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ORIGINAL RESEARCH

COMPARATIVE EVALUATION OF MICROHARDNESS OF BULK FILL AND CONVENTIONAL COMPOSITE IN HIGH AND LOW VISCOSITY

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ABSTRACT

Background: Composite resins are widely applied in dental restorations, yet conventional layering is slow and may lead to shrinkage. Bulk-fill composites simplify placement with thicker increments, though their hardness and overall mechanical reliability compared with traditional types are still uncertain.
Objective: This study aimed to assess and compare the surface microhardness of conventional and bulk-fill composites with different viscosities to determine their relative suitability for stress-bearing restorations.
Methods: Sixty cylindrical specimens were prepared from four composite groups (n = 15 each): Estelite® Posterior (high-viscosity conventional), Palfique® Universal Flow (low-viscosity conventional), Beautifil-Bulk Restorative (high-viscosity bulk-fill), and Beautifil-Bulk Flowable (low-viscosity bulk-fill). Specimens were polymerized following manufacturer instructions and tested using a Vickers microhardness tester under a 200 g load for 15 seconds. Mean values were analyzed using one-way ANOVA with Tukey's post hoc test ($p < 0.05$).
Results: Estelite® Posterior exhibited the highest microhardness (78.92 ± 7.74 MPa), significantly greater than Palfique® Universal Flow (53.18 ± 6.55 MPa), Beautifil-Bulk (53.18 ± 10.73 MPa), and Beautifil-Bulk Flowable (50.86 ± 4.72 MPa) ($p \le 0.001$). No statistically significant differences were observed among the flowable and bulk-fill groups ($p > 0.05$).
Conclusion: Conventional composites demonstrated superior microhardness compared with both bulk-fill and flowable systems, underscoring their continued relevance in high-stress clinical applications. Nevertheless, recent improvements in bulk-fill formulations have reduced performance gaps, suggesting their potential as efficient alternatives in cases where reduced chair time and simplified placement are prioritized. Further studies evaluating additional mechanical and biological properties are warranted to establish their long-term clinical reliability.

***Keywords*: Composite resin, Bulk-fill, Viscosity, Microhardness, Restorative dentistry.**

INTRODUCTION

Composite resins have become indispensable restorative materials in modern dentistry due to their esthetic appeal, direct handling, and ability to bond to tooth structures. Despite their widespread use, a central limitation of light-cured composites is the inadequate depth of polymerization, which compromises their mechanical properties and long-term clinical performance [1,2].

Incomplete curing not only reduces hardness and color stability but also promotes the release of residual monomers that may affect biocompatibility[3]. Consequently, the incremental technique, involving 2-mm thick layers, has long been regarded as the gold standard to ensure sufficient light penetration and minimize polymerization shrinkage [4,5].

The method needs extended time but particular techniques must be used to stop voids and weak interlayer bonds [6].

The creation of bulk-fill resin composites emerged as a solution to these issues because they allow 4 mm placement steps while preserving sufficient curing depth and material properties [7].

The materials exist in two forms which include high-viscosity bulk-fills that function as complete restorative materials and low-viscosity bulk-fill flowables that work best as base layers because of their low filler content and poor wear resistance [8]. The clinical success of these composites depends on viscosity because it affects their workability and their ability to adapt to cavity walls and their polymerization process. The flow characteristics of low-viscosity resins are good but their mechanical strength is lower than high-viscosity materials which achieve better wear and deformation resistance through their higher filler content [9,10].

The evaluation of restorative materials through mechanical properties includes surface microhardness which serves as an effective indirect method to assess curing depth and degree of conversion and deformation resistance [11].

The microhardness values indicate the resistance of dental materials to wear and their ability to maintain polish and their long-term clinical performance [12].

The assessment of posterior restorations under heavy occlusal pressure needs to compare between standard composite materials and bulk-fill materials of both high and low viscosity.

The literature presents inconsistent findings about bulk-fill composites outperforming conventional composites through microhardness testing because researchers have tested different commercial products. Saati *et al.* (2022) [13] shows conventional resins achieve higher hardness values according to their study. Ilie, (2022) [14] and some materials show similar or superior values for specific bulk-fill materials based on their composition and filler content and curing methods [15].

The different results demonstrate that researchers need to perform additional studies which compare materials with different viscosity levels.

Accordingly, the present study was designed to investigate and compare the microhardness of conventional composites and bulk-fill composites of both high and low viscosity.The research investigates viscosity-microhardness connections to determine if bulk-fill materials match conventional restorative systems in mechanical performance which will help dental practitioners make better treatment choices.

MATERIALS AND METHODS

Study Design

This in vitro investigation was conducted to evaluate and compare the surface microhardness of four commercially available composite resins, encompassing both conventional and bulk-fill types with different viscosity profiles. The study followed a controlled laboratory design, with standardized sample preparation and testing procedures to minimize methodological bias.

Four resin composites were selected based on their viscosity and restorative classification (Table 1). The high-viscosity conventional composite tested was Estelite® Posterior (Tokuyama, Japan). A low-viscosity flowable composite was represented by Palfique® Universal Flow (Tokuyama, Japan). For bulk-fill materials, Beautifil-Bulk Restorative (Shofu Inc., Japan) was selected as a high-viscosity bulk-fill, while Beautifil-Bulk Flowable (Shofu Inc., Japan) represented the low-viscosity bulk-fill category.

All materials were used in shade A2, and their manufacturer-reported compositions, filler content, and physical characteristics are outlined in Table 1.

Table 1. Compositions and characteristics of the tested composites

Commercial Brand	Type	Manufacturer	Main Matrix and Additives	Filler Load
ESTELITE® POSTERIOR	High-viscosity conventional composite	Tokuyama®	Matrix based on Bis-GMA with TEGDMA and Bis-MPEPP	84 wt% (70 vol%)
PALFIQUE® UNIVERSAL FLOW	Low-viscosity composite	Tokuyama®	Combination of Bis-GMA, UDMA, Bis-MPEPP, TEGDMA with stabilizers (antioxidant, UV absorber)	71 wt% (57 vol%)
Beautifil-Bulk Restorative	High-viscosity bulk-fill	Shofu Inc.	Bis-GMA and UDMA enriched with S-PRG fillers containing fluoroboroaluminosilicate glass	87 wt% (74.5 vol%)
Beautifil-Bulk Flowable	Low-viscosity bulk-fill	Shofu Inc.	Resin blend (Bis-GMA, UDMA, TEGDMA) with S-PRG fillers and polymerization initiators	73 wt%

Sample Preparation

A total of **60 specimens** were prepared, with fifteen specimens allocated to each material group (n = 15 per group). Two custom-made cylindrical molds were fabricated from stainless steel:

Mold A: 5 mm in diameter × 4 mm in depth, used for bulk-fill composites.

Mold B: 5 mm in diameter × 2 mm in depth, used for conventional composites. The materials were added into the molds in a single increment according to their classification (4 mm for bulk-fill, 2 mm for conventional) and covered with a clear Mylar strip and a glass slide to ensure a flat surface and minimize the oxygen inhibition layer. Each specimen was polymerized using a Woodpecker LED curing unit (intensity: 1000 mW/cm²; wavelength range: 420–480 nm) with the cure tip placed in direct contact with the surface. The curing time followed the manufacturer's recommendations for each product.

Microhardness Testing

After curing, all specimens were stored at room temp. (23 ± 2°C) for 24 hours prior to testing. The Vickers hardness number (VHN) was determined with a digital hardness testing device (HVS-1000, Jinan Liangong Testing Technology Co., Ltd., China). Each measurement involved pressing a diamond-shaped indenter, set at a 136° angle, under a 200 g load for a dwell time of 15 seconds. Three indentations were made on each specimen's top surface at equidistant points, and the mean value was calculated as the representative VHN for that sample. Representative images of sample preparation and indentation are shown in Figures 1,2.

Figure 1. (Photomicrograph of an indentation made with the hardness tester)

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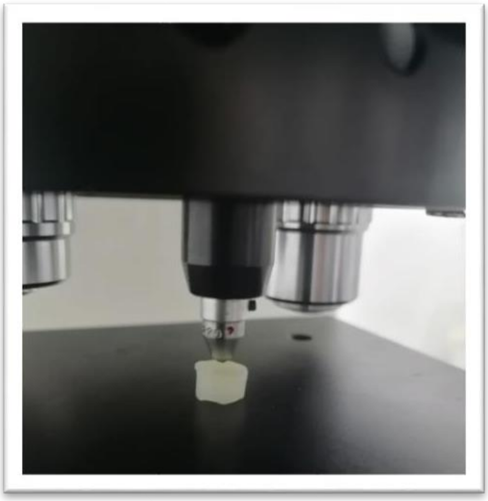

Figure 2 (Micro-Vickers hardness machine applying load with diamond indenter)

