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In Vitro Assessment of Brix 3000 and Ceramic Bur in Comparison with Conventional Method for Caries excavation in Primary Molars

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ORIGINAL STUDY

In Vitro Assessment of Brix 3000 and Ceramic Bur in Comparison With Conventional Method for Caries Removal in Primary Molars

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Abstract

Purpose: To assess the effectiveness and topographic features of Brix 3000 and ceramic bur for the caries excavation in primary molars in comparison to the conventional approach in vitro. **Patients and methods:** For this investigation, 30 carious primary molars were chosen and sectioned mesiodistally, followed by caries excavation using Brix 3000 (group I), ceramic bur (group II), and diamond bur (group III), each group comprising 20 samples. Caries removal efficiency and efficacy were measured, and then selected samples were examined under scanning electron microscopy (SEM). **Results:** Regarding efficiency, diamond bur was the most efficient, followed by ceramic bur, while Brix 3000 was the least efficient. Regarding efficacy, the ceramic and diamond bur groups exhibited the highest efficacy, with no significant differences between them, whereas the Brix 3000 group exhibited the lowest efficacy. SEM results showed that surfaces treated with Brix 3000 exhibited distinct remaining dentine textures; a smear layer with uniform and cracked surfaces appeared in some areas, while in other places, rough and porous surfaces were observed. The SEM images of rotatory instrument groups involving (ceramic and diamond burs) showed a smear layer but exposed dentinal tubules were more evident in the diamond bur group. **Conclusion:** Ceramic bur offers a promising treatment for caries removal as it combines efficacy and efficiency. Brix 3000 produced an irregular surface with minimal smear layers and more open dentinal tubules in comparison with rotating instruments.

Keywords: Minimal invasive, Brix 3000, Ceramic bur, Diamond bur, Caries management, Primary molars

1. Introduction

Dental caries is one of the most frequent chronic conditions impacting people around the globe. It can happen in both permanent and primary dentitions at any point in life. Untreated carious lesions frequently result in poor quality of life as well as functional, cosmetic, and psychological issues. Many approaches, including traditional and minimally invasive dentistry (MID), have been employed to treat dental cavities [1].

Because of inadequate tactile perception, the conventional approach tends to over-prepare the cavities, which can occasionally cause pulp exposure. Furthermore, the heat produced during the cutting process may have a negative impact on the pulp, resulting in pain and inflammation. According to findings from previous studies, dental drills are the most stressful treatment-related factors that trigger pain in many patients, particularly in younger patients. This has led to an increase in demand for further studies in more innovative techniques and materials in the caries management sector [2].

Brix 3000 is a chemomechanical caries removal agent (CMCR) that was introduced in 2012 as a papain base. It comes with a proteolytic enzyme derived from the latex of the leaves and papaya fruits of the Carica plant. Papain has a concentration of roughly 10 % (3000 U/mg), and its bio-encapsulation incorporates emulsion buffer technology, which raises the gel's pH to the ideal level

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needed to encapsulate the enzymes and expose them to the collagen so they may perform its proteolysis function, facilitating the caries removal process. Furthermore, it carries a dermatological certificate confirming the product's nontoxicity to the skin, mouth, or eyes, showing that it does not react when it encounters healthy tissue. Besides, it has antibacterial and antifungal properties [3].

Considering minimally invasive tooth preparation, an innovative rotary cutting instrument known as a ceramic bur evolved for excavation of cavities at a slow speed. It is made of stabilized zirconia and a unique alumina-based ceramic and is obtainable at a speed of 1000–1500 RPM in the four sizes 012, 014, 018, and 023 specified by the International Organization for Standardization (ISO). Ceramic burs have several advantages, such as their optimal cutting efficiency, optimal tactile feeling, smooth and pleasant operation, and absence of corrosion. They are distinguished by their exceptional capacity to excavate carious dentin while preserving tooth structure [4].

The null hypothesis was that there would be no difference in caries removal efficacy, time of caries removal, or topographic features among the three caries excavation methods investigated; thus, this study was conducted in vitro to evaluate and compare the efficacy of CMCR and ceramic bur compared with the conventional approach in the treatment of dental caries in primary molars.

2. Patients and methods

2.1. Study design and ethical approval

Thirty extracted primary molars were obtained from the Pediatric Dentistry Department patient out clinic at Al-Azhar University's Faculty of Dental Medicine for Girls. Research ethics committee approval for using extracted human teeth was obtained from the Faculty of Dental Medicine for Girls, Al-Azhar University, with code (P-PE-21-17).

2.2. Sample size calculation and statistical power of the clinical part

To achieve sufficient power for conducting a statistical test of the null hypothesis—which states that there is no difference between groups, a power analysis was created. Based on the findings of Elkafrawy *et al.*, an effect size (f) of 0.91 was computed by assuming an alpha level of 0.05, a beta of 0.2, i.e. Power = 80 %. 30 samples total, 10 samples for each group were the anticipated sample size (n). The computation of sample size was accomplished with G*Power 3.1.9.7 [5].

2.3. Sample selection and preparation

The study included 30 recently extracted human primary molars without pulpal contact and with significant occlusal or proximal decay extending midway through the dentin with a cavity opening diameter of greater than or equal to 2 mm and accessibility to hand instruments without pulpal exposure, as confirmed by clinical (visual inspection and probing) and periapical radiographs. Teeth with pulpal or periapical pathology, developmental abnormalities, or any signs of cracks, defects, or damage from extraction were excluded [6].

A pumice and water slurry were used to remove the debris after it had been cleaned with a hand scaler. After that, distilled water was used to flush it, and compressed air was utilized for drying it for 5 s. To reduce alterations, they were kept at 4 °C for no more than a month in a 0.9 % saline solution. The teeth were sectioned into two equal parts mesiodistally by cutting through the lesion center with a diamond circular disc (Brown Alumina Oxoide, Henan Tianze Imp). A divider and scale were used to measure the depth of each carious half. Lesions that were not around the same depth were eliminated to minimize bias [6,7].

2.4. Study groups

The total sample size was 60 halves that were randomly assigned into three groups, each comprising 20 samples [7].

Group I: 20 carious samples excavated using Brix 3000.

Group II: 20 carious samples excavated using ceramic bur.

Group III: 20 carious samples excavated using diamond bur.

2.5. Excavation procedure

Group I: Brix 3000 (S.R.L., Argentina) (Fig. 1) was used to excavate 20 carious samples. It was put

Fig. 1. Brix 3000.

on the carious lesion and left on for 2 min, as directed by the manufacturer. Using a sharp spoon excavator, passive scraping was used to remove the gel and soften carious dentine as soon as it became cloudy. Repeated applications followed by excavation of softened caries were done, when required, until complete elimination of infected dentine. The gel was eliminated with a dampened cotton pellet, and the cavity was thoroughly washed with water [3].

Group II: Using ceramic burs (CeraBur, K1SM, Komet Brasseler; Lemgo, Germany) (Fig. 2) and a low-speed handpiece (Strong, Saeshin Precision Co, LTD, Korea), 20 carious samples were excavated. The sizes provided are in two ISO sizes (014 and 018). Without the use of a water coolant, excavation was done in a circular motion from the occlusal aspect's center to its periphery [4].

Group III: Using a diamond bur (Many, Japan) with two ISO sizes (014 and 018) and a low-speed handpiece (Strong, Saeshin Co., Korea), 20 carious samples were excavated until complete elimination of soft caries and recognition of hard dentin [7].

2.6. Evaluation of caries removal efficacy

Evaluation of caries removal was carried out by a calibrated examiner who was not a participant in the treatment procedures and was unaware of the group status. After a thorough excavation, caries was removed using tactile and visual methods. The following measures were utilized to determine the caries-free state of the dentin: dentin discoloration, hardness on probing, and the distinct sound of unaffected dentin on probing [8].

For further confirmation, caries detector dye (Seek, Ultradent, Inc., USA) was used. It was applied for 10 s, followed by 10 more seconds of water washing. Until the clinician determined that the dentin was caries-free or that no more cavities could be removed, the excavation process was repeated in each group. The Ericson scale is a caries removal efficiency scoring system that was used to assess its effectiveness [4].

(a) Complete caries removal.
(b) Caries exist in the cavity's base.
(c) Caries exist in the cavity's base and/or one wall.
(d) Caries exist in the cavity's base and/or two walls.
(e) Caries exist in the cavity's base and/or more than two walls.
(f) Caries exist in the cavity's bases, walls, and margins.

2.7. Evaluation of caries excavation time (efficiency)

The duration of the caries removal procedure was measured in seconds, starting with the application of the gel in the CMCR group or the use of the handpiece in bur groups (ceramic and diamond burs), and ending with the final dentin hardness detection [9].

2.8. Scanning electron microscopy examination (SEM)

Following caries excavation, a sequence of graded alcohol solutions with concentrations of 100, 95, 70, and 50 % were used successively for 10 min each to wash and dehydrate the chosen samples. Following a distilled water rinse, they remained 24 h submerged in 0.1 M phosphate buffer (pH 7.4) containing 2.5 % glutaraldehyde. For the gold-sputter coating, the specimens were placed on aluminum stubs. The surfaces of the residual dentine were subjected to scanning electron microscopy (SEM) examination (JEOL Ltd., Japan; JSM-5500 LV) [10] (see Figs. 5 and 6).

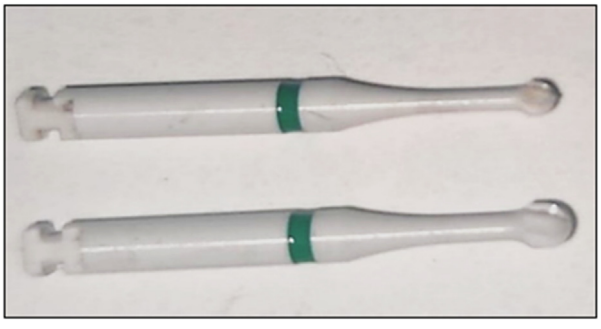

Fig. 2. Ceramic burs.

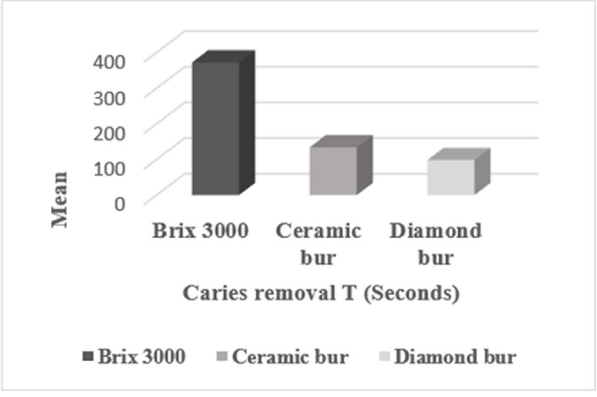

Fig. 3. Mean value of caries removal time in all groups.

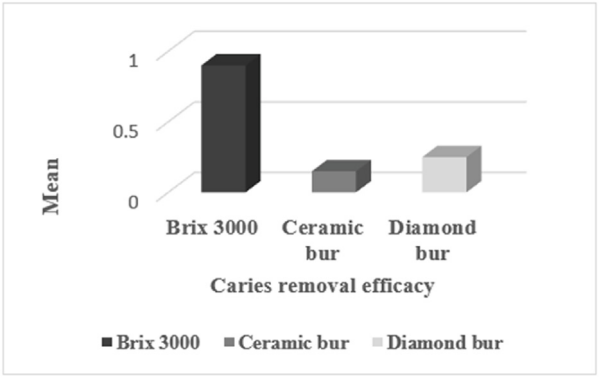

Fig. 4. Mean value of caries removal efficacy in all groups.

