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Comparison of the efficacy of smart polymer burs with Carisolv gel in removing dental caries and reducing pain in children - a clinical study.

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Abstract:

Introduction The disadvantages of using conventional method in dental caries removal, such as patient discomfort, pain, and use of local anesthesia, in addition to thermal effects on dental pulp as a result of using high speed rotating burs, have increased the need for new approaches in removing caries can be more acceptable to patients and more conservative for dental tissues. Such as chemo-mechanical method (Carisolv) and smart polymer burs**.**

Methodology:. A total of 44 carious primary mandibular molars were selected for the study from children aged (6-8) years, they were selected from Damascus schools.

Results: Statistical analyzes of the samples showed that there were no significant differences between groups ($p > 0.05$) for patient pain but there were significant differences between groups ($p<0.05$) for the effectiveness of caries removal.

Conclusion: Smart polymer burs are as effective as Carisolv gel in reducing pain during dental treatment in children but are less effective in removing dental caries.

Key words: Smart Burs, Carisolv Gel, Primary Molars.

مقارنة فعاليّة سنابل البوليمير الذّكيّة بهلام ال Carisolv في إزالة نخور الأسنان المؤقتة وإنقاص الألم عند الأطفال – دراسة سريريّة.

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الملخص:

المقدمة: إنّ مساوئ استخدام الطريقة التقليديّة في إزالة النخور السّنية كانزعاج المرضى والألم المرافق والحاجة الى التخدير الموضعيّ ، إضافة للتأثيرات الجانبيّة المحتملة على اللّب السّني نتيجة للحرارة والضغط المرافقين لاستعمال السّنابل الدوارة زادت من الحاجة لطرائق حديثة لإزالة النخور كبديل محتمل يعتبر أكثر تقبلاً للمرضى وأكثر محافظة للنسج السّنية. كالطريقة الكيميائيّة الميكانيكيّة (Carisolv) وسنابل البوليمير الذكيّة.

الطرائق: تألّفت العينة من (44) رحى ثانية مؤقتة سفليّة مصابة بآفّة نخرية عاجية لا تتجاوز 2/3 العاج شعاعيّاً من الصنف الأول لدى الأطفال الذين تتراوح أعمارهم بين (6–8) سنوات، تمّ اختيارهم من مدارس دمشق، وتمّ انتقاء المدارس من منطقة واحدة لتوحيد معايير النّاحية الإجتماعيّة و الإقتصاديّة. أُزيل النخر بإحدى الطريقتين: الطريقة الأولى باستخدام السنابل الذكيّة والطريقة الثانية هي مُحل النخر الكيميائيّ هلام ال Carisolv وذلك لكلّ طفل عشوائيّاً.

أظهرت التحاليل الاحصائيّة للعّينات عدم وجود فوارق ذات دلالة إحصائيّة ما بين المجموعات ($p>0.05$) بالنسبة للألم أثناء المعالجة، أمّا من حيث الفعاليّة فكان هلام ال Carisolv الأكثر فعاليّة في إزالة النخر و ذلك بدلالة إحصائيّة ($p<0.05$).

الاستنتاجات: تتمتّع سنابل البوليمير الذّكية بفعالية هلام ال Carisolv نفسها في إنقاص الألم أثناء المعالجة السّنية عند الأطفال ولكنّها أقل فعاليّة في إزالة النخر السّنيّ.

الكلمات المفتاحية: السنابل الذكية، هلام Casrisolv، أرحاء مؤقتة.

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Introduction

Dental caries is a daily concern for dentists. Dental caries is the most common chronic disease in childhood, and its prevalence continues to rise despite all preventive and care measures (Anwar et al., 2017; Fernanda et al., 2021). Initially, dental burs were used in dental treatments since their invention in 1900. Mechanical methods became more common with the invention of the air turbine, which allowed dentists to perform procedures faster while reducing the severe pain caused by the vibration of rotary instruments (Kinoshita et al., 2003). However, mechanical cavity preparation is often associated with pain and patient anxiety. Although local anesthesia can reduce pain, the fear of injections, noise, and vibration remains a source of discomfort (Kinoshita et al., 2003). Many parents consider caries removal an unpleasant experience for their children, viewing traditional rotary instruments as invasive and often associated with fear and anxiety. It leads children to avoid dental visits, worsening their dental problems and making treatment more complicated (Fernanda et al., 2021; Anwar et al., 2017; Viral P. Maru et al., 2015).

Therefore, there is a need to explore modern, minimally invasive techniques for caries removal that preserve healthy tooth structure. Among these techniques are chemomechanical caries removal (CMCR) and smart polymer burs (Fernanda et al., 2021; Hetal et al., 2021; Anwar et al., 2017).

Objective

This study aims to:

1. Compare the effectiveness of smart polymer burs (SS WHITE, USA) in reducing pain during dental treatment in children aged 6–8 years with that of Carisolv gel.
2. Compare the effectiveness of smart polymer burs (SS WHITE, USA) in caries removal in children aged 6–8 years with that of Carisolv gel.

Literature Review

Santos et al. (2019) noted that most children find dental visits distressing due to sounds, strange tastes, unfamiliar materials, discomfort, and even pain, leading to fear and anxiety during conventional dental procedures (Santos et al., 2019). It poses a significant challenge for dentists. Facco et al. (2021) explained that the high-frequency noise from air turbine handpieces causes discomfort and complicates dental treatment. Painful experiences, such as restorative procedures without anesthesia, can trigger dental fear and anxiety in children. Even a single painful stimulus or repeated mildly uncomfortable treatments can have the same effect (Facco, Bacci, & Zanette, 2021).

With advancements in restorative materials and caries removal techniques, focusing on removing only infected dentin while preserving healthy tissue, studies on alternative, less painful, and more patient-friendly methods, especially for children, have become essential.

Asal et al. (2021) reported that smart burs were first described by Boston in 2000. These polymer burs selectively remove infected dentin while preserving affected dentin (Asal, Abdellatif, & Hammouda, 2021). Somani et al. (2019), Abinaya et al. (2020), and Asal et al. (2021) noted that these burs, marketed by SS WHITE (USA), come in various sizes (RA-4, RA-6, RA-8) and operate at low speeds (500–800 RPM). Unlike traditional metal burs, their cutting edges are made of polyether-ketone-ketone (PEKK), allowing minimally invasive dentin removal with less exposure of dentinal tubules, reducing pain (Somani et al., 2019; Abinaya et al., 2020; Asal, Abdellatif, & Hammouda, 2021).

Inamdar et al. (2020) and Jeannine et al. (2019) explained that these smart burs have a Knoop hardness of 50, making them harder than soft carious dentin (0–30 Knoop) but softer than healthy dentin (70–90 Knoop). This design ensures selective caries removal while preserving healthy dentin, as the burs wear down upon contact with harder tissue (Inamdar et al., 2020; Jeannine et al., 2019).

Chemomechanical caries removal (CMCR) involves applying a chemical solution to soften carious dentin, followed by gentle excavation with hand instruments. Cardoso et al. (2020) described CMCR as a simple, cost-effective, and minimally invasive method, widely accepted, especially among children and anxious patients. The process relies on sodium hypochlorite (NaOCl) or enzymatic agents to dissolve infected tissue, with the gel changing color or forming bubbles to indicate completion. Enzymatic agents may also have anti-inflammatory properties, enhancing treatment outcomes and reducing pain (Cardoso et al., 2020).

In 1997, Carisolv (Mediteam) was introduced as a minimally invasive CMCR method, developed through collaboration between Swedish universities,

scientists, and manufacturers (Maru et al., 2015). The red, viscous gel contains 0.5% NaOCl, three amino acids (glutamic acid, leucine, lysine), and sodium hydroxide (Yazici et al., 2003). Special hand instruments with blunt edges ensure controlled caries removal while minimizing damage to healthy dentin (Maru et al., 2015).

Materials and Methods

Sample Selection

The study sample consisted of 44 carious second primary mandibular molars with Class I dentinal caries (not exceeding two-thirds of dentin thickness radiographically) in children aged 6–8 years, selected from schools in Damascus. To ensure socioeconomic uniformity, schools were chosen from a single area (Damar-Wadi Al-Masharee).

Children underwent initial clinical screening in schools, followed by detailed clinical and radiographic examination using a digital camera at the Pediatric Dentistry Clinic, Damascus University. Teeth were randomly and equally allocated into two treatment groups using a randomization table (numbered 1–44).

Inclusion Criteria

1. Medically healthy children with no cardiac or hematologic conditions (Keller et al., 1998).
2. Carious lesions (Class I) on second primary mandibular molars, limited to two-thirds of dentin thickness, requiring restoration (Hadley et al., 2000).
3. No pulp exposure (Vashisht et al., 2010).
4. Cooperative children (Grade 4 or 5 on the Salviov-Tinawi 5-point scale) (Tinawi, 1989).
5. No dental malformations or developmental defects (Ericson et al., 1999).

Study Materials

1. Basic instruments: Mirror, probe, tweezers.
2. Rubber dam (The Hygienic Corp., USA) – Includes:
   - Dental dam
   - Rubber dam clamps
   - Mdesy punch and clamp holder
3. Topical anesthetic gel
4. Micromotor handpiece
5. Prophylaxis brushes & paste
6. Local anesthetic (Xylestesin-A, 2% lidocaine, 3M ESPE)
7. Aspirating syringe (Medesy, Italy)
8. DIAGNOdent laser fluorescence device (Kavo, 2004) – For caries detection.
9. Caries detector dye (Voco Caries Marker, Germany)
10. Smart polymer burs (SmartPrep, SS White Burs Inc., USA)
11. Carisolv gel (MediTeam, Sweden)
12. Carisolv hand instruments (various tips for different cavity areas)
13. Calcium hydroxide liner (Kerr)
14. High-viscosity glass ionomer cement (GIC) (GC Fuji IX GP, GC Corp., Japan)
15. Mixing spatula & pad
16. Bite paper

Study Protocol

Group 1: Smart Polymer Burs (SmartPrep) (Aswathi et al., 2017)

1. Tooth cleaning with a prophylaxis brush.
2. Topical anesthetic for clamp placement.
3. Rubber dam isolation.
4. Outlining cavity margins with a turbine handpiece & conventional burs (for access & removal of unsupported enamel).
5. Selection of appropriate SmartPrep bur (RA4, RA6, RA8) based on lesion size.
6. Slow-speed caries removal (500–800 RPM, no water cooling). Excavation proceeded from center to periphery until bur cutting edges dulled (indicating no further caries removal).
7. Caries detection dye application (10 sec), then rinsing (5 sec) to identify residual caries (Hosoya et al., 2007).
8. Evaluation by three blinded examiners using Ericson's scale.
9. Repeat excavation if needed (confirmed by DIAGNOdent & dye).
10. Calcium hydroxide liner in deep areas.
11. Restoration with GIC.

Group 2: Chemomechanical Caries Removal (Carisolv) (Ericson et al., 1999)

1. Tooth cleaning & isolation (same as Group 1).
2. Carisolv gel application:
   - Mixing the two gel components.

- Applying the Star 2/Star 3 tips for initial penetration.
- Waiting 30 sec for chemical softening (gel turns cloudy).

3. Excavation with Carisolv hand instruments:

- Star 3 tip for general caries removal.
- Multistar tip for large lesions.
- Flat 3/Flat 0 tips near pulp & difficult areas.
- Gentle scraping motions (avoiding force).

4. Reapplication until gel remains clear (indicating complete caries removal).

5. Final evaluation (caries detector dye & DIAGNOdent).

6. Calcium hydroxide liner & GIC restoration.

Outcome Measures

1. Pain Assessment (SEM Scale – Wright, 1991)

A 4-point objective scale (based on Sound, Eye, Movement – SEM) was used:

- 1: No pain.
- 2: Mild pain.
- 3: Moderate pain.
- 4: Severe pain.

2. Caries Removal Efficacy (Ericson Scale)

Evaluated by three blinded examiners post-treatment:

- 0: Complete caries removal.
- 1: Caries at cavity floor.
- 2: Caries at floor + 1 wall.
- 3: Caries at floor + 2 walls.
- 4: Caries at floor + >2 walls.
- 5: Caries at floor, walls, and margins.

Statistical Analysis

The study was designed as a clinical in vivo investigation. Data were recorded on research forms, coded, and entered into a computer using Microsoft Excel 2007. Statistical analysis was performed using SPSS Statistics 17.0 at a 95% confidence interval and a significance level of $p < 0.05$.

Normality Testing:

The Shapiro-Wilk test was used to assess data distribution. Results confirmed a normal distribution for all study variables, allowing the application of the following statistical tests:

1. Chi-square test (χ^2) – Used for categorical data comparisons.
2. Kruskal-Wallis test – Applied for non-parametric comparisons between multiple groups.
3. Mann-Whitney U test – Used for non-parametric comparisons between two independent groups.

Table (1): The SEM scale scoring criteria.

Score	Designation	Sound	Eyes	Motor
0	Comfort Mild discomfort	No sound Vague sounds	No indication	Relaxed body. Muscle tightness suggests discomfort.
1			Dilated pupils with no tears	
2	Moderate discomfort	Elevated volume with a clear verbal complaint	Tears present, accompanied by abrupt eye movements	Abrupt and unpredictable motions of the body and hands.
3	Severe discomfort	Yelling, weeping, and verbal grievances suggest intense discomfort	Intense crying	Hand gestures for protection, withdrawing head away.

