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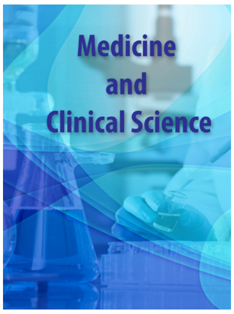

Evaluation of Marginal Adaptation of Direct and Semi-direct Resin Restorations Using Stereomicroscopy: An In Vitro Study

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Abstract

Objective: *This study aimed to evaluate the marginal adaptation at the tooth-restoration interface of Class II box-type cavities restored using direct and semi-direct techniques with two different types of composite materials.*

Materials and Methods: *Class II box-shaped cavities were prepared in 28 extracted maxillary premolar teeth, which were randomly divided into two experimental groups, each consisting of 14 samples.*

- ***Group I:*** *Direct composite restorations*
- ***Group II:*** *Semi-direct composite restorations*

Each group was further subdivided into two subgroups (A and B), comprising 7 samples each based on the type of composite material employed, specifically Nova Compo C and Estelite Sigma Quick, along with their corresponding adhesive systems.

Following restoration, all samples were longitudinally sectioned in a mesiodistal direction to create two halves (buccal and lingual). Marginal adaptation was assessed by measuring gaps at the tooth-restoration interface under a 40X stereomicroscope, supplemented by a 10X digital camera and specialized software. The gingival floor was analyzed at four distinct points on the buccal and lingual halves, with gap measurements taken at each site. The collected data were tabulated, and statistical significance was determined using the T-test ($p < 0.05$).

Results: *The findings indicated no statistically significant differences in marginal adaptation along the gingival floor between the direct and semi-direct restorative techniques. However, among the composite materials examined, Estelite Sigma Quick demonstrated superior adaptability compared to Nova Compo C.*

Conclusion: *This study concluded no significant difference in marginal adaptation between the direct and semi-direct restoration techniques along the gingival floor. However, the type of composite resin utilized significantly affected marginal adaptation, with Estelite Sigma Quick exhibiting reduced gap formation compared to Nova Compo C.*

Introduction

Composite resins have gained considerable popularity in dentistry due to their ability to closely mimic natural tooth structures. Their aesthetic appeal is enhanced by a broad spectrum of colors and translucency [1], coupled with favorable mechanical properties, including fracture toughness, flexural strength, and tensile strength [2]. Despite advancements in restorative materials and techniques over recent decades, insufficient marginal adaptation can result in oral fluid infiltration at the restorative material-tooth interface. This can lead to postoperative complications such as tooth sensitivity, marginal discoloration, and recurrent caries, which collectively diminish the longevity of composite restorations and can ultimately contribute to clinical failure [3].

The semi-direct technique, a simplified chairside method introduced and refined in the 1980s [4,5], allows dentists to fabricate restorations during a single appointment using either intraoral or extraoral procedures [6]. In the intraoral approach, composite increments are directly placed into the prepared cavity of the isolated tooth, followed by polymerization in the mouth. Once polymerized, the restoration is removed, finished, and polished extraorally before being luted back into the cavity. Conversely, in the extraoral semi-direct technique, a flexible die facilitates the chairside

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fabrication of the restoration from composite material, which is then cured outside the oral cavity and subsequently luted into the cavity using resin cement, thus circumventing the need for laboratory fabrication [7,8].

Stereomicroscopy has proven to be an effective tool for evaluating the marginal adaptation of dental restorations.

Aim of This Study (General Objective)

The primary objective of this study is to evaluate and compare the marginal adaptation at the tooth-restoration interface of Class II box-type cavities restored using both direct and semi-direct techniques with two types of composite resins, employing their corresponding universal adhesive systems under stereomicroscopy. The composite materials assessed will include:

1. **Nova Compo C**
2. **Estelite Sigma Quick.**

Materials & Methods

The study utilized a sample size of N=28 extracted, caries-free human permanent maxillary premolars. The teeth were ultrasonically cleaned with a scaler to remove any debris and subsequently stored in distilled water until the experimental stage [9]. For cavity preparation, the teeth were fixed in a phantom dental base using self-cure acrylic resin (Prothyl Press Evo, Zermach, Italy) and wax.

