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A clinical and Microbiological Assessment of the Efficacy of Chemo-mechanical Caries Removal versus Conventional Caries Removal Methods in Children: A Randomized Controlled Clinical Trial

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ABSTRACT:

Background: *Effective caries removal in pediatric dentistry is vital for reducing discomfort and maintaining oral health. Traditional methods like drilling can be invasive, prompting interest in alternatives such as the chemo-mechanical caries removal method.*

Aim: *This study aimed to compare the efficacy, pain and satisfaction, treatment time, and microbiological outcomes of a sodium hypochlorite-based chemo-mechanical caries removal method (CarieMove® Gel) with conventional drilling in pediatric patients.*

Methods: *A randomized controlled clinical trial involved 30 children aged 7-9 years with bilateral class 1 caries in first permanent molars, as per the International Caries Detection and Assessment System (ICDAS) No 4, with no pulp involvement. CarieMove® Gel was randomly applied to one side for caries removal, while the conventional drilling method was used on the other side. Caries removal efficacy, pain and satisfaction, caries excavation time and microbial presence before and after treatment were registered. Data were collected, and tabulated statically analyzed at a 5% significance level (p ≤0.05).*

Results: *Comparative analysis showed similar overall efficacy between the chemo-mechanical and conventional methods, with no significant difference (p=0.083). Pain and patient satisfaction pain perception were significantly higher with the chemo-mechanical method (p<0.001), despite a longer treatment time (p<0.001). Microbiological evaluations revealed no significant difference in bacterial count between both methods (p=0.893). Conclusion: This study highlighted the efficacy and acceptability of CarieMove® Gel as a promising alternative to traditional drilling for caries removal in pediatric patients. While both methods were effective, CarieMove® Gel resulted in a higher patient satisfaction. Although treatment time was slightly longer, the increased comfort and positive experiences suggest its value for young children.*

Keywords: *Chemo-mechanical caries removal, CarieMove® Gel, Conventional caries removal, Randomized controlled Clinical trial, Pediatric dentistry.*

1. INTRODUCTION

Dental caries is a prevalent chronic disease affecting dental hard tissues which necessitates diverse treatment approaches. [1] Traditional methods such as rotary drilling often associated with patient discomfort and prompt the exploration of alternative techniques. These include A traumatic restorative treatment (ART), [2] air abrasion, [3] laser therapy, [4] sono-abrasion, [5] and chemo-mechanical caries removal (CMCR). [6]

Untreated tooth decay can destroy the tooth inner pulp, often requiring extensive treatment or even tooth extraction. To prevent and treat cavities effectively, it is essential to focus on managing them over time for each individual patient using minimally invasive, tissue-preserving techniques. [7]

The conventional use of rotary instruments for caries removal often induces psychological distress in both children and parents due to associated anxiety and fear. [8]

The aversive of noise generated by rotary instruments, coupled with the frequent need for anesthesia, contribute significantly to dental anxiety in children. This can lead to delayed or avoided dental treatment, resulting in advanced caries and, consequently, more complex treatment procedures requiring anesthesia. [9]

Moreover, rotary instrumentation during caries removal can induce harmful pressure and heat, which potentially damage the dental pulp. Additionally, this method often results in the inadvertent removal of healthy dental tissue. Furthermore, the use of water coolant to reduce heat generation during high-speed drilling can increase aerosol contamination, posing risks related to the transmission of various pathogens, including COVID-19. [10] Consequently, there is a compelling need for alternative materials and techniques to replace conventional drilling in caries management.

The traditional approach to caries treatment, as advocated by G.V. Black in 1891, [11] emphasized extensive cavity preparation to prevent decay recurrence. This concept has evolved into a philosophy of minimal intervention dentistry, prioritizing the preservation of healthy tooth structure through limited cavity preparation. [12]

Chemo-mechanical caries removal (CMCR) offers several advantages, including reduced pain and anxiety, particularly in pediatric patients, by selectively targeting infected dentin while preserving sound tooth structure and avoiding pulp irritation. [12] This approach is especially beneficial for uncooperative children or those with special health care needs. [12]

Chemo-mechanical caries removal (CMCR) agents can be categorized into sodium hypochlorite-based and enzyme-based formulations. Early research in CMCR utilized 5% sodium hypochlorite (NaOCl) solutions. [13]

However, the aggressive nature of NaOCl on sound dental tissue necessitates the development of a modified formula. By incorporating a balanced emulsion formulation containing sodium chloride, sodium hydroxide, and glycine, the compound GK-101 is created. [14]

GK-101, was introduced in 1976 and approved by FDA.[15] It consists of two solutions containing sodium hypochlorite and N-monochloro-glycine. GK-101 requires a specialized delivery system for optimal application. This system includes a reservoir to warm the solution and a pump for controlled delivery.

GK-101E, later marketed as Caridex™, [16] was introduced in 1984 as an improved version of the original Gk101 CMCR formula. This iteration incorporates amino butyric acid in place of glycine, resulting in the formation of N-monochloroaminobutyric acid (NMAB). This modification enhances the efficacy of the NaOCl-based CMCR system. [14]

Carisolv, was introduced in 1998, [16] and became the first commercially available NaOCl-based CMCR agent. This gel formulation offers advantages over previous iterations by eliminating the need for heating and specialized delivery systems. While sharing similarities in mechanism of action with Caridex, Carisolv incorporates a unique combination of three amino acids to target various components of carious lesions. [17]

Enzyme-based CMCR agents encompass formulations such as Papacarie®, Carie-Care™, Biosolv®, and Brix 3000®. Papacarie®, was introduced in 2003, [18] and utilizesed papain, as an enzyme derived from papaya, as its primary active component. Papain exhibits proteolytic, anti-inflammatory, and antibacterial properties, contributing to its effectiveness in caries removal.

Biosolv®, was launched in 2006, [18] and it represents another enzyme-based CMCR agent. This formulation incorporates pepsin enzyme within a phosphoric acid and sodium phosphate base. To ensure optimal application, manufacturers recommend the use of specific plastic instruments.

Carie-Care™, was introduced in 2010, [19] and it represents another enzyme-based CMCR agent. It is derived from papaya extract, it incorporates chloramines and dyes as its primary active components. The inclusion of essential oils, such as clove oil, provides additional benefits like mild anesthesia and anti-inflammatory effects. A gelling agent is incorporated to improve the product consistency. Comparative studies show that while both Papacarie® and Carie-Care™ effectively remove caries, Papacarie® exhibits superior efficacy in reducing bacterial load within the infected lesion.

Brix 3000® was introduced in 2016, [9] and it represents a recent advancement in papain-based CMCR gel by increasing papain concentration to 3000 u/mg and utilizing encapsulated buffer emulsion technology. Brix 3000® achieves optimal pH for enzyme activity which enhances its effectiveness

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in breaking down collagen fibers within decayed tissue. Notably, the absence of chloramines in Brix 3000® contributes to its improved toxicological safety profile. [9]

CarieMove is a new CMCR agent based on sodium hypochlorite. [20] Unlike traditional drilling, it uses a special gel to soften the decayed area before gently removing it. This method is simpler with no special application tool. Unfortunately, the researchers are unable to find any research testing the effectiveness of this material (CarieMove) in CMCR. That is why this study aims to compare the clinical and microbiological aspects to conventional drilling for caries removal in pediatric patients.

2. Materials, Subjects, and Methods

This study is a randomized controlled clinical trial with split-mouth design using the following subjects and materials.

Sample size calculation:

Based on a previous study (Aswathi et al., 2017),[21] the sample size is calculated using G. Power software v3.1.2; Informer Technologies, Inc. Sample size of at least 25 molars in each methos of caries removal is required to provide a power of 0.80 and α 0.05. The sample size is increased to 30 molars per group for more precise results and to compensate for any drop out.

Ethical considerations:

The study is conducted after the approval of the ethical committee of Faculty of Dentistry, Mansoura University, Egypt with the code number: A0303023PP. An informed written consent form is signed by each child's parent or guardian who participats in this study after detailed explanation of treatment with their right to withdraw at any time. The present clinical trial is registered as a randomized controlled clinical trial in Clinical Trials.gov under the number: NCT06531148.

Subjects:

A total of 30 children 7-9 years old are randomly recruited from the out-patient pediatric dental clinic, Faculty of Dentistry, Mansoura University, with the following inclusion and exclusion criteria:

I. Inclusion criteria:

1- No history of systemic diseases
2- Cooperative children
3- Each child has two bilateral first permanent molars with simple Class 1 occlusal caries involving dentin according to international caries detection and assessment system (ICDAS) No 4
4- The selected molars have normal structure and morphology

II. Exclusion criteria:

1- Molars have clinical and radiographic signs of pulp involvement
2- Children with special health care needs
3- Molars have already been restored or have developmental anomalies
4- Molars with proximal caries

Study design:

The study is a randomized controlled clinical trial conducted using a split-mouth technique. It adheres to the Consolidated Standards of Reporting Trials (CONSORT) guidelines, as illustrated in the flow chart (Figure 1).

3. Randomized controlled clinical trial with split-mouth design

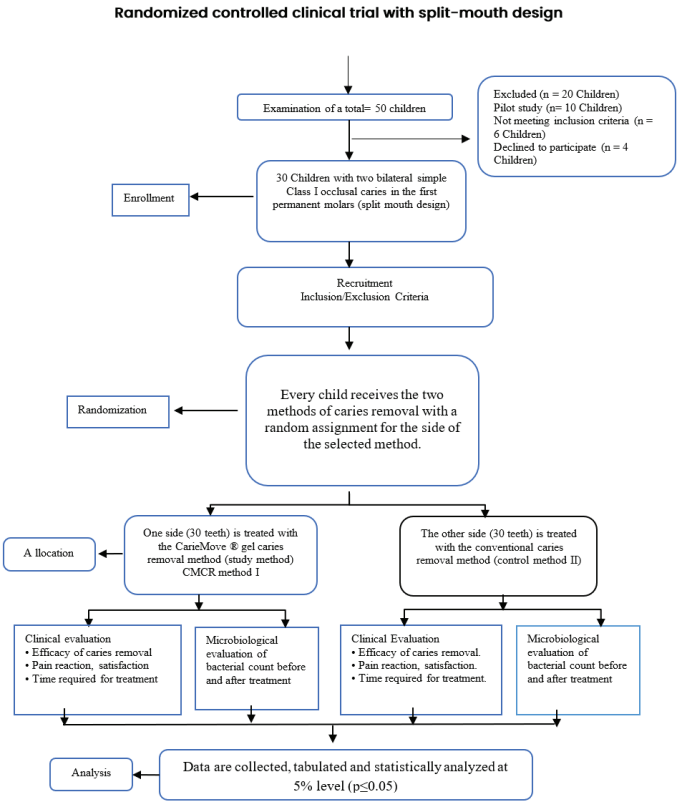

Figure 1. Schematic diagram showing the study design and group assignment following Consolidated Standards of Reporting Trials; CONSORT. Flow chart

Random allocation of the participants:

1. Participant Assignment:

A total of 30 children each with 60 bilateral first permanent molars are involved in the study. Each child is assigned a unique sequential number from 1 to 30.

2. Treatment Methods:

Each child receives a different method of caries removal. The specific method assigned to each child is determined randomly.

3. Randomization Process:

The choice of which side (right or left) would receive the selected caries removal method is assigned using the GraphPad randomization tool available at [Graph Pad] (https://www.graphpad.com).

4. Allocation Concealment:

To ensure that the allocation is concealed and unbiased, the sequentially Numbered, Opaque, Sealed Envelopes (SNOSE) [22] technique is employed:

- An independent individual, not involved in the study, prepares the envelopes prior to the start of the study.
- Each envelope contains the two treatment methods of caries removal assigned to a specific child.
- The randomization sequence remains sealed and secured until the treatment for the children commences.

This process ensures that the allocation of treatment methods is both random and concealed, minimizing any potential biases in the treatment assignment.

The Clinical Procedure

The clinical procedure treatment is performed according to the following steps. [23]

1. Digital periapical x-ray is taken.
2. Each tooth is isolated using cotton rolls.
3. The isolated tooth is cleaned using wet cotton pellets to remove any debris and plaque before starting the procedure of caries removal.
4. An initial superficial sample from the carious dentin is removed for both methods I & II, using a sterile sharp spoon excavator and placed into a sterile Eppendorf tube containing nutrient broth for microbiological culture.

Caries removal is carried out using either of the two following methods:

I. CarieMove® Chemo-mechanical Caries Removal (CMCR) Agents (method I):

Method, I received chemo-mechanical caries removal using CarieMove® Gel on one randomly selected side of carious teeth. The gel is applied as per the manufacturer's protocol [24] using a sterile sharp spoon excavator. After two minutes, softened decayed dentin is gently scraped away in a pendulum motion until sound dentin is visually confirmed with caries detector dye.

II. Conventional Drilling Method for Caries Removal (Method II):

In this method, caries removal is performed using a high-speed handpiece with a carbon steel round bur. The cavities are then inspected using the caries detector dye as method I to assess the extent of remaining caries. After caries removal, a sample of dentin is obtained from the cavity floor in both methods using a sterile sharp spoon excavator. The dentin samples are transported to sterile Eppendorf tubes for bacterial count examination. [25] Local anesthesia is administered only in cases of severe pain.

Evaluation of caries removal

III. Clinical Evaluation

Efficacy:

The efficacy of caries removal using the explorer and caries detector dye is examined in two methods using the Ericsson scale. [26] The clinical parameter is that the explorer should not adhere sharply to the dentin without a catch, and no evidence of soft caries should be detected by applying caries detector dye (Cario-Finder®) to the carious lesion for one minute. After the caries is removed by various methods, it is examined by an assessor who is trained to measure and calibrate the Ericsson scale.

After the caries is removed by the various methods, it is examined by a trained gold standard assessor who is blinded to the used method. The efficacy of caries removal is recorded by both the operator and the gold standard trained assessor. The disagreement between both is checked by another

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expert to reach a consensus. The completeness of caries removal is determined based on the agreement between the operator and assessor.

To check the reproducibility of inter- reliability, prior to starting the study, a pilot study, group of 10 children not involved in the study, is checked by both the operator and assessor for the caries removal efficacy of both methods. To ensure consistency in assessments, inter-examiner variabilities are assessed prior to and at the end of the study using Cohen's Kappa test.

Pain and patients' satisfaction:

Child satisfaction and pain are assessed by the blinded trained assessor using the Facial Image Scale (FIS). This scale consists of five facial expressions ranging from very happy to very unhappy. Children select the face that best match their feelings after each treatment. Scores range from 1 (most positive) to 5 (most negative). [27]

Time assessment

The total working time for caries removal, including local anesthesia administration if required, is recorded in minutes using a stopwatch. All treatments on first permanent molars are performed by a single operator. A gold standard assessor, blinded to the techniques used (chemo-mechanical or low-speed bur), conducts the clinical evaluation of caries removal, child satisfaction, and pain experience. [28]

II. Microbiological Investigation

Caries excavation is performed in a single dental visit for all the sixty teeth of the 30 selected children. In both methods, the tooth is isolated with a cotton roll and holder. A standardized superficial baseline sample of carious dentin is taken from each lesion using a sterile sharp spoon excavator. [29]

Dentin samples are immediately placed in sterile Eppendorf tubes, each containing 1 mL of standardized nutrient broth. These samples are promptly transported to the Microbiology and Immunology Laboratory at Faculty of Medicine, Mansoura University, arriving within two hours of collection. To ensure even bacterial distribution, samples are diluted in 1 mL of sterile nutrient broth and mixed vigorously using a vortex. A 10-microliter aliquot is then inoculated onto blood agar plates and incubated at 38°C for 48 hours. Colony counts are subsequently determined to calculate the total bacterial count per milliliter of the original sample. [29]

Restoration of the cavities:

Following caries removal using either treatment method, the cavities are restored with a light-cured Beautiful-Bulk composite resin, Shofu Dental Gmbh company, adhering strictly to the manufacturer's guidelines. Children were given post-operative instructions, such as avoiding chewing hard foods on the filled tooth, as the final restoration may have been slightly different and have a different texture than the original tooth. If sensitivity persisted for more than a few weeks, they are asked to call the clinic for an examination.

