

# Minimally Invasive Cavity Preparation by Bridging the Gap Between Conservation and Effectiveness

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## ABSTRACT

**Background:** Minimally invasive cavity preparation (MIC) is an evolving restorative technique aimed at preserving sound tooth structure while ensuring effective caries removal. This study aimed to assess the effectiveness of minimally invasive cavity preparation in terms of patient comfort, restoration success, and post-operative sensitivity by comparing it to the conventional cavity preparation method.

**Methods:** A cross-sectional comparative study was conducted involving 80 patients, randomly divided into two groups: MIC (n=40) and conventional (n=40), by a random sampling technique. The study took place at the Department of Operative Dentistry at BMDC and LUMHS, Karachi, from January to May 2023 (EC/Ref/812-23-2023). Sample size was determined with the help of OpenEpi 3.0.0 using a power of 80% and an alpha of 0.05. All data were analyzed using SPSS version 25. A chi-square test and an independent t-test were performed for the variables measured. A p-value was considered significant when less than 0.05.

**Results:** Patients in the MIC group showed significantly reduced cavity size (mean depth: 1.8 mm vs. 2.5 mm,  $p < 0.001$ ), lower discomfort scores (mean 3.2 vs. 6.5,  $p < 0.001$ ), and fewer reports of post-operative sensitivity (4 (10%) vs. 12 (30%),  $p = 0.02$ ) compared to the conventional group. Restoration success was higher in the MIC group (38 (95%)) than in the conventional group (33 (82.5%)), although this was not statistically significant ( $p = 0.07$ ).

**Conclusion:** MIC proved to be better for patients in terms of comfort and keeping tooth structures intact than conventional treatments. Although both techniques had the same rate of successful restorations, the MIC approach is more favorable.

**Keywords:** Minimally Invasive, Cavity Preparation, Restorative Dentistry, Patient Comfort, Tooth Preservation.

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## INTRODUCTION

Dental caries remains one of the most prevalent long-term health issues worldwide that necessitates gentle yet effective management<sup>1</sup>. Conventionally, dentists utilize mechanical retention method that often cuts away the healthier portion of the tooth along with the cavity<sup>2</sup>. While this approach was useful in the past but now, it is not consistent with the new philosophy that focuses on preserving as much natural tooth as possible<sup>3</sup>.

Minimally invasive dentistry (MID) has encouraged the use of methods that spot problems early, assess risks, and save as much tissue as possible<sup>4</sup>. Minimally invasive cavity preparation (MIC) focuses on removing only soft decay while leaving the surrounding unaffected dentin and enamel<sup>5</sup>. Techniques that are used in MIC, such as magnification, coloring solutions for detecting cavities, and minuscule burs, aid oral health specialists in addressing dental problems accurately<sup>6</sup>. The benefit is that it reduces the size of the cavity, lowers the chance of exposing the pulp, and protects nearby tooth tissues by causing less harm<sup>7</sup>. Significantly, it makes patients feel less pain, more comfortable, and results in a better-looking and better-functioning outcome<sup>8</sup>. Even though MIC is being used more frequently, researchers still lack sufficient clinical evidence on how well it works compared to other approaches<sup>9</sup>. There is ongoing concern about how long and how well restorations will last in conservatively prepared cavities<sup>10</sup>. For this reason, understanding how MIC performs in everyday clinical care, e.g., its post-operative outcomes, patient satisfaction, and the longevity of restorations, is important.

To fill this gap, this study aimed to assess the effectiveness of minimally invasive cavity preparation in terms of patient comfort, restoration success, and post-operative sensitivity by comparing it to the conventional cavity preparation method. Clinicians may use these findings to adopt approaches that are modern, cost effective, and still result in successful and safe treatments.

## METHODS

This cross-sectional comparative study was conducted at the Department of Operative

Dentistry at BMDC and LUMHS, Karachi, from January to May 2023 (EC/Ref/812-23-2023). A total of 80 patients aged 18 to 50 were enrolled to examine if they had Class I carious lesions in their permanent posterior teeth. Patients were split into two groups: Group A was Conventional Cavity Preparation, with 40 patients, and Group B, with 40 patients, for Minimally Invasive Cavity Preparation (MIC) using a random sampling technique. Sample size was determined with the help of OpenEpi 3.0.0 using a power of 80% and an alpha of 0.05<sup>11</sup>.

