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Effect Of Ultrasonic Agitation And Preheating On Marginal Adaptation Of Bulk Fill Composites.An In Vitro OCT (Optical Coherence Tomography) Study

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Abstract

Aim and Objective: The aim of our study was to explore the impact of ultrasonic agitation and preheating on the marginal adaptation of bulk fill composites. Utilizing OCT for in-depth analysis in vitro, our results revealed that ultrasonic activation achieved the most superior marginal adaptation, followed by moderately positive outcomes with the preheating technique. The control group, assumed to be untreated or conventionally treated, exhibited comparatively inferior marginal adaptation. Objectives included comparing ultrasonic activation, preheating, and the control group. Ultrasonic activation had the most significant positive impact, followed by preheating, while the untreated control group showed the least favorable results. The study offers valuable insights for enhancing the performance of bulk fill composites in dental applications.

Method : The study involved 40 human premolar teeth acquired for orthodontic purposes, subjected to a rigorous disinfection process and stored in saline solution. Exclusion criteria ensured standardized specimens with specific cavity characteristics. Class II cavities, 3mm wide and 1.5mm deep, featuring butt joint margins, were created on mesial surfaces, 1mm apically to the CEJ. Teeth were horizontally sectioned below the CEJ for OCT imaging using the Cirrus HD-OCT system, allowing detailed analysis of the experimental procedures.

Statistical Analysis: Data were analyzed with SPSS 21. One-way ANOVA was used to compare the mean marginal gaps at enamel and dentin margins between the study groups. Post hoc Tukey tests were used for two-by-two comparisons of the groups. Paired t-test was used to compare the gaps at enamel margins with those at dentin margins in each group. Statistical significance was set at $P<0.05$.

Results :Marginal Gap Variation in Ultrasonic activation: Lowest mean marginal gaps.Preheating: Intermediate mean marginal gaps,Control group: Highest mean marginal gaps.Paired t-tests consistently demonstrated significantly lower mean marginal gaps at enamel walls compared to dentin walls ($P<0.0001$).

Conclusion : To summarize, our study revealed that ultrasonic activation significantly enhanced the marginal adaptation of bulk fill composites, followed by preheating, with the untreated control group showing the least favorable results.

Keywords: Optical Coherence Tomography, Bulk fill composites, Marginal adaption.

Introduction

The utilization of posterior composite resin restorations has markedly increased due to their appealing aesthetics, conservative nature, and advancements in their physical and mechanical characteristics. However, a prevalent issue associated with these restorations is inadequate adaptation, leading to the creation of spaces between the dental restoration material and the tooth structure gives rise to several issues, including the seepage of oral fluids, heightened postoperative sensitivity, and the potential for recurring cavities .[1]

The efficacy and lasting quality of composite resin restorations in clinical scenarios heavily depend on specific material characteristics. These encompass factors like polymerization shrinkage, viscosity, packing ability, and bonding proficiency. Effectively addressing and optimizing these material traits is pivotal for enhancing the long-term success and performance of posterior composite resin restorations. Augmenting the filler content in commonly used high-viscosity composite resins improves their physical and mechanical properties, along with enhancing their packing capabilities. However, this enhancement poses a challenge in adequately adapting the restorative material to the cavity walls, often leading to the development of interfacial gaps and an increased risk of microleakage.[2] Nowadays, a range of resin-based composite materials is accessible for direct restorative procedures. Among the most prevalent are micro- and nano-hybrid composites. However, hybrid composites, particularly those with a high filler concentration, might induce stress and struggle to conform adequately to the internal cavity, resulting in residual gaps.

The incremental technique was introduced to counter these challenges. Nevertheless, this method demands precision and is time-intensive. To address these adaptation issues encountered with composite resins, a recommended technique involves employing flow able composite resins as a liner before introducing a composite resin with higher filler content into the cavity. This approach aims to enhance adaptation by utilizing the Utilize flowable composite resin first to ensure optimal adaptation to the cavity walls before applying the higher viscosity composite for improved conformity.[3]

Raising the filler content in commonly used high-viscosity composite resins enhances their physical and mechanical properties, along with better packing capabilities. However, this intensification poses a challenge when it comes to effectively adapting the restorative material to the cavity walls. This often results in the formation of interfacial gaps and an upsurge in microleakage.

To address these adaptation issues encountered with composite resins, a recommended technique involves employing flowable composite resins as a liner before introducing a composite resin with higher filler content into the cavity. This approach aims to enhance adaptation by utilizing the flowable composite resin to achieve better conformity to the cavity walls before applying the higher viscosity composite. [4-5]

Materials Methods And Specimen Preparation

Armamentarium

Tetric N-ceram Bulk fill/IVA Ivoclar Vivadent Self etch ,Composite, Tofflemier®GDC Diamond burs,Airrotor ®NSK,Contra-angle hand piece ® (NSK, Japan), Ultrasonic scaler®Supreme,OCT® spectral D and Composite warmer.

