

Original Article

Chemomechanical Caries Removal Versus Conventional Drilling for Managing Deep Carious Lesions in Primary Molars of Preschool Children

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Received: 02 January 2026

Revised: 13 January 2026

Accepted: 03 March 2026

Published: 15 March 2026

HOW TO CITE

Muhammad Haris Zia et al. 2026. Chemomechanical Caries Removal Versus Conventional Drilling for Managing Deep Carious Lesions in Primary Molars of Preschool Children. Journal of Health, Wellness and Community Research. 4, 5 (Mar. 2026), 1–7. DOI:https://doi.org/10.61919/hhcnm264

ARTICLE INFORMATION

Author Contributions	Concept: MHZ, IK; Design: MHZ, IK, FN; Data Collection: FN, AA, SN, NF, AS; Analysis: MHZ, IK; Drafting: MHZ, FN, AA, SN, NF, AS. All authors reviewed and approved the final manuscript.
Ethical Approval	The study was approved by research ethical board of Watim Dental College & Hospital, Rawalpindi, Pakistan
Informed Consent	Written informed consent was obtained from all participants
Conflict of Interest	The authors declare no conflict of interest.
Funding	No external funding.
Data Availability	Available from the corresponding author on reasonable request.
AI Declaration	No generative AI was used for conceptualization, analysis, or content generation. AI use was limited to language refinement, and the authors remain fully responsible for the accuracy, originality, validity, and integrity of the manuscript's content.

ABSTRACT

Background: Conventional rotary caries excavation may produce pain and unfavorable behavioral responses in preschool children, whereas chemomechanical techniques may provide a less mechanically intensive alternative. **Objective:** To compare immediate pain perception, behavioral cooperation, and caries-removal time between papain-based chemomechanical excavation with Cariclast and conventional rotary bur excavation in preschool children with deep carious lesions in primary molars. **Methods:** This assessor-blinded, two-arm parallel randomized controlled trial was conducted in Central Punjab, Pakistan, from August 2025 to December 2025. Eighty children aged 3–5 years were randomized equally between treatment groups. Pain was assessed using the Wong-Baker FACES Pain Rating Scale, behavioral cooperation using the Frankl Behavior Rating Scale, and procedure duration in minutes. Complete-case outcome analyses included 76 children (38/group). **Results:** Mean post-treatment pain was lower with Cariclast than with rotary excavation (1.84 ± 0.92 vs 4.68 ± 1.14 ; mean difference -2.84 , 95% CI -3.31 to -2.37 ; $p < 0.001$). Frankl scores were higher with Cariclast (3.42 ± 0.55 vs 2.21 ± 0.66 ; mean difference 1.21 , 95% CI 0.93 to 1.49 ; $p < 0.001$). Caries-removal time was longer with Cariclast (18.45 ± 3.12 vs 9.24 ± 2.05 minutes; $p < 0.001$). **Conclusion:** Cariclast was associated with lower immediate pain and more favorable behavioral cooperation but required longer caries-removal time than conventional rotary excavation. **Keywords:** Cariclast; Chemomechanical caries removal; Dental caries; Papain; Pediatric dentistry; Primary molars; Randomized controlled trial.

INTRODUCTION

Dental caries remains a common oral health problem in children and, when lesions progress deeply into dentin, may compromise tooth structure, pulpal health, mastication, and the preservation of primary teeth until their normal

exfoliation. Management of deeply carious lesions in preschool children is particularly challenging because effective removal of infected dentin must be balanced against the child's ability to tolerate the procedure. Conventional rotary excavation provides relatively rapid removal of carious tissue but may expose young children to mechanical vibration, noise, pressure, and other sensory stimuli that can increase procedural discomfort and adversely influence cooperation during dental treatment (1,2).

Minimally invasive approaches have therefore received increasing attention in pediatric restorative dentistry. Chemomechanical caries removal is designed to soften infected dentin chemically or enzymatically so that it can be removed with hand instruments while reducing reliance on rotary instrumentation. Papain-based preparations are among the agents developed for this purpose and are intended to facilitate selective removal of softened carious dentin while preserving comparatively firm underlying tissue (1). Clinical studies in pediatric populations have suggested that chemomechanical techniques may reduce pain and improve treatment acceptability when compared with conventional rotary excavation, although these potential benefits are commonly accompanied by a longer excavation time (2,3).

