

Chemomechanical Caries Removal with Respect to COVID-19 in Dentistry

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ABSTRACT

The invention and application of engine driven or rotary instruments in operative treatment of carious lesions has resulted in removal of considerable tooth structure. As possible alternatives to conventional techniques of caries removal, chemomechanical caries removal systems have emerged. Minimally invasive dentistry adopts a philosophy that integrates prevention, remineralization, and minimal intervention for the placement and replacement of restorations, thus reaching the treatment objective using the least invasive surgical approach, with the removal of the minimal amount of healthy tissues. Chemomechanical caries removal (CMCR) is a method for minimally invasive, gentle dentin caries removal based on biological principles which is an effective alternative to the traditional method.

Keywords: Chemomechanical caries removal, Carisolv, Papacarie

INTRODUCTION

One of the most common chronic oral infections is dental caries which also is the second largest cause of tooth loss after periodontitis.¹ Over the years there has been subsequent reduction in the caries prevalence in the developed countries but it continues to be a widespread one throughout the world. Traditionally, caries was removed mechanically with hand excavators and rotary instruments leading to overextended

cavities, healthy tissue removal, pressure and heat on pulp, vibration, noise, pain stimulus, and need for local anesthesia.²⁻⁴ The main disadvantages of conventional caries removal with bur and high speed motor are-(i) the perception by patients that drilling is unpleasant, (ii) frequent requirement of local Anesthesia, (iii) drilling can cause deleterious thermal effects, (iv) can also cause pressure effects on the pulp, and (v) use of drill may result in excessive removal of sound tooth structure.(vi) Generation of bioaerosols.^{5,6}

Painless dentistry, minimal intervention and thus giving relief, comfort, and solace and thereby instilling a positive attitude toward dental treatments is becoming the new rule in dentistry. The best way to ensure a maximum life for the natural tooth is to respect the sound tissue and protect it from damage by using minimally-invasive techniques in restorative dentistry.⁷

There have been huge advancements regarding restorative dental materials with more dependence on adhesive ones. The management of dental caries has drastically evolved from G.V. Black's "Extension for prevention" to "Construction with conservation".⁸ An innovative approach called "chemo-mechanical caries removal" technique which is minimally invasive and painless has been developed to overcome

the shortcomings of traditional approach of caries management.⁹

Background

The main constituents of dentin are minerals (70%), water (10%) and an organic matrix (20%). Among the organic constituents 18% are collagenous proteins and the rest includes the non-collagenous proteins like chondroitin sulphate, proteoglycans and phosphoryns.^{10,11} Collagen has a high content of amino acid proline and glycine with the polypeptide chains being coiled into triple helices known as tropocollagen units. These tropocollagen units are oriented side by side to form fibrils and it is the covalent bonding between these tropocollagen units and the polypeptide chains that renders collagen fibrils the desired stability.

These collagen fibrils form a dense meshwork which becomes mineralized. During the caries process the acid produced by plaque bacteria from the carbohydrates initially cause solubilisation of the mineralized portion of enamel. As caries progresses the dentinal tubules provides access to the bacteria along the acids causing demineralisation of the dentin. When the organic matrix has been demineralized, the collagen and other matrix components are then susceptible to enzymatic degradation, mainly by bacterial proteases and other hydrolases. When the collagen is degraded during the caries process two zones become evident-an inner layer which is partially demineralized and can be re-mineralized and in which the collagen fibrils are still intact, known as affected dentine, and there is an outer layer where the collagen fibrils are partially degraded and cannot be remineralized, known as infected dentine.¹³ An efficient process of caries removal should identify the mineralized portion as well as the demineralized one, and remove only the latter. Chemomechanical caries removal is a noninvasive technique eliminating infected dentine via a chemical agent. This process not only removes infected tissues, it also

preserves healthy dental structure, avoiding pulp irritation and patient discomfort. This is a method of caries removal based on dissolution. Instead of drilling, this method uses a chemical agent assisted by an atraumatic mechanical force to remove soft carious structure.¹⁴

Evolution of Chemomechanical Caries removal Agents

Habib *et al.* first studied the effect of sodium hypochlorite which is a non-specific proteolytic agent on carious dentin.⁹ Sodium hypochlorite being too unstable and corrosive to healthy tissues it was incorporated into Sorensen's media which contains glycine sodium chloride and sodium hydroxide. This involved the chlorination of glycine to form N-Monochloroglycine (NMG) which was more effective in removal of carious dentine than hypochlorite alone. The reagent subsequently became known as GK 101 and marketed in 1972 as first CMCR agent.¹⁶ In the same year, GK-101 was approved by the United States Food and Drug Administration (FDA). GK-101 consisted of 0.05% N-monochloroglycine (NMG) and NaOCl, and was prepared by mixing two solutions. Solution A consisted of 25 mL each of 2M NaCl, 2M NaOH and 2M glycine, and solution B consisted of 10 mL of 4–6% NaOCl. GK-101 required a special delivery system consisting of a reservoir (for warming the freshly prepared solution to 41 °C) and a pump (similar in shape to a straight handpiece) attached to a 20-gauge needle delivery tip. The delivery tip was applied to the carious lesion with minimal pressure via a paintbrush-like motion, since it was reported that excessive pressure led to an increase in the patient's pain response and blocked solution flow through the needle tip.¹⁵ GK-101 disrupted the organic structure of dentine by chlorination of the partially degraded collagen in the carious lesion and the conversion of hydroxyproline to pyrrole-2-carboxylic acid.⁹ Kurosaki *et al.* however studied the effect of GK 101 and the conferred that it would soften only the

first layer of carious dentine, and would not affect the second layer, and it has a very slow action.¹⁶

This led to the modification in the composition of GK101 and the glycine residue was replaced with aminobutyric acid. GK101E was developed which is basically ethyl derivative [N-monochloro-DL-2 amino butyrate (NMAB)] of GK-101 (NMG). The mechanism of action of NMAB on denatured collagen fibrils was similar to that of NMG, which involved the chlorination of the partially degraded collagen in the carious lesion and the conversion of hydroxyproline to pyrrole-2-carboxylic acid.¹¹ In addition to the chlorination reaction, cleavage of the denatured collagen fibrils might have occurred as a result of the oxidation of glycine residues.¹⁷ GK-101E was marketed as 'Caridex™' (National Patent Dental Products, Inc., New Brunswick, NJ, USA) and received FDA approval in 1984. Like GK101, caridex also required complex delivery system.¹⁸ Yip *et al.* reported that the addition of urea to Caridex enhanced the efficiency of caries excavation in deciduous teeth. The clinical usage and acceptance of both GK-101 and GK-101E solutions was very limited because neither showed a significant improvement in caries excavation compared with the conventional caries removal methods.¹⁹

In 1998 Carisolv was introduced as the latest sodium hypochlorite based chemomechanical agent. It was similar in structure to caridex but it required neither heating nor special delivery system; hence was more acceptable. The original Carisolv was red in colour, consisted of two syringes; one containing carboxy-methylcellulose-based gels and amino acids (glutamic, leucine and lysine); the other containing 0.25% NaOCl.¹⁴ The amino acids reacted with different moieties of the carious lesion. The addition of carboxy-methylcellulose created a higher viscosity of the Carisolv gel, which enhanced its handling properties compared to the Caridex solution.²⁰ In 2004, Carisolv was modified by removing

the red colouring agent, decreasing the amino acid concentration by half and almost doubling the NaOCl concentration from 0.25% to 0.475%.²¹ The manufacturer of Carisolv introduced a set of non-cutting tip instruments in order to increase caries removal efficiency and provide maximum conservation of the residual caries-affected dental tissue. The non-cutting tip has a 90° edge that allows a simple scraping movement for caries excavation which cannot be achieved with conventional spoon excavators that cut the dentine in one direction using a scooping motion.²¹ Recently, the Carisolv manufacturer has introduced a preset Carisolv treatment programme into an electronic endodontic motor PowerDrive (Medi Team Dentalutveckling AB). This uses a specially designed handpiece with non-cutting tip 'burs' operated in a similar manner to a conventional slow-speed handpiece. The manufacturer claims that this method has a much greater control of tissue removal at very low sound and vibration levels.²¹

Gradually the chemomechanical agents shifted from being sodium hypochlorite based to enzyme based products and Papacarie was the first in the lot. Papacarie is a Portuguese word meaning 'caries eater' and was first introduced by Bussadori *et al.* in 2003. It consists of papain enzyme, chloramine, toluidine blue, salts, preservatives, a thickener, stabilizers and deionized water; papain being the main constituent and chloramine was added to enhance removal of denatured tissues.^{22,23} Papain is a proteolytic enzyme with bactericidal and anti-inflammatory actions and it is obtained from the latex of the leaves of green adult *Carcica papaya* tree.²⁴ Papain acts by cleaving collagen molecules partially destroyed by the action of caries, and is able to digest dead cells and eliminating the fibrin coat formed by the caries process. It also acts only on carious tissue which lacks the plasmatic protease inhibitor alpha-1-antitrypsin, but its proteolytic action is inhibited on healthy tissue, which contains this substance.²² The

degraded portion of the carious dentine collagen is chlorated by the chloramine and is easily removed with excavator. Toluidine blue is a photosensitive pigment that fixes into bacterial membrane.²²