2.9. Statistical analysis

The submitted data was examined for normality using the Shapiro–Wilk and Kolmogorov–Smirnov tests, and the findings demonstrated that all the data originated from a normal distribution (parametric data). Data between groups were compared using the one-way ANOVA test, and multiple comparisons were performed using Tukey's post-hoc test.

3. Results

3.1. Caries removal time (seconds)

The highest mean value was recorded in group I (Brix 3000), followed by group II (ceramic bur), with the lowest value recorded in group III (diamond bur). Tukey's Post Hoc revealed a statistically significant difference between groups ($P = 0.00001$) (Table 1, Fig. 3).

3.2. Caries removal efficacy

The diamond and ceramic bur groups had the lowest scores with an insignificant difference, while the Brix 3000 group had the highest scores. A statistically significant difference between the groups was found using Tukey's Post Hoc ($P = 0.001$) (Table 2, Fig. 4).

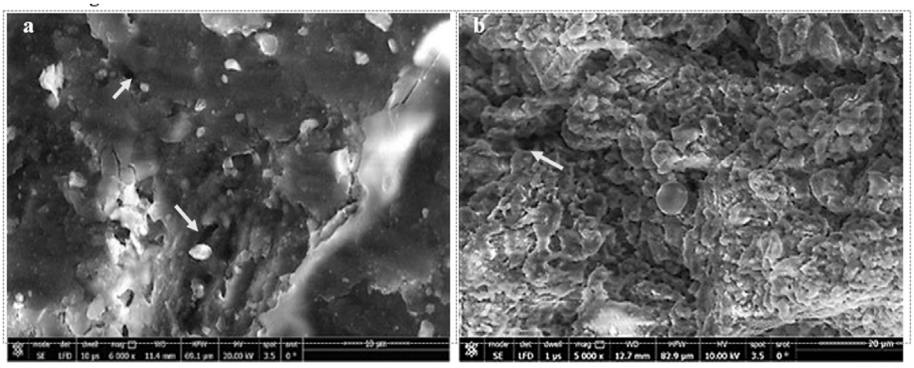

Fig. 5. Scanning electron microscopy of the residual dentine surface after caries excavation with Brix 3000. (a) Showing a smear layer with a cracked and uniform surface and a few patent open dentinal tubules (arrowhead). Areas of mineral aggregations can also be seen (Mag 6000×). b) Showing a rough and porous dentine surface with many open dentinal tubules (arrowhead) (5000 × Mag).

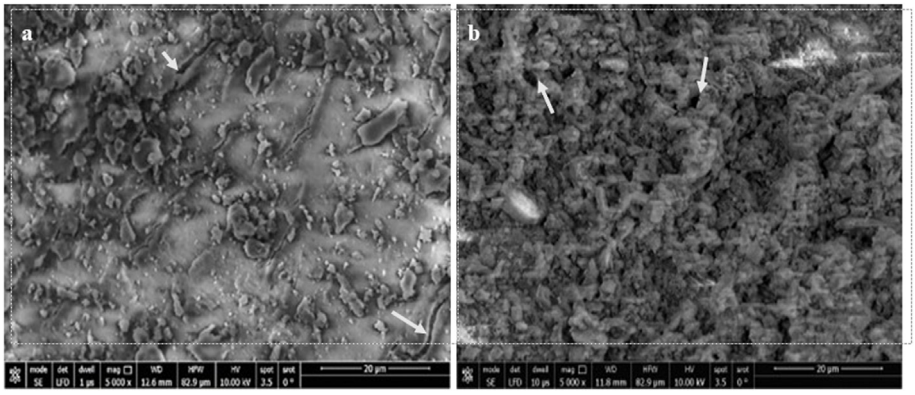

Fig. 6. Scanning electron microscopy of the residual dentine surface after caries excavation using drilling methods. a: Scanning electron microscopy of the residual dentine surface after caries excavation using ceramic bur showing smear layer covered with a layer of debris, area of fissures (arrowhead), dentinal tubules orifices are not visible (5000 × Mag). b: Scanning electron microscopy of the residual dentine surface after caries excavation using diamond bur showing many patent dentinal tubules (arrowhead) with smear layer (5000 × Mag).