Statistical Analysis

For each experimental group, descriptive statistics were expressed as mean values accompanied by their standard deviations. Because the design included more than two independent groups, one-way ANOVA was applied to compare differences across them, and Tukey's post hoc test was subsequently used for pairwise comparisons. A probability value of less than 0.05 was considered statistically significant. All statistical procedures were carried out using SPSS software, version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Microhardness of Tested Composites

The mean Vickers microhardness values (±SD) for all four groups are presented in Table 2. Among the tested materials. Estelite® Posterior exhibited the highest mean hardness value (78.92 ± 7.74 MPa), followed by Palfique® Universal Flow (53.18 ± 6.55 MPa) and Beautifil-Bulk (53.18 ± 10.73 MPa). The lowest hardness was observed for Beautifil-Bulk Flowable (50.86 ± 4.72 MPa).

Table 2. Mean Vickers microhardness values (MPa) of the tested composites

Composite	Vickers Microhardness (MPa) Mean ± SD
Estelite® Posterior	78.92 ± 7.74
Palfique® Universal Flow	53.18 ± 6.55
Beautifil-Bulk	53.18 ± 10.73
Beautifil-Bulk Flowable	50.86 ± 4.72

Intergroup Comparisons

The one-way ANOVA demonstrated highly significant variation among the studied groups ($p < 0.001$). Subsequent Tukey's post hoc comparisons showed that Estelite® Posterior exhibited significantly higher values compared with all bulk-fill and flowable composites. Specifically, the differences were:

- Estelite® Posterior vs. Palfique® Universal Flow: Mean difference = 25.74, t = 5.26, $p < 0.001$
- Estelite® Posterior vs. Beautifil-Bulk: Mean difference = 25.74, t = 5.26, $p < 0.001$

- Estelite® Posterior vs. Beautifil-Bulk Flow: Mean difference = 28.06, t = 5.74, p < 0.001

No statistically considerable differences were established among the low- and high-viscosity bulk-fill groups or between Palfique® Universal Flow and Beautifil-Bulk:

- Palfique® Universal Flow vs. Beautifil-Bulk: **Mean** difference = 0, p = 1
- Palfique® Universal Flow vs. Beautifil-Bulk Flow: Mean difference = 2.32, p = 0.642
- Beautifil-Bulk vs. Beautifil-Bulk Flow: Mean difference = 2.32, p = 0.642

Table 3. Intergroup comparison of microhardness values

Comparison	**Mean Difference**	**t**		**p**
Estelite® Posterior – Palfique Flow	25.74	5.26		<0.001
Estelite® Posterior – Beautifil-Bulk	25.74	5.26		<0.001
Estelite® Posterior – Beautifil-Bulk Flow	28.06	5.74		<0.001
Palfique Flow – Beautifil-Bulk	0	0		1.000
Palfique Flow – Beautifil-Bulk Flow	2.32	0.47		0.642
Beautifil-Bulk – Beautifil-Bulk Flow	2.32	0.47		0.642

These tabulated results are further visualized in Figures 3 and 4, which highlight both the mean trends and the variability within each group.

Figure 3 illustrates the mean Vickers hardness (MPa) of the four tested composites with error bars representing ±SD. Estelite® Posterior demonstrated the highest mean microhardness (78.92 ± 7.74 MPa), markedly improved than all other groups (p < 0.001). In contrast, Palfique® Universal Flow (53.18 ± 6.55 MPa), Beautifil-Bulk (53.18 ± 10.73 MPa), and Beautifil-Bulk Flowable (50.86 ± 4.72 MPa) exhibit no notable differences among themselves (p > 0.05). The chart emphasizes the superior hardness of conventional composites compared with bulk-fill and flowable categories.

