long-term durability and clinical performance in stress-bearing posterior restorations. However, further long-term in vivo clinical studies are recommended to validate these laboratory findings under actual oral conditions.

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