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Comparative Evaluation of the Effect of Two Different Ultrafast Curing Exposure Durations on the Surface Hardness of Bulk-Fill Composite: An In Vitro Study

(Effect of Ultrafast Curing on Bulk Fill Composite Hardness.)

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KEYWORDS

Bulkfill composite; Ultrafast curing; Microhardness; Light curing units

ABSTRACT:

Introduction: Bulk-fill composite resins were introduced to address the shortcomings of conventional composites, including limited depth of cure and polymerization shrinkage. Recently, high-intensity ultrafast curing protocols have been introduced to reduce clinical chairside time. However, concerns remain regarding their influence on polymerization efficiency and mechanical properties.

Objectives: To evaluate the impact of two ultrafast curing times on the surface hardness of bulk-fill composite resin in comparison with the conventional curing method.

Methods: Thirty standardized specimens of bulk-fill composite resin were prepared using a custom Teflon mold (10 mm diameter × 2 mm thickness). Samples were randomly divided into three groups (n=10): Group I – ultrafast curing for 1 second, Group II – ultrafast curing for 3 seconds, and Group III – conventional curing for 20 seconds. Specimens were finished, polished, and stored for 24 hours before evaluation. Surface microhardness was assessed using a Vickers microhardness testing device. Statistical analysis was carried out with SPSS software version 21, employing the Kruskal–Wallis test followed by post-hoc pairwise comparisons.

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Results: Mean microhardness values were highest in Group III (256.48±8.92 VHN), followed by Group II (105.60±2.69 VHN) and Group I (62.80±1.70 VHN). A statistically

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significant difference was noted among all the groups ($p < 0.001$).

Conclusions: Conventional curing demonstrated significantly higher surface hardness compared to ultrafast curing modes. Adequate curing time remains essential for achieving optimal polymerization and mechanical strength of bulk-fill composite restorations.

1. Introduction

Resin-based composites (RBCs) are extensively utilized in restorative dentistry due to their excellent esthetic qualities, adhesive properties, and reliable mechanical performance.[1] Over recent decades, ongoing advancements in filler technology and resin matrix formulation have markedly improved the clinical performance of composite materials.[2] However, polymerization shrinkage and restricted depth of cure continue to be significant challenges with conventional composite resins, often requiring incremental placement techniques to achieve proper polymerization and reduce internal stresses.[3]

The incremental technique, although effective, is time-consuming and technique-sensitive.[4] Improper layering may result in void formation, marginal gaps, postoperative sensitivity, and reduced restoration longevity.[5] To overcome these limitations, bulk-fill composite resins were introduced.[6] These materials permit placement in thicker increments, generally between 4–5 mm, without adversely affecting polymerization efficiency.[7] Their improved translucency, modified photoinitiator systems, and optimized filler distribution enhance light transmission and improve curing depth compared with conventional composites.[8]
Light curing represents a crucial step in composite restoration, as the mechanical properties of the material largely depend on the degree of conversion attained during polymerization.[9] Factors influencing polymerization include light intensity, exposure duration, wavelength compatibility, distance from light source, and composite composition.[10] Insufficient polymerization can lead to decreased hardness, increased wear, marginal breakdown, and potential restoration failure.[11]

Recent advancements in light-curing technology have resulted in the introduction of high-intensity light-emitting diode (LED) curing units capable of delivering higher radiant energy in shorter exposure times.[12] Ultrafast curing protocols, which involve exposure times as short as 1–3 seconds, have been introduced with the goal of reducing chairside time and improving clinical efficiency.[13]Despite these advantages, there are concerns regarding the adequacy of polymerization achieved with extremely short exposure durations.[14]

Surface microhardness testing is widely employed as an indirect technique to assess the degree of polymerization of composite materials.[15] Increased microhardness values are generally associated with improved cross-linking density and enhanced mechanical properties.[9] Therefore, evaluating the effect of ultrafast curing durations on surface hardness is essential to determine their clinical reliability.

