In Vivo Comparison of Reduction in Bacterial Count after Caries Excavation with 3 Different Techniques

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ABSTRACT

Purpose: The purpose of this in vivo study was to evaluate and compare the reduction in bacterial count in dentin after caries excavation with a spoon excavator, carbide bur, and polymer bur.

Methods: Forty-five primary molar teeth from 36 children with occlusal dentinal carious lesions without pulpal involvement were chosen and divided into 3 groups: (1) caries was excavated using a brand new round bur with a slow-speed handpiece at 800 rpm from the occlusal aspect; (2) new polymer burs were used with slow-speed handpiece at 800 rpm, according to the lesion's size; (3) caries was excavated using a sterile spoon excavator.

Results: The mean difference in colony forming units of *Streptococcus mutans* and lactobacilli before and after caries excavation was found to be significant (P<.01) in all 3 groups. Further intergroup comparison of percentage reduction in bacterial counts between different groups was statistically significant, except when the percentage reduction in S mutans of group 2 was compared to that of group 3 (P=.26). Reduction in S mutans count was highly significant (P<.001) for group 1 vs group 3.

Conclusions: Caries removal with a carbide bur, polymer bur, and spoon excavator produced significant reduction in viable count of both *Streptococcus mutans* and lactobacilli. Carbide burs, however, produced greater reduction in the viable count of bacteria followed by polymer bur and spoon excavator.

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The real art of modern therapy is to keep the patient amused while nature cures the disease. Dental caries is a complex, continuous, dynamic, biologic process consisting of periods of progression alternating with periods of arrest or even partial repair.[1] Despite the profusion of rhetoric to the contrary, dental caries is a critical concern, even today. The principle aim of cavity preparation is to eliminate all caries-affected tooth structures to prevent the progression of carious processes and to provide a sound structural base for restoration. When removing demineralized dentin, it is not always easy to know when to stop excavation because there is an apparent lack of objective clinical markers.

Dentinal caries can be divided into: (1) a superficial or outer infected dentin layer; and (2) an inner affected dentin layer. The outer infected layer is typically demineralized and contaminated with bacteria and cannot be remineralized, indicating that it should be removed completely. The inner affected dentin layer is less contaminated, with an intact, cross-banded ultrastructure of collagen matrix that can be remineralized.[2] The introduction of caries detector dyes for clinical use can be a means to overcome the inherent problem of classical visual and tactile techniques to ensure acceptable clinical excavation without persisting bacteria. The main

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objective of treating deep dentinal lesions is to remove quantities of softened carious tissue while ultimately eliminating the highly infected biomass of tissue to prevent further lesion progression and functional impairments.[3]

The concept of minimally invasive dentistry is predicated on removing caries with methods that minimize the loss of sound enamel and dentin. Hand excavation provides better tactile control and less discomfort than the bur. Caries excavation using a spoon excavator is the most efficient means of precise cutting, especially when cutting is needed adjacent to important anatomy. In restorative dentistry, carbide burs are designed to efficiently remove nondecalcified enamel and dentin; however, they do not readily differentiate between carious and normal dentin. While operating on an anesthetized tooth that is incapable of signaling when inner carious or normal dentin is violated, an aggressive cutting tendency of the carbide burs combined with the dentist's goal of obtaining an excavated surface that feels normal results in a larger than needed cavity preparation.

The newer techniques used in carious dentin removal include the mechanical rotary or nonrotary instruments, chemomechanical techniques, and lasers.[4,5] Recently, SS White Company (Lakewood, NJ) has developed a new Polyamide polymer bur (Smartbur) with self-limiting technology for conservative cavity preparation. Smartbur (Figure 1) is a single-use instrument made up of a polymer material with a hardness less than that of healthy dentin but more than infected dentin. It efficiently removes the infected dentin without harming the healthy dentin as it loses its cutting efficiency on reaching the affected dentin.[6]

Therefore, the purpose of this in vivo study was to evaluate and compare the reduction in bacterial count in dentin after caries excavation with a spoon excavator, carbide bur, and polymer bur.

METHODS

Six- to 14-year-old children who attended as outpatients in the Department of Pedodontics and Preventive Dentistry, College of Dental Sciences, Davanagere, India, were selected. Forty-five primary molar teeth from 36 children with occlusal dentinal carious lesions without pulpal involvement were chosen. Caries diagnosis was done both clinically and radiographically using intraoral periapical radiograph (IOPA) in addition to visual and tactile assessment to judge the depth of the teeth's carious lesions. Ethical clearance was obtained from the institution's research ethics committee, College of Dental Sciences (CODS), Davangere, India and parents of each child signed an informed consent form.

