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Original Article

Comparison of Microleakage between Conventional and Clark's Class II Composite Restoration: An *in vitro* Dye Penetration Study

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Abstract

Introduction: Class II composite restorations commonly fail at the proximal gingival third due to inadequate polymerization and marginal adaptation. The traditional box preparation does not account for the flow and curing characteristics of composite materials. Dr. David Clark introduced a novel cavity design with "infinity margins" that improves resistance form, material flow, and light penetration. Bulk-fill composites, capable of curing in thicker layers and bonded-base techniques have also been explored to minimize polymerization shrinkage and microleakage.

Purpose: This study aimed to compare the extent of microleakage in Class II composite restorations using bonded base techniques (glass ionomer [GIC] used as base): The conventional cavity design and Clark's cavity design with the bulk-fill injection molding technique.

Materials and Methods: Twenty-four extracted human pre-molars were divided into two groups (n = 12). Group 1 followed the conventional Class II preparation and restoration with a GIC base and bulk-fill composite. Group 2 used Clark's preparation method, microabrasion, and restoration using the injection molding technique with a flowable and warmed bulk-fill composite. All specimens underwent thermocycling and were immersed in 2% methylene blue for 24 h. After sectioning, microleakage was evaluated under a stereomicroscope and scored on a scale from 0 (no leakage) to 3 (maximum leakage).

Results: Group 2 (Clark's technique) demonstrated lower microleakage, with 25% of samples showing score 0 and 41.67% score 1. No samples in this group exhibited a score 3 leakage. In contrast, Group 1 (conventional technique) exhibited higher leakage, with 58.3% showing score 2 and 41.67% score 3.

Conclusion: Clark's technique, when used with injection molding and bulk-fill composite, resulted in significantly reduced microleakage compared to the conventional method. This suggests better marginal adaptation and curing, indicating that Clark's technique may be preferable for Class II restorations. However, further studies with larger sample sizes are recommended to confirm these findings.

Key words: Clark's cavity design, Class 2 composite restoration, Dye penetration and stereomicroscope, Microleakage

INTRODUCTION

Class II composite restoration often fails in the proximal gingival third, which is attributed to the possibilities of under-polymerized sections in inaccessible areas that eventually lead to marginal deterioration, microleakage, fractures, and unesthetic margins. Dr. David Clark introduced a new form of cavity design that adapted to the properties of the composite. He advocated separate occlusal and proximal cavity preparations with infinity margins extending into the enamel.[1] His technique is said to improve the resistance form, flow of material, increase the depth of penetration of light cure source, and reduce microleakage.[1]

Bulk-fill composites were introduced to mitigate the problems of the conventional layering technique, such as

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incorporation of voids and contamination, increased time for restoration, and inadequate curing. This material can be cured at 4 mm thick layers as opposed to the traditional 2 mm layer and is said to have lower shrinkage.[2] Thus, it may show less microleakage than conventional composites and it is recommended in Clark's technique.

Several methods were employed to reduce the effects of polymerization shrinkage. One technique often applied in class 2 composite restoration is the application of a gingival seat base with flowable composite or glass ionomer cement (GIC) which acts as a "shock absorber" for the stress generated by the shrinkage.[3] Such an approach is called the bonded-base restorative technique.[4] This method involves placing an intermediate layer, typically a GIC or a low-modulus resin-based material on the dentin floor as the first increment of the restoration. Feiz *et al.* stated that the use of a bonded-base technique could reduce microleakage, for bulk-fill composite restorations too.[5]

The present study compared the microleakage in class 2 composite restorations done in pre-molars restored with two different techniques; the conventional cavity design restored with a bulk-fill composite and cavities prepared according to Clark's design and restored using bulk-fill injection molding technique.

MATERIALS AND METHODS

Sample Preparation

The present study was approved by the Institutional Ethics Committee with an IEC/IRB No. KMCTDC/IEC/C/2024/04. The teeth samples were selected as per the inclusion and exclusion criteria shown in Table 1.

Methodology

Twenty-four samples were divided equally into two groups with 12 samples per group and mounted onto metallic jaws.

Group 1 Specimen Preparation

Class 2 proximal boxes of dimensions 3mm width, 1.5 mm axial depth and occluso- gingival length upto1 mm below CEJ, were prepared [Figures 1 and 2] depict the digramatic representation of conventional class 2 preparation. Tofflemire matrix band and retainer and wooden wedges were placed to attain proximal contact and contour, as shown in the [Figure 3].