Table 1. Descriptive statistics of caries removal time among the three groups (Tukey's Post Hoc).

	Minimum	Maximum	Median	Mean	SD	*P* value
Caries removal T (s)						
Brix 3000	240	480	360	372[a]	88.5438	0.00001*
Ceramic bur	110	160	270	134[b]	17.359	
Diamond bur	67	168	91	98.4[c]	30.7975	

SD: standard deviation.
*Significant difference as *P* less than 0.05. Means with different superscript letters were significantly different as *P* less than 0.05. Means with the same superscript letters were insignificantly different as *P* greater than 0.05.

Table 2. Descriptive statistics of caries removal efficacy among the three groups (Tukey's Post Hoc).

	Minimum	Maximum	Median	Mean	SD	*P* value
Caries removal efficacy						
Brix 3000	0	2	1	0.90[a]	0.79	0.001*
Ceramic bur	0	1	0	0.15[b]	0.37	
Diamond bur	0	1	0	0.25[b]	0.44	

SD: standard deviation.
*Significant difference as *P* less than 0.05. Means with different superscript letters were significantly different as *P* less than 0.05. Means with the same superscript letters were insignificantly different as *P* greater than 0.05.

4. Discussion

Dental caries is a predominant condition that affects individuals of any age. The focus on managing carious lesions has shifted to a less invasive and biological approach. Since healthy dentin has the capacity to remineralize, the goal of MID has been to remove infected dentin with the conservation of tooth structure as much as possible. This study aimed to assess the efficiency, efficacy, and topographic aspects of dentin following caries removal using MID such as CMCR and ceramic bur versus traditional treatments in primary teeth [11].

In terms of caries removal efficiency, the results revealed that diamond bur, followed by ceramic bur, was the most efficient, with Brix 3000 being the least efficient. According to the results, the diamond bur groups took less time in the interim. The reason might be the diamond bur's high rotational speed (>20,000 rpm) relative to ceramic bur's (1000–1500 rpm). However, as it provides little tactile feedback, leading to increased dentinal tubule cutting, children would experience more pain, subsequently consuming more time in vivo. Ceramic burs provide more tactile feedback than diamond burs, which minimizes dentinal tubule cutting and discomfort [4,7,12].

The Brix 3000 group needed a significantly longer time to remove caries than the group of ceramic burs. The medium and hard consistency of the lesions often required multiple applications of the gel to break down the infected dentine, usually two to three times, followed by mechanical excavation. In certain cases, access to the lesion in the presence of undermined enamel required the use of conventional drills. Conversely, Alumina-yttria ceramic, used to produce ceramic burs, usually has exceptional cutting and wear resistance, making it simple to access carious lesions on their own without assistance, which was consistent with earlier reports showing a significant difference between the CMCR and drilling methods [7,9,13].

That was also in harmony with a previous study that revealed a highly significant difference in the time required to remove dental caries in the CMCR group over the ceramic bur group. This could be due to the lesion consistency, since a hard caries lesion required numerous administrations of Brix 3000 gel to dissolve the diseased dentine [4]. Another study discovered that ceramic burs came in second place to conventional burs in terms of caries removal efficiency [13].

This contradicted another study, which showed that the difference in working time between the CMCR system and drilling methods was not statistically significant [14]. Another study found that conventional burs took less time to remove caries than ceramic burs, but the difference was not statistically significant [15].

Efficacy refers to the removal of infected dentin while maintaining healthy dentin. To ensure full caries eradication, visual and tactile criteria were gathered and validated using a caries-detecting dye to identify any residual carious lesions. The Brix 3000 group received the greatest score (The least efficacy), while the diamond and ceramic bur groups received the lowest score (The highest efficacy), with no significant difference between them. In most specimens of the Brix 3000 group, firm, leathery, carious dentine in the cavity's wall and

base remained. This was similar to a prior study, which concluded that CMCR did not effectively eliminate caries and so could not substitute rotary instruments [16]. A recent study indicated that ceramic burs were more efficient in removing diseased carious dentin than smart burs and diamond points [17].

This contradicted a prior study that found CMCR to be as effective as conventional methods. The findings revealed that caries from all teeth were removed completely in the CMCR group; however, in the drilling group, one tooth was determined to be incomplete. Further evaluation with the Facelight equipment revealed that cavities were completely removed in 19 of 23 teeth in the CMCR group and 20 of 23 teeth in the drilling group without significance [18].

Histological findings revealed distinct differences in dentin surface between the three groups. Surfaces treated with Brix 3000 revealed a variety of residual dentine patterns. A smear layer with a regular and cracked surface was detected in some places, while a rough, porous surface with many open dentinal tubules due to a minimal smear layer was detected in others, which was consistent with earlier studies [17,18]. The use of encapsulated buffer emulsion technology and papain, which both work to break down partially degraded collagen molecules and disintegrate the fibrin 'mantle' created via the carious process while maintaining intact collagen fibrils [19].

The gel's initial high pH and mechanical excavation have been accountable for the development of open tubules in CMCR. On the other hand, the existence of some regions occluded by the smear layer might be explained by the debris that remained after excavation to remove the softened carious tissue from the tubule openings. Previous investigations have reported the observation of microcracks. The hydrophilic property of the gel is thought to be the source of these fissures since it dehydrates the dentine surface [20,21].

SEM images of cutting rotatory instrument groups (ceramic and diamond burs) demonstrated a regular smear layer. Also, exposed dentinal tubules were seen in some locations. These results were compatible with those of a previous study [21]. The smear layer in the ceramic bur group was more regular and homogeneous, whereas dentinal tubules were more evident in the diamond bur group. This could be related to diamond burs' high rotational speed and nonselective nature, which remove simultaneously infected and affected dentine, resulting in more exposure of dentinal tubules and greater sensitivity when compared with ceramic burs that remove only infected dentine, indicating a more conservative nature of ceramic burs [21].

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That was in harmony with a previous study comparing diamond bur and polymer bur, which is the precursor of ceramic bur and share the same mechanism of action; both their hardness is less than infected dentine and higher than affected dentine. It illustrated that the diamond bur group generated a moderate smear layer with patent dentinal tubules, while the polymer bur group created a dense smear layer with few evident dentinal tubules [7].

That was contradictory to a previous study indicating that the dentin surface subsequently conventional caries treatment revealed an uneven, porous surface with nearly complete elimination of the smear layer [22].

4.1. Conclusion

Ceramic bur is a promising substitute treatment for caries removal since it combines efficacy and efficiency in comparison with the CMCR group (Brix 3000).

Brix 3000 produced an irregular surface with a minimal smear layer and more open dentinal tubules in comparison with cutting rotating instruments.

4.2. Recommendations

Until now, the data is scarce regarding the dentine topographic features following caries excavation using Brix 3000 and ceramic, so further research is mandatory.

Further clinical investigations are required to assess the efficacy of ceramic burs in terms of patient satisfaction, restoration longevity, and long-term effects on dentine health.

Further research is also required to evaluate the ideal type and time for application of the conditioner

required to remove the smear layer to achieve optimal retention of the adhesive restorations.

Ethics information

Research ethics committee approval for using extracted human teeth was obtained from the Faculty of Dental Medicine for Girls, Al-Azhar University, with code (P-PE-21-17).

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Biographical Information

The Pediatric Dentistry Department patient out clinic at Al-Azhar University's Faculty of Dental Medicine for Girls, Egypt.

Conflict of interest

There are no conflicts of interest.

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