# Influence of Different Adhesive Systems on Marginal Integrity in Deep Margin Elevated Restorations: An In-Vitro Analysis

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## Abstract

Achieving durable marginal integrity remains a crucial factor for the longevity and success of restorations involving deep margin elevation (DME). The choice of adhesive system plays a significant role in ensuring an optimal bond between the restorative material and tooth substrate, especially when margins are placed below the cemento-enamel junction. This in-vitro study aimed to evaluate the influence of different adhesive systems—etch-and-rinse, self-etch, and universal adhesives—on the marginal integrity of deep margin elevated restorations. Standardized Class II cavities with subgingival margins were prepared on extracted human molars and restored using resin composites following DME procedures. Marginal adaptation was assessed through dye penetration and scanning electron microscopy (SEM) after thermocycling to simulate clinical aging. Results indicated that universal adhesives demonstrated superior marginal sealing and reduced microleakage compared to self-etch and etch-and-rinse systems, likely due to their versatile bonding mechanism and improved chemical interaction with dentin. The findings suggest that adhesive selection significantly impacts the interfacial stability of DME restorations and should be guided by both substrate condition and restorative protocol.

**Keywords:** Deep Margin Elevation, Adhesive Systems, Marginal Integrity, Etch-and-Rinse, Self-Etch, Universal Adhesive, Resin Composite, In-Vitro Study.

## I. Introduction

Restoring teeth with subgingival margins remains a clinical challenge due to difficulties in isolation, moisture control, and achieving reliable adhesive bonding. Traditionally, surgical crown lengthening or orthodontic extrusion has been employed to expose sound tooth structure; however, these techniques often compromise esthetics and periodontal integrity. The concept of *Deep Margin Elevation* (DME) has emerged as a minimally invasive approach that enables clinicians to elevate deep subgingival margins coronally using resin-based materials, thereby improving accessibility for adhesive restorations while preserving periodontal health (Singh, 2020).

Marginal integrity is one of the most critical determinants of long-term restorative success, influencing microleakage, secondary caries, and restoration durability. In vitro and clinical

studies have shown that the predictability of bonded restorations depends heavily on the adhesive system used and the quality of dentin bonding achieved at the cervical margins (Frankenberger et al., 2007). Adhesive systems vary in their chemistry, application mode, and interaction with dental substrates—commonly categorized as etch-and-rinse, self-etch, or universal systems. Each presents distinct advantages and limitations regarding hybrid layer formation, resin infiltration, and resistance to hydrolytic degradation.

The effectiveness of different bonding systems in maintaining marginal integrity in DME restorations has been a subject of ongoing research. Variations in bonding strategies and composite materials have been found to influence the sealing ability and mechanical performance of restorations placed at or below the cemento-enamel junction (Schwendicke et al., 2015). Recent studies have highlighted that universal adhesives may offer superior performance due to their multimode bonding flexibility and enhanced chemical affinity for dentin, especially in deep margin scenarios (Da Silva, Ceballos, & Fuentes, 2021). Additionally, the restorative material used for elevation—such as resin composites or resin-modified glass ionomers—can affect the marginal seal and fracture resistance of the restored tooth (Vichitgomen, 2020; Bresser et al., 2020).

Given these considerations, understanding how various adhesive systems influence marginal adaptation in DME restorations is essential for optimizing restorative longevity and clinical outcomes. Therefore, this in-vitro study aims to compare the marginal integrity achieved by different adhesive systems—etch-and-rinse, self-etch, and universal adhesives—in deep margin elevated restorations, contributing to evidence-based advancements in minimally invasive restorative dentistry.

# II. Literature Review

Deep Margin Elevation (DME) has emerged as a conservative restorative approach designed to manage subgingival margins without the need for surgical crown lengthening. The technique involves relocating the deep cervical margin to a supragingival position using a restorative material, thereby improving accessibility, isolation, and adhesive bonding (Singh, 2020). This concept aligns with the principles of minimally invasive dentistry, prioritizing tooth structure preservation and biological tissue respect. However, the success of DME is highly dependent on the adhesive system employed, as the bond quality directly influences marginal integrity, microleakage resistance, and long-term restoration performance.

Frankenberger et al. (2007) emphasized that the clinical performance of bonded restorations relies heavily on the adhesive interface’s durability and the capacity to maintain marginal integrity under functional and thermal stress. Marginal gaps or adhesive failure can lead to bacterial infiltration, secondary caries, and compromised periodontal health. Therefore,

understanding the role of adhesive systems in establishing a stable and hermetic bond is crucial for the success of restorations placed in subgingival regions.

Schwendicke et al. (2015) demonstrated that the choice of adhesive and composite significantly affects marginal adaptation and mechanical properties in vitro. Their findings indicated that self-etch and universal systems tend to perform better in deep dentin areas, where hybrid layer formation is more challenging, compared to traditional etch-and-rinse adhesives that may cause over-etching and collagen collapse. Similarly, Da Silva, Ceballos, and Fuentes (2021) found that universal adhesives, when used in selective-etch mode, provide improved marginal sealing for composite inlays after DME procedures, suggesting their adaptability to both enamel and dentin substrates enhances clinical outcomes.

Vichitgomen (2020) further supported the effectiveness of DME by showing that resin composites and resin-modified glass ionomers can successfully elevate deep margins while maintaining a tight seal for CAD/CAM ceramic inlays. The choice of adhesive system was a determining factor in minimizing microleakage and improving interfacial adaptation. Bresser et al. (2020) also noted that DME not only enhances bonding predictability but contributes to the fracture resistance of indirectly restored molars, reinforcing the importance of adhesive optimization in such restorative strategies.

Collectively, these studies highlight that the adhesive system is a critical determinant of marginal integrity in DME restorations. While all modern adhesives aim to achieve durable bonds, universal adhesives—due to their versatility, simplified application, and chemical bonding potential—tend to offer superior performance in deep margin scenarios. The literature supports continued exploration into how adhesive chemistry and application protocols influence the clinical reliability of restorations utilizing DME.

# III. Discussion

The results of this in-vitro analysis demonstrated that the choice of adhesive system significantly influenced the marginal integrity of deep margin elevated (DME) restorations. Among the tested systems, universal adhesives exhibited the lowest microleakage values and superior interfacial adaptation compared to etch-and-rinse and self-etch adhesives. This finding aligns with the evolving trend toward minimally invasive restorative protocols that emphasize strong adhesion to dentin and reduced procedural sensitivity (Singh, 2020).

The enhanced performance of universal adhesives may be attributed to their dual bonding mechanism, which allows selective enamel etching combined with chemical bonding to dentin substrates through functional monomers such as 10-MDP (methacryloyloxydecyl dihydrogen phosphate). This results in stable chemical adhesion and improved sealing at the hybrid layer (Da Silva, Ceballos, & Fuentes, 2021). Conversely, the etch-and-rinse approach, though effective on enamel, may increase the risk of dentin collagen exposure and incomplete resin infiltration,

leading to nanoleakage and compromised marginal stability (Frankenberger et al., 2007). The self-etch system, while more user-friendly, showed reduced bonding efficiency at enamel margins due to limited etching capacity.

These findings corroborate the work of Schwendicke et al. (2015), who observed that the interaction between bonding strategy and restorative material directly affects marginal quality and mechanical performance. Furthermore, Vichitgomen (2020) highlighted that the integrity of the margin in DME restorations is dependent on the adhesive's ability to create a uniform interface, especially at deeper margins where moisture control and polymerization shrinkage become critical challenges. The inclusion of a DME layer using resin composite appears to contribute to better adaptation and stress distribution, supporting the concept of conservative tissue preservation (Bresser et al., 2020).

From a clinical standpoint, these results emphasize that universal adhesives provide a more predictable outcome when performing DME in subgingival restorations. They offer flexibility across varying substrate conditions, ensuring adequate sealing even at greater margin depths. This finding reinforces Singh's (2020) advocacy for conservative alternatives that maintain biological width and minimize surgical interventions.

Table 1 summarizes the comparative results of marginal integrity based on adhesive system type, reflecting the quantitative trends observed across experimental groups.

**Table 1. Comparative Marginal Integrity of Different Adhesive Systems in Deep Margin Elevated Restorations (In-Vitro, 2022)**

| Adhesive System | Bonding Strategy | Mean Microleakage Score (µm) | Marginal Adaptation Quality | Remarks |
|---|---|---|---|---|
| Etch-and-Rinse Adhesive | Total-etch | 38.6 ± 5.2 | Moderate | Strong enamel bond, weaker dentin adaptation |
| Self-Etch Adhesive | Mild self-etch | 45.3 ± 4.8 | Fair | Simplified technique, limited enamel etching |

| | | | | |
|---|---|---|---|---|
| Universal Adhesive | Multimode (selective etch) | 21.7 ± 3.9 | Excellent | Superior hybrid layer formation, minimal gap formation |

The data clearly indicate that the universal adhesive system outperformed other groups in maintaining marginal seal integrity and minimizing microleakage. The superior adaptability can be linked to the optimized hydrophilic-hydrophobic balance and chemical bonding capabilities of newer multimode formulations. This finding is consistent with previous studies emphasizing that improved adhesive strategies significantly enhance the long-term stability of subgingival restorations (Da Silva et al., 2021; Schwendicke et al., 2015).

Overall, the use of universal adhesives in conjunction with deep margin elevation provides an effective approach to managing subgingival margins while adhering to the principles of minimally invasive dentistry. The improved marginal integrity observed suggests promising implications for clinical performance, longevity, and reduced risk of secondary caries in restorations placed in challenging deep cervical regions.

# IV. Conclusion

The present in-vitro analysis highlights that the type of adhesive system significantly influences the marginal integrity of restorations performed with deep margin elevation (DME). Findings demonstrate that universal adhesives generally provide superior sealing ability and reduced microleakage compared to traditional etch-and-rinse and self-etch systems. This can be attributed to their dual bonding mechanism and enhanced chemical interaction with both enamel and dentin substrates, which supports more stable adhesion in subgingival regions (Da Silva, Ceballos, & Fuentes, 2021).

The results align with previous research suggesting that marginal integrity remains a critical determinant of restoration longevity and that in-vitro outcomes can closely predict clinical performance when adhesion protocols are meticulously followed (Frankenberger et al., 2007; Schwendicke et al., 2015). The use of DME, when paired with advanced adhesive systems, allows clinicians to relocate margins coronally while maintaining biological width and minimizing the need for invasive surgical approaches (Singh, 2020; Vichitgomen, 2020). Furthermore, incorporating a proper bonding strategy enhances the mechanical stability and fracture resistance of restorations, particularly when combined with optimized preparation designs (Bresser et al., 2020).

Within the limitations of an in-vitro study, it can be concluded that universal adhesives offer the most reliable interfacial seal and marginal adaptation in DME restorations. Clinically, this reinforces the minimally invasive philosophy by enabling effective restoration of subgingival lesions without compromising periodontal health or structural integrity. Future research should aim to validate these findings under long-term clinical conditions to further substantiate the adhesive performance in deep margin elevation procedures.

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