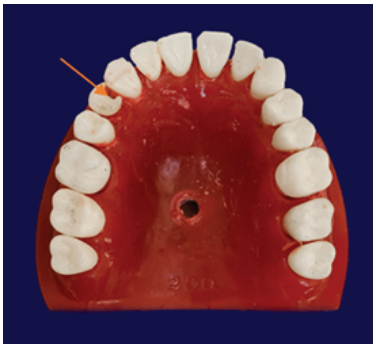

***Figure 1**. Samples embedded in a phantom dental base*

Box-only Class II cavities were precisely prepared by a single researcher using a diamond bur and a high-speed handpiece with air-water cooling. All cavities were standard dimensions on the mesial surfaces of the premolars, measuring 4 mm in buccolingual width, 2 mm in mesiodistal depth, and with the gingival margin positioned 1 mm above the cementoenamel junction (CEJ) [10].

The samples were divided into two experimental groups: Group I for direct composite restorations and Group II for semi-direct composite restorations, each consisting of 14 samples. Each group was further subdivided into two subgroups (A and B), each with 7 samples.

Direct Composite Restorations (DR)

After stabilizing each tooth in the phantom dental base, a matrix band and wedge were placed. The prepared cavities were total-etched with 37% phosphoric acid for 15 seconds, rinsed with water for 10 seconds, and air-dried for 2 seconds [10]. The bonding agent was applied for 20 seconds, following the manufacturer's directions, then air-dried gently, and light-cured for 10 seconds using an LED light-curing unit (Woodpecker) with an output of 2300 mW/cm². Composite material was then

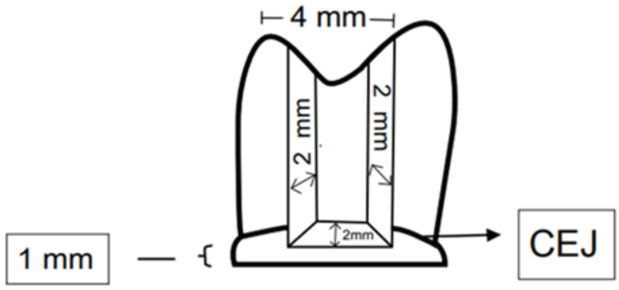

***Figure 2**. Measurements of box-only type cavity preparation*

Prepared teeth samples (n= 28)	Group I (n= 14) Direct composite restorations (DR)	Group A (n= 7) Nova Compo B plus bond Nova Compo C composite
		Group B (n= 7) Tokuyama Universal Bond Estelite Sigma Quick
	Group II (n= 14) Semi- direct composite restorations (SDR)	Group A (n= 7) Nova Compo B plus bond Nova Compo C composite
		Group B (n= 7) Tokuyama Universal Bond Estelite Sigma Quick

***Figure 3**. Prepared samples restored by direct and semi-direct restorations*

applied using the incremental technique (2 mm thick); each increment was light-cured for 20 seconds from a distance of 2 mm.

Semi-Direct Composite Restorations (SDR)

For the semi-direct method, each tooth was stabilized in the phantom dental base, and impressions of the prepared teeth and adjacent structures were made using a perforated tray with fast-setting alginate (Hydrogum 5, Zhermack, Germany). The impression was filled with a model silicone die (Die Silicone, Voco, Germany). Once the flexible die set, the composite restoration was fabricated directly on the model for subgroup A. Composite (Nova Compo C) was applied in 2 mm-thick increments over the flexible model, light-cured using an iLED Curing Light Max (Woodpecker, China) at 2300 mW/cm² for 20 seconds, by the manufacturer's guidelines. After removal from the model, the semi-direct restoration was light-cured on both internal and external faces for 40 seconds [11]. The final restoration was then seated into the prepared cavity to ensure a proper fit, with the occlusal and proximal surfaces finished and polished using an FG composite kit.