This study involved a deliberate acquisition of 40 human premolar teeth specifically intended for orthodontic purposes. Each tooth underwent a stringent disinfection process involving immersion in a 70/30 ethanol solution for a duration of 10 minutes. Following disinfection, the teeth were meticulously stored in a normal saline solution, maintaining a constant temperature of 4 degrees Celsius to preserve their integrity and condition for subsequent analysis.

To ensure a consistent and standardized set of specimens, a comprehensive set of exclusion criteria was applied. These criteria were stringent, excluding teeth with various conditions such as root fractures, open apices, curved canals, multiple roots, any sign of caries or restorations, substantial anatomical irregularities, and even teeth exhibiting calcified canals.

The cavities utilized for the experimental procedures were deliberately standardized as Class II cavities, designed in a box-like shape. These cavities were precisely crafted, measuring 3 mm in width from the buccal to the lingual aspect and reaching a depth of

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1.5 mm axially. Notably, these cavities featured butt joint margins, a specific design choice, and were meticulously located on the mesial surfaces of the teeth for consistent analysis. Furthermore, the gingival margins of these cavities were meticulously positioned 1 mm apically to the CEJ (Cemento-Enamel Junction) for accurate placement.

During the experimental phase, the tooth specimens were horizontally sectioned below the CEJ to facilitate their orientation on OCT (Optical Coherence Tomography). Each tooth was placed on a dedicated chin rest mounted on a custom-designed stand to ensure stability during imaging procedures. Imaging was conducted using the Cirrus HD-OCT system (Carl Zeiss Meditec, Dublin, CA, USA), providing high-resolution scans for detailed analysis and assessment.

Results

Our study statistical analysis of restoration margin gaps at enamel and dentin walls with composite resins under different thermal conditions revealed significant differences among the three study groups. The one-way ANOVA indicated considerable variations in gap formation between the groups at both the enamel wall–composite and dentinal wall–composite interfaces ($P<0.0001$). Further comparisons using post hoc Tukey tests showed that both composite resins exhibited lower mean marginal gaps at enamel and dentin margins when the preheating technique was employed. Paired t-tests across all study groups consistently demonstrated that the mean marginal gaps at enamel walls were significantly less than those at dentin walls ($P<0.0001$).our experimental setup included three groups: one where ultrasonic activation was performed on the composite for 60 seconds before filling it into the cavity and curing it, another group where the composite was preheated and then cured in the cavity, and a control group. Using Optical Coherence Tomography (OCT) to analyze marginal adaptation, we found that ultrasonic activation resulted in superior marginal adaptation, followed by the preheating technique, and then the control group.

Disscussion

Bulk-fill composites have garnered attention for their ability to facilitate greater light penetration, enabling the curing of larger depths, typically ranging from 4 to 5 mm.[6,7] This feature saves considerable clinical placement time, primarily achieved by modifications in the initiator within these composites. The enhanced light penetration allows for more efficient curing of thicker layers, streamlining the restorative process and offering time-saving advantages during dental procedures. The use of flowable composite resins as a liner before placing a higher filler content composite resin in the cavity is a common practice. However, this approach heightens the procedural technique sensitivity and reduces the durability of the restoration due to the lower filler content of the flowable composite resin .Darabi F[8]reported superior adaptation and reduced marginal gaps when employing the preheating technique. Their studies highlighted that preheating the composite material led to improved adaptation at restoration margins and resulted in smaller marginal gaps compared to other methods or control groups**.** According to Alizade Oskoee et al.the application of the preheating technique resulted in a reduction of gap formation specifically at the gingival margins of Class V cavities Their study highlighted that employing the preheating method led to a decrease in gaps specifically at these margins, showcasing its potential for enhancing marginal integrity in this specific type of cavity. Their study indicated that this delay resulted in a minimal increase in pulpal temperature, estimated to be approximately 2°C. According to their findings, this slight rise in temperature was well within the tolerable range for the pulp, suggesting that this approach could be safely implemented without significant adverse effects on pulpal health.

