EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 71, 2595:2604, JULY, 2025
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
CONSERVATIVE DENTISTRY AND ENDODONTICS
Submit Date : 29-03-2025 • Accept Date : 15-05-2025 • Available online: 15-07-2025 • DOI : 10.21608/edj.2025.372105.3432

CHEMO-MECHANICAL EFFECTIVENESS OF PAPACARIE IN REMOVAL OF DENTAL CARIES IN BOTH PRIMARY AND PERMANENT TEETH: IN-VITRO COMPARATIVE STUDY

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ABSTRACT

Objective: Comparatively analyze the clinical efficiency of Papacarie as a chemo-mechanical caries removal agent in both dentitions by measuring the microhardness, volume, and surface area of prepared cavity.

Methodology: Twenty-six deciduous and permanent molar teeth with occlusal decay were selected. They were equally split up into two groups (n=13); group I (deciduous molars), and group II (permanent molars). All cavities were subjected to initial measurement of microhardness by Vickers test, and pre-scan with Cone Beam Computed Tomography (CBCT) for assessing lesions' volume and surface area. They underwent treatment with Papacarie Duo. The caries infected dentin was removed with spoon excavator. Until a clear gel was achieved, the gel application was repeated. Cavities were initially inspected for caries removal using "visual inspection and tactile sensation", and then caries detection dye was used. The microhardness of cavities was measured again. A postoperative CBCT scan was conducted. The results were tabulated, one-way ANOVA analysis of variance was performed.

Results: No significant variations were recorded in microhardness values after caries removal in group I (P=0.137), while highly significant variations were seen in group II (P=0.001). Significant variations were recorded among both groups before caries removal (P=0.041) and after caries removal (P=0.024). CBCT analysis reported no significant variations between either the cavity volume (P=0.942,0.862) or surface area (P=0.254,0.993) before and after caries removal in both groups.

Conclusion: Papacarie is an effective caries removal agent in both primary and permanent dentitions.

KEYWORDS: Chemo-mechanical caries removal, Papacarie, Vickers microhardness test, CBCT.

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INTRODUCTION

Dental caries is considered the most common non-communicable disease worldwide presenting a health risk[1]. Removal of caries using the traditional methods as rotary instruments results in substantial loss of dental structure. The infected dentin which is severely contaminated and weakened must be removed prior to the placement of the restoration. However, the hard dentin which is demineralized partially and bacteria-free should be preserved as it can be remineralized[2,3].

Initially, the caries was removed by using hand drills, then they were swiftly overtaken by James Morrison's treadle instrument basing on Singer's sewing machine mechanism. The removal of carious lesions with surgical intervention has been utilized for more than a century since there was lack of comprehension about the "conservation of the tooth's remaining structure"[4]. Sir G.V. Black's "extension for prevention" strategy was required at that moment because there was no other feasible choice.

Dental caries management has been evolved in the earlier years to attain the conservative strategy. The awareness about conservatism along with tooth structure's remineralization, allowing shifting from "extension for prevention" thought of GV Black to "prevention of extension" concept[2,5]. However, "Our objective must be the eternal preservation of what is left rather than the meticulous replacing of what is lost"[6].

Numerous methods and substances are available for preparing cavities and removing caries as minimal intrusive alternatives to the conventional methods. These include the hall technique, air and sono-abrasions, air polishing, enzymes, ultrasonic instrumentation, laser techniques, fluorescence excavation, and chemo-mechanical caries removal (CMCR)[7-10].

CMCR assists in removing any infected dentin by employing a chemical agent instead of a drill. In light of its simplicity, researchers found that using this technique on children who are afraid of receiving dental care is encouraging[11,12]. In addition, the majority of feared dental procedures are cavity preparation, induction of anesthetic solution, and teeth extraction[13].

CMCR was constructed earlier with the use of a solution of 5% sodium hypochlorite in 1970; then GK 101 in 1972, and GK 101e in 1975 which was patented in the United States as Caridex. Swedish researchers developed Carisolv in 1998, while Papacarie® was produced in Brazil[14,15]. Furthermore, Carie- Care™ was presented in 2010 while Brix3000™ in 2016[16,17]. Papacarie®, Carie-Care™ , and BRIX 3000™ are all CMCR agents based on enzymes, while Caridex, and Carisolv are based on sodium hypochlorite. Considering their high price and short shelf life, CMCR techniques may be not as useful as conventional treatments.