Data analysis:

All data are collected, tabulated, and statistically analyzed at a 5% level of significance ($p \leq 0.05$) using the Statistical Package for the Social Sciences (SPSS) software (IBM Corp., Released 2017, IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY: IBM Corp). The normality of the data is assessed using Shapiro-Wilk test, and descriptive statistics (frequencies, percentages, means, standard deviations, medians, and ranges) are calculated. The Chi-square test is used to compare categorical variables, while independent t-tests or Mann-Whitney U tests are employed to compare groups based on data distribution.

Null Hypothesis

The null hypothesis is that there is no difference in the efficacy of caries removal of CarieMove® gel (CMCR) method compared to the convention drilling method in both clinical and microbiological outcomes.

5. Results

The current study includes a total of 30 children aged 7-9 years old with a mean age of 7.67±0.76. Every child had a bilateral simple Class I occlusal caries in his first permanent molars according to international caries detection and assessment system (ICDAS) No 4.

I. Evaluation of Clinical Outcomes

1. The efficacy of caries removal among the two methods:

The comparison of caries removal efficacy using the Ericson scale between the two methods shows that the mean Ericson scale scores are almost identical: 1.40 ± 0.86 for the chemo-mechanical method and 1.37 ± 0.49 for the conventional method as shown in table 5, with no statistically significant difference ($p=0.920$). When it is broken down by Ericson

scale grades, a statistically significant difference is observed only in the occurrence of caries at the base and two walls of cavities. The CMCR method records 13.3% of the caries compared to absence of caries at the base and two walls in the conventional caries removal method (p=0.046).

The other comparisons, including caries at the base or base and one wall, shows no statistically significant differences between the two methods of caries removal. Complete caries removal is achieved in 10% of the CMCR method while, it is not attained in conventional method with no statistically significant difference p= 0.083 as shown in table 1.

Table 1. Comparison between studied methods according to caries removal efficacy by Ericson scale

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
Ericson scale	Mean ± SD	1.40 ± 0.86	1.37 ± 0.49	Z: 0.096, p=0.920
	Median (Range)	1.00 (0.00-3.00)	1.00 (1.00-2.00)	
Ericson scale grades	Caries at the base of the cavity	16(53.3%)	19(63.3%)	X2= 0.257, p= 0.612
	Caries at the base of the cavity and one wall	7(23.3%)	11(36.7%)	X2= 0.889, p= 0.346
	Caries at the base of the cavity and two walls	4(13.3%)	0(0.0%)	X2= 4.000, p= 0.046*
	Complete caries removal	3(10.0%)	0(0.0%)	X2= 3.000, p= 0.083

Z: Mann Whitney test, X2: Chi square test, * statistically significant p≤0.05.

2. Pain and patients' satisfaction:

The comparison of patient satisfaction and pain experience between the two methods of caries removal shows a highly statistically significant difference (p<0.001) as shown in table 2. The chemo-mechanical method gets significantly higher satisfaction, with 6.7% of children rate their experience as excellent and 40.0% rating it as good, while no children in the conventional caries removal method give these ratings. In contrast, the conventional caries removal method has a much higher proportion of poor (53.3%) and very poor (33.3%) satisfaction ratings, compared to zero rating in children in the chemo-mechanical caries removal method.

Table 2. Comparison between study methods according to children satisfaction

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
Pain and patients' satisfaction	Excellent	2(6.7%)	0(0.0%)	X2: 47.200, p<0.001*
	Good	12(40.0%)	0(0.0%)	
	Medium	16(53.3%)	4(13.3%)	
	Poor	0(0.0%)	16(53.3%)	
	Very poor	0(0.0%)	10(33.3%)	

X2: Chi square test, * Statistically significant p≤0.05.

3. Evaluation of the time taken to remove caries in each method

The analysis of the time needed for caries removal in both methods reveals statistically significant difference as shown in table 3. The chemo-mechanical caries removal method requires considerably more time, with a mean of 9.38 ± 0.46 minutes, compared to 3.53 ± 0.30 minutes for the conventional method. This difference is highly statistically significant (p<0.001).

Table 3. Comparison between the studied methods regarding time needed for caries removal

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
Time needed for caries removal (min)	Mean ± SD	9.38 ± 0.46	3.53 ± 0.30	Z: 6.653, p<0.001*
	Median (Range)	9.41 (8.51-10.00)	3.65 (3.00-4.00)	

Z: Mann Whitney test, * statistically significant p≤0.05.

III. Evaluation of Microbiological Findings:

Table 4 shows that there is no statistically significant difference between the two methods of caries removal regarding the total bacterial count (TBC) before the intervention, with a p-value of 0. 893..

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Table 4. Comparison between the two methods of caries removal regarding total bacterial count before intervention

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
TBC before intervention (CFU/mL)	Mean ± SD	302.00 ± 58.92	300.00 ± 55.46	Z: 0.135, p=0.893
	Median (Range)	290.00 (180.00-430.00)	300.00 (200.00-410.00)	

Z: Mann Whitney test No statistically significant difference p>0.05.

Table 5 shows that there is no statistically significant difference between the two methods in terms of total bacterial count (TBC) after the intervention, with a p-value of 0.737.

Table 5. Comparison between two methods of caries removal regarding TBC after intervention

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
TBC after intervention (CFU/mL)	Mean ± SD	42.33 ± 66.00	50.00 ± 67.16	Z: 0.288, p=0.737
	Median (Range)	0.00 (0.00-160.00)	0.00 (0.00-150.00)	

Z: Mann Whitney test No statistically significant difference p>0.05.

The analysis of the differences in total bacterial count (TBC) changes between the chemo-mechanical method and the conventional method is shown in table 6. There is no statistically significant difference between the two methods in terms of changes in total bacterial count (TBC). The data include the frequency of mild changes and no growth in TBC for each method.

Table 6. Comparison between study methods according to TBC change

		Chemo-mechanical Method	Conventional Method	Test, p-value
		n=30	n=30	
TBC change	Mild change in TBC	9(30.0%)	11(36.7%)	X2: 0.075, p=0.784
	No growth	21(70.0%)	19(63.3%)	

X2: Chi square test. No statistically significant difference p>0.05.

6. Discussion

The age range of 7 to 9 is particularly important for studying permanent molars, as children are transitioning from a primary to mixed dentition. This study focuses on this age group to explore strategies for preventing and treating cavities in developing first permanent molars. To make the dental experience less intimidating for young children, the researchers choose to use cotton roll isolation instead of rubber dams. Cotton rolls, combined with a saliva ejector, effectively manage moisture and reduce anxiety, leading to a more positive treatment experience and better outcomes. [30]

All children are recruited from the Pediatric Dental Clinic at the Faculty of Dentistry, Mansoura University, to ensure consistency in cultural and sociodemographic factors.

The results of the current study show that both CarieMove® gel CMCR and conventional rotary methods are comparable and effective in caries removal with no statistically significant differences.

This agrees with the results of several studies by Kotb et al. (2009), [31] Jawa et al. (2010), [32] Maru et al. (2015), [33] Sahana et al. (2016), [34] and Alsayed et al. (2024). [35] All of them showed that there are no a statistically significant differences in caries removal efficacy between CMCR different agents and conventional rotary method of caries removal. The consistency between these studies reinforces the reliability of CMCR methods as a viable or alternative to traditional methods specially in children dentistry. (p=0.930)

Contrary to the current findings, Aswathi et al. (2017) [21] report no statistically significant differences between the polymer bur and the CMCR agent Cari-Care in terms of complete caries removal. In contrast, the researchers' findings show that the CMCR agent achieves complete removal in 10% of cases. This discrepancy may arise from differences in caries removal methods, as Aswathi et al. use a polymer bur to remove caries, while the Carie-Care agent may provide more sensitive results for caries removal than the CMCR CarieMove® and the conventional method used in the present study.

