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Original Article

Influence of Selective Caries Removal on Post-Operative Sensitivity in Permanent Molars

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ABSTRACT

Background: Post-operative sensitivity after restoration of deep carious lesions is a common patient-centered concern that may reduce comfort and satisfaction after dental treatment. Complete caries excavation can increase pulpal irritation in deep lesions, whereas selective caries removal preserves affected dentin near the pulp and may reduce early discomfort. Objective: To compare short-term post-operative sensitivity after selective caries removal versus complete excavation in permanent molars with deep carious lesions. Methods: This randomized controlled trial enrolled 60 adults aged 18–45 years with deep occlusal or occlusoproximal caries in permanent molars. Participants were allocated equally to selective caries removal or complete excavation. All cavities were restored immediately using resin-modified glass ionomer cement under standardized clinical protocols. Post-operative sensitivity was assessed using a visual analogue scale at 24 hours, 72 hours, and 7 days. Biting sensitivity and the association between cavity depth and VAS scores were also evaluated. Results: Selective caries removal produced lower VAS scores than complete excavation at 24 hours (2.1 ± 0.9 vs. 3.8 ± 1.1), 72 hours (1.4 ± 0.7 vs. 2.6 ± 0.9), and 7 days (0.6 ± 0.4 vs. 1.2 ± 0.6). Biting sensitivity was also less frequent after selective removal at 24 hours and 72 hours. Cavity depth showed stronger positive correlations with sensitivity after complete excavation. Conclusion: Selective caries removal reduced early post-operative sensitivity compared with complete excavation in permanent molars, supporting conservative excavation for short-term patient comfort. Keywords: Caries, Dental; Dental Pulp; Postoperative Complications; Randomized Controlled Trial; Resin-Modified Glass Ionomer; Sensitivity, Dental; Tooth, Permanent.

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INTRODUCTION

Dental caries remains a major public health and clinical concern because progression of untreated lesions into dentin frequently requires operative restorative management. Permanent molars are particularly vulnerable because of their posterior position, occlusal anatomy, high functional loading, and frequent involvement in deep occlusal and occlusoproximal lesions. Conventional management of deep carious lesions has historically relied on complete caries excavation, in which softened dentin is removed until firm dentin is reached before placement of the definitive restoration. Although this technique aims to remove infected tissue and create a stable restorative foundation, excessive excavation in deep lesions may reduce remaining dentin thickness, increase pulpal proximity, and heighten the risk of pulpal irritation or exposure (1–3).

Post-operative sensitivity is an important patient-centered outcome after restorative treatment of deep carious lesions. It may occur as discomfort or pain in response to thermal stimuli, biting pressure, or spontaneous pulpal irritation, and even when short-lived, it can reduce patient satisfaction and confidence in restorative dental care. The development of post-operative sensitivity is multifactorial and may be influenced by cavity depth, remaining dentin thickness, dentinal tubule exposure, operative trauma, pulpal inflammation, restorative material properties, and individual pain perception. In deep lesions, complete excavation may intensify these mechanisms by removing affected but potentially remineralizable dentin from the pulpal floor, thereby reducing the biological barrier between the restoration and the dentin-pulp complex (4–7).

Selective caries removal has gained increasing attention as a minimally invasive alternative for managing deep carious lesions. This approach involves removing infected dentin from the peripheral cavity walls to ensure an adequate marginal seal while intentionally preserving affected dentin over the pulpal floor where further excavation may endanger pulp vitality. The rationale is based on the distinction between irreversibly infected dentin and affected dentin that may retain the capacity for remineralization under a well-sealed restoration. By preserving tooth structure and limiting operative trauma near the pulp, selective caries removal may reduce pulpal irritation and provide a more biologically favorable environment for restoration placement (8–10).

