

Review Article

Chemomechanical Caries Removal Agents and Their Applications in Pediatric Dentistry

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Abstract:

There are different methods for management of dental carious lesion, these include conventional rotary caries removal, air abrasion, atraumatic restorative therapy, lasers and chemomechanical caries removal (CMCR). Mechanical caries removal technique was the standard for caries treatment. Although, this method has several disadvantages, where the non-selective dental tissues removal lead to healthy and infected dental tissues removal. The minimal intervention and awareness to patient comfort is very essential especially for the children, fearful and uncooperative patients. Chemomechanical caries removal is an alternative treatment of active caries. It involves the caries removal of only infected carious dental tissues. So, the removal of sound dental tissue is avoided, the fear and anxiety from handpiece vibration is also reduced which is more comfortable to the patients. CMCR technique acts by dissolution of the carious tissue with application of a natural or synthetic agent. CMCR agents were classified into sodium hypochlorite or enzyme-based agents. Examples of sodium hypochlorite-based agents are GK-101E, Carisolv and Cariemove; examples of enzyme-based agents are Papacarie, Carie-care, BiosolvTM and Brix 3000. This paper reviews in brief the differences between the chemomechanical caries removal agents.

Key words: Papacarie; Carisolv; Infected dental tissues; Chemomechanical.

Introduction:

Caries removal with the rotary method is considered psychologically traumatic due to anxiety and fear of children and their mothers (Rao, Panwar and Narula, 2020). The aversion from noise of rotational instrument and the use of anesthesia are the major factors for this psychological trauma (Hegde *et al.*, 2016). These factors lead to rejection of children to dental treatment, which leads to

the caries advancement to emergency situations. In these situations, unfortunately, the caries managements are more complicated, making anesthesia mandatory (Hegde *et al.*, 2016).

Besides, the attention towards the value of preserving sound dental tissues combined with a patient-friendly approach are becoming self-evident. Whenever possible, sound dentin should be preserved, and

invasive management should be kept to a minimum(Bjørndal *et al.*, 2019).

Minimal intervention dentistry is a philosophy that integrates prevention, remineralization and minimal invasive treatment. It achieves the objectives using the least invasive approach, with minimal amount of sound dental tissues removal (Showkat *et al.*, 2020) . It includes the following different techniques:, Atraumatic restorative technique (ART), air abrasion, Laser, Sono abrasion, and chemomechanical caries removal (CMCR) (Showkat *et al.*, 2020)

CMCR is the eliminating of infected dental tissues via synthetic or natural agents. This technique not only removes infected dental tissues, it also preserves healthy structures, avoiding patient discomfort and pulpal tissues irritation. Restoration of cavities prepared by this method requires materials such as glass ionomer or composite resins which chemically bond to the dental tissues rather than materials such as amalgams which involve cutting a designed cavity to mechanically retain the restoration (Ganesh and Parikh, 2011).

CMCR has multiple advantages such as: less pain perception and more comfortable, less anxiety and discomfort especially in school children, removes only the infected layer of dentin that leads to more dental tissue preservation, no pulpal tissue irritation, better caries removal in uncooperative children, and use in physically handicapped patients and in patients with infectious diseases like T.B (Rao, Panwar and Narula, 2020). CMCR agents are classified into sodium

hypochlorite or enzyme-based agents (Hamama, Yiu and Burrow, 2014).

Sodium hypochlorite (NaOCl) based CMCR agent:

The first studies on CMCR were done using a 5% NaOCl solution(Dhamija and Pundir, 2016). However, NaOCl alone was aggressive to sound dental tissues, which induced the addition of a buffer solution (sodium chloride , sodium hydroxide, and glycine), generating a new formula (GK-101) (Hamama, Yiu and Burrow, 2014).

GK-101:

GK-101 was introduced in 1972, in the United States Food and the Drug Administration (FDA) approved it in the same year. GK-101 consisted of two solutions of NaOCl and 0.05% of N-mono-chloro-glycine (NMG), by mixing these solutions it was prepared. Solution A consisted of 10 mL of 4–6% NaOCl and solution B consisted of 25 ml of NaOH, NaCl and glycine(Hamama, Yiu and Burrow, 2014). 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. A study revealed that GK-101 dental caries excavation time was 8.5 min. and the using of burs still an important subsequent step to finish the excavated cavities. Laboratory

results revealed that the GK-101 had no side effect on the platelet count, white or red cells of blood (Venkataraghavan *et al.*, 2013).