GIC liner was placed on the gingival seat, followed by etching with 37% phosphoric acid (EAZETCH, India) and application of dentin bonding agent (Te-Econom Bond,

Table 1: Inclusion and exclusion criteria of the study

Inclusion criteria	Exclusion criteria
Non-carious pre-molars freshly extracted for therapeutic or periodontal reason	Teeth having caries or developmental anomalies on the crown

Figure 1: Conventional class 2 cavity preparation

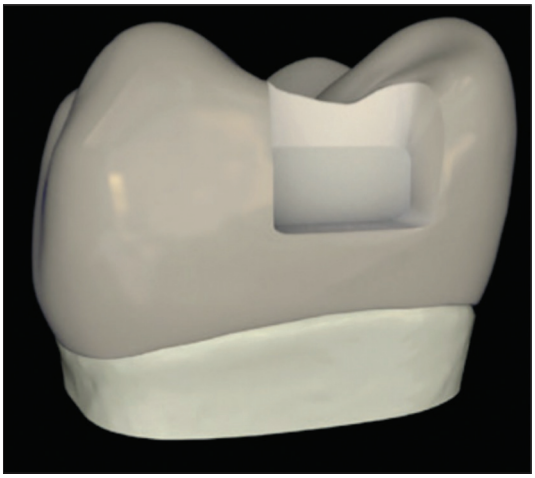


Figure 2: Convention class 2 cavity design

Figure 3: Tofflemire matrix band and retainer placed

Figure 4: Completed conventional class 2 restoration

Figure 5: Disclosing agent applied with brush

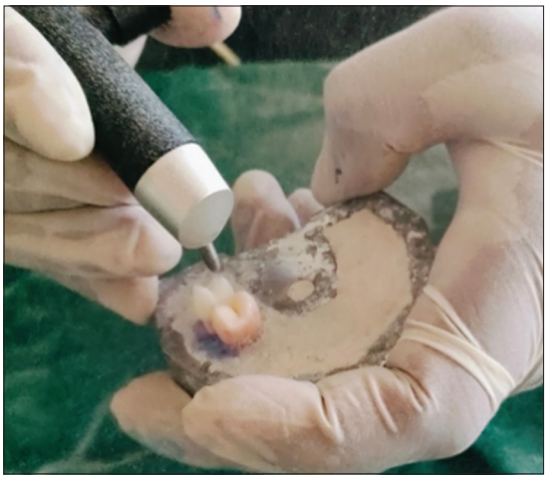


Figure 6: Stained biofilm was removed with microabrasion

Ivoclar Vivadent, Zurich, Switzerland) and cured. Two layers of 4 mm-thick bulk-fill (3M Filtek bulk-fill, USA) composite was added and cured separately to completely restore the cavity [Figure 4]. A final 3-point curing was done to ensure optimum polymerization.

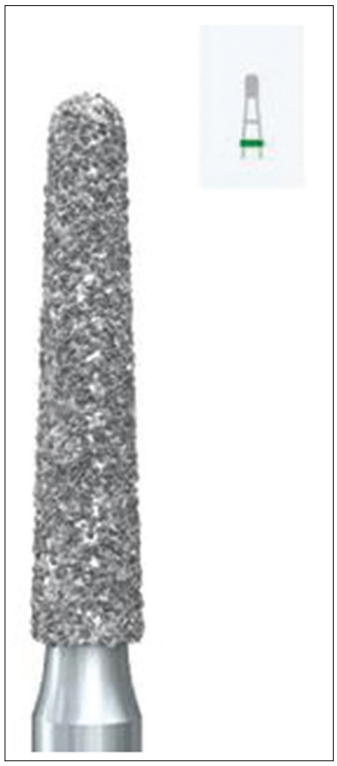


Figure 7: 6856 FG 018 bur (Strauss, Israel) used for cavity preparation

Figure 8: FG008 Bur (Strauss, Israel) was used to break the facial and lingual contact

Group 2 Specimen Preparation

The cavity preparation was done following the steps given by Clark.[1]

Disclosing agent was applied with brush on to the mounted premolar which was selected for clark's cavity design [Figure 5] and stained biofilm removed by micro abrasion [Figure 6]. The proximal cavity was prepared using a 6856 FG 018 bur (Strauss, Israel) [Figure 7]. FSD 3F FG008 Bur (Strauss, Israel) [Figure 8] was used to break the facial and lingual contact and FG O31 8833 (Strauss, Israel) [Figure 9] bur was used to obtain the radial bevel. The cavity was saucer-shaped with double serpentine/disappearing margins [Figure 10]. Bioclear matrix and diamond wedge were placed [Figure 11].