Additionally, CMCR agents have many benefits over conventional drilling techniques. These include decreased awareness of pain, no inflammation of pulpal tissue, as well as; they are also helpful in patients with physical disabilities and those involving infectious illeness[14]. Clinical procedures that are promising to be less scary, causing anxiety and lengthy, may be highly advantageous not only to the patients but also to the operator.

Papacarie gel is as effective as traditional methods yet less painful, containing papain, toluidine blue, and chloramine. Papain breaks down collagen links causing deterioration, as they are protected by alpha-1 anti-trypsin enzyme in healthy tissue which is not present in the infected tissue. Consequently, cleavage of polypeptide chains and hydrolysis of collagen fibril cross-links occur. However, Papacarie gel becomes a commonly utilized agent for conservative caries removal[18].

Surface microhardness can act as impartial clinical indicator to distinguish between infected, affected, and non-carious dentin, since the hardness of healthy dentin is substantially higher than that

of carious one[19]. Vickers test is a simple, reliable, and fast way to determine the hardness of brittle materials like tooth structure. In addition, Cone Beam Computed Tomography (CBCT) is used for volumetric evaluation to assess the change in cavity surface area and volume after caries removal[20].

The null hypothesis of the research that, no significant differences between the clinical efficiency of Papacarie as a chemo-mechanical caries removal agent in both deciduous and permanent dentitions.

Aim of the work

Comparatively analyze the clinical efficiency of Papacarie as a chemo-mechanical caries removal agent in both deciduous and permanent dentitions by measuring the microhardness, volume, and surface area of prepared cavity.

METHODOLOGY

Ethical approval

The Ethical Approval of the research was accepted by The Research Ethics Committee of Faculty of Oral and Dental Medicine, Al-Salam University, Egypt. (Research Code: Sue 01170724 8).

Study design

The study is a comparative in-vitro research. It was caried out at Pediatric Dentistry Department, Faculty of Dentistry, Sinai University. Parents and pediatric patients were informed of the research.

Samples size estimation

To assess the effectiveness of Papacarie as a chemo-mechanical caries removal agent in both deciduous and permanent dentitions, Paired t test was used for comparative analysis among groups. According to previous studies by Anwar et al., and Santos et al., in 2020, using the G*power statistical power analysis program (version 3.1.9.7) for estimation of sample size. A total sample size (n=26; divided to 13 in each group) is generated that was enough to identify an impact size of (F= 1.043974), with an actual power (1-β error) of 0.8 (80%) and a significance level (α error) 0.05 (5%) (figure 1) [21-24].

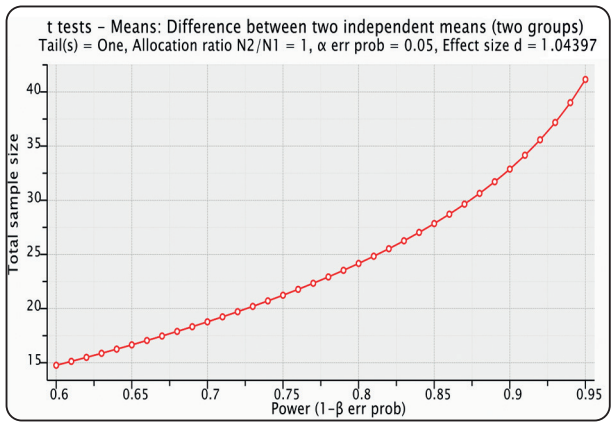

Fig. (1) X-Y Plot for a range of values

The criterion for inclusion and exclusion in the study:

Criteria for inclusion:

1. A large cavitated occlusal lesion involving the dentin (Black's Class I cavity)
2. Periapical xray displaying dentinal cavities up to 2/3 of the dentinal thickness.
3. Carious lesions are soft to medium-hard in consistency.
4. Colors vary from pale yellowish to brown.

Criteria for exclusion:

1. Examples of cases that need restorations but are not class I.
2. Teeth that are severely damaged.
3. Periapical xray displaying dentinal cavities of more than 2/3 of the dentinal thickness.
4. Caries spreading beneath the gingiva or affecting the pulp.
5. Developmentally or medically compromising circumstances.
6. Heavily restored teeth.
7. Enamel caries.