Although numerous studies have evaluated the curing efficiency of bulk-fill composites under varying light intensities and exposure durations, there is limited evidence regarding the effectiveness of ultrafast curing protocols in comparison with conventional curing methods.[13] Therefore, the present in-vitro study was undertaken to assess and compare the surface hardness of bulk-fill composite resin polymerized using two ultrafast curing durations and a conventional curing protocol.

2. **Objectives**

2. To assess the surface hardness of bulk-fill composite resin polymerized using an ultrafast curing duration of 1 second.

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3. To assess the surface hardness of bulk-fill composite resin polymerized using an ultrafast curing duration of 3 seconds.
4. To assess the surface hardness of bulk-fill composite resin cured using a conventional curing protocol of 20 seconds.
5. To compare the surface hardness values obtained among the three different curing protocols.

3. Methods

This in vitro experimental study included thirty specimens of bulk-fill composite resin fabricated using a custom-made Teflon mold measuring 10 mm in diameter and 2 mm in thickness. The composite material was carefully inserted into the mold to prevent air bubble formation. A Mylar strip followed by a glass slide was positioned over the composite to achieve a smooth and standardized surface finish.

The prepared specimens were randomly allocated into three groups (n = 10):
Group I – Ultrafast curing for 1 second
Group II – Ultrafast curing for 3 seconds
Group III – Conventional curing for 20 seconds

Following polymerization, all specimens were finished using 1200-grit silicon carbide abrasive paper and subsequently polished with Sof-Lex polishing discs. The specimens were then stored in distilled water at room temperature for 24 hours before microhardness evaluation.

Surface microhardness was measured using a Vickers microhardness tester. Three indentations were created at separate locations on each specimen, and the average value was recorded as the final microhardness value.

Statistical analysis

Statistical analysis was conducted using SPSS software version 21. Data normality was evaluated prior to analysis, and intergroup comparisons were performed using the Kruskal–Wallis test, followed by post-hoc pairwise comparison tests. A p-value of less than 0.05 was considered to indicate statistical significance.

4. **Results**

Mean microhardness values revealed that Group III (conventional curing) exhibited the highest hardness values, followed by Group II and Group I. Intergroup comparison using the Kruskal–Wallis test demonstrated highly significant differences among all groups ($p<0.001$). Post-hoc pairwise comparisons confirmed statistically significant differences between each group combination.

Group III showed significantly superior hardness compared to Groups I and II, indicating improved polymerization efficiency with longer exposure duration.

Table 1: Mean microhardness values for bulk fill composite under different curing protocols.

Group	Curing protocol	Mean microhardness (VHN ± SD)
Group I	Ultrafast curing – 1 s	62.80 ± 1.70
Group II	Ultrafast curing – 3 s	105.60 ± 2.69
Group III	Conventional curing – 20 s	256.48 ± 8.92

Table 2: Intergroup statistical comparison using the Kruskal–Wallis test .

Test	H value	p value
Kruskal Wallis test	43464.87	<0.001 (Highly significant)

Table 3 Post hoc pairwise comparisons are presented .

Comparison	p value	Interpretation
Group I vs Group II	<0.001	Highly significant

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Group I vs Group III	<0.001	Highly significant
Group II vs Group III	<0.001	Highly significant

Graph 1: Graphical representation of comparison of microhardness of bulk fill composite resin at different curing cycles.