Effects of Chemomechanical Agents on Dental pulp and hard tissues:

Carisolv has no adverse effects on the exposed pulp and some studies showed similar results as Ca(OH)₂ pulp capping material which may be attributed to the highly alkaline pH of the material. These results were confirmed on animal models. Bulut *et al.* conducted a study on human teeth which were meant to be extracted for extraction purpose and found similar reparative effects.^{25,26}

Sakoolnamarka *et al.*²⁷ and Hamama *et al.*²⁸ reported that the Ca:P ratio of residual dentine following Carisolv removal of carious dentine did not significantly differ from the Ca:P ratio of sound dentine. This may imply that Carisolv is an effective method of removing caries-infected dentine. Scanning electronmicroscope observations of the dentine surface following Carisolv treatment showed that the excavated surface has an irregular surface topography and was also partially covered with a smear layer and that the hardness of residual dentine following Carisolv treatment was lower than the hardness of residual dentine following conventional caries removal methods.²⁸⁻³⁴ Furthermore, it was found that the hardness of the residual dentine gradually decreased towards the caries excavation edge.^{27,28} Based on these findings, Magalhaes *et al.*³⁴ concluded that 'Carisolv chemomechanical caries removal method seemed to be less effective in caries removal than conventional rotary methods'. However, Sakoolnamarka *et al.*,²⁷ correlating hardness values to the Ca:P ratio, concluded that Carisolv seemed to be an effective method in preserving cariesaffected dentine, but usually showed lower hardness values.²⁸

The studies performed as yet confirms no adverse effect of papacarie on the pulp tissue and the residual dentin

content. However further studies are needed to confirm the results.^{28,35}

Caries excavation Time:

In 2004, the new Carisolv gel was introduced after several attempts to improve the efficiency of the gel and reduce the excavation time. Fure and Lingstrom²² compared the caries excavation time of the original and new Carisolv gels and reported there was no significant difference in moderately-sized carious lesions; (new gel 6.7+/- 4.1 min vs original gel: 7.6 +/- 4.2 min; p > 0.05). Conversely, in deep lesions, the new gel exhibited a shorter mean excavation time compared with the original gel; (new gel: 9.0 +/- 7.0 min vs original gel 11.6 +/- 4.4 min; p < 0.05). A recent study²⁹ showed that the relatively longer excavation time using Carisolv may be attributed to the number of times the gel has to be applied; usually in the order of six, to remove the carious lesion. The end-point is when the gel no longer becomes turbid.

Clinical trials were carried out to find the excavation time for papacarie and it was found that papacarie has similar excavation time as that of conventional rotary instrumentation but less time than carisolv.²⁸

Recent advancements

Biosolv (SFC-V and SFC-VIII, 3M-ESPE AG, Seefeld, Germany) is a new experimental enzymatic chemomechanical caries removal agent. The information about Biosolv remains very limited and is based mainly on the manufacturer's claims.³⁶

Chemomechanical Caries removal in COVID-19 pandemic

The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has precipitated the COVID-19 pandemic. The World Health Organisation (WHO)³⁷ has recommended a society-wide quarantine approach (during acute or peak phases of the disease), social distancing and handwashing followed by contact tracing. Alongside this, most countries have

suspended elective and non-urgent dental care, closing many practices with only emergency treatment provision. However, the WHO has taken a cautious and risk assessment approach and recommended that situations where aerosol generating procedures (AGPs) are carried out should be reduced to a minimum, with additional precautions in place.^{38,39} Studies of microbial content of aerosols and splatter generated during dental procedures have mostly involved aerobic bacteria. Viral studies are sparse, focusing on blood-borne HIV and hepatitis B.^{40,41}

With the aim on performing caries excavation without generating aerosol, Atraumatic restorative treatment or chemomechanical caries removal is always a better alternative during this pandemic. A recent systematic review found CMCR time-consuming, but effective, for caries removal.⁴²

CONCLUSION

Chemomechanical caries removal may be a slow process for caries removal as compared to the conventional rotary methods as available. But it is no doubt a safer option to proceed in the current scenario as it is a non aerosol generating procedure.

Conflict of Interest

There are no conflicts of interest.

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