Samples grouping

A total of 26 deciduous and permanent molar teeth were collected for the study. They were equally split up into two main groups of 13 samples each. Group I: deciduous molars; Group II: permanent molars. All the samples were kept in saline solution for no more than three months after the contaminants on the surface had been cleansed[22]. The two research groups received treatment from the Papacarie Duo gel.

Samples fixation

The molars' samples were inserted in cylindrical molds filled with self-cure acrylic resin (Acrostone, Egypt). At the soft dough stage, molars were embedded in the acryl and pressed till the cemento-enamel junction. After setting, the acrylic blocks were taken out of the molds and thoroughly examined (figure 2). The dentin's carious state of each sample was evaluated using the clinical standards (visual inspection and probing)[25].

Assessment of cavity microhardness

The first parameter considered was the microhardness of the cavity. It was examined by the test of Vickers' hardness. The diamond pyramid indenters were used for the testing. Three indentations at various points were made on the examined surface of each sample under a 50 g load applied for 15s. The mean of three indentation scores have been estimated and represented as the sample's hardness value. A microscope of ×200 was used for measurements (TUKON™ 1102) (figure 3)[26].

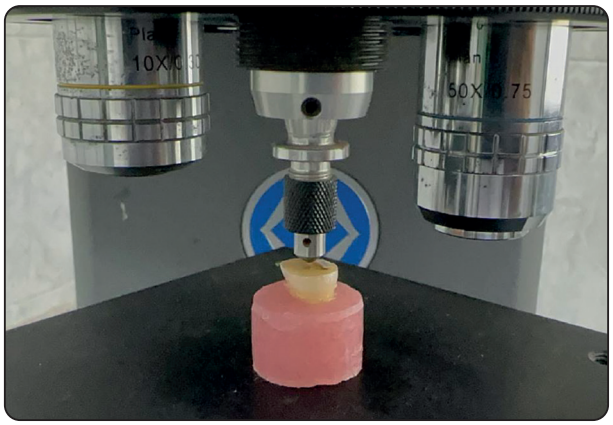

Fig. (3) : Microhardness test

Assessment of the volume and surface area of the cavity

The second parameter was the volume and surface area of the carious cavity. A pre-scan CBCT (Planmeca ProMax, Helsinki, Finland) was taken.

Study method

Papacarie Duo gel application was done according to the manufacturer's guidelines. It was kept for about 40 seconds in the cavity. The infected dentin got scrapped using the spoon excavator. Until a clear gel was achieved and a healthy dentin was visible, the gel application was repeated[21]. We used moist cotton pellets to remove the residual gel, and a spray of air and water to clean and dry the cavity.

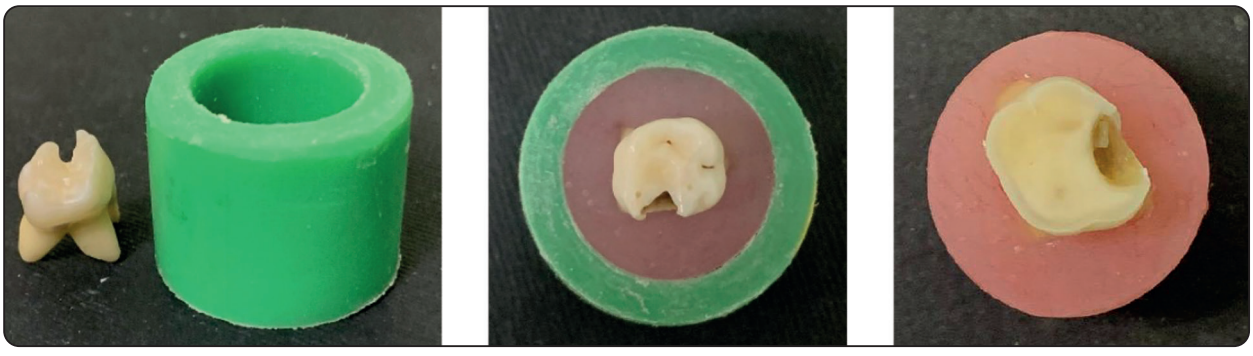

Fig. (2) : Sample fixation

Cavities were first examined for complete caries elimination using Ericson *et al*.'s criteria which includes "visual inspection and tactile sensation"[27]. When the tip of the explorer was passed with ease over the floor of the cavity and no tug-back sensations were felt, caries was considered eliminated. To confirm complete removal of carious lesions, caries detection dye (Kuraray, Osaka, Japan) was used following the recommendations of manufactures. After cavity drying, a disposable sponge tip applicator was used to apply 1% acid red caries dye which was left for 10 seconds in the cavity, then water-washed and air-water-sprayed to dry. Only the infected dentin tinted a dark pink was removed; while the affected dentin tinted a light pink was left intact[28].

After complete caries removal, the microhardness of cavity floor in all samples was measured again. In addition, the samples were also exposed to a post-scan CBCT to measure the volume and surface area of residual dental structure (figure 4). The proportion of the differences in volume and surface area between pre-scan and post-scan were computed using the formula below:

$\frac{b-a}{a} \times 100$ = proportion of difference in volume/surface area between pre-scan and post-scan where b = post-scan CBCT volume/surface area and a = pre-scan CBCT volume/surface area.

Statistical Analysis

All data were gathered and statistically analyzed. One-way ANOVA analysis of variance was performed. Statistical analysis was made with IBM® SPSS® Statistics Version 23 for Windows and the significance level was set at $p<0.05$.

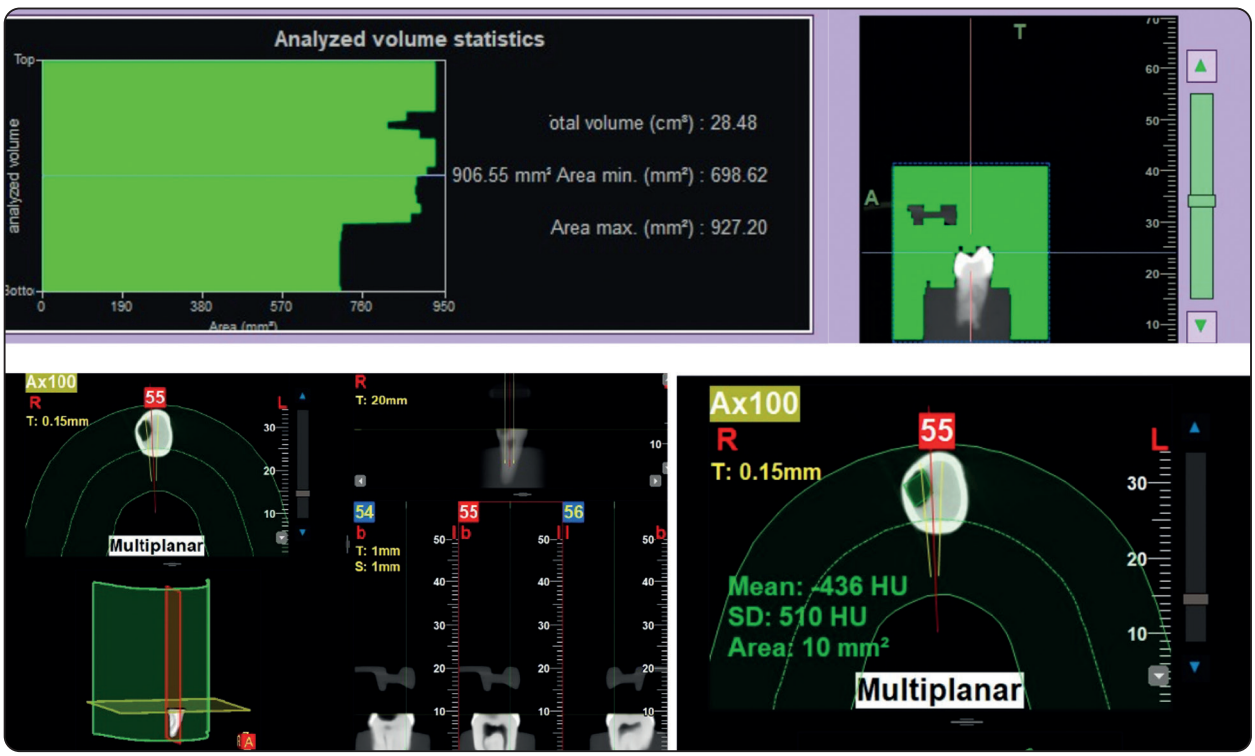

Fig. (4) Cone beam computed tomography volume and surface area analysis

RESULTS

Cavity microhardness analysis:

Data were obtained regarding the microhardness values of the cavity floor at each indentation, with the mean values and standard deviation of each group being subsequently calculated. Regarding to the results after application of Papacarie Duo gel and complete caries removal, table1 & figure 5 revealed that the microhardness mean values were decreased in both groups. No statistically significant variations were recorded in group I (P=0.137), while highly significant differences were noted in group II (P=0.001*). In addition, statistically significant variations were recorded among both groups before caries removal (P=0.041*), and after caries removal (p=0.024*).

TABLE (1) Statistical analysis of microhardness mean values before and after caries removal in both groups

Groups / Microhardness	(Group I) Deciduous molars (mean ± standard deviation)	(Group II) Permanent molars (mean ± standard deviation)	P value
Before caries removal	30.55±	35.15±	**0.041***
After caries removal	27.83±	21.90±	**0.024***
P value	**0.137**	**0.001***	

Statistically significant P<0.05

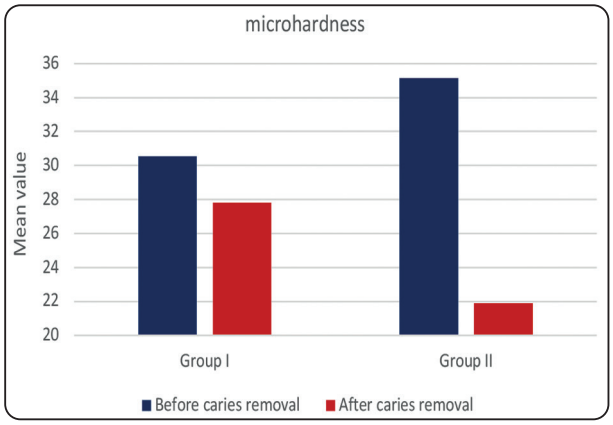

Fig. (5) Bar chart showing the microhardness mean values before and after caries removal in both groups

CBCT analysis

Based on the analysis of statistics used to determine the proportion of cavity volume change, table 2 & figure 6 represented that no differences were recorded among the cavity volume mean values before and after caries removal in both groups (P=0.942,0.862) respectively. Similarly, for the changes of cavity surface area mean values after caries removal, table 3 & figure 7 revealed no statistically significant variations in both groups (P=0.254,0.993).

TABLE (2) Statistical analysis of cavity volume (mm3) mean values before and after caries removal in both groups.

Groups / Cavity volume	(Group I) Deciduous molars (mean ± standard deviation)	(Group II) Permanent molars (mean ± standard deviation)
Before caries removal	28.44±2.3	28.97±5.4
After caries removal	28.83±4.1	28.48±4.08
Mean difference %	1.37	-1.69
P value	**0.942**	**0.862**

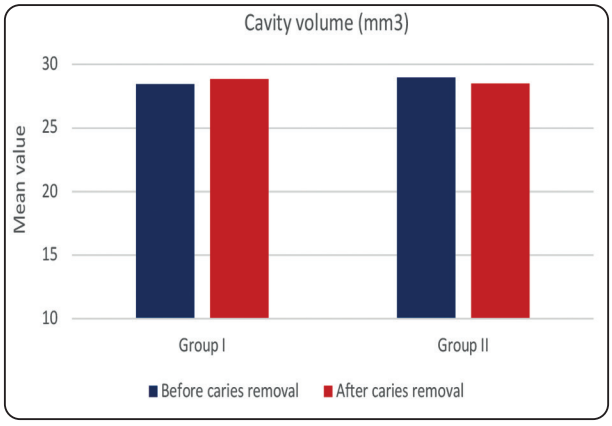

Fig. (6) Bar chart showing cavity volume (mm3) mean values before and after caries removal in both groups

TABLE (3) Statistical analysis of cavity surface area (m2) mean values before and after caries removal in both groups.

Groups / Cavity Surface area	(Group I) Deciduous molars (mean ± standard deviation)	(Group II) Permanent molars (mean ± standard deviation)
Before caries removal	8.53±3.1	1.43±1.1
After caries removal	10.06±6.20	1.31±0.84
Mean Difference %	18	-8.39
P value	**0.254**	**0.993**

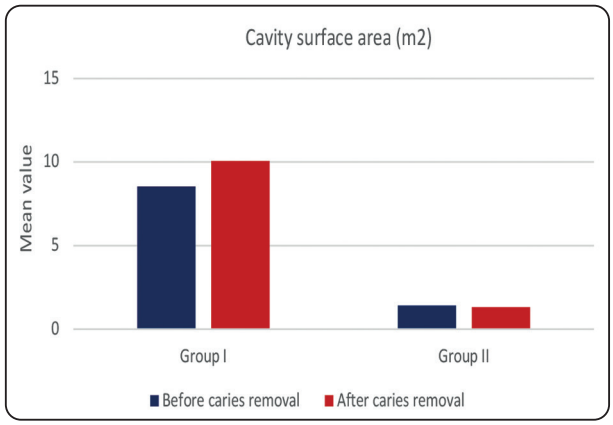

Fig. (7) Bar chart showing Cavity surface area (m2) mean values before and after caries removal in both groups

DISCUSSION

The main objective of conservative treatment is preservation of sound tooth structure during caries removal. Therefore, numerous products were produced to remove caries conservatively using chemical action instead of mechanical one[25].

The chemo-mechanical caries removal methods became a matter of concern due to its preservative of natural tooth structure, by which only the infected decayed dentin is eliminated while the hurtful elimination of affected dentin is prevented, reducing the requirement for anesthetic solution[29].

Papacarie gel was selected as it is simple, cheap, and easily manipulated along with its effectiveness in infected dentin ilumination[30,31]. The papain enzyme, which was isolated from the mature Carica papaya tree, is necessary for the mechanism of action with its proteolytic, anti-inflammatory, and bactericidal action[32].

Microhardness is a physical property that allows for evaluation of the effects of chemical or physical agents on dental surfaces that found great variability in microhardness, not only in different teeth, but also in different regions of the same tooth[34].

In the current study, on comparing the microhardness values of both groups after caries removal it was found that, the values were decreased with no statistically significant differences recorded in group I (P = 0.137), and highly significant differences recorded in group II (P = 0.001). The results came in agreement with Hamama's study who explained the decrease in microhardness values by that the caries-infected dentine was only removed, leaving behind the caries-affected dentine with lower hardness values[35-37].

However, these results were not consistent with the Mollica' study**,** which has revealed that the microhardness of dentin left after using Papacarie was greater than that after caries elimination with other traditional techniques, such as hand-excavation method. These findings were conflicted with that, there was no evidence of precipitating Papacarie to any minerals into the dentinal tissues increasing their hardness[38].

Also, the results of microhardness values were not in accordance with Canderio's study, which was observed that enzymatic chemical agents (ECAs) did not represent any significant variations in microhardness compared to the control group, denoting that when the materials were applied, healthy dentin and enamel showed good quality. The differences could be related to substrates; which concede with the variations among two groups (primary and permanent molars) in our study[39].

Moreover, significant variations were recorded among both groups before and after caries removal (P = 0.041, 0.024), which came in accordance with the findings of Haghgou's study. This probably could be attributed to some variations among the primary and permanent teeth, like variations in mineralization and thickness, as these variables have an impact on the results[40].

Regarding to the results of CBCT we found that, no significant differences were reported among either the cavity volume or surface area before and after caries removal in both groups. However, these results came in agreement with other studies which stated that chemo-mechanical techniques were the most successful in removing caries since they preserve tissues while doing so[41,42].

These findings were not in accordance with both Cosgun and Neves's studies, which found that the chemo-mechanical agents represented less changes in cavity volume as opposed to other different caries removal methods. The differences between the findings could be related to the distinct methods of assessment[28,43].

CONCLUSION

Under the circumstances of current research, we found that:

1- The chemo-mechanical caries removal agents have great prospective for use in minimal intervention dentistry, and in caries removal in both primary and permanent dentitions.

2- Papacarie gel caused significant reduction in the microhardness of cavities in permanent teeth, with none significant effect on the microhardness of cavities in deciduous ones.

3- Papacarie gel didn't show any significant changes on the cavity volume and surface area in both deciduous and permanent teeth.

Financial support

Nil

Conflicts of interest

There is no conflict of interest

Author Contributions

All the authors were equally contributed

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