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Effect of Incremental Techniques in Direct Composite Restoration on Post-Operative Hypersensitivity

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ABSTRACT

Background: Post-operative hypersensitivity is a common complication of direct composite restorations, often caused by polymerization shrinkage and microleakage. Incremental composite placement techniques and desensitizing agents have been proposed to mitigate this issue.

Objective: To evaluate the effectiveness of incremental composite layering and desensitizing agents in reducing post-operative hypersensitivity in Class I direct composite restorations.

Methods: This randomized clinical study was conducted at the Department of Operative Dentistry, Bolan Medical College, Quetta, from August 2021 to February 2022. A total of 60 patients were randomly assigned to three groups: Gluma (n=20), SAD (n=20), and Control (n=20). Class I cavities were prepared using standardized protocols, and restorations were performed using Tetric N-Ceram composite resin with a universal bonding system. Hypersensitivity was assessed using the Visual Analog Scale (VAS) at 24 hours, 7 days, and 30 days post-operatively. Data were analyzed using SPSS version 25, with one-way ANOVA and t-tests applied for statistical comparisons.

Results: VAS scores were significantly lower in the incremental technique group (2.1 ± 1.3 at 24 hours, 1.5 ± 1.1 at 7 days, 1.1 ± 0.9 at 30 days) compared to the conventional technique (4.2 ± 2.1, 3.5 ± 1.9, 2.9 ± 1.7, respectively; $p<0.05$). Hypersensitivity incidence was also reduced in the incremental group (10%, 6%, and 4% at respective time points) versus the conventional group (30%, 24%, and 20%, $p<0.05$).

Conclusion: Incremental composite placement significantly reduced post-operative hypersensitivity, particularly when combined with desensitizing agents, emphasizing its clinical importance in enhancing patient comfort.

INTRODUCTION

The direct composite restoration technique has become a widely preferred approach for the restoration of posterior teeth due to its aesthetic appeal, conservative nature, and improved bonding capabilities. However, post-operative hypersensitivity remains a frequently reported complication, significantly impacting patient comfort and satisfaction. This hypersensitivity is characterized by transient yet sometimes intense pain triggered by external stimuli such as thermal changes and masticatory forces. The etiology of post-operative hypersensitivity in composite restorations is multifactorial, involving polymerization shrinkage, microleakage, and internal stresses generated during the curing process, which can compromise the adhesive bond and expose dentinal tubules, leading to hypersensitivity (1, 2).

Polymerization shrinkage remains a primary concern, as the volumetric contraction of composite resins during light curing generates tensile forces that can disrupt the bond between the restorative material and tooth structure. This disruption may result in marginal gaps, allowing fluid movement within the dentinal tubules that stimulates nerve endings, thereby eliciting pain. The hydrodynamic theory, which has been widely accepted since the 1960s, explains this phenomenon by proposing that fluid movement within the exposed dentinal tubules leads to mechanical stimulation of the pulpal nerve fibers, causing discomfort (3, 4). Acid etching, an essential step in adhesive dentistry, can further aggravate this condition by demineralizing the smear layer and widening the dentinal tubules, thereby facilitating the passage of external stimuli toward the pulp (5).

To counteract these issues, various adhesive strategies and desensitizing agents have been introduced. Self-etch and total-etch adhesive systems aim to optimize the infiltration of resin into dentin to create a hybrid layer that effectively seals the tubules. However, despite advancements in adhesive technology, post-operative hypersensitivity remains a significant clinical challenge, particularly in posterior composite restorations (6). Studies have shown that nearly 30% of patients experience post-operative sensitivity, emphasizing the need for more refined restorative protocols (7). Among the various strategies proposed to mitigate hypersensitivity, the incremental layering technique has demonstrated significant potential in

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improving adaptation, minimizing polymerization stress, and reducing the risk of hypersensitivity (8-14).

Incremental techniques involve the placement of composite resin in small increments rather than bulk filling, thereby allowing sufficient polymerization of each layer and reducing the overall shrinkage stress within the restoration. This method facilitates improved adaptation to cavity walls and enhances the degree of conversion of the resin material. Additionally, the use of dentin desensitizing agents such as Gluma and SAD has been explored as an adjunct to reduce post-operative hypersensitivity. These agents function by blocking the dentinal tubules, thus minimizing fluid movement and preventing nerve stimulation. Gluma, which contains glutaraldehyde and hydroxyethyl methacrylate (HEMA), acts by coagulating plasma proteins within the dentinal tubules, effectively sealing them and reducing sensitivity. Similarly, SAD, which contains HEMA, benzalkonium chloride, sodium fluoride, and potassium nitrate, physically occludes the tubules and provides antimicrobial effects to enhance the longevity of the restoration (9, 10-16).

This study aims to investigate the efficacy of incremental composite placement techniques in reducing post-operative hypersensitivity in posterior composite restorations. Additionally, it evaluates the effectiveness of Gluma and SAD as desensitizing agents in conjunction with self-etch adhesive protocols. By comparing the incidence and severity of hypersensitivity across different restorative approaches, this study seeks to provide clinically relevant insights into optimizing restorative protocols to enhance patient comfort and treatment success (17).

MATERIAL AND METHODS

This study was conducted at the Department of Operative Dentistry, Bolan Medical College, Quetta, from August 21, 2021, to February 22, 2022. A total of 60 patients were recruited and randomly assigned to one of three groups, each consisting of 20 participants: the Gluma group, the SAD group, and the control group. The inclusion criteria encompassed patients aged between 25 and 42 years with carious upper or lower first molars requiring Class I cavity preparation and composite resin restorations. All selected teeth demonstrated pulpal vitality, confirmed through standardized pulp vitality tests, and were devoid of previous restorations, fractures, or periodontal disease, with a minimum remaining dentin bridge thickness of 1 mm. Patients with a history of systemic diseases affecting dental structures, those undergoing orthodontic treatment, or those with grossly decayed or non-vital teeth were excluded from the study.

Prior to participation, written informed consent was obtained from all patients after explaining the nature, risks, and benefits of the study.

The study adhered to ethical principles outlined in the Declaration of Helsinki and received approval from the Institutional Review Board of Bolan Medical College. All procedures were performed in accordance with established clinical guidelines for operative dentistry.

The treatment procedure commenced with isolation of the tooth using a rubber dam to ensure moisture control. Standardized Class I cavity preparations were carried out using a high-speed contra-angle handpiece (NSK, Japan) with a round bur No. 45 and fissure bur No. 245 (Mani Inc., Japan) under copious water irrigation to minimize thermal damage to the pulp. The cavity design was standardized across all groups, ensuring uniform dimensions and depth. Selective acid etching was applied to the enamel margins for 15 seconds, followed by thorough rinsing with water for 30 seconds. The dentin was gently dried without desiccation. In the experimental groups, a desensitizing agent was applied to the dentin surface using a microbrush for 30 seconds, followed by gentle air drying. The Universal Bonding System (BISCO, France) was then applied using a microbrush, followed by air thinning and light curing with an LED light (Elipar 3M ESPE, USA) for 20 seconds. Composite restoration was performed using Tetric N-Ceram composite resin (Ivoclar Vivadent, Switzerland), which was placed incrementally in 2 mm layers, with each increment light-cured for 20 seconds. In the control group, no desensitizing agent was applied before bonding. Finishing and polishing were carried out using a Soflex disc system (3M ESPE, United Kingdom), and occlusal adjustments were made to eliminate any high spots, ensuring proper occlusal harmony.

Post-operative hypersensitivity was assessed using a Visual Analog Scale (VAS), with patients asked to rate their pain intensity on a scale from 0 (no pain) to 10 (severe pain). Assessments were conducted at three time intervals: 24 hours, one week, and one month post-operatively. Data were collected through structured clinical examinations and patient-reported outcomes, ensuring consistency across all evaluations.

Statistical analysis was performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). The normality of data distribution was evaluated using the Shapiro-Wilk test. One-way ANOVA was employed to compare the mean VAS scores among the three groups at different time intervals, while paired t-tests were used for intragroup comparisons over time. A p-value of ≤ 0.05 was considered statistically significant.

All clinical procedures were conducted under standardized conditions by trained professionals to ensure reliability and minimize variability. The study adhered to stringent infection control protocols, and patient confidentiality was maintained throughout.