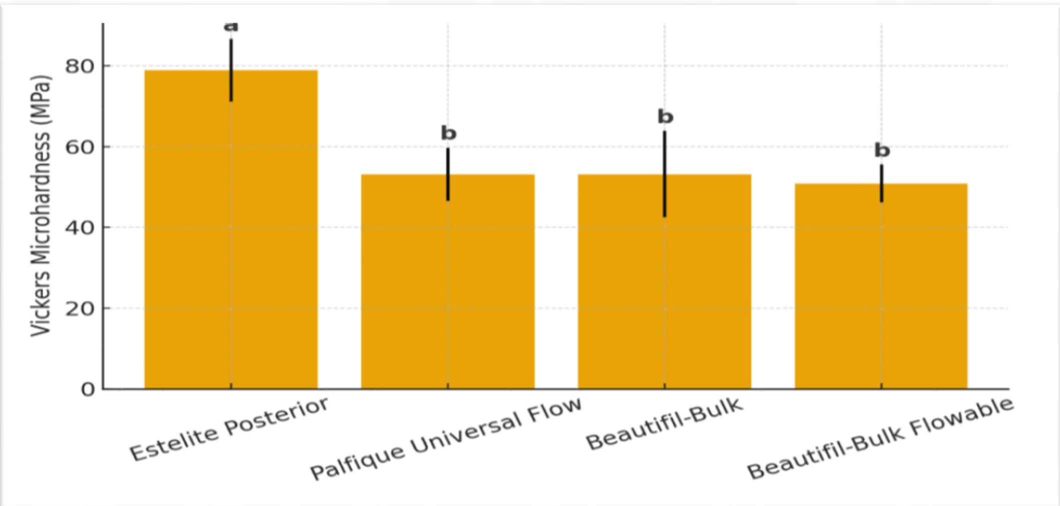

Figure 3. Bar chart showing mean ± SD microhardness values of the four composites. Different letters (a, b) above the bars indicate statistically significant differences (p < 0.05).

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Figure 4 demonstrates the distribution of individual hardness values. While Estelite® Posterior consistently shows higher readings with minimal overlap, the distributions of Palfique® Universal Flow and Beautifil-Bulk overlap substantially, confirming the lack of statistical difference.

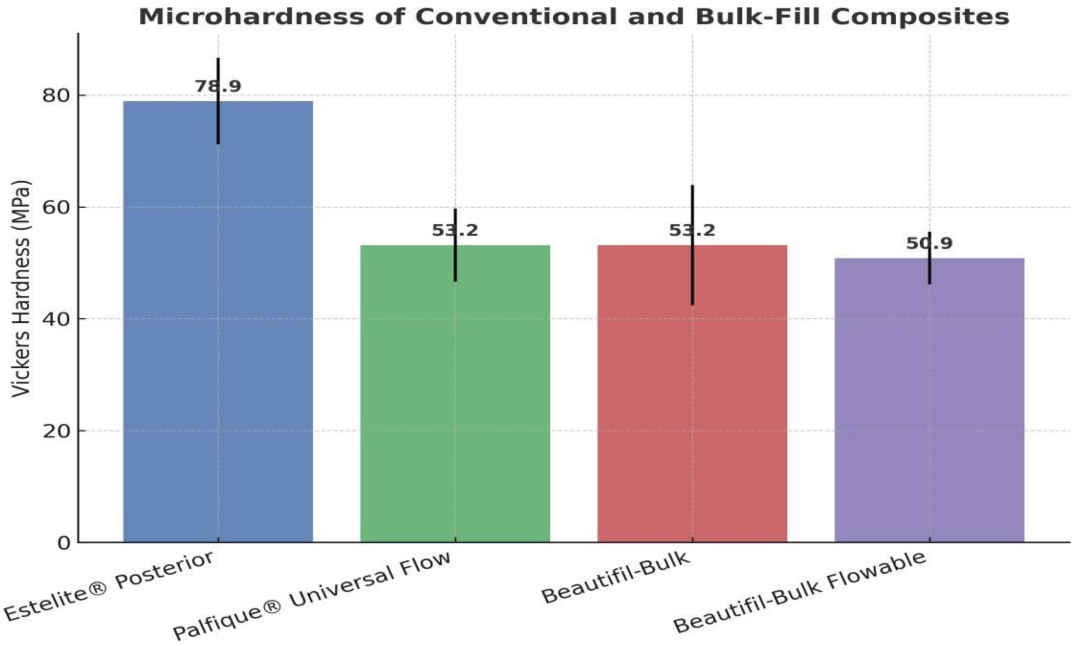

Figure 4. Box plot showing the distribution of individual Vickers hardness values across composite groups.

DISCUSSION

The present research sought to compare the surface microhardness of conventional and bulk-fill composites with different viscosities. The results demonstrated that Estelite® Posterior, a high-viscosity conventional composite, exhibited the highest microhardness values (78.92 ± 7.74 MPa), which were significantly greater than those of all bulk-fill and flowable groups. In contrast, Palfique® Universal Flow, Beautifil-Bulk, and Beautifil-Bulk Flowable showed lower hardness values without significant differences among them. These findings provide important insights into how resin composition and viscosity influence mechanical performance and consequently clinical applicability.