It was less effective in removing the entire dental carious lesion. (Hamama, Yiu and Burrow, 2014) Adjustment were done in the formula of GK-101 producing GK-101E to overcome the previous disadvantages (Hamama, Yiu and Burrow, 2014).

Caridex:

Subsequent studies revealed that the NaOCl based CMCR system was more efficient if amino butyric acid was added instead of glycine, the product then being N-monochloroaminobutyric acid (NMAB), it was ethyl derivative of NMG and was introduced as GK-101E in 1975, because of the addition of ethyl group. It was marketed as 'Caridex™' and was approved by FDA in 1984 (Chatterjee *et al.*, 2020).

Mechanism of action:

It was as that of NMG, include the chlorination reaction of partially destructed collagen in the dental lesion. Also, the glycine residues oxidation might lead to cleavage of degraded collagen.

GK-101E was effective in decreasing the time of caries excavation. They referred this difference in time to the lag period between the solution application and removal of caries. NMG showed a period of 30-90 seconds. But, NMAB solution exhibited no lag period (Hamama, Yiu and Burrow, 2014). Addition of the urea to Caridex might improve the dentine caries excavation efficiency in primary teeth, by breaking down the hydrogen bond between denatured

collagen so making them more soluble to be excavated (Hamama, Yiu and Burrow, 2014).

Carisolv:

The work by Medi Team in Sweden was continued on a system of CMCR agent known as Carisolv in January 1998. The Carisolv was originally red in color in the form of two syringes, one containing NaOCl solution and the other containing three amino acids: glutamic, lysine and leucine acid with carboxymethyl cellulose, to make a viscous consistency of the gel (Hamama, Yiu and Burrow, 2014). In 2004, Carisolv was modified by reducing the amino acid to half concentration, and doubling the concentration of sodium hypochlorite and removing the red coloring agent. It became in the form of multi-mix syringe that contains all ingredients and delivers the exact amount of required material (Hamama, Yiu and Burrow, 2014). The significant difference from Caridex was the use of three amino acids to neutralize aggressive effect of sodium hypochlorite on sound dental tissues. Carisolv has the same chemical action as Caridex in softening the carious dental tissues but leaving the healthy dental tissues unaffected (Puri *et al.*, 2020).

Meller et al. used soft micro brushes mounted on handpiece to speed up the process of excavation of dental caries. However, they reported that it was not efficient (Hamama, Yiu and Burrow, 2014).

Mechanism of action:

The mechanism of action of Carisolv is similar to that of Caridex..

Biological effects of Carisolv on the dental hard tissue and pulp:

A study had examined the application effect of Carisolv CMCR on the exposed dental pulp in rat (Hamama, Yiu and Burrow, 2014), revealed that Carisolv gel had no side effect on the dental pulp tissue, and some of the studies reported that Carisolv has an action similar to Ca(OH)₂ pulp capping materials. Also, it was revealed that Carisolv had a haemostatic and a bactericidal effects on dental pulp, which is related to the alkalinity of the Carisolv (Hamama, Yiu and Burrow, 2014).

A previous study was conducted to examine the effect of the carisolv gel on human pulpal tissue because the repair of rat pulpal tissue is higher than human pulpal tissue (Aubeux *et al.*, 2021). Although, findings of this study was in accordance with the previous animal studies (Hamama, Yiu and Burrow, 2014).

A lot of researches revealed that Carisolv had no side effects on the content of dental tissues. An in vitro study revealed that the Calcium: phosphate ratio of dentin after Carisolv caries tissue removal did not significantly differ from that of sound dentin. This might revealed that Carisolv is an efficient in removing the infected carious dental tissue^(6,14).

The excavation time

The old Carisolv gel required longer excavation time than the rotary method (Zaghloul, 2018). The new gel was introduced in 2004, following several trials to enhance the effectiveness of old gel. A

previous study done to **compare** the caries removal time of new carisolv and the original form, revealed that no significant differences regarding the moderate carious lesions. While regarding the deep lesions, the new Carisolv gel required shorter time compared to the old one (Hamama, Yiu and Burrow, 2014).

A study conducted in 2013, revealed that the longer caries excavation time of carisolv gel, may be related to the application of the gel to remove the carious dental lesion (Hamama *et al.*, 2013).

Cariemove

It is one of NaOCl based CMCR (Fig.1), there was lack of sufficient literature about it and its effectiveness in caries removal.



Fig. 1: Cariemove CMCR

Enzyme-based chemomechanical caries removal agents:

Papacarie:

Bussadori *et al.* introduced Papacarie CMCