

Effect of chemomechanical excavation (Carisolv™) on residual cariogenic bacteria

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Abstract

The chemomechanical excavation approach fits the "adhesive cavity" design criteria by producing a rounded internal outline of cavity walls. However, such a relatively new and conservative approach should be at least as effective as conventional bur excavation in the removal of residual caries. Objectives: The aim of the present study was to test the effect of Carisolv™ chemomechanical excavation on caries removal and residual cariogenic bacteria as compared with conventional bur excavation using simple chair side methods. Methods and Materials: A total 15 patients (mean age 42.7 ± 11.3), presenting with a number of isolated class V carious lesions, were selected for the study. The carious lesions in each patient were randomly assigned to one of the excavation methods: (i) caries removal with Carisolv™ (n=22), (ii) conventional excavation with a bur (n=24). The carious lesions were measured before and after excavation by laser fluorescence, using DIAGNOdent®, and a microbial assay (Replica test) was used in evaluating the presence of cariogenic bacteria. Results: Both methods yielded similar results in DIAGNOdent® readings (9.9 and 7.9 for chemomechanical and bur excavation, respectively) and microbial assay (2.8 and 2.9% for chemomechanical and bur excavation, respectively). No significant difference was observed between the two excavation methods ($p > 0.05$). Conclusions: This suggests that the efficacy of chemomechanical excavation in carious removal and cariogenic bacterial reduction equals that of conventional bur excavation. *First published in Int Dent S Afric 2007; 9: 64-72.*

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Introduction

Recent developments in adhesive dentistry over the last decades have changed dramatically changed the clinical approach to cavity preparation. These changes have paved the way for more minimalistic means of cavity preparation in which sound tooth structure is preserved¹. Traditionally, caries may be removed mechanically with burs, hand excavators, and air-abrasion, or chemomechanically². Whereas, diamond and tungsten carbide burs simultaneously and indiscriminately remove caries-infected and caries-affected dentine, the chemomechanical technique (Carisolv™) aims to preserve tooth structure and to excavate caries on the basis of biological principles. The existence of two layers of carious dentine has been shown previously^{3,4}. This technique is based on the ability of sodium hypochlorite combined with three amino acids (Glutamic acid, Leucine, and Lysine) to selectively remove, already denatured collagen fibers in the outer layer of the carious lesion⁵. The use of this technique also improved the process of residual caries diagnosis, which has traditionally been carried out visually and relies mainly on tactile probing. Evaluating the cloudiness of the Carisolv™ solution, as a measure of the presence of caries in terms of denatured collagen, offered the clinician an additional tool for caries diagnosis. Combining this approach with digital detection of caries autofluorescence (DIAGNOdent®) was shown to be an effective and promising method⁶.

However, despite these improvements in caries diagnosis and treatment, the question of residual cariogenic bacteria still remains a major point. It has been well reported in the literature that the presence of cariogenic bacteria around and beneath restorations is the most important factor in restoration failure. In a comprehensive survey of prospective studies on the clinical performance of posterior resin composites it was found, that secondary caries was one of the main reasons for failure⁷. An accurate and reliable antimicrobial approach is important for effective long-term treatment success.

Sodium hypochlorite is commonly used as a disinfecting agent, owing to its antimicrobial activities⁸. This antimicrobial agent has been shown to be effective against bacteria in dental infections⁹ and cariogenic bacteria¹⁰. The sodium hypochlorite incorporated into the chemomechanical excavation gel was found to maintain these antibacterial properties¹¹.

Laboratory detection of cariogenic bacteria is fairly accurate but requires the use of elaborate microbiological techniques¹². Dentine sampling is the most commonly used method for evaluating the presence of cariogenic bacteria within the carious dentine^{12,13}. However, these methods are complicated and hardly suitable as chair-side procedures. A method for imprint sampling of cariogenic bacteria from tooth surfaces was reported by Rosenberg et al.¹⁴. According to this method an imprint of the tooth surface (or cavity) can be taken using sucrose containing impression material (chewing gum), and incubated in a selective medium for cariogenic bacteria. In the present study, we implemented this simple chair side technique for the detection of cariogenic bacteria on the tooth surface before and following cavity preparation, using a conventional bur or chemomechanical excavation.

The aim of the present study was to evaluate the effect of Carisolv™ chemomechanical excavation on caries removal and residual cariogenic bacteria as compared with that of conventional bur excavation.

Material and methods

Study Population

Fifteen patients (mean age 42.7±11.3) presenting with a number of isolated class V carious lesions were selected from the Hadassah Dental Faculty patient list. Informed consent was obtained and the experiment protocol was approved by the institute's Helsinki Committee. All the patients received professional teeth cleaning and oral hygiene instructions a week before the experiment.