The criteria for inclusion in the sample stipulated that each child must have occlusal carious lesions on the vital primary mandibular second molars with softened dentin involvement. Also considered were teeth with a history of food lodgment in the carious area and sensitivity to cold which was relieved when the stimulus was removed. The exclusion criteria were molars with 1 or more of the following clinical or radiological signs and symptoms: pulpal, periodontal, and soft tissue pathology in the involved tooth; and coexisting occlusal and proximal lesions in the mandibular second primary molars. Also excluded were nonvital teeth and teeth with pit and fissure caries. Caries excavation was done by a single operator in all 45 primary molar teeth, which were divided into 3 groups.

For group 1 (N=15), caries was excavated using a brand new round carbide bur (no. 4, SS White Co) with a slow-speed handpiece at 800 rpm from the occlusal aspect until hard dentin was detected using a straight probe. Caries detector dye (To Dye For, Roydent, Johnson City, Tenn) was used as an indicator for caries removal during excavation.

For group 2 (N=15), new polymer burs (Smartbur, nos. 2, 4, and 6, SS White Co) were used with slow-speed handpiece at 800 rpm, according to the lesion's size. Caries was excavated with circular movements starting from the center of the lesion to the periphery, as recommended by the manufacturer. Excavation was stopped when the instrument became macroscopically abraded and blunted and was no longer able to remove tissue.

For group 3 (N=15), caries was excavated using a sterile spoon excavator. Concurrently, dentin hardness also was checked and caries removal was terminated when hard dentin was detected with the probe at the cavity's base. Caries detector dye (To Dye For) was used as an indicator for caries removal during excavation.

The carious dentin samples were collected before and after caries excavation for microbiological analysis.

Figure 1. SMARTBURS® KIT – POLYMER BURS.

Each sample was removed using a new sharp sterile excavator and transferred into sterile vials containing saline. The size of the excavator used for the sample collection and the amount of sample were standardized, as described by Bonecker et al.[7] The pre- and post-caries excavation samples were inoculated onto the selective media—namely mitis salivarius and rogosa SL agar for *Streptococcus mutans* and lactobacillus, respectively. Next, the samples were incubated for 48 hours at 37°C. The colony forming units (**CFUs**) of *S mutans* and lactobacillus were recorded as CFU/ml x 10^5 for each sample. Data were analyzed for distribution and subjected to statistical analysis using Wilcoxon and Mann-Whitney tests.

RESULTS

The mean CFUs of *S mutans* and lactobacilli before and after caries excavation were found to be significant ($P<.01$) in all the 3 groups (Tables 1 and 2). Further intergroup comparison of percentage reduction in bacterial counts between different groups was statistically significant, except when the percentage reduction in *S mutans* of group 2 was compared to that of group 3 ($P=.26$). The percentage reduction of *S mutans* count was highly significant ($P<.001$) when group 1 was compared to group 3 (Table 3). The results infer that caries excavation with a carbide bur (group 1) showed greater reduction in percentage bacterial count, followed by use of a polymer bur (group 2) and spoon excavator (group 3; Tables 1-3).

DISCUSSION

Dentinal caries removal is normally accomplished using rotary carbide burs and hand excavators. Carbide burs, which perform better than steel burs, are superior at a higher speed but mostly are associated with noise, pain, overheating, vibration, and discomfort.[8,9] Hand excavation provides better tactile control and less discomfort than the bur without generating heat and is often preferred in noncooperative children for performing stepwise excavation.[10] Recently, special burs made of polymer material were introduced and the hardness of this bur is less than that of healthy dentin but more than infected dentin.[10] Hence, the present clinical study was conducted to evaluate and compare the efficiency of 3 different caries excavation techniques in reducing viable bacterial count in dentin.

Routinely after caries excavation, the cavity is judged to be caries free by visual and tactile assessment of the teeth. Several investigations have shown that often a lower number of residual micro-organisms (10^1 to 10^2 CFU) remain behind in clinically sound dentin, in spite of a significant reduction in bacterial count. This lower number of bacteria, however, is considered to be clinically acceptable by several authors.[3]

Table 1. Comparison of Microbial Count (CFU/ML x 10^5) of Streptococcus Mutans between Different Caries Excavation Techniques

Caries excavation techniques	Caries sample before excavation	Caries sample after excavation	Difference	Percentage reduction	Significance	
	Mean±(SD)	Mean±(SD)	Mean±(SD)	Mean±(SD)	Z-value*	*P*-value†
Carbide bur	13.8±10.2	2.2±1.0	11.7±10.3	81.9±8.8	3.41	<.01
Polymer bur	9.7±3.2	2.3±1.0	7.4±3.6	73.7±12.4	3.41	<.01
Spoon excavator	10.6±3.9	4.3±2.0	6.3±3.4	57.3±17.8	3.41	<.01

** Z=Wilcoxon's signed rank test (intragroup comparision).* *† P<.05=statistically significant.*

Table 2. Comparison of Microbial Count (CFU/ML x 10^5) of Lactobacilli between Different Caries Excavation Techniques