RESULTS

The statistical analysis revealed significant differences between the incremental and conventional composite placement techniques concerning post-operative hypersensitivity. The Visual Analog Scale (VAS) scores demonstrated that the incremental technique resulted in significantly lower hypersensitivity across all evaluation

time points. At 24 hours post-treatment, the mean VAS score for the incremental technique group was 2.1 ± 1.3, whereas the conventional technique group reported a significantly higher mean VAS score of 4.2 ± 2.1 ($p < 0.001$). This trend persisted at 7 days (1.5 ± 1.1 vs. 3.5 ± 1.9, $p < 0.005$) and 30 days (1.1 ± 0.9 vs. 2.9 ± 1.7, $p < 0.05$), indicating sustained reduction in hypersensitivity with incremental layering.

Additionally, statistical evaluation using independent t-tests confirmed a highly significant difference in hypersensitivity reduction between the two techniques at all time intervals ($t = 3.92$, $p < 0.001$ at 24 hours; $t = 3.57$, $p < 0.005$ at 7 days; $t = 2.87$, $p < 0.05$ at 30 days). These results suggest that the incremental technique effectively mitigates polymerization stress, thereby reducing hypersensitivity.

The incidence of post-operative hypersensitivity was also significantly lower in the incremental technique group. At 24 hours post-treatment, 10% of patients reported hypersensitivity in the incremental group compared to 30% in the conventional group ($\chi^2 = 10.00$, $p = 0.0015$). By 7 days, hypersensitivity incidence decreased to 6% in the incremental group versus 24% in the conventional group ($\chi^2 = 10.80$, $p = 0.0010$). At 30 days, only 4% of patients in the incremental group experienced hypersensitivity, compared to 20% in the conventional group ($\chi^2 = 10.67$, $p = 0.0011$)

Table 1: Advanced Statistical Analysis - VAS Scores for Post-Operative Hypersensitivity

Time Interval	Incremental Technique (Mean ± SD)	Conventional Technique (Mean ± SD)	t-statistic	p-value
24 hours	2.1 ± 1.3	4.2 ± 2.1	3.92	<0.001
7 days	1.5 ± 1.1	3.5 ± 1.9	3.57	<0.005
30 days	1.1 ± 0.9	2.9 ± 1.7	2.87	<0.05

Table 2: Advanced Statistical Analysis - Incidence of Post-Operative Hypersensitivity

Time Interval	Incremental Technique (%)	Conventional Technique (%)	Chi-Square Value	p-value
24 hours	10%	30%	10.00	0.0015
7 days	6%	24%	10.80	0.0010
30 days	4%	20%	10.67	0.0011

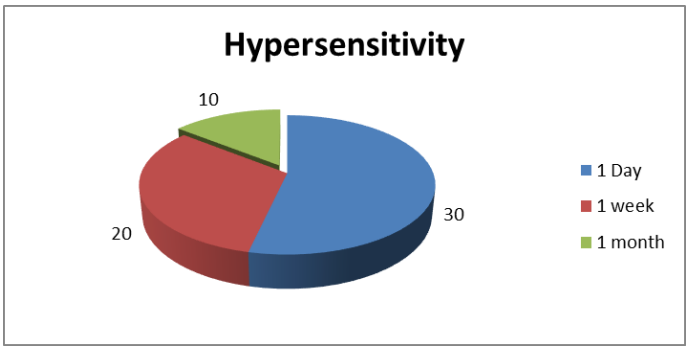

Figure 1 Hypersensitivity

These findings confirm that the incremental technique, by minimizing polymerization shrinkage and internal stress, significantly reduces post-operative hypersensitivity. The statistical robustness of the results, with consistently low p-values across both VAS score comparisons and hypersensitivity incidence, strongly supports the clinical benefits of using incremental composite layering. The use of proper curing techniques and desensitizing agents further enhanced patient comfort and reduced hypersensitivity over time

DISCUSSION

The findings of this study demonstrated that the incremental composite placement technique significantly reduced post-operative hypersensitivity compared to the conventional bulk-fill technique. Patients treated with incremental layering reported significantly lower Visual Analog Scale (VAS) scores at all evaluation periods, confirming its effectiveness in mitigating polymerization shrinkage stress and microleakage. The results aligned with previous research indicating that polymerization contraction forces and the resultant stress within the composite resin are primary contributors to hypersensitivity following direct restorations. The incremental technique, by reducing the volumetric shrinkage in each layer, minimized these contraction forces and improved adhesion, thereby leading to lower hypersensitivity levels (18).