A twin ring (Bioclear, USA) was positioned to stabilize the matrix [Figure 12], a thin layer of flowable composite was first injected and left uncured. Then bulk-fill composite (3M Filtek bulk-fill, USA), warmed at 68°C, was injected into the cavity steadily to allow the material to push the first layer of the flowable composite out like a snow-plow until the whole cavity was filled with the bulk-fill material uniformly. Then it was cured by the three-point curing method through a transparent matrix. Figure 13 illustrates the completed Clark's Class II composite restoration.

Microleakage Test

Specimens were separated from the metallic jaw and thermocycled for 500 cycles between 5 and 55°C with a dwell time of 30 s. Samples were then coated with transparent nail polish lacquer till 1mm away from the tooth-restoration margin and then immersed in 2% methylene blue dye for 24 h. Specimens were removed, rinsed, and dried, then sectioned mesio-distally along the long axis and observed under a stereomicroscope and the microleakage was scored.

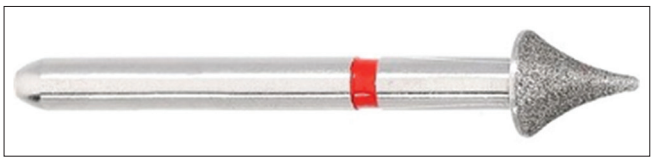


Figure 9: FG O31 8833 (Strauss, Israel) bur was used to obtain the radial bevel

Figure 10: Clark's class 2 cavity design

Figure 11: Bioclear matric and diamond wedge was palced

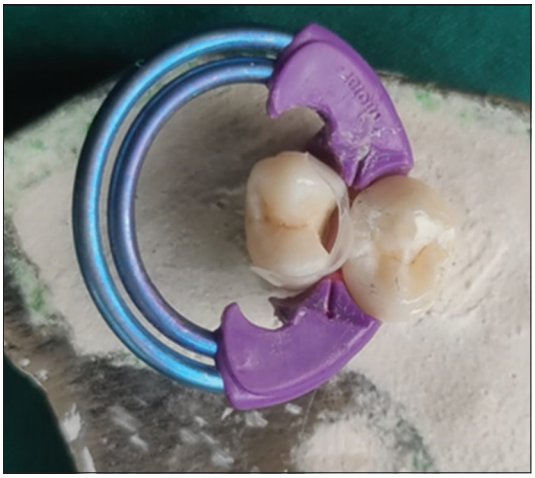


Figure 12: Twin ring was placed as retainer

Figure 13: Completed Clark's class 2 restoration

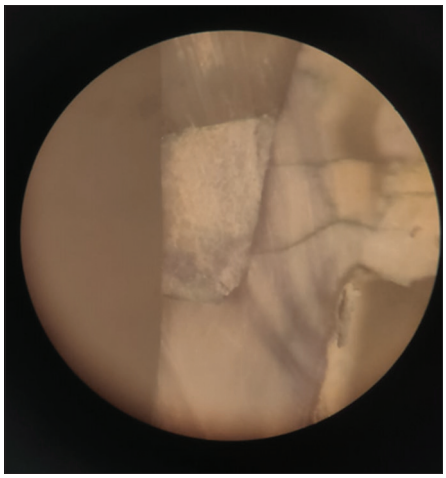
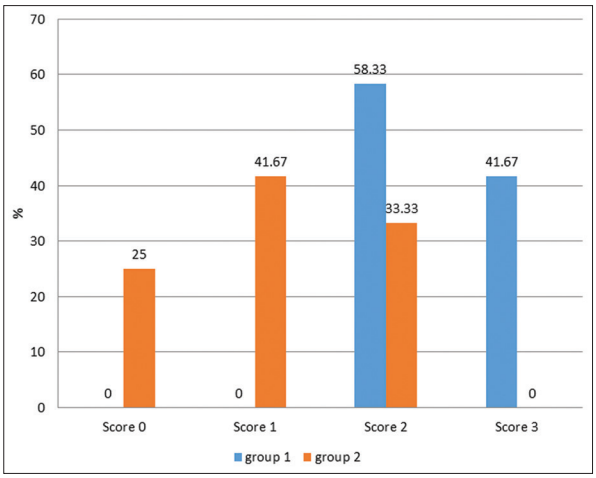


Figure 14: Stereomicroscopic image of a group 1 specimen showing microleakage corresponding to score 1



Graph 1: Bar diagram showing distribution of samples by microleakage score in the two groups

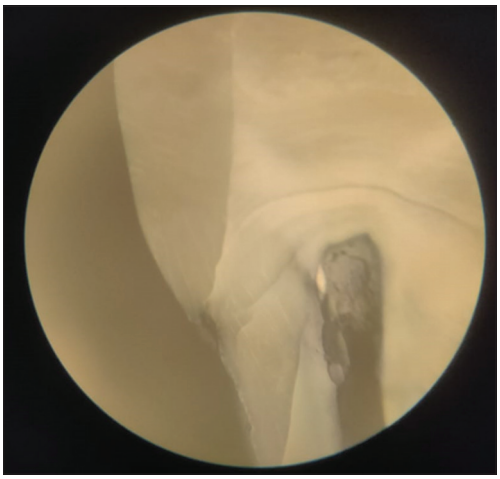


Figure 15: Stereomicroscopic image of group 2 specimen showing no microleakage, denoted as score 0