Experimental Protocol

The carious lesions (active lesions, vital teeth) in each patient were randomly assigned to one of the excavation methods: (i) chemomechanical excavation with Carisolv™ (Medi Team, Dentalutveckling AB, Svedalen, Sweden) (n=22), (ii) conventional excavation with a bur (n=24). Chemomechanical excavation was conducted according to the manufacturer's instructions using the hand tools and gel supplied in the kit. Bur excavation was conducted using low speed round burs. The treatments were performed by three experienced dental practitioners. Caries excavation was twofold monitored, before and after excavation, by a single operator blinded to the mode of excavation assigned to each tooth. Measurements included DIAGNOdent® (Kavo, Biberach, Germany) readings of the carious lesion and the microbial contact assay (Replica Test; 14) for the detection of mutans streptococci on tooth surfaces. The measurements are described in detail below.

Microbial Assay

The replica test, using an impression matrix, was carried out by pressing a commercial gum containing sucrose (West, banana chewing gum, ION, Greece) against the buccal tooth and cavity surface. An imprint of the sampled teeth was obtained for further bacterial cultivation¹⁴. The imprinted matrix was immersed in a liquid mutans streptococci selective medium (composed of tryptose, proteose peptone, trypan blue, gentian violet, potassium tellurite and bacitracin) and incubated at 37°C for 24 h. The bacterial colonies, stained dark blue,

were clearly visible (Figure 1). After 24 hrs of incubation, the imprints were photographed using a digital camera (Coolpix 5000, Nikon, Japan). Digital image analysing software (ImageJ NIH) was used in evaluating cariogenic bacterial growth by quantifying the amount of blue colour produced on the imprint of the sampled tooth surface/cavity.

Fluorescence caries measurement

The DIAGNOdent® laser fluorescence system (Kavo, Biberach, Germany) was used to measure the carious lesion before and after excavation¹⁵. Measurements were performed by a single operator according to the manufacturer's instructions. The probe tip for smooth surfaces (B) was selected and the device was calibrated against a porcelain reference object and sound tooth surface. The device was held against the carious lesion and the maximal reading was recorded.

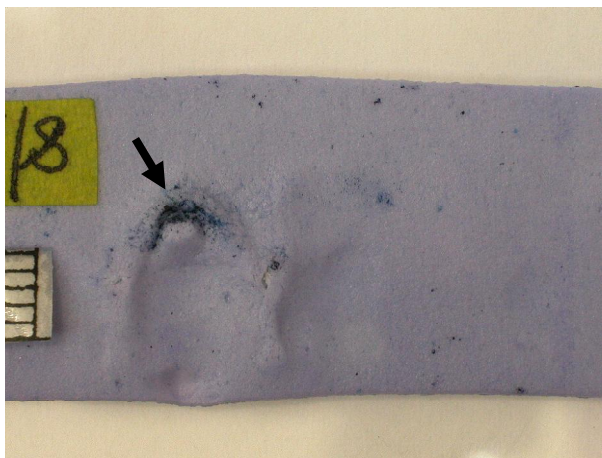


Figure 1. Shows the results of a typical replica test. An imprint of the sampled tooth is presented following incubation in a liquid mutans streptococci selective medium at 37°C for 24 h. The bacterial colonies, stained dark blue are clearly visible (arrow).

Statistical Analysis

The mean results and standard deviations of the various parameters were compared using ANOVA. P value of 0.05 or less was considered statistically significant.

Results

The results are shown in Figures 2 and 3. No statistical difference was observed between the two excavation methods before and after treatment both in terms of both the microbial assay (ANOVA, $p=0.31$ and $p=0.71$, pre- and post treatment, respectively) and the laser fluorescence readings (ANOVA, $p=0.34$ and $p=0.26$, pre and post treatment, respectively).

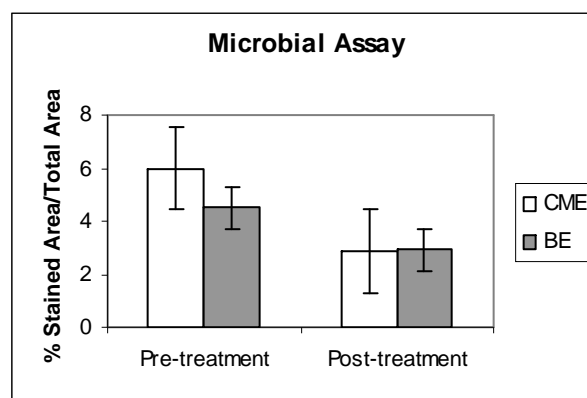


Figure 2. Mean result and standard deviation of the % of cariogenic bacteria CFU stained area as measured using the replica test before and after caries removal by chemomechanical (CME) or bur (BE) excavation.