Previous randomized clinical investigations have examined chemomechanical caries removal in primary teeth using products such as Papacarie and Carie-Care. Akindele et al. compared chemomechanical and conventional mechanical caries removal in children with carious primary molars and reported advantages of the chemomechanical approach in relation to pain and treatment acceptability (2). Similarly, Katiyar et al. evaluated chemomechanical and rotary-mechanical caries removal with respect to treatment time and pain perception in pediatric dental patients, demonstrating that patient comfort and procedural efficiency may differ substantially between the two approaches (3). Comparative evidence has also shown that minimally invasive caries-removal techniques can influence children's pain experience during restorative treatment (4). In addition, a randomized clinical trial evaluating Carie-Care in primary teeth reported differences in treatment duration, pain or comfort, and behavioral response, further supporting the relevance of patient-centered outcomes when selecting an excavation technique for children (5).

Despite this evidence, uncertainty remains regarding the relative performance of papain-based chemomechanical excavation specifically in preschool children aged 3–5 years with deep carious lesions in primary molars. This age group presents particular clinical challenges because limited coping ability and tolerance of dental procedures may influence both pain reporting and behavioral cooperation. Moreover, the potential improvement in immediate comfort and cooperation associated with avoidance of rotary instrumentation must be considered alongside the longer procedural time frequently reported for chemomechanical techniques. Direct evidence simultaneously examining pain perception, behavioral cooperation, and excavation time in this narrowly defined preschool population therefore remains clinically relevant.

Accordingly, this randomized controlled trial was conducted to compare papain-based chemomechanical caries removal using Cariclast with conventional rotary bur excavation in preschool children requiring management of deep carious lesions in primary molars. The study evaluated immediate post-treatment pain perception using the Wong-Baker FACES Pain Rating Scale, behavioral cooperation using the Frankl Behavior Rating Scale, and caries-removal time. It was hypothesized that chemomechanical excavation would be associated with lower pain scores and more favorable behavioral cooperation than conventional rotary excavation, although requiring a longer procedural duration.

MATERIAL AND METHODS

This assessor-blinded, two-arm, parallel-group randomized controlled trial was conducted over six months, from August 2025 to December 2025, in a pediatric dentistry setting in Central Punjab, Pakistan. The study was designed to compare papain-based chemomechanical caries removal using Cariclast with conventional rotary bur excavation in preschool children with deep carious lesions affecting primary molars. Children aged 3–5 years were screened for eligibility. Participants were eligible if they had at least one occlusal deep carious lesion extending into dentin in a primary molar and had no history of spontaneous pulpal pain, swelling, or fistula formation. Children with systemic illness, special healthcare needs, known allergy to papain or latex, or uncooperative behavior at the baseline assessment were excluded.

A total sample of 80 children was planned. The sample-size determination was based on statistical power assumptions derived from comparable published interventional studies in pediatric cariology, using a two-sided significance level of 5%, statistical power of 80%, and an anticipated dropout rate of 10%. During recruitment, 92 children were screened; 12 either did not meet the eligibility criteria or declined participation, leaving 80 participants for randomization. Participants were allocated in a 1:1 ratio to the Cariclast chemomechanical group or the conventional rotary bur group, with 40 children initially assigned to each arm.

The random allocation sequence was generated using computer-based block randomization with variable block sizes. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes, which were opened by an independent clinical assistant immediately before treatment. Because the two caries-removal procedures differed visibly and mechanically, blinding of the treating operator and participating children was not feasible. Outcome assessors responsible for behavioral assessment and procedural evaluation were kept unaware of group allocation. Baseline demographic and clinical information included age, sex, primary molar location, and baseline behavioral status assessed using the Frankl Behavior Rating Scale.

Children allocated to the intervention group underwent chemomechanical caries removal using a papain-based gel (Cariclast). The gel was applied directly to the carious cavity and allowed to act for approximately 30–60 seconds to soften the degraded dentinal tissue. The softened material was then removed gently using blunt spoon excavators. Application and excavation cycles were repeated until the gel remained clear and the cavity floor was clinically firm on examination. Caries excavation in this group was performed without local anesthesia. Children assigned to the control group underwent conventional caries excavation using low-speed round steel burs under continuous water irrigation following rubber dam isolation. Both treatment protocols were delivered during a single clinical session.

Pain perception was assessed immediately after completion of the caries-removal procedure using the Wong-Baker FACES Pain Rating Scale. Behavioral cooperation was assessed using the Frankl Behavior Rating Scale at baseline and following treatment. Procedural duration was recorded in minutes using a digital stopwatch and represented the time required to complete the caries-removal procedure. Higher Wong-Baker scores represented greater perceived pain, whereas higher Frankl ratings represented more favorable behavioral cooperation. The principal comparisons therefore examined post-treatment pain, post-treatment behavioral cooperation, change in Frankl behavior from baseline, and caries-removal time between the two treatment groups.

Of the 80 randomized participants, four had incomplete final outcome data because of uncooperative behavior during the final assessment or incomplete data capture; two were from the Cariclast group and two were from the rotary bur group. Consequently, inferential analyses were performed on the 76 participants with complete outcome data, comprising 38 children in each group. Baseline characteristics were summarized for the full randomized cohort of 80 participants, whereas post-intervention and change analyses were based on the final complete-case sample of 76 participants.

Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. Distributional normality of continuous variables was evaluated using the Shapiro-Wilk test. Between-group comparisons of continuous outcomes were performed using independent-samples t-tests, while categorical baseline characteristics were compared using chi-square tests. Within-group changes in behavioral scores from baseline to post-treatment were evaluated using paired-samples t-tests. Changes in behavioral cooperation over time and differences in these changes between treatment groups were further examined using repeated-measures analysis of variance, including time, treatment group, and the time-by-group interaction. Pearson correlation analysis was used to examine the relationship between procedural duration and post-treatment pain scores separately within each treatment group. Effect estimates for principal between-group comparisons were reported with 95% confidence intervals, and statistical significance was set at a two-sided p-value of <0.05.

RESULTS

A total of 92 preschool children were screened for eligibility. Twelve did not meet the eligibility criteria or declined participation, leaving 80 children who underwent randomization. Forty participants were allocated to chemomechanical caries removal with Cariclast and 40 to conventional rotary bur excavation. Four participants had

incomplete final outcome data, with two from each group, resulting in 76 participants with complete post-treatment data for the outcome analyses.

Baseline demographic and clinical characteristics of the randomized participants are presented in Table 1. The mean age of the total cohort was 4.12 ± 0.74 years, and 42 (52.5%) participants were male. Mandibular primary molars accounted for 46 (57.5%) of the treated teeth. Baseline characteristics were comparable between the treatment groups, including age (4.15 ± 0.71 vs 4.08 ± 0.77 years; $p=0.672$) and baseline Frankl behavior score (2.08 ± 0.60 vs 2.12 ± 0.64 ; $p=0.775$).

Table 1. Baseline demographic and clinical characteristics of randomized participants (N=80)

Characteristic	Total sample (N=80)	Cariclast group (n=40)	Rotary bur group (n=40)	p-value
Age, years	4.12 ± 0.74	4.15 ± 0.71	4.08 ± 0.77	0.672
Male sex, n (%)	42 (52.5)	22 (55.0)	20 (50.0)	0.653
Female sex, n (%)	38 (47.5)	18 (45.0)	20 (50.0)	—
Mandibular primary molar, n (%)	46 (57.5)	24 (60.0)	22 (55.0)	0.651
Maxillary primary molar, n (%)	34 (42.5)	16 (40.0)	18 (45.0)	—
Baseline Frankl score	2.10 ± 0.62	2.08 ± 0.60	2.12 ± 0.64	0.775

Data are presented as mean $\pm$ SD or n (%). Between-group comparisons were performed using independent-samples t-tests for continuous variables and chi-square tests for categorical variables. SD, standard deviation.

Table 2. Between-group comparison of post-treatment outcomes among participants with complete outcome data (n=76)

Outcome	Cariclast group (n=38), mean $\pm$ SD	Rotary bur group (n=38), mean $\pm$ SD	Mean difference (95% CI)	p-value	Hedges g
Wong-Baker FACES pain score	1.84 ± 0.92	4.68 ± 1.14	$-2.84 (-3.31 \text{ to } -2.37)$	<0.001	-2.71
Frankl behavior score	3.42 ± 0.55	2.21 ± 0.66	$1.21 (0.93 \text{ to } 1.49)$	<0.001	—
Caries-removal time, min	18.45 ± 3.12	9.24 ± 2.05	$9.21 (8.00 \text{ to } 10.42)$	<0.001	3.45

Mean differences are calculated as Cariclast minus rotary burs. CI, confidence interval; SD, standard deviation. Hedges g was calculated from the reported group means, standard deviations, and sample sizes.