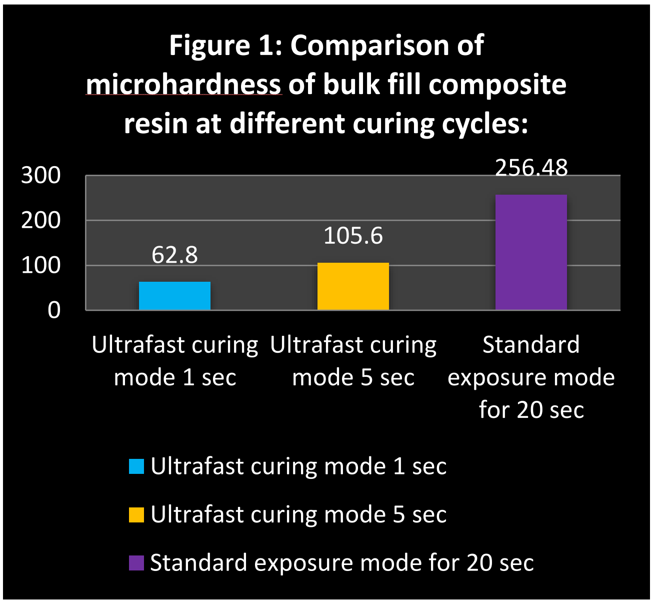

Figure 1: Comparison of microhardness of bulk fill composite resin at different curing cycles:

5. **Discussion**

The present study assessed the influence of ultrafast curing exposure durations on the surface hardness of bulk-fill composite resin. Surface hardness is a critical mechanical property that indicates the degree of conversion and the formation of the polymer network within composite materials.[9] Proper polymerization is necessary to ensure longevity, wear resistance, and long-term clinical performance of composite restorations.[1]

Bulk-fill composites were developed to simplify restorative procedures by enabling the placement of thicker increments while preserving adequate polymerization properties.[6] These materials possess increased translucency and modified filler systems, which improve light penetration and enhance depth of cure.[8] Despite these advantages, achieving optimal polymerization depends significantly on the curing protocol employed.[13]

In the present study, conventional curing for 20 seconds produced significantly higher microhardness values compared with ultrafast curing durations of 1 and 3 seconds. This finding indicates that longer exposure durations allow sufficient energy delivery for adequate polymer cross-linking.[10] The reduced hardness observed in ultrafast curing groups suggests incomplete polymerization due to insufficient energy exposure.[11]

High-intensity light sources can deliver greater radiant energy within shorter durations; however, extremely short exposure times may not provide adequate time for photoinitiator activation and polymer chain formation.[12] Incomplete polymerization may lead to inferior mechanical properties, increased monomer release, and decreased restoration longevity.[11] These results emphasize the need to maintain an appropriate balance between curing duration and light intensity to obtain optimal polymerization outcomes.[13]

The composition of bulk-fill composites also plays a crucial role in determining curing efficiency.[10] Factors such as filler size, filler loading, and resin matrix composition influence light attenuation and polymerization depth.[5] Increased filler content may scatter light, reducing penetration into deeper layers of the material.[8] Therefore, adequate curing duration is essential to ensure uniform polymerization throughout the specimen thickness.[14]

Previous investigations have reported similar findings, demonstrating that shorter curing durations may result in reduced microhardness and degree of conversion.[6,7] Studies evaluating ultrafast curing modes have emphasized the need for sufficient radiant exposure to maintain mechanical integrity of composite restorations.[13] Furthermore, inadequate polymerization may lead to marginal leakage, postoperative sensitivity, and eventual failure of the restoration over time.[11]

The clinical relevance of the present findings lies in the increasing adoption of ultrafast curing technologies in restorative dentistry.[12] While these systems offer advantages such as reduced chairside time and improved workflow efficiency, clinicians must exercise caution when selecting curing parameters.[13] Ensuring adequate curing duration is essential to maintain restoration strength and longevity.[10]

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Furthermore, the findings of this study suggest that although ultrafast curing may be beneficial in specific clinical situations, conventional curing protocols remain more reliable for achieving optimal mechanical properties.[15] Future investigations should aim to assess the long-term performance of restorations polymerized using ultrafast curing protocols under simulated oral conditions.[14]

6.Conclusion

Within the limitations of this in-vitro study, conventional curing for 20 seconds resulted in significantly greater surface microhardness than ultrafast curing durations of 1 and 3 seconds. Sufficient curing time continues to be essential for achieving optimal polymerization and desirable mechanical properties of bulk-fill composite restorations.

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