Despite the biological rationale supporting selective caries removal, clinical uncertainty remains regarding its routine use in permanent molars. Some clinicians remain concerned that residual affected dentin may permit bacterial persistence or lesion progression beneath restorations, while others emphasize the potential benefits of pulpal preservation and reduced operative trauma. Existing evidence has increasingly supported conservative caries management in relation to pulp vitality and restoration survival, but direct evaluation of short-term post-operative sensitivity as a patient-reported outcome remains less consistently addressed, particularly in adult permanent molars. This gap is clinically relevant because post-operative discomfort affects patient experience immediately after treatment and may influence acceptance of minimally invasive restorative approaches (11–14).

The present randomized controlled trial was therefore designed using a PICO framework. The population comprised adults aged 18–45 years with deep occlusal or occlusoproximal carious lesions in permanent molars; the intervention was selective caries removal; the comparator was complete caries excavation; and the primary outcome was post-operative sensitivity measured by visual analogue scale at 24 hours after restoration. Secondary outcomes included VAS sensitivity at 72 hours and 7 days, biting sensitivity at 24 hours, 72 hours, and 7 days, and the association between cavity depth and post-operative VAS scores. The study was conducted to test the hypothesis that selective caries removal would result in lower early post-operative sensitivity than complete excavation in permanent molars restored under standardized clinical conditions (15).

MATERIALS AND METHODS

This study was conducted as an individually randomized, two-arm, parallel-group controlled clinical trial comparing selective caries removal with complete caries excavation in permanent molars affected by deep carious lesions. The trial was carried out in outpatient dental clinics in the Urban Region of Sindh over a four-month recruitment and intervention period. Participants were allocated in a 1:1 ratio to either the selective caries removal group or the complete excavation group. Post-operative sensitivity outcomes were assessed at 24 hours, 72 hours, and 7 days after restoration, allowing evaluation of early patient-reported discomfort during the immediate post-operative period.

Eligible participants were adults aged 18–45 years presenting with at least one permanent molar having a deep occlusal or occlusoproximal carious lesion without clinical or radiographic signs of irreversible pulpitis. Teeth were considered eligible when the lesion required operative restorative treatment and the involved molar was suitable for direct restoration following caries removal. Participants were excluded if the affected tooth had a previous restoration, history of endodontic treatment, signs of irreversible pulpitis or pulpal necrosis, severe periodontal disease, or if the participant had a systemic condition likely to alter

pain perception or interfere with valid reporting of post-operative sensitivity. When more than one eligible molar was present in the same participant, one tooth was selected for intervention to avoid clustering of outcomes within individuals.

Participants were recruited consecutively from eligible patients attending the outpatient dental clinics during the study period. Eligibility was confirmed through clinical examination and radiographic assessment before enrollment. Written informed consent was obtained from all participants before randomization. Baseline demographic and clinical information was recorded before intervention, including age, sex, lesion location, baseline sensitivity score, and cavity-related clinical characteristics. Baseline sensitivity was assessed before operative treatment to document pre-treatment discomfort and support comparison between the intervention groups.

Randomization was performed using a computer-generated allocation sequence, and participants were assigned to the two study groups in equal numbers. Allocation concealment was maintained using sealed opaque envelopes that were opened only after participant enrollment and baseline data recording. This process was used to reduce selection bias and prevent foreknowledge of treatment assignment during recruitment. Because the two caries removal procedures were clinically distinguishable, operator blinding was not feasible; however, standardized operative protocols, predefined outcome measures, and uniform follow-up timing were used to reduce performance and measurement bias.

All restorative procedures were performed by experienced dental practitioners under rubber dam isolation to maintain a dry operative field and reduce contamination. In the selective caries removal group, infected dentin was removed from the peripheral cavity walls until firm dentin was achieved to support restoration sealing, while a layer of affected dentin was preserved over the pulpal floor in areas close to the pulp. In the complete excavation group, softened dentin was removed from the cavity, including the pulpal floor, until firm dentin was reached throughout the preparation. In both groups, cavities were restored immediately using resin-modified glass ionomer cement according to manufacturer-recommended conditioning and placement procedures. All restorations were completed during the same appointment, and no staged excavation protocol was used.

The primary outcome was post-operative sensitivity measured using a 10-point visual analogue scale at 24 hours after restoration. The VAS ranged from 0, indicating no pain or sensitivity, to 10, indicating the worst imaginable pain or sensitivity. Secondary outcomes included VAS sensitivity scores at 72 hours and 7 days, presence of biting sensitivity at 24 hours, 72 hours, and 7 days, and the relationship between cavity depth and post-operative VAS sensitivity scores. Biting sensitivity was assessed using a standardized patient-reported and clinical procedure in which participants reported discomfort during biting pressure after restoration. Follow-up assessments also included clinical evaluation for signs of pulpal inflammation, restoration failure, or need for emergency intervention during the short-term observation period.

The principal exposure variable was the caries removal technique, categorized as selective caries removal or complete excavation. The main continuous outcome variable was VAS sensitivity score at each follow-up time point, while biting sensitivity was treated as a categorical post-operative outcome. Baseline variables included age, sex, lesion location, baseline VAS sensitivity, and cavity-related clinical characteristics. Cavity depth was considered an important clinical variable because deeper lesions reduce remaining dentin thickness and may increase the risk of pulpal irritation, particularly when complete excavation is performed. Standardization of rubber dam isolation, operative technique within each group, restorative material, restoration timing, and follow-up intervals was used to improve reproducibility and limit procedural confounding.

The sample size consisted of 60 participants, with 30 participants assigned to the selective caries removal group and 30 assigned to the complete excavation group. This sample size was based on previous clinical studies evaluating post-operative sensitivity after caries removal, in which approximately 25–30 participants per arm were considered adequate to detect clinically meaningful differences in early pain outcomes. Equal allocation was used to maintain balance between groups and improve precision of comparative estimates for post-operative sensitivity.

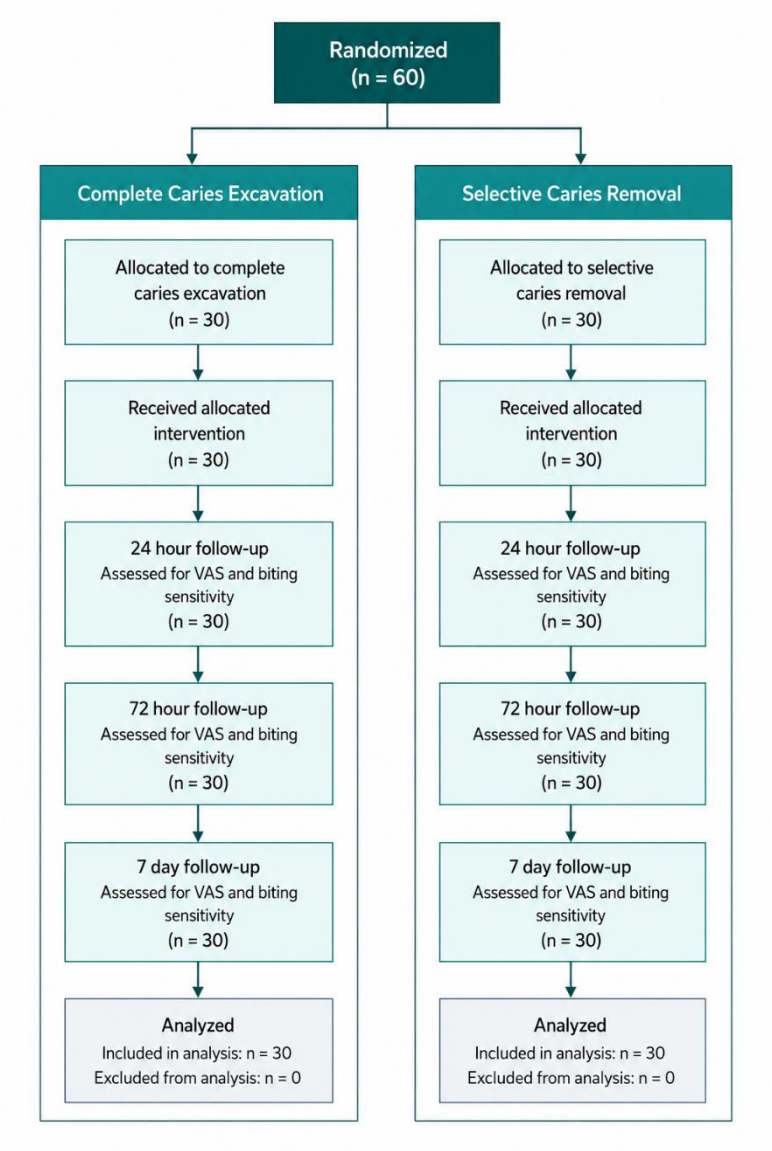

Figure 1 CONSORT Flowchart

Data were checked for completeness, consistency, and plausibility before statistical analysis. Continuous variables were summarized as mean and standard deviation, while categorical variables were summarized as frequency and percentage. Baseline comparability between groups was assessed descriptively and through appropriate statistical comparisons. Normality of continuous variables was evaluated using the Shapiro–Wilk test. Between-group differences in VAS sensitivity scores at individual follow-up time points were assessed using independent-samples t-tests when assumptions were satisfied. Repeated-measures analysis was used to evaluate the change in VAS sensitivity over time and to assess whether the pattern of post-operative sensitivity differed between the two treatment groups. Categorical outcomes, including biting sensitivity, were compared using Chi-square testing, with Fisher's exact test considered where expected cell counts were small. Correlation analysis was used to examine the association between cavity depth and post-operative VAS scores within each treatment group. Statistical significance was set at $p < 0.05$.

All randomized participants were included in the final analysis because complete follow-up data were available at 24 hours, 72 hours, and 7 days. No participant required emergency intervention, and no intraoperative complication requiring exclusion from analysis was reported. Written informed consent was obtained from all participants, and confidentiality of participant information was maintained throughout data collection, analysis, and reporting. The study procedures were planned to ensure participant safety, reproducibility of the intervention, transparent outcome assessment, and consistency with ethical principles for clinical research involving human participants.

RESULTS

A total of 60 participants were enrolled and randomized equally into the selective caries removal group and the complete excavation group, with 30 participants in each arm. Recruitment and intervention procedures were completed over four months, while post-operative sensitivity outcomes were assessed during the first 7 days after restoration. All randomized participants completed the 24-hour, 72-hour, and 7-day follow-up assessments, and all were included in the final analysis. No intraoperative pulp exposure, emergency intervention, or post-operative restoration failure was reported during the short-term follow-up period.

Table 1. Baseline Demographic and Clinical Characteristics of Participants

Variable	Total Sample (N=60)	Selective Removal (n=30)	Complete Excavation (n=30)	p-value
Age, years, Mean ± SD	28.4 ± 6.2	28.1 ± 6.0	28.7 ± 6.4	0.709
Female, n (%)	32 (53.3)	16 (53.3)	16 (53.3)	1.000
Male, n (%)	28 (46.7)	14 (46.7)	14 (46.7)	1.000
Occlusal lesion, n (%)	39 (65.0)	20 (66.7)	19 (63.3)	0.787
Occlusoproximal lesion, n (%)	21 (35.0)	10 (33.3)	11 (36.7)	0.787
Baseline sensitivity VAS, Mean ± SD	2.3 ± 0.8	2.2 ± 0.7	2.4 ± 0.9	0.341

Footnote: Continuous variables were compared using independent-samples t-tests from reported summary values. Categorical variables were compared using Chi-square or Fisher exact testing as appropriate. VAS, visual analogue scale; SD, standard deviation.

Baseline characteristics were balanced between the two randomized groups. The mean age was 28.1 ± 6.0 years in the selective removal group and 28.7 ± 6.4 years in the complete excavation group, with no statistically important difference between groups. Sex distribution was identical across both arms, with females representing 53.3% of each group. Lesion distribution was also comparable, with occlusal lesions present in 66.7% of the selective removal group and 63.3% of the complete excavation group. Baseline VAS sensitivity was similar between groups, with mean scores of 2.2 ± 0.7 and 2.4 ± 0.9, respectively, supporting baseline comparability before intervention.

Table 2. Post-Operative VAS Sensitivity Scores by Treatment Group

Time Point	Selective Removal, Mean ± SD	Complete Excavation, Mean ± SD	Mean Difference	95% CI	p-value	Cohen's d
24 hours	2.1 ± 0.9	3.8 ± 1.1	-1.70	-2.22 to -1.18	<0.001	-1.69
72 hours	1.4 ± 0.7	2.6 ± 0.9	-1.20	-1.62 to -0.78	<0.001	-1.49
7 days	0.6 ± 0.4	1.2 ± 0.6	-0.60	-0.86 to -0.34	<0.001	-1.18

Footnote: Mean difference was calculated as selective removal minus complete excavation. Confidence intervals, p-values, and Cohen's d were derived from reported group means, standard deviations, and sample sizes. VAS, visual analogue scale; SD, standard deviation; CI, confidence interval.

Post-operative VAS sensitivity was consistently lower in the selective caries removal group than in the complete excavation group at all follow-up points. At 24 hours, the selective removal group had a mean VAS score of 2.1 ± 0.9 compared with 3.8 ± 1.1 in the complete excavation group, corresponding to a mean difference of -1.70 points and a large standardized effect. At 72 hours, the between-group difference remained evident, with scores of 1.4 ± 0.7 versus 2.6 ± 0.9 and a mean difference of -1.20 points. By day 7, sensitivity had decreased in both groups, but the selective removal group still showed lower VAS sensitivity, with a mean difference of -0.60 points. The progressive reduction across follow-up indicates that post-operative sensitivity declined over time in both groups, while the complete excavation group retained higher sensitivity throughout the short-term recovery period.

Table 3. Post-Operative Biting Sensitivity by Treatment Group

Time Point	Selective Removal, n (%)	Complete Excavation, n (%)	Risk Difference	95% CI	Relative Risk	95% CI	Odds Ratio	95% CI	Fisher Exact p-value
24 hours	6 (20.0)	15 (50.0)	-0.30	-0.53 to -0.07	0.40	0.18 to 0.89	0.25	0.08 to 0.79	0.029
72 hours	3 (10.0)	10 (33.3)	-0.23	-0.43 to -0.03	0.30	0.09 to 0.98	0.22	0.05 to 0.91	0.057
7 days	1 (3.3)	4 (13.3)	-0.10	-0.24 to 0.04	0.25	0.03 to 2.11	0.22	0.02 to 2.14	0.353

Footnote: Risk difference was calculated as selective removal minus complete excavation. Relative risk and odds ratio compare selective removal with complete excavation. Fisher exact testing was used because of small event counts at some follow-up points. CI, confidence interval.

Biting sensitivity followed the same direction as VAS sensitivity, with fewer events in the selective removal group at each follow-up point. At 24 hours, biting sensitivity was reported by 20.0% of participants after selective removal compared with 50.0% after complete excavation, corresponding to a risk difference of -0.30 and a relative risk of 0.40. At 72 hours, biting sensitivity decreased to 10.0% in the selective removal group and 33.3% in the complete excavation group, with a relative risk of 0.30. By day 7, the frequency was low in both groups, affecting 3.3% and 13.3% of participants, respectively. The exact-test p-value at 72 hours was 0.057 despite a favorable risk estimate, indicating that the result should be interpreted cautiously because of the small number of events.

Table 4. Correlation Between Cavity Depth and Post-Operative VAS Sensitivity Scores

Group	Time Point	r	95% CI	p-value
Selective Removal	24 hours	0.31	-0.06 to 0.60	0.095
Selective Removal	72 hours	0.22	-0.15 to 0.54	0.243
Selective Removal	7 days	0.15	-0.22 to 0.48	0.429
Complete Excavation	24 hours	0.62	0.33 to 0.80	<0.001
Complete Excavation	72 hours	0.48	0.14 to 0.72	0.007
Complete Excavation	7 days	0.32	-0.05 to 0.61	0.085

Footnote: Confidence intervals and p-values were derived from reported Pearson correlation coefficients using n=30 per group. VAS, visual analogue scale; CI, confidence interval.

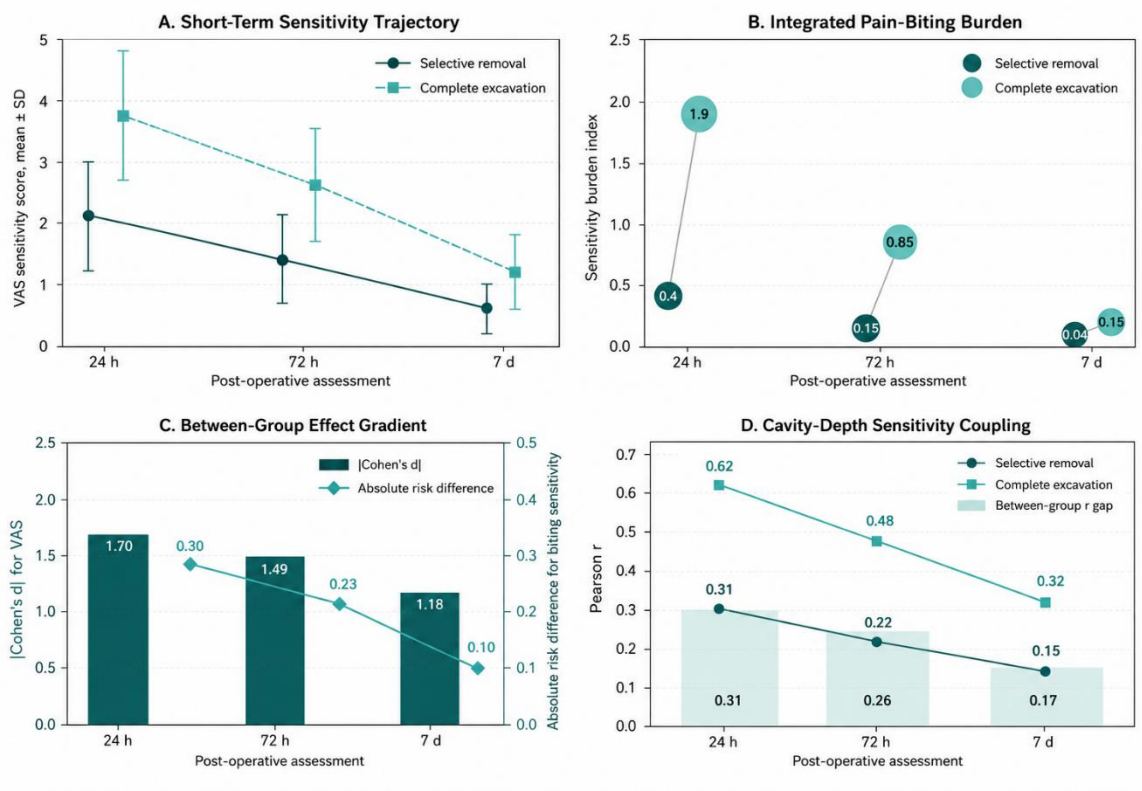

Figure 2 Integrated Short-Term Post-Operative Sensitivity Profile After Selective Caries Removal Versus Complete Excavation

The panelled figure demonstrates a consistent reduction in early post-operative sensitivity after selective caries removal compared with complete excavation. Mean VAS sensitivity remained lower after selective removal at 24 hours, 72 hours, and 7 days, with the largest absolute difference observed at 24 hours. The integrated sensitivity burden index, derived by multiplying mean VAS score by the corresponding biting sensitivity proportion, showed a substantially higher early symptom burden after complete excavation, particularly at 24 hours, where the burden index was 1.90 compared with 0.42 after selective removal. The between-group effect gradient showed large standardized differences in VAS sensitivity across all time

points, while the absolute difference in biting sensitivity was greatest at 24 hours. The cavity-depth correlation profile further indicated stronger coupling between lesion depth and post-operative sensitivity after complete excavation, with the largest correlation gap at 24 hours, supporting the clinical interpretation that preservation of affected dentin over the pulpal floor may attenuate depth-related post-operative discomfort in deep permanent molar lesions.

Cavity depth showed a stronger positive association with post-operative VAS sensitivity in the complete excavation group than in the selective removal group. In the complete excavation group, cavity depth was associated with higher VAS sensitivity at 24 hours, with r=0.62 and a 95% CI of 0.33 to 0.80. The association remained evident at 72 hours, with r=0.48 and a 95% CI of 0.14 to 0.72, but weakened by day 7. In the selective removal group, the correlations were smaller at all time points and the confidence intervals crossed zero, suggesting that preservation of affected dentin over the pulpal floor may have reduced the relationship between lesion depth and early post-operative discomfort.

Overall, the findings indicate that selective caries removal was associated with lower short-term post-operative sensitivity than complete excavation in permanent molars. The largest between-group difference was observed at 24 hours, with a mean VAS reduction of 1.70 points and lower biting sensitivity frequency in the selective removal group. Although sensitivity decreased over time in both groups, the selective removal group maintained lower VAS scores through day 7. The correlation findings further suggest that cavity depth was more strongly related to post-operative discomfort when complete excavation was performed, supporting the clinical relevance of conservative pulpal-floor dentin preservation in deep carious lesions.

DISCUSSION

The present randomized controlled trial demonstrated that selective caries removal was associated with lower short-term post-operative sensitivity than complete caries excavation in permanent molars with deep occlusal or occlusoproximal carious lesions. The difference was most pronounced during the immediate post-operative period, with the selective removal group reporting lower VAS scores at 24 hours and 72 hours, followed by continued but smaller between-group separation at 7 days. Biting sensitivity followed a similar clinical pattern, occurring less frequently after selective removal during early follow-up. These findings support the biological premise that preserving affected dentin over the pulpal floor may reduce operative trauma, maintain a protective dentin barrier, and lessen early stimulation of the dentin-pulp complex. The results are particularly relevant because post-operative sensitivity is a patient-centered outcome that directly influences comfort, satisfaction, and confidence after restorative treatment.

The observed reduction in early sensitivity is consistent with the principles of minimally invasive dentistry and vital pulp preservation. Complete excavation in deep lesions may reduce remaining dentin thickness and increase dentinal tubule exposure, thereby increasing fluid movement and pulpal irritation. In contrast, selective caries removal aims to remove infected dentin from the cavity periphery while preserving affected dentin near the pulp, where additional excavation may increase the risk of pulpal insult. This conservative approach is supported by evidence suggesting that the dentin-pulp complex may respond favorably when the lesion is sealed and unnecessary pulpal-floor excavation is avoided (16). The present findings extend this concept by showing clinically measurable differences in patient-reported sensitivity during the first week after restoration.

The correlation findings provide additional insight into the possible mechanism of reduced sensitivity. Cavity depth showed a stronger positive association with post-operative VAS scores in the complete excavation group than in the selective removal group, especially at 24 hours and 72 hours. This suggests that deeper lesions may produce greater discomfort when complete excavation is performed, likely because aggressive dentin removal places the restoration closer to the pulp and increases pulpal vulnerability. In the selective removal group, the weaker depth-sensitivity association indicates that preservation of affected dentin may attenuate the clinical impact of cavity depth on early post-operative discomfort. This interpretation remains biologically plausible but should be considered cautiously

because correlation analysis does not establish causality and cavity-depth measurement details were not fully reported.

The results are also compatible with emerging clinical evidence on selective caries removal and conservative management of deep lesions. Recent clinical work has highlighted the potential of selective caries removal to reduce post-operative sensitivity in deep cavities, while other studies have emphasized that conservative excavation may preserve pulp vitality and maintain acceptable restorative outcomes when an adequate peripheral seal is achieved (17,18). The present study contributes to this evidence by focusing on adult permanent molars and by using repeated short-term sensitivity assessments at clinically relevant time points. The magnitude of the VAS differences, particularly at 24 hours and 72 hours, suggests that the benefit is not limited to statistical significance but may also have practical relevance for patient comfort during the early recovery period.

Several methodological features strengthen the interpretation of the findings. The randomized allocation of participants into equal groups improved baseline comparability and reduced selection bias. The use of standardized operative procedures, rubber dam isolation, immediate restoration with the same restorative material, and uniform assessment intervals reduced procedural variability. Complete follow-up through 7 days minimized attrition bias and allowed all randomized participants to be included in the final analysis. The use of both VAS sensitivity and biting sensitivity also provided complementary assessment of post-operative discomfort, combining a continuous patient-reported pain scale with a clinically relevant functional symptom.

Despite these strengths, the findings should be interpreted within important limitations. The sample size was modest, with 30 participants per group, and the study was conducted in a single urban region, which may limit generalizability to broader populations, rural settings, or patients with different caries patterns. The follow-up period was limited to 7 days, so the study cannot determine long-term restoration survival, pulp vitality, secondary caries development, or delayed pulpal complications. Operator blinding was not feasible because the intervention techniques were clinically distinguishable, and the manuscript does not provide sufficient detail regarding assessor blinding, operator calibration, trial registration, or formal sample-size calculation parameters. In addition, post-operative sensitivity is partly subjective and may be influenced by individual pain thresholds, anxiety, prior dental experiences, and reporting behavior. These limitations do not negate the observed short-term benefit but do require a conservative interpretation of the clinical implications.

The study also has statistical considerations relevant to interpretation. Repeated comparisons across multiple time points may increase the risk of type I error if not handled through a prespecified primary endpoint or repeated-measures model. The revised analysis appropriately identifies 24-hour VAS sensitivity as the primary endpoint and treats later VAS scores and biting sensitivity as secondary outcomes. Biting sensitivity involved small event counts at later follow-up, making exact testing more appropriate than routine Chi-square testing. Future trials should prespecify the primary outcome, report effect estimates with 95% confidence intervals, include group-by-time interaction testing, and consider mixed-effects models to account for repeated measures and baseline sensitivity.

Clinically, the findings support selective caries removal as a reasonable conservative approach for reducing early post-operative sensitivity in comparable deep permanent molar lesions, provided that case selection, peripheral sealing, and restorative technique are carefully controlled. The results should not be interpreted as evidence that selective removal is superior for all carious lesions or that it guarantees long-term restorative success. Rather, the study suggests that when deep lesions are managed under standardized conditions, preservation of affected dentin near the pulp may offer a short-term comfort advantage over complete excavation. Larger multicenter randomized trials with longer follow-up, clearly defined cavity-depth measurements, assessor blinding where feasible, and evaluation of pulp vitality and restoration survival are needed to determine whether this early symptomatic benefit translates into durable clinical advantage (19–23).

CONCLUSION

Selective caries removal in permanent molars with deep carious lesions was associated with significantly lower short-term post-operative sensitivity than complete caries excavation, particularly during the first 24 to 72 hours after restoration. The technique also showed lower biting sensitivity and appeared to reduce the influence of cavity depth on early post-operative discomfort. These findings support the use of selective caries removal as a conservative, patient-centered approach for managing deep molar caries when appropriate sealing and restorative protocols are followed. However, because the study was limited by modest sample size, single-region recruitment, and short 7-day follow-up, the conclusions should be restricted to early post-operative sensitivity rather than long-term restoration success or pulp survival.

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