The ultrasonic scaler was employed to generate heat based on the idea that the preheating process could enhance the mobility of monomer molecules within the composite material. This increased mobility was believed to potentially improve the degree of conversion (DC) of the material while simultaneously reducing void volume. The advantage of this technique was its feasibility for chairside application, making it a convenient method to facilitate these material enhancements in real-time during dental procedures. In our study, we employed three distinct approaches: Ultrasonic activation involved subjecting the composite to ultrasonic energy for 60 seconds before filling it into the cavity. Subsequently, it underwent the curing process.The preheating technique involved warming the composite in a

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warmer before placement into the cavity, followed by curing and the control group did not involve any specific treatment beyond standard procedures. Using Optical Coherence Tomography (OCT), we meticulously analyzed the marginal adaptation of all three groups. The findings revealed that ultrasonic activation resulted in superior marginal adaptation compared to both the preheating technique and the control group. Following ultrasonic activation, the preheating method exhibited moderately good marginal adaptation, while the control group showed comparatively lesser adaptation at the restoration margins. The findings showcasing superior marginal adaptation with ultrasonic activation offer significant practical implications in clinical dentistry. Implementing ultrasonic activation techniques could potentially enhance the quality of composite restorations by improving their adaptation at restoration margins. Dentists might consider integrating ultrasonic devices into their procedural protocols to achieve better outcomes in composite restorations.

However, further research could delve deeper into optimizing the parameters of ultrasonic activation, such as duration and intensity, to refine its efficacy in enhancing marginal adaptation. Additionally, investigating the long-term clinical performance and durability of restorations prepared with ultrasonic activation compared to conventional methods would provide valuable insights into its practical benefits.

Conclusion

This study's findings on ultrasonic activation in composite restorations are quite promising for dental practices. The emphasis on superior marginal adaptation highlights the potential for this technique to significantly improve the precision and fit of dental restorations. Marginal adaptation refers to how well a dental restoration fits against the tooth structure at its edges. Poor marginal adaptation can lead to issues like recurrent decay, bacterial infiltration, and compromised restoration integrity. Therefore, achieving superior marginal adaptation is critical for the long-term success of dental restorations. Ultrasonic activation involves using ultrasonic energy to enhance the placement and adaptation of composite materials. This method offers several advantages over conventional techniques. For instance, the ultrasonic vibrations help improve the flow and adaptation of the composite material into the preparation, leading to better marginal sealing and less micro-gap formation. By highlighting the superiority of ultrasonic activation in achieving this crucial aspect of dental restorations, the study suggests that integrating this technique into dental practices could significantly enhance the overall quality and longevity of restorations. Further research and refinement of ultrasonic activation methods could lead to even more precise and consistent results. This might involve exploring different frequencies or power settings to optimize the technique for various clinical scenarios. Additionally, investigating its compatibility with different composite materials and evaluating its long-term performance in diverse patient populations could provide valuable insights. Ultimately, the potential benefits extend to improved patient care and treatment outcomes. Enhanced marginal adaptation translates to better restoration durability, reduced chances of secondary decay, and potentially longer-lasting dental work. Patients would experience improved oral health and reduced need for frequent repairs or replacements of restorations, leading to overall satisfaction with their dental treatment.

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Figure Legends

Figure 1: Extracted premolars,

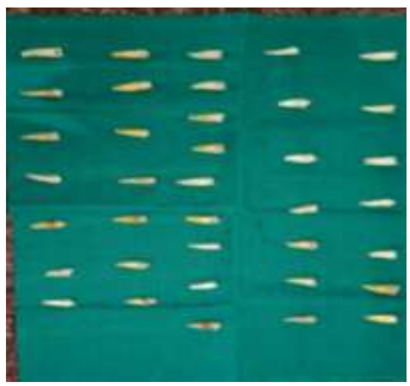

Figure 2;Class II cavities, designed in a box-like shape

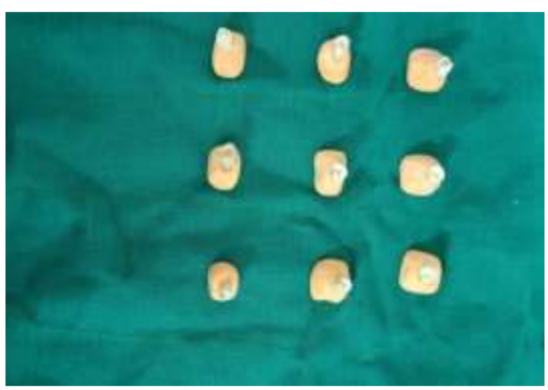

Figure 3: Contra-angle hand piece

Figure 4: Diamond burs

Figure 5: Tefflon Coated Non Stick Composite Inst

Figure 6 Tetric N-ceram Bulk fill/IVA Ivoclar Vivadent Self etch Composite

Figure 7:Composite warmer

Figure : 8 Optical Coherence Tomography

Figure 9 Ultrasonic scalar

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