The present study results demonstrate that CarieMove® gel (CMCR) significantly reduce pain and improve comfort in children during caries removal procedures compared to the conventional drilling caries removal technique. This aligns with the findings of several studies, Kotb et al. (2009),[31]

Singh et al. (2011),[36] Anegundi et al. (2012),[37] Maru et al. (2015),[33] Sontakke et al. (2019),[38] Balachandran et al. (2020)[39] Ali et at. (2023)[40] and Ghanem et al. (2023)[41].

All of them show that there is a statistically significant reduction in pain with the various CMCR agents, resulting in a substantial reduction in patient discomfort compared to the traditional drilling technique. The consistent findings across these studies highlight the effectiveness of the CMCR method as a patient-friendly alternative.

The present study results prove that the time required for caries removal using the CarieMove® gel (CMCR) method is significantly longer (9.38 minutes) than that of conventional rotary methods (3.53 minutes) a statistically significant difference ($p < 0.001$).

The results of this research are consistent with the findings of several studies, Singh et al. (2011),[36] Anegundi et al.(2012), [37], Goomer et al. (2013),[46] Maru et al. (2015),[33] Almaz et al. (2016).[42] All of them show that there are statistically significant differences in time taken for caries removal with the CMCR method that is approximately times longer than that of conventional rotary techniques. The longer duration in all studies suggests a common pattern in the operational efficiency of CMCR methods, which may be attributed to the nature of the procedures involved.

Contrary to the present results, Kotb et al. (2009),[31] find that the operating time for the Papacarie method does not differ statistically significantly from that of conventional drilling techniques. This discrepancy may stem from differences in study design, such as sample size and the new chemo-mechanical agent (Papacarie), or the specific settings in which the procedures are performed. It involves the chemical softening of carious dentin, highlighting the importance of context in interpreting results.

Furthermore, a contradictory result is recorded by Ali et al. (2023),[40] who found that Carisolv was faster than traditional drilling in terms of caries removal duration, with a statistically significant difference. These discrepancies may arise from several factors, including variations in patient demographics and the specific methodologies employed across studies. Notably, the type of carious lesions such as primary caries and the use of Carisolv® gel can significantly influence the overall efficiency of the caries removal process. Additionally, the size of the cavity may play a crucial role, as different materials and techniques might yield varying results depending on whether the cavity is small or large. Understanding these nuances is essential for accurately interpreting the outcomes of different caries removal methods.

The present study results prove that there is no statistically significant difference in total bacterial count (TBC) between the CMCR caries removal method and conventional drilling before or after the intervention, with p-values of 0.893 and 0.737, respectively. This suggests that both methods are similarly effective in managing bacterial reduction in carious lesions, which is an important consideration in dental treatment.

This agrees with the results of several studies by Singhal et al. (2016)[43] and Mahdi, Haidar (2019)[44], both of which show that there is no statistically significant difference. This suggests that while chemo-mechanical agents may be effective, they do not necessarily outperform each other in terms of bacterial reduction.

Contrary to the present results, a study by Prabhakar et al. (2018),[45] regarding bacterial reduction efficacy can be attributed to several methodological differences, including sample size, bacterial strain evaluation, and measurement techniques. While Prabhakar et al. report that the round tungsten carbide bur significantly reduces bacterial deposits compared to the Carie-Care technique ($p < 0.001$), the present study, which focuses only on permanent teeth, finds no significant difference in total bacterial count between CMCR CarieMove® and conventional drilling method. These discrepancies highlight the complexities of assessing treatment efficacy and underscore the need for standardized methodologies and materials in future research to enable clearer comparisons and conclusions regarding caries excavation techniques.

7. Conclusion

Based on the results and within the limitation of this study, the researcher can draw the following conclusions:

The CarieMove® gel agent, as a CMCR method, is an effective and well-accepted alternative to traditional drilling for removing Class I caries in children. Both methods demonstrate similar effectiveness and produce no significant differences in total bacterial counts. However, the CarieMove® gel requires more time for treatment. Therefore, when choosing a caries removal technique, it is essential to consider efficacy, patient satisfaction, and treatment duration.

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Declaration of Competing Interests

The authors declare that they have no conflicts of interest that could have influenced their study or findings.

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