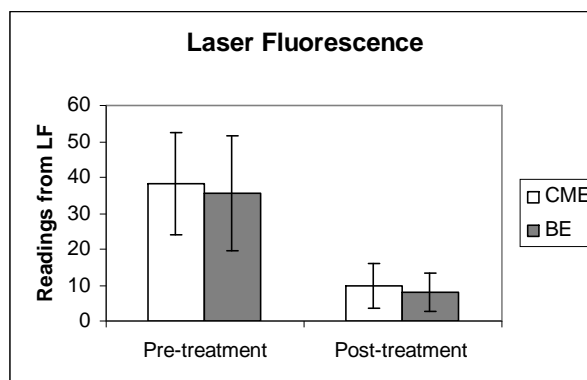


Figure 3. Mean result and standard deviation of the laser fluorescence readings as measured using the DIAGNOdent® before and after caries removal by chemomechanical (CME) or bur (BE) excavation.

Both excavation methods showed a similar efficacy in reducing cariogenic bacterial concentration, resulting in mean bacterial concentration (expressed as percentage of stained area within the total cavity area) of less than 3% (2.8 ± 2.9 and $2.9 \pm 2.3\%$ for chemomechanical and bur excavation, respectively) for both methods. Laser fluorescence readings as measured by the

DIAGNOdent[®] were significantly reduced by both methods to mean readings of less than 10 (9.9 ± 6.3 and 7.9 ± 5.2 for chemomechanical and bur excavation, respectively) levels defined by the manufacture as "no caries".

Discussion

Traditional bur excavation and the chemomechanical excavation used in this study both showed a similar efficacy in caries removal, as measured using DIAGNOdent[®], and in reduction of the amount of cariogenic bacteria, as measured using the replica test. These results are in agreement with those of other investigators^{12,16-18}, who used different bacteriological methods, mainly culture of dentine samples.

Dentine sampling is traditionally carried out by sampling the deepest dentine within the carious lesion or cavity preparation, using a sterile low speed round bur. These samples are later processed and evaluated for their bacterial content. The microbial assay used in this study (i.e. replica test) is a simple chair-side method that does not require extensive microbiological expertise. In contrast to the dentine sampling techniques commonly used in this type of investigation, the replica test does not require sampling dentine for laboratory analysis, thus eliminating the need for healthy tissue removal once the cavity preparation has been completed. Furthermore, this method helps to overcome a problematic aspect of dentine sampling, i.e. variations in sample volume. These variations were attributed to diverse factors, such as the differences in dentine consistency, sampling procedures and drying time¹².

However, despite its many advantages, the replica test used in this study still requires incubation and growth of the bacteria and suffers from the same drawbacks as the traditional cultivation methods in comparison with molecular methods (i.e. PCR), especially in underestimating the number of bacteria. The criteria for complete caries removal are subjective and open to interpretation by the clinician. In the present study we supported

these criteria using objective laser fluorescence (DIAGNOdent[®]) readings. According to the DIAGNOdent[®] criteria all the cavities were considered caries free following excavation with both excavation methods.

Various studies have shown that clinically caries-free dentine still contains residual cariogenic bacteria and it has been suggested that the small number of persisting cariogenic bacteria is of no clinical significance^{13,19}. However, the location of the residual cariogenic bacteria may also be of significance. For instance, bacteria located in the vicinity of the dentine-enamel junction are of more clinical significance with regard to secondary caries formation than those situated in other parts of the cavity²⁰. Use of the replica test provides an imprint sample of the entire cavity surface, enabling additional information to be obtained regarding the topographical distribution of the residual cariogenic bacteria within the various parts of the cavity surface.

Other studies have shown that although chemomechanical excavation is more time consuming than traditional bur excavation²¹ and can take up to three times longer²², the estimated quantity of tissue removed is significantly lower²². The approach now gaining acceptance worldwide of treating caries as a disease rather than a lesion²¹ places great emphasis on the reduction of the cariogenic bacterial load as part of this treatment. The results of our study indicate that the antimicrobial ability of the chemomechanical excavation enables it to achieve the same reduction in the cariogenic bacterial load as the bur excavation, while using a more minimalistic approach.