Microleakage Scoring[6]

- 0 = no dye penetration occurs
- 1 = dye penetration reaches one-third of the cavity wall
- 2 = dye penetration of more than one-third until two-thirds of the cavity wall
- 3 = dye penetration reaches two-thirds of the cavity wall until the cavity base.

Proposed Statistical Analysis

All statistical procedures will be performed using the Statistical Package for the Social Sciences 20.0. Calculations for the power (80%) of the study will be performed before commencement of the study. All quantitative variables are expressed in mean and standard deviation. Qualitative variables will be expressed in percentages. Independent *t*-test will be used for association between quantitative variables. A probability value $P < 0.05$ will be considered statistically significant.

Table 2: Micoleakage scoring of the two groups

Group	Microleakage score			
	Score 0	Score 1	Score 2	Score 3
Group 1	0	0	7	5
Group 2	3	5	4	0

Table 3: Distribution of samples by microleakage score in the two groups

Group	Micoleakage score			
	Score 0 (%)	Score 1 (%)	Score 2 (%)	Score 3 (%)
1	0	0	58.33	41.67
2	25	41.67	33.33	0

RESULTS

Table 2 presents the distribution of microleakage scores in Groups 1 and 2. Table 3 displays the percentage of samples corresponding to each score. Graph 1 illustrates a bar diagram showing the percentage distribution of scores within each group.

The results showed that the samples with the lowest scores, that is: Score 0 and score 1, were observed only with Clark's technique, with 25% samples showing score 0 and 41.6% samples with score 1. No samples showed severe leakage with a score 3.

However, in the conventional technique, all samples scored high leakage, with 58.3% having a score 2 and the remaining half with a score 3. Figure 14 and 15 shows stereomicroscopic images of group 1 and 2 after sectioning of teeth.

DISCUSSION

The traditional conventional box preparation has been followed for composite restorations since its introduction. The zone prone for failure in such Class 2 cavity restorations was the deep-seated gingival floor. The curing lamp tip does not reach close enough to facilitate adequate curing of the composite layer here. Another possible reason for de-bonding is the bonding substrate on the gingival seat, which is often dentin, which is more technique sensitive and has lower bond strengths when compared to enamel, resulting in bond failure during polymerization. The box design, which was effective for a condensable material, such as amalgam, tends to leave voids in the line angles with composite.

Understanding these drawbacks and taking advantage of newly introduced bulk-fill composites,[7] the better flow and strength qualities of warmed composites[8] and better bonding from enamel; Clark redesigned the cavity preparation to adapt to these properties of composite. His design converted the interfacial tension joints to compression joints. Compression joint can reduce the tooth flexure and deboning.[9]

Removing the biofilm or smear layer is paramount with bonding techniques and it may be done effectively by micro abrasion.[10] This improves the wettability and bonding to uncut enamel.[5] The infinity edge margin of Clark's design also contributed to lesser micro leakage by providing compression zones and better restoration-tooth transition.

The flowable composite was injected first and not cured in Group 2, this was followed with warm composite injected into the flowable composite layer, which was displaced out of the sides of the restoration.[9] This technique was reported to improve adaptation and reduce leakage versus separate layers of flowable.[11]

Most Class II cavities have gingival margins located apical to the CEJ, often extending into dentin or cementum.[12] As a result, the cervical margins of restorations are commonly placed on these substrates, which can compromise the marginal seal compared to restorations placed on enamel.[12] Therefore, in this study, the gingival seat was positioned 1 mm apical to the CEJ, ensuring it was located solely on dentin.

In this study, microleakage was assessed using the dye penetration method with 2% methylene blue, chosen for its simplicity, cost-effectiveness, and ability to offer clear visualization of the cavity in digital images due to its strong contrast with surrounding tissues.[13,14] Microleakage was evaluated using a stereomicroscope, a straightforward and efficient tool that allows three-dimensional visualization of specimens. It also facilitates real-time observation on monitors and offers a wide range of resolution and magnification settings, along with improved visibility through various illumination features.[14-16]

CONCLUSION

Within the limits of this study, we may conclude that Clark's technique may be considered over the conventional technique for a proximal composite restoration with lesser chances of failure due to microleakage. However, further studies are required with a larger sample size.

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