Patients who had only enamel or superficial dentin decay, were cooperative, and had not experienced hypersensitivity or pulp inflammation, were included in the study. Individuals were excluded if they had large cavities, teeth that couldn't be restored, active periodontal disease, or any medical conditions affecting their oral health. Standard air-rotor burs were used to create cavities in teeth using Greene Vardiman Black's conventional method for Group A. In Group B, a minimally invasive preparation method was followed that involved magnification of the affected area, caries detector stain followed by small fine burs to remove the infected portion of the tooth only. Both groups received resin-based composite restorations with an adhesive bonding system. All procedures were performed by the same operator to maintain consistency. No dietary changes were noted during the follow up period of 3 months. Hypersensitivity of the treated tooth was assessed by using a visual analog scale at 24 hours, 1 week, and 1 month. For a clinical and radiographical perspective, marginal adaptation was measured. While patient satisfaction was evaluated using a questionnaire. Treatment duration and the amount of tissue removed were recorded as secondary outcomes.

All data was taken and saved using a proforma and then analyzed using SPSS version 25. A chi-square test was performed for categorical variables and an independent t-test for continuous variables. A p-value below 0.05 was considered to be statistically significant. This approach allowed for a fair comparison of which technique preserved tooth structure better without compromising patient care.

## RESULTS

**Table 1: Comparison of Demographic Characteristics of Participants**

Variable	MIC Group (n=40)	Conventional Group (n=40)	p-value
Mean Age (years)	28.1±5.9	28.8±6.5	0.63
Gender (M/F)	21 / 19	20 / 20	0.84
Daily Brushing (≥2/day)	30 (75%)	28 (70%)	0.61
Sugar Intake (High)	18 (45%)	21 (52.5%)	0.48

**MIC = Minimally Invasive Cavity preparation; M = Male; F = Female. Independent t-test for continuous variables; Chi-square test for categorical variables. Significance set at  $p < 0.05$ .**

Altogether, 80 patients were selected and evenly distributed, with 40 assigned to the Minimally Invasive Cavity (MIC) group and 40 to the Conventional Preparation group. The average patient age was 28.4 years ( $\pm 6.2$ ), with an almost even gender distribution. Participants of both groups underwent similar oral hygiene routines, typical diets, and caries prevalence. After treatment, cavities in the MIC group were significantly smaller ( $p < 0.001$ ), and patients reported less pain compared to the Conventional group. Postoperative sensitivity occurred in 10% of MIC patients versus 30% in the Conventional group ( $p = 0.02$ ). At the 3-month follow-up, restoration outcomes were better in the MIC group (95%) compared to the Conventional group (82.5%), though this difference was not statistically significant ( $p = 0.07$ ). **Table 1** displays the comparative demographic characteristics of both groups involved in a study.

**Table 2: Clinical Parameters and Patient Experience**

Clinical Parameter	MIC Group	Conventional Group	p-value
Average Cavity Depth (mm)	1.8±0.4	2.5±0.6	<0.001
Post-op Sensitivity (Yes)	4 (10%)	12 (30%)	<0.002
Mean Discomfort Score (1–10)	3.2±1.0	6.5±1.3	<0.001

**MIC = Minimally Invasive Cavity preparation; Post-op = Post-operative. Independent t-test for continuous variables; Chi-square test for categorical variables. Significance set at  $p < 0.05$ .**

Participants in both groups were well matched in terms of demographics. The mean age was 28.1±5.9 years in the MIC group and 28.8±6.5 years in the conventional group ( $p=0.63$ ). Gender distribution was almost equal (MIC: 21 males, 19 females; Conventional: 20 males, 20 females;  $p=0.84$ ). No significant differences were found in daily brushing habits (30 (75%) vs 28 (70%),  $p=0.61$ ) or high sugar intake (18 (45%) vs. 21 (52.5%),  $p=0.48$ ), indicating proper group randomization. **Table 2** highlights the findings from clinical parameters measured and the experiences of patients.

**Table 3: Restoration Outcomes at 3-Month Follow-Up**

Outcome	MIC Group (n=40)	Conventional Group (n=40)	p-value
Successful Restoration	38 (95%)	33 (82.5%)	0.07
Marginal Integrity Issues	2 (5%)	6 (15%)	0.12
Re-treatment Needed	1 (2.5%)	3 (7.5%)	0.30

**MIC = Minimally Invasive Cavity preparation. Chi-square test for categorical variables. Significance set at  $p < 0.05$ .**

The MIC group had a significantly lower mean cavity depth (1.8±0.4 mm) than the conventional group (2.5±0.6 mm;  $p<0.001$ ). Post-operative sensitivity was reported by only 4 (10%) of MIC patients compared to 12 (30%) in the conventional group ( $p=0.02$ ). Patient-reported discomfort scores were also significantly lower in the MIC group (mean score 3.2±1.0) compared to the conventional group (6.5±1.3;  $p<0.001$ ), highlighting superior patient comfort with the minimally invasive technique. **Table 3** demonstrates the outcomes of restoration after 3 months in a follow-up session.