Results

Pain Level Assessment During Treatment

Effect of Treatment Method on Pain Levels

Table 2 presents the results of the Mann-Whitney U test analyzing the significance of differences in pain level during treatment between the two studied treatment groups (smart polymer burs vs. Carisolv caries-removing agent) in the research sample.

The data in Table 2 show that the significance value (p-value) is substantially greater than 0.05 when comparing pain level frequencies between the smart polymer bur group and the Carisolv group. This indicates that at a 95% confidence level, there are no statistically significant differences in pain levels during treatment between the two groups in the study sample.

Table (2): Pain Level Assessment During Treatment

Groups	U-value	p-value
Polymer bur vs. Carisolv	200.500	0.183

Assessment of Residual Caries Immediately After Treatment

Results of Mann-Whitney U Test

Table 3 displays the results of the Mann-Whitney U test evaluating the significance of differences in frequencies of residual caries immediately after treatment between the two treatment groups (smart polymer burs vs. Carisolv) in the research sample.

Table 3 reveals that the significance value (p-value) is significantly less than 0.05 when comparing frequencies of residual caries between the smart polymer bur group and the Carisolv group. This demonstrates that at a 95% confidence level, there are statistically significant differences in residual caries frequencies immediately post-treatment between the two groups. By examining the mean rank values, we conclude that the smart polymer group showed higher levels of residual caries compared to the Carisolv group in the study sample.

Table (3): Assessment of Residual Caries Immediately After Treatment

Groups	U-value	*p*-value
Polymer bur vs. Carisolv	59.5000	< 0.001

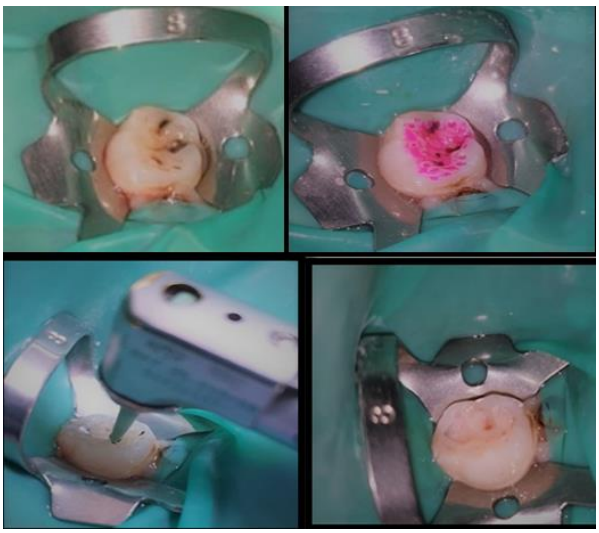

Figure (1): Polymer bur group

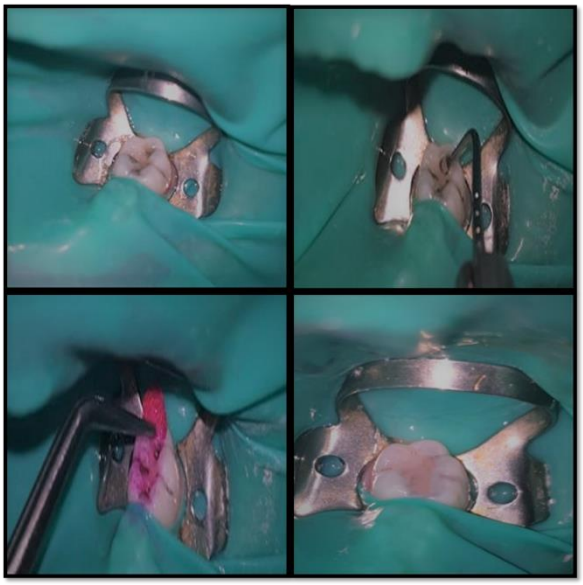

Figure (2): Carisolv group.

Discussion

Traditional caries removal using rotary instruments often causes discomfort in children and anxious patients, as high-speed burs generate pressure, vibration, and heat, typically requiring local anesthesia for pain control. This clinical study evaluated modern alternatives to conventional methods by comparing smart polymer burs (SmartPrep) with chemomechanical caries removal (Carisolv gel) in treating Class I cavities of second primary mandibular molars in 6-8-year-olds under standardized conditions with rubber dam isolation. While both methods showed comparable effectiveness in reducing procedural pain ($p>0.05$), Carisolv demonstrated significantly better caries removal efficacy ($p<0.05$), as smart burs failed to completely eliminate decay in some cases, suggesting they cannot currently replace conventional techniques despite their patient-friendly advantages. These findings indicate that although smart burs offer similar pain reduction benefits to Carisolv, their inferior caries removal capability limits their clinical utility as a standalone alternative in pediatric dentistry.