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摘要

化学机械备洞方法，通过产生一个洞壁的圆形内部轮廓而适用于“粘合剂牙洞”设计标准。然而，这样一种相对较新及保守的方法，在清除残留龋损方面应至少与传统的牙钻备洞方法同样有效。目标：当前研究的目的在于测试 CarisolvTM 化学机械备洞方法在清除龋损以及残留致龋细菌方面的效果，并与传统的简单的椅侧方法牙钻备洞进行比较。

方法和材料：挑选了15位病人（平均年龄 42.7 ± 11.3 ），这些病人有孤立的V类牙损。每位病人的牙损被随机分配使用下述备洞方法之一：(i) 使用CarisolvTM清除牙损（n=22），(ii) 使用牙钻的传统备洞方法（n=24）。

龋损在备洞前后使用DIAGNOdent®进行激光荧光方法测量，致龋细菌的存否用微生物化验（复制试验）的方法评估。

结果：两种方法在DIAGNOdent®读数上结果相似（化学机械方法9.9，牙钻备洞方法7.9），在微生物试验上也相似（化学机械方法2.8%，牙钻备洞方法2.9%）。

在两种备洞方法之间未能观察到显著差异（ $p > 0.05$ ）。

结论：表明化学机械备洞方法在清除龋损和降低致龋细菌上与传统的牙钻备洞方法功效相等。

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Resumen

El enfoque de excavación quimomecánica cabe los criterios del concepto “cavidad adhesiva” por producir un perfil redondeado interno de paredes de cavidad. Sin embargo, un tal enfoque relativamente nuevo y conservativo debería ser al menos tan efectivo que una excavación convencional de broca en la eliminación de caries residual. Objetivos: La meta del estudio presente era probar el efecto de la excavación quimo-mecánica CarisolvTM sobre eliminación de caries y bacterias cariogénicas residuales en comparación con excavación convencional con broca usando métodos simples de lado de silla. Métodos y materiales: Seleccionados para el estudio fue un total de 15 pacientes (edad media 42.7 ± 11.3), presentando con un número de lesiones con caries aisladas de Clase V. Las lesiones con caries en cada paciente

fueran a designadas al atar a uno de los métodos de excavación: (i) eliminación de caries con CarisolvTM (n=22), (ii) excavación convencional con una broca (n=24). Las lesiones con caries fueran medidas antes y después de excavación por fluorescencia de láser, empleando DIAGNOdent®, y la presencia de bacterias cariogénicas fue evaluada en utilizar un juicio microbiológico (prueba de Replica). Resultados: Ambos los métodos han producido resultados semejantes en las lecturas de DIAGNOdent® (9.9 y 7.9 para excavación quimo-mecánica y de broca, respectivamente). No fue observada ninguna diferencia significativa entre los dos métodos de excavación ($p > 0.05$). Conclusiones: Este sugiere que la eficacia de excavación quimo-mecánica en eliminación de caries y reducción de bacterias cariogénicas es igual a esa de la excavación convencional por broca. Publicado primero en *Int Dent S Afric* 1007; 9: 64-72.

Resumo

O enfoque quimomecânico à excavação se adapta aos critérios ao projeto de “cavidade adesiva” por produzindo um contorno interno arredondado de las paredes de uma cavidade. No entanto, um tal enfoque relativamente novo e conservador deve ser pelo menos tão eficaz como a excavação convencional pela broca na extração de cárie. Objetivos: A meta da presente investigação era pôr à prova o efeito da excavação quimomecânica CarisolvTM sobre a extração de cárie e as bactérias cariogénicas residuais em comparação com a excavação com broca convencional fazendo uso dos métodos simples na cadeira a lado. Metodos e Material: Um total de 15 pacientes (idade média 42.7 ± 11.3), apresentando-se com várias lesões cariadas isoladas de classe V, estiveram seleccionados para o estudo. As lesões cariadas em cada paciente estiveram designadas aleatoriamente a um dos métodos de excavação: (i) extração de

cárie com Carisolv™ (n=22), (ii) escavação convencional com uma broca (n=24). As lesões cariadas estiveram antes e depois da escavação pela fluorescência de laser, fazendo uso de DIAGNOdent(R), e a presença das bactérias cariogênicas foi avaliada fazendo uso de uma análise microbiana (2.8 e 2.9% para escavações quimomecânica e de broca, respectivamente). Não foi observada nenhuma diferença significativa entre os dois métodos de escavação ($p>0.05$). Conclusões: Isto sugere que a eficácia da escavação quimomecânica na extração cariada e redução bacteriana cariogênica é igual a essa da escavação convencional de broca. Publicado primeiro em *Int Dent S Afric* 2007; 9: 64-72.

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