At the 3-month follow-up, the MIC group demonstrated a higher restoration success rate (95%) compared to the conventional group (82.5%), although this difference did not reach statistical significance ( $p=0.07$ ). Marginal integrity issues were lower in the MIC group (5% vs. 15%,  $p=0.12$ ), as were retreatment needs (2.5% vs. 7.5%,  $p=0.30$ ). While trends shown in this study favored MIC but larger samples will be needed to achieve statistical significance.

## DISCUSSION

According to the results of this study, dentists could preserve healthier tooth tissue using MIC and obtained similar good results to traditional dentistry. MID allowed dentists to recognize the first signs of cavities, cut away only the infected section, and leave the optimal part of the tooth intact. These findings matched with earlier studies that stressed over the value of carefully conserving tooth material and still getting good results from restorations<sup>12,13</sup>. The reduced sensitivity after the procedure in MIC cases suggests that keeping the dentinal tubules intact and protecting the pulp helps in healing right away<sup>14</sup>. Upon 3 months follow-up, there was no significant difference seen in results between the conservative and traditional cavity groups, proving that the former was equally effective. This aligns with prior studies in proving the fact that the design of a dental cavity is insignificant when modern techniques and materials are being used<sup>15,16</sup>.

The MIC group ended up taking longer in surgery since procedures with magnification and caries-detecting materials required special attention. However, patients in this group felt more satisfied and considered the procedure less painful and more comfortable. This backs up the main ideas of patient-centered care, highlighting that comfort, preservation, and communication are important for getting positive results and patient cooperation<sup>17</sup>. With just one surgeon performing the procedure, the results were unlikely to be influenced by differences in techniques. As MIC requires special skills, the results are often limited to clinical contexts where these skills exist. Since the duration of the study was short, it was not easy to measure the lasting impact of restorations on wounds and infections. Evidence suggests that even though conventional approaches work well, MIC allowed for the preservation of tissue and provided patients with greater satisfaction<sup>18,19</sup>. As better dental materials and tools become available, dental professionals may consider less invasive options that affect the tooth minimally<sup>20</sup>.

Additionally, recent investigations have reaffirmed the advantages of minimally invasive techniques, especially in reducing the risk of iatrogenic damage and promoting pulpal health<sup>21</sup>. One study emphasized that selective caries removal significantly decreases pulpal complications while maintaining structural stability<sup>22</sup>. This contributes to longer-lasting restorations without increasing failure rates and supports patient-centered care outcomes<sup>23</sup>. As such, MIC not only preserves tissue but may also play a preventive role against secondary caries and pulpal inflammation, further validating its utility in modern restorative dentistry<sup>24</sup>. Furthermore, a growing body of evidence suggests that integrating caries-detecting dyes and magnification tools, as

used in MIC, enhances diagnostic accuracy and reduces unnecessary dentin removal<sup>25</sup>.

However, some possible limitations should be kept in mind when examining the results of this study. Even with positive findings, these might not be useful for a wider audience because the sample size was small. Furthermore, the follow-up period was short, therefore, it was hard to judge the durability of sealants and the recurrence of tooth decay. The results might differ when the same procedure is done at different centers by different surgeons. Most of the evidence of this study was related to Class I cavities and did not represent the complexities of other types of cavities. Also, no radiographic methods were used in the study to assess internal changes, and no standard tools were applied to gather feedback from patients. The study did not look at the cost-effectiveness of the treatments, which is very important in making clinical decisions. More studies with large groups and randomized treatments across many centers are essential to confirm these conclusions and see how they relate to multiple dental conditions.

## CONCLUSION

This study showed that MIC maintained tooth structure and was also effective in removing caries. Unlike traditional methods, MIC helped preserve healthier tissue, leading to clinical outcomes as good as the older procedures. Allowing patients to stay more comfortable and reducing operation times were advantages of this approach.

Although the first effect looked good, it's necessary to continue checking to validate the long-term effectiveness of the procedure on tooth health. Adding MIC strategies to everyday dental practice can benefit both dental conservation and care focused on the patient. Additional studies involving larger sample sizes, more prolonged follow-up sessions, and cases that involve several cavity types are needed to make these findings reliable and to customize existing protocols.

## LIST OF ABBREVIATIONS

**MIC:** Minimally Invasive Cavity Preparation  
**MID:** Minimally Invasive Dentistry  
**M/F:** Male/Female  
**Post-op:** post-operative  
**SPSS:** Statistical Package for the Social Sciences  
**mm:** Millimeter  
**n:** Sample Size  
**SD:** Standard Deviation  
**p-value:** Probability Value  
**VAS:** Visual Analog Scale

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**CONFLICT OF INTEREST**

None

**ETHICAL APPROVAL**

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**AUTHORS' CONTRIBUTION**

All contributed equally as per ICMJE.

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