Discussion of Pain Assessment

Many researchers have recommended using subjective pain scales (such as verbal rating scales where patients describe their pain as "no pain," "mild pain," or "severe pain") for pain evaluation. However, a study by Abdulhameed et al. (1989) demonstrated that these scales are unreliable in pediatric studies, as children often struggle to effectively describe their pain, resulting in classifications based solely on descriptive terms that are insufficient for objective pain assessment (Abdulhameed et al., 1989). Consequently, this study adopted objective scales, where trained observers interpret behavioral or physiological indicators of pain. When experiencing pain, patients exhibit visible signs through their behavior and appearance. The study employed the Sound, Eye, and Movement (SEM) scale (Wright, 1991) (Table 1), an objective pain assessment tool that monitors external manifestations and correlates them with pain intensity. Results showed no statistically significant differences in pain levels during treatment between the SmartPrep polymer bur group and the Carisolv group. The reduced pain associated with Carisolv may be attributed to its thermal insulating properties (Braun et al., 2001), its body-temperature application (preventing thermal pulp stimulation), and its high pH, which may alleviate pain (Ansari et al., 2003). Additionally, the absence of vibration and the quiet nature of the procedure likely contributed to improved patient comfort. These findings align with the clinical study by Al-Tayar (2009), which compared Carisolv to other caries removal methods and confirmed its superior pain reduction. Similarly, Katiyar et al. (2021) found Carisolv significantly less painful than traditional rotary methods (Katiyar et al., 2021). However, these results contrast with Soni et al. (2015), who reported that Carisolv caused less pain than SmartPrep burs in children aged 4–14, potentially due to heat generation from the burs (Soni et al., 2015).

Discussion of Caries Removal Evaluation:

The study results revealed a statistically significant difference ($p<0.05$) in residual caries immediately

after treatment, with the smart polymer bur group showing higher remaining caries compared to the Carisolv group. This limitation of smart burs may be attributed to their inability to effectively remove caries underlying intact enamel, as their hardness is inferior to that of sound enamel and sclerotic dentin. These findings contradict Soni et al. (2015), who compared multiple caries removal methods (conventional burs, hand excavation, smart burs, and Carisolv) in children aged 4-14 years and reported superior efficacy of smart burs over Carisolv (Soni, Sharma & Sood, 2015). However, our results align with Prabhakar and Kiran's 2009 clinical study on first permanent molars, which found that smart burs were significantly less effective than conventional methods (Prabhakar & Kiran, 2009). Similar conclusions were drawn by Kumar et al. (2016) in their study of 80 carious primary molars, demonstrating smart burs' inferior performance compared to alternative techniques (Kumar et al., 2016). The findings also correspond with Abinaya et al. (2020), who confirmed smart burs' reduced effectiveness relative to other methods (Abinaya et al., 2020), and with Asal et al.'s 2021 microbiological study showing Carisolv's superior caries removal efficacy (Asal, Abdellatif & Hammouda, 2021).

Conclusions

1. The use of smart polymer burs for dental caries removal is a safe method, but it is not as effective as the chemomechanical approach. Therefore, it cannot be considered a significant alternative for caries removal.
2. Disadvantages of smart burs include: the need to create cavity access using conventional rotary burs, the requirement to use multiple burs for complete excavation of small carious lesions due to bur wear upon contact with sound dentin and healthy dental tissues, in addition to their high cost and limited availability.
3. The main drawback of the chemomechanical method is its inability to affect enamel, necessitating wider cavity access and potential need for repeated gel applications, which prolongs treatment time.

Recommendations for Future Research

1. Conduct clinical trials to evaluate the efficacy of modern caries removal materials.
2. Perform histological studies on the effects of both Carisolv gel and smart burs on dental pulp.
3. Investigate temperature rise in dental tissues following smart bur use.
4. Conduct microbiological studies to assess the antimicrobial efficacy of both Carisolv gel and smart burs in reducing microorganisms within carious cavities post-excavation.
5. Study the time required for complete removal of carious dentin using both Carisolv gel and smart burs.

Clinical Recommendations

1. Based on this study's findings, we preliminarily recommend using Carisolv gel for caries removal in pediatric patients, particularly for children with dental anxiety.
2. Within the parameters of this study, we do not recommend using smart burs despite their good patient acceptance, as they are less effective than the chemomechanical method for caries removal and are currently not economically viable for clinical use.

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