Conventional Composites versus Bulk-fill Systems

Estelite Posterior demonstrates superior hardness according to previous studies which found conventional composites perform better than bulk-fill materials in deformation resistance tests [16, 17].The material reaches its performance level because of its 84 wt% filler content which creates a highly cross-linked polymer structure when combined with Bis-GMA and TEGDMA resin matrix [18].The denser molecular structure produces better wear resistance and lower polymerization shrinkage that results in higher microhardness values. The Estelite Posterior material achieves better curing performance because of Radical-Amplified Photopolymerization (RAP) technology which enhances conversion rates during short exposure periods [19]. The combination of these characteristics makes conventional composites the standard material for restorations that need to withstand stress.

The Role of Viscosity in Bulk-fill Composites

An interesting observation in the current study is the absence of significant differences in microhardness between high-viscosity Beautifil-Bulk and its low-viscosity counterpart Beautifil-Bulk Flowable, as well as between Palfique® Universal Flow and Beautifil-Bulk.The study results contradict the common belief that materials with higher viscosity and added fillers will achieve better hardness results [20].

Comparison with Previous Studies

The current study supports the results which Park et al. (2021) [22] and Ludovichetti et al. who observed lower hardness values in low-viscosity bulk-fill composites compared with conventional resins, but also highlighted improved performance in newer formulations. The study by Santin et al. (2021) [24] found that bulk-fill composites reached hardness levels which matched or surpassed conventional systems through the combination of specific filler materials and proper polymerization methods. Discrepancies across studies may be attributed to differences in curing light intensity, specimen thickness, and material formulation, all of which inf[lu]ence the degree of conversion [25].

Clinical Implications

From a clinical perspective, the present findings confirm that conventional composites—particularly Estelite® Posterior—remain the preferred choice for stress-bearing posterior restorations due to their superior surface hardness and long-term resistance to masticatory forces. At the same time, the practical benefits of bulk-fill systems, especially their ability to be placed in 4-mm increments, provide considerable advantages in terms of reduced chair time and simplified restorative procedures. The comparable hardness values observed between flowable and high-viscosity bulk-fill composites further indicate that viscosity alone should not dictate material selection. Instead, clinicians are encouraged to base their choice on the specific clinical scenario, cavity size, and patient-related factors: flowable bulk-fills may be more suitable for small cavities or as liners beneath occlusal restorations, whereas high-viscosity bulk-fills can be effectively employed in larger cavities where procedural efficiency is a priority.

Study Limitations and Future Directions

The present study was limited by its in vitro design, which cannot fully replicate intraoral conditions. Parameters such as thermal cycling, water sorption, and mechanical fatigue were not evaluated, though they are critical for long-term clinical durability. Furthermore, the study focused solely on microhardness; other properties such as flexural strength, polymerization shrinkage, and marginal adaptation were not examined. Future research should incorporate multi-parameter mechanical testing, long-term aging protocols, and clinical trials to validate whether the observed differences in microhardness translate into significant variations in clinical performance.

Limitations and Future Directions

Despite the promising findings of this study, it must be emphasized that the results were obtained under controlled *in vitro* conditions, which fail to reproduce the complex dynamics of the oral environment. Thermal cycling, hydrolytic degradation, and cyclic masticatory loading are among the most relevant intraoral challenges that directly affect the durability of resin composites. Future studies should therefore incorporate artificial aging protocols and mechanical fatigue testing to more accurately simulate the long-term performance of restorative materials under clinical conditions.

CONCLUSION

Within the limiting of this in vitro analysis, the findings demonstrated that conventional composites (Estelite® Posterior) exhibited significantly superior microhardness compared with both high- and low-viscosity bulk-fill materials. This advantage is likely attributed to their higher filler content, optimized resin matrix, and more efficient polymerization chemistry. Conversely, Palfique® Universal Flow, Beautifil-Bulk, and Beautifil-Bulk Flowable showed comparable hardness values, suggesting that recent improvements in bulk-fill formulations allow them to perform similarly despite differences in viscosity. From a clinical perspective, these results emphasize that conventional composites remain the material of choice for high-stress posterior restorations, where long-term wear resistance is paramount. Nevertheless, the practical benefits of bulk-fill systems, including reduced chair time and simplified placement, justify their use in selected cases, particularly in moderate-load restorations or when procedural efficiency is prioritized.

Future investigations should extend beyond surface hardness to incorporate other mechanical and biological parameters, such as flexural strength, polymerization shrinkage, marginal adaptation, and long-term aging under oral conditions. Such studies would provide a more comprehensive understanding of whether bulk-fill composites can reliably substitute conventional systems in diverse restorative scenarios.

DECLARATIONS

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Competing and conflicting interests

The authors declare no competing interests or conflicts of interest related to this work.

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