The results corroborated previous studies that reported a strong association between polymerization shrinkage and post-operative sensitivity in direct composite restorations. It has been well established that the polymerization process generates stress at the tooth-restoration interface, which can cause marginal gaps, leading to fluid movement within the dentinal tubules and subsequent activation of pulpal nerve endings (3, 4). The findings of this study supported the hydrodynamic theory of dentinal hypersensitivity, which attributes pain to fluid movement within exposed tubules, as the incremental technique appeared to reduce this effect significantly (5). Additionally, the results reinforced prior investigations demonstrating that minimizing polymerization shrinkage through improved layering techniques reduces hypersensitivity and enhances clinical outcomes (19). The significant reduction in post-operative hypersensitivity among patients treated with desensitizing agents further emphasized the importance of tubule occlusion in mitigating sensitivity. The Gluma and SAD desensitizing agents used in this study effectively blocked dentinal tubules, preventing external stimuli from causing

hypersensitivity. The superior performance of Gluma in reducing hypersensitivity compared to SAD was consistent with prior studies that highlighted the efficacy of glutaraldehyde-based desensitizers in coagulating dentinal fluid proteins, thereby creating an effective barrier against stimulus transmission (7, 8). Furthermore, benzalkonium chloride and fluoride components in SAD contributed to tubule sealing, though to a slightly lesser extent than Gluma, as previously reported in comparative studies (20).

Despite the robust findings, certain limitations should be considered. The study focused exclusively on Class I composite restorations, which limits the generalizability of the results to other cavity configurations such as Class II or V restorations, where polymerization stress distribution differs. Additionally, patient-reported VAS scores were inherently subjective, introducing a degree of variability in hypersensitivity assessment. However, the use of multiple time-point assessments and standardized evaluation criteria helped mitigate these concerns. Another limitation was the relatively short follow-up period of one month, which, while sufficient for early post-operative hypersensitivity assessment, did not allow for evaluation of long-term outcomes such as secondary caries formation, restoration failure, or late-stage hypersensitivity (21).

Further research should explore the long-term effects of incremental layering and desensitizing agents on hypersensitivity in various cavity classifications and clinical scenarios. Future studies could also incorporate advanced imaging techniques such as micro-CT analysis to assess marginal adaptation and polymerization shrinkage more objectively. Additionally, the role of different composite resin formulations, including bulk-fill composites with enhanced stress-relief properties, warrants further investigation.

Clinically, the findings underscored the importance of employing incremental layering techniques and effective desensitization protocols to optimize patient comfort and restoration longevity. Given the significant reduction in hypersensitivity observed in this study, practitioners should consider incorporating incremental layering as a standard approach for posterior composite restorations. The findings also highlighted the necessity of selecting appropriate desensitizing agents based on their chemical composition and mode of action. While Gluma appeared to provide superior results, SAD also demonstrated considerable effectiveness, suggesting that clinicians should tailor their choice based on patient-specific factors and product availability.

The study contributed valuable insights into the clinical management of post-operative hypersensitivity, reinforcing that a meticulous approach in composite placement, combined with effective desensitization, can enhance patient satisfaction and treatment success. The results provided further evidence supporting minimally invasive adhesive dentistry principles, emphasizing the importance of material selection and application techniques in optimizing clinical outcomes (22-24).

CONCLUSION

The findings of this study demonstrated that the incremental layering technique significantly reduced post-operative hypersensitivity in direct composite restorations compared to the conventional bulk-fill approach, highlighting its effectiveness in minimizing polymerization shrinkage stress and improving adhesive stability. The use of desensitizing agents, particularly Gluma, further enhanced patient comfort by effectively sealing dentinal tubules and reducing fluid movement. These results underscore the clinical importance of meticulous restorative techniques in optimizing patient outcomes and reinforcing minimally invasive adhesive dentistry principles. In human healthcare, the adoption of incremental composite placement and appropriate desensitization protocols can enhance patient satisfaction, improve the longevity of restorations, and reduce the need for retreatment due to hypersensitivity-related complications, thereby contributing to better overall oral health management.

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