Table 3. Baseline-to-post-treatment change in Frankl behavior scores among participants with complete outcome data (n=76)

Group	Baseline, mean $\pm$ SD	Post-treatment, mean $\pm$ SD	Mean change (95% CI)	p-value
Cariclast (n=38)	2.08 ± 0.60	3.42 ± 0.55	$1.34 (1.11 \text{ to } 1.57)$	<0.001
Rotary bur (n=38)	2.12 ± 0.64	2.21 ± 0.66	$0.09 (-0.16 \text{ to } 0.34)$	0.482

Positive change values indicate higher post-treatment Frankl scores. Within-group comparisons were reported using paired-samples t-tests. CI, confidence interval; SD, standard deviation.

Table 4. Association between caries-removal time and post-treatment pain score (n=76)

Group	n	Pearson r	95% CI	p-value
Cariclast	38	0.12	$-0.21 \text{ to } 0.42$	0.473
Rotary bur	38	0.58	$0.32 \text{ to } 0.76$	<0.001

CI, confidence interval. Confidence intervals for Pearson correlation coefficients were derived using Fisher z transformation.

Post-treatment outcomes are presented in Table 2. Children treated with Cariclast had a mean Wong-Baker FACES pain score of 1.84 ± 0.92 compared with 4.68 ± 1.14 in the rotary bur group, corresponding to a mean between-group difference of -2.84 points (95% CI -3.31 to -2.37 ; $p<0.001$). The standardized between-group difference for pain was Hedges $g=-2.71$. Post-treatment Frankl behavior scores were 3.42 ± 0.55 in the Cariclast group and 2.21 ± 0.66 in the rotary bur group, with a mean difference of 1.21 points (95% CI 0.93 to 1.49 ; $p<0.001$).

Changes in behavioral scores from baseline are shown in Table 3. The Cariclast group demonstrated a mean increase of 1.34 points in Frankl score (95% CI 1.11 to 1.57 ; $p<0.001$), whereas the rotary bur group showed a mean change of 0.09 points (95% CI -0.16 to 0.34 ; $p=0.482$). The reported repeated-measures analysis demonstrated a time effect ($F=142.65$, $p<0.001$), a group effect ($F=68.32$, $p<0.001$), and a time-by-group interaction ($F=84.12$, $p<0.001$).

Caries-removal time was longer with chemomechanical excavation. The mean procedure duration was 18.45 ± 3.12 minutes in the Cariclast group compared with 9.24 ± 2.05 minutes in the rotary bur group, giving a between-group difference of 9.21 minutes (95% CI 8.00 to 10.42; $p < 0.001$) and a standardized mean difference of Hedges $g = 3.45$.

The association between procedural duration and post-treatment pain is presented in Table 4. In the Cariclast group, caries-removal time was weakly correlated with pain score ($r = 0.12$, 95% CI -0.21 to 0.42 ; $p = 0.473$). In the rotary bur group, the corresponding correlation was positive ($r = 0.58$, 95% CI 0.32 to 0.76 ; $p < 0.001$).

DISCUSSION

The present randomized controlled trial found that papain-based chemomechanical caries removal with Cariclast was associated with lower immediate post-treatment pain and more favorable behavioral cooperation than conventional rotary bur excavation in preschool children with deep carious lesions in primary molars. These patient-centered advantages were accompanied by a substantially longer caries-removal time. Taken together, the findings indicate a clinically relevant trade-off between procedural comfort and treatment duration when selecting a caries-removal approach for young children.

The lower pain scores observed with chemomechanical excavation are consistent with previous pediatric studies comparing enzymatic or chemomechanical caries-removal techniques with conventional rotary excavation. Akindele et al. reported lower pain and better treatment acceptability with Papacarie compared with conventional mechanical caries removal in children with primary molar caries (2). Katiyar et al. similarly demonstrated differences in pain perception and treatment duration between chemomechanical and rotary-mechanical methods in pediatric dental patients (3). Comparable findings have also been reported in randomized studies evaluating minimally invasive caries-removal approaches, in which chemomechanical treatment was associated with favorable pain-related outcomes during restorative care (4). These observations support the present finding that reducing reliance on rotary instrumentation may improve the immediate treatment experience for young children.

Several procedural features may plausibly contribute to the lower pain scores observed with the chemomechanical approach. Papain-based agents are intended to soften degraded carious dentin so that it can be removed with hand instruments, thereby reducing the need for prolonged rotary instrumentation and the associated vibration, pressure, and acoustic stimulation (1). These differences in sensory exposure may be particularly relevant in preschool children, who may have limited ability to cope with unfamiliar dental stimuli. However, the present study did not directly measure dental anxiety, pulpal nociception, or physiological responses to vibration; therefore, these mechanisms should be regarded as plausible explanations rather than demonstrated biological pathways.

Behavioral cooperation was also more favorable following chemomechanical treatment. This finding is broadly consistent with previous clinical evidence suggesting that chemomechanical methods may improve treatment acceptability in children (2,5). Ghanem et al., in a randomized clinical trial evaluating Carie-Care in primary teeth, reported favorable responses in child comfort and behavior despite the greater time required for chemomechanical excavation (5). In the present study, the Frankl score increased more substantially in the Cariclast group than in the rotary bur group. This pattern suggests that a less mechanically intensive excavation technique may support better cooperation during treatment. Nevertheless, because the Frankl Behavior Rating Scale reflects observed behavior rather than a direct measure of anxiety, the findings should not be interpreted as evidence that chemomechanical treatment reduced dental anxiety itself.

The main disadvantage of the chemomechanical technique was its longer procedure time. Caries removal required approximately twice as long with Cariclast as with conventional rotary burs, a finding consistent with earlier comparative studies in pediatric dentistry (3,5). The additional time is likely related to the need for repeated application, softening, and manual excavation cycles. Longer chair time is clinically relevant in preschool children because tolerance of prolonged mouth opening and sustained cooperation may be limited. The choice of technique may therefore depend on the relative importance of reducing procedural discomfort versus completing excavation more rapidly, as well as the individual child's behavior, clinical condition, and treatment setting (7).

The observed association between treatment duration and pain differed between the two groups. Procedure time showed little association with pain in the Cariclast group, whereas a moderate positive correlation was reported in the rotary bur group. This pattern may indicate that longer exposure to rotary instrumentation is accompanied by

greater discomfort in some children. However, because the analysis was correlational and based on a relatively small complete-case sample, the finding should be interpreted cautiously and does not establish that treatment duration itself caused higher pain (8,9).

From a clinical perspective, the present findings suggest that papain-based chemomechanical excavation may be useful when minimizing immediate procedural discomfort and promoting behavioral cooperation are important treatment considerations. This may be particularly relevant in young children who can complete treatment but have limited tolerance for rotary instrumentation. At the same time, the longer excavation time should be incorporated into clinical decision-making. The present findings should not be interpreted as demonstrating superior overall clinical effectiveness, because the study evaluated immediate pain, behavior, and procedural duration rather than long-term restorative survival, recurrent caries, pulpal outcomes, or objective completeness of caries removal (10,11).

The study has several strengths. Random allocation, allocation concealment using sequentially numbered opaque sealed envelopes, balanced treatment groups, and the use of established pediatric pain and behavior scales provided a structured basis for comparison. Restriction to children aged 3–5 years also allowed evaluation of a clinically important preschool population that can be difficult to manage during operative dental treatment. In addition, the study assessed both patient-centered outcomes and procedural duration, thereby capturing benefits and disadvantages relevant to everyday pediatric practice (12,13).

Several limitations should also be considered. Four randomized participants did not contribute complete final outcome data, and the reported outcome analyses were therefore based on 76 complete cases rather than the entire randomized cohort. Blinding of the operator and participants was not possible because the procedures were visibly and mechanically different, and the practical effectiveness of assessor blinding requires careful consideration. The Frankl Behavior Rating Scale is ordinal, although the reported statistical analysis treated the score as a continuous variable. The study also relied on immediate post-treatment outcomes and did not assess restoration longevity, recurrent caries, pulpal vitality, or long-term patient acceptance (14,15). Children with uncooperative behavior at baseline were excluded, which limits generalization to children with severe behavioral management difficulties. In addition, the study did not report an objective quantitative measure of residual caries or excavation completeness, and procedural time should therefore not be interpreted as a direct measure of caries-removal efficacy. These limitations indicate that the results are most appropriately interpreted as evidence concerning immediate pain, behavioral cooperation, and treatment duration within the studied preschool population (16).

CONCLUSION

Among preschool children with deep carious lesions in primary molars, papain-based chemomechanical caries removal using Cariclast was associated with lower immediate pain scores and more favorable behavioral cooperation than conventional rotary bur excavation, although it required a longer caries-removal time. These findings indicate that chemomechanical excavation may provide a more comfortable treatment experience for appropriately selected young children when the additional procedural time is clinically acceptable, while conclusions regarding long-term restorative effectiveness or pulpal outcomes cannot be drawn from the present study.

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