To enhance the adhesion of the resin cement, both the inner surface of the restoration and the tooth preparation were sandblasted with a sandblaster (Dento-Prep, Ronvig, Denmark) for 10 seconds from a distance of 5 centimeters [8]. The preparations and inner surfaces were then etched with 37% phosphoric acid for 15 seconds, rinsed with water for 10 seconds, and air-dried for 2 seconds [10]. Bond was

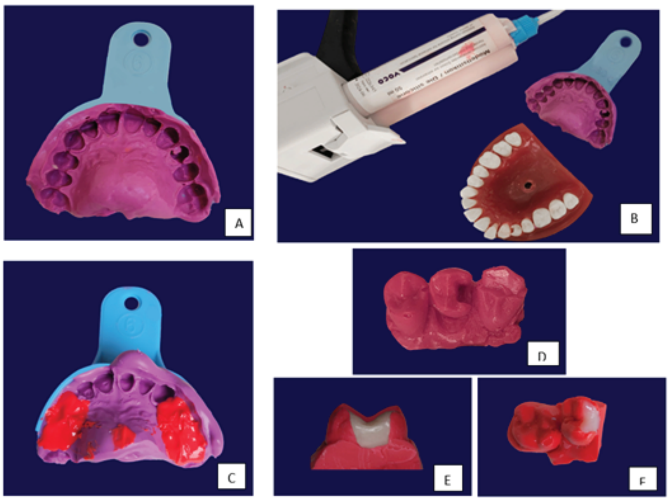

Figure 4. *Steps of Semi-direct restoration. A: An Impression for die fabrication. B: VOCO die silicone used. C; Silicone being applied to make an esthetic die. D; Flexible die showing tooth preparation. E; Side view of restoration. F; Occlusal view of restoration*

applied to both the inner surface of the restoration and the tooth preparation, followed by an air blast and left uncured. Finally, resin cement was applied to the restoration before seating it into the preparation. Any excess cement was removed, and the occlusal, buccal, and lingual surfaces were light-cured for 40 seconds [8].

After restoration, all samples were sectioned longitudinally in the mesiodistal direction through the center of the restorations to yield two halves (buccal and lingual), allowing for examination of the tooth-restoration interface.

Figure 5. *Sectioning of the tooth longitudinally in a mesiodistal direction*

The samples were then examined under a stereomicroscope (KSW4000, Krusse Co., Germany) at a right angle to the field of view of the sectioned segment with a magnification factor of 40X. A specialized digital camera (ToupTek U3CCD) (dce-pw35 camera) (ToupTek Photonics Co., China) was employed with a magnification of 10X, achieving a combined magnification of 400X (40X × 10). The tooth-restoration interface along the gingival floor was evaluated at four distinct points on the buccal and lingual halves, with a total distance of 2000 microns, ensuring a 500-micron distance between each measurement point.

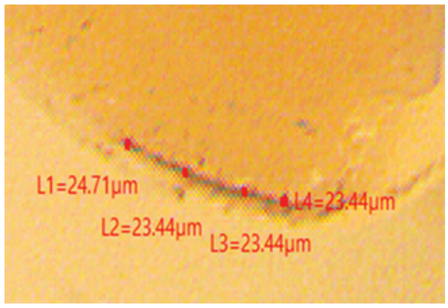

Figure 6. *An example of a gingival floor as seen under stereomicroscope 400X. An image of the software (Image View, Version; x64) associated with the digital camera for measurement of the gingival floor. During measurement, the red line indicates the gap measured in µm, with a distance of 500 microns between each point for consistent measurements.*

Data Analysis

Data were analyzed using SPSS. Assumptions of normal distribution were verified. Numerical data were reported as mean and standard deviation. The independent T-test was applied to detect significant differences ($p < 0.05$) between the means of the marginal adaptation measurements of different parameters. One-way ANOVA was utilized to identify and localize the sources of significant differences in the observed gaps at various points.

Results

This results section presents a comprehensive analysis of the gaps produced by direct and semi-direct techniques for the gingival floor, utilizing Nova Compo C and Estellite Sigma Quick composites. Through statistical comparisons, including mean gap measurements and T-tests, the findings highlight differences in gap sizes and variability between the two techniques. Specifically, the semi-direct techniques generally yielded larger mean gaps with greater variability, as reflected in both sets of composite materials. The use of T-tests further elucidated the statistical significance of these differences, providing valuable insights into the clinical implications of technique selection for dental restorations.

Table 4.1. compares the gaps in direct and semi-direct techniques for the gingival floor using Nova Compo C composite. For the direct technique (Group I), the mean gap was found to be 13.65 µm with a standard deviation of 3.67 µm. In contrast, the semi-direct technique (Group II) exhibited a larger mean gap of 14.37 µm and a higher standard deviation of 5.97 µm. This indicates that the semi-direct technique not only has a greater average gap but also demonstrates more variability in its measurements compared to the direct technique.

Table 4.1. *The difference between the gaps of direct and semi-direct techniques of the gingival floor using Nova Compo C composite in micrometer (group I and II, subgroup A).*

Technique / Surface	Direct		Semi-direct	
	(Group I - Subgroup A)		(Group II- Subgroup A)	
	Mean	Std. Deviation	Mean	Std. Deviation
Gingival floor	13.65	3.67	14.37	5.97

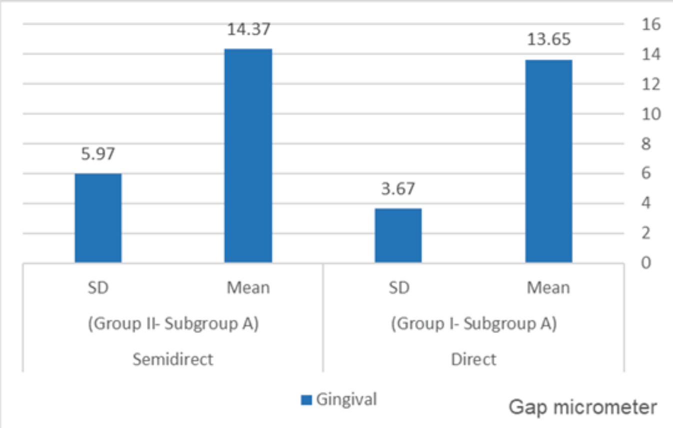

Chart 4.1. *Comparison Summary of Means and Standard Deviations of Direct and Semi-direct Techniques Using Nova Compo C Composite*

Chart 4.1. illustrates the gap measurements in micrometers for the gingival floor, comparing the direct and semi-direct techniques. It shows that the semi-direct technique, represented by a mean gap of 14.37 µm and a standard deviation of 5.97 µm, has a higher average gap and greater variability compared to the direct technique, which has a mean of 13.65 µm and a standard deviation of 3.67 µm. This visual representation reinforces the findings that the semi-direct technique results in larger and more inconsistent gaps than the direct technique.

Table 4.2. T-test Comparison of Means Between Direct and Semi-direct Techniques Along the Gingival Floor

Surface (Gingival floor)	N	T-test	P-value
Direct technique	56	-0.79	0.4
Semi-direct technique	56		

Notes:

- Means the p-value < 0.05; ** means the p-value < 0.01; SD = standard deviation. The independent T-test was used.

Table 4.2. presents the results of a T-test comparing the means of direct and semi-direct techniques for the gingival floor. Both techniques had a sample size of 56, resulting in a T-value of -0.79. The P-value is reported at 0.4, which exceeds the standard significance threshold of 0.05. This indicates that there is no statistically significant difference between the mean gap measurements of the two techniques. Overall, the findings suggest that the direct and semi-direct techniques yield similar outcomes in terms of gap widths along the gingival floor.

Table 4.3. *The difference between the gaps of direct and semi-direct techniques of the axial wall and gingival floor using Estellite Sigma Quick composite in micrometer (group I and II, subgroup B).*

Technique / Surface	Direct		Semi-direct	
	(Group I - Subgroup B)		(Group II- Subgroup B)	
	Mean	Std. Deviation	Mean	Std. Deviation
Gingival	11.58	3.09	13.31	3.09

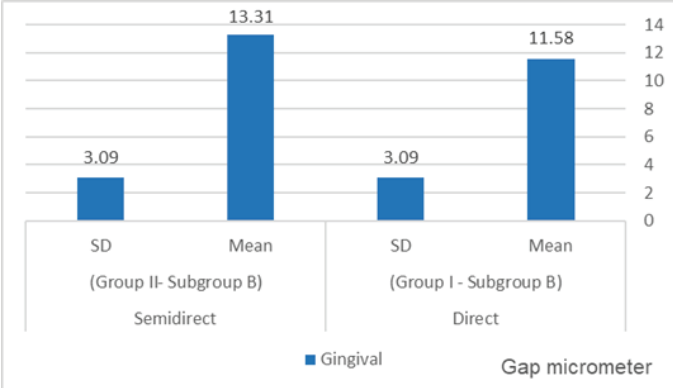

Chart 4.1. *Comparison Summary of Means and Standard Deviations of Direct and Semi-direct Techniques Using Estellite Sigma Quick Composite*

Table 4.3 and Chart 4.2 compare gaps in micrometers for the gingival floor using direct and semi-direct techniques with Estellite Sigma Quick composite. The direct technique (Group I - Subgroup B) has a mean gap of 11.58 µm with a standard deviation of 3.09 µm, while the semi-direct technique (Group II - Subgroup B) shows a higher mean gap of 13.31 µm, also with a standard deviation of 3.09 µm. This indicates that the semi-direct technique results in a larger average gap than the direct technique. However, both techniques exhibit the same level of variability in their measurements, as reflected by their identical standard deviations. These findings suggest that the semi-direct approach leads to greater gaps along the gingival floor compared to the direct method.

Table 4.4. *T-test Comparison of Means Between Direct and Semi-direct Techniques Along the Gingival Floor.*

Surface (Gingival floor)	N	T-test	P-value
Direct technique	56	-2.19	0.05
Semi-direct technique	56		

Notes:

- Means the p-value < 0.05; ** means the p-value < 0.01; SD = standard deviation. The independent T-test was used.

Table 4.4. presents the results of a T-test comparing the means of the direct and semi-direct techniques for the gingival floor, with each technique having a sample size of 56. The T-value is reported as -2.19, and the P-value is exactly 0.05, which is at the threshold for statistical significance. This indicates that there is a statistically significant difference between the mean gap measurements of the two techniques at the 0.05 level, suggesting that the semi-direct technique likely results in larger gaps compared to the direct technique along the gingival floor.

Discussion

This study aimed to evaluate the marginal adaptation of Class II box-type cavities restored using direct and semi-direct techniques with two types of resin composites, Nova Compo C and Estelite Sigma Quick. The results indicate distinct differences in the marginal adaptation at the tooth-restoration interface between the techniques and the composite materials used. Specifically, while there was no statistically significant difference in marginal adaptation between the direct and semi-direct techniques when using Nova Compo C, the semi-direct technique demonstrated larger mean gaps with greater variability when Estelite Sigma Quick was employed. These findings align with previous literature suggesting that marginal adaptation is critical in determining the longevity and effectiveness of dental restorations, as inadequate adaptation can lead to clinical issues such as microleakage, postoperative sensitivity, and secondary caries [3].

Furthermore, the T-test analysis revealed that the type of composite significantly influenced marginal adaptation. Estelite Sigma Quick exhibited better performance with reduced gap formation compared to Nova Compo C. This could potentially be attributed to the superior physical and mechanical properties of Estelite Sigma Quick, including its viscosity and bonding capabilities, which may enhance the interface sealing at the tooth restoration boundary. The consistent standard deviations across the two techniques when using Estelite Sigma Quick imply that this composite provides reliable performance in terms of adaptation, which is essential for clinicians when selecting materials for restorative procedures.

The stereomicroscopy employed in this study allowed for precise gap measurements and detailed analysis of the interfaces, reinforcing its efficacy in evaluating clinical restorations. Such methodology provides vital insights into the quality of the dental restorations and underscores the importance of proper technique and material selection in achieving optimal patient outcomes.

Conclusion

In conclusion, this study demonstrated no significant difference in marginal adaptation between direct and semi-direct techniques along the gingival floor for Class II cavities. However, the type of composite resin used plays a crucial role, with Estelite Sigma Quick exhibiting better marginal adaptation compared to Nova Compo C. These findings suggest that while the technique may not impact adaptation significantly, the choice of composite material is critical in enhancing the longevity and effectiveness of dental restorations. Future research should explore a broader range of composite materials and restorations in different clinical scenarios to further refine our understanding of these variables in restorative dentistry.

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