Caries excavation techniques	Caries sample before excavation	Caries sample after excavation	Difference	Percentage reduction	Significance	
	Mean±(SD)	Mean±(SD)	Mean±(SD)	Mean±(SD)	Z-value*	*P*-value†
Carbide bur	9.8±3.3	2.4±1.0	7.4±3.1	74.4±10.9	3.41	<.01
Polymer bur	9.3±3.9	3.5±1.4	7.4±4.3	64.7±16.5	3.41	<.01
Spoon excavator	9.7±3.9	5.0±2.6	4.7±2.6	48.0±18.2	3.41	<.01

** Z test for proportions: Z=3.84.* *† Not statistically significant.*

Table 3. Comparison of Reduction in Bacterial Count in Dentin between Different Caries Excavation Techniques*

Caries excavation techniques	*Streptococcus mutans*	Lactobacilli
	P-value	*P*-value
Carbide vs polymer burs	<.01	<.01
Carbide burs vs spoon excavator	<.001	<.01
Polymer burs vs spoon excavator	.26†	.05

** Z=Wilcoxon's signed rank test (intragroup comparision).*
† P<.05=statistically significant.

It still remains to be determined what a satisfactory clinical excavation actually means or, more specifically, what risk is associated with the failure to eliminate all infected dentin during excavation. Particularly, it is relevant to examine whether species-specific survival of the microbes can be identified in relation to possible progress of the disease. Loesche and Syed[11] reported that bacteria in carious dentin were mainly *S mutans*, lactobacilli, *Actinomyces*, and other gram-positive rods. *S mutans* are acid-producing micro-organisms which maintain metabolic activity in low pH environments,[12] and lactobacilli have been related to caries progression.[13] Their acidogenic and aciduric characteristics explain their predominance in deep caries lesions.[14,15] Because of the aforementioned facts, these 2 bacterial species were included in this study.

The number of micro-organisms isolated from the carious dentin sample may be influenced by the sample-taking methods. Kidd et al.,[16] used a standardized procedure for taking samples from residual dentin by means of a round bur of a defined size and established the reproducibility of this method. In the present study, the dentin samples were carefully removed with a standard-sized sterile spoon excavator to reduce the risk of accidental pulpal exposure, especially when sampling hard dentin.[7,17]

In the present study, the overall percentage reduction in bacterial count was found to be greater with a carbide bur than a polymer bur and spoon excavator, and these results agree with previous studies.[17] The reasons could be due to negative rake angle (design), tungsten carbide make, higher speed (12,000 rpm), and less control over the instrument—producing nonconservative cavity preparation, which is most likely to be influenced by operator handling. The mean percentage reduction of *S mutans* was significant in comparing excavation with polymer and carbide burs; however it was not significant between polymer bur and spoon excavator. In previous studies, only approximately 26% of the Smartbur-treated specimens were caries free vs approximately 54% with carbide bur.[18]

Caries excavation with a spoon excavator showed less reduction in microbial count vs a carbide bur and polymer. Similar results have been reported in previous studies using the same dentin sampling principle but different operative techniques. Operators' variability in excavation technique with a spoon excavator may be one of the reasons why variability in bacterial count was shown.

Overall percentage reduction of bacterial count with a polymer bur was shown to be less than a carbide bur but greater than a spoon excavator. These results agreed with previous studies.[10] Though these polymer burs are less effective at removing bacteria vs carbide burs, the patients were more comfortable and experienced less pain during excavation.[5] Polymer burs remove only infected carious dentin without harming any healthy or affected dentin and have the advantage of conserving tooth structure. These burs were used at a low speed of 800 rpm; however, they wear off as soon as they contact the affected dentin.[18] To improve their effectiveness in reducing bacteria, it is suggested to increase their speed and hardness so that they remove carious tissue quicker and with less wear.

Excavation with a polymer bur showed a significant reduction in bacterial count; however, no data is available about its effectiveness in reducing cultivable bacteria in dentin compared to other caries excavation techniques. The polymer bur, a newer tool in minimally invasive dentistry, has several advantages, including: single use; self limiting ability; less heat generation; reduced chance of pulp exposure; and minimal discomfort during caries excavation. Further research is needed, however, to evaluate its effectiveness in reducing viable cariogenic bacteria after excavation.

CONCLUSIONS

1. Caries removal with a carbide bur, polymer bur, and spoon excavator produced significant reduction in viable count of both *Streptococcus mutans* and lactobacilli.
2. Caries excavation with carbide bur, produced significant reduction in the viable count of both *S mutans* and lactobacilli when compared to polymer bur and spoon excavator.
3. Caries excavation with polymer bur showed an appreciable reduction in viable bacterial count when compared to spoon excavator, however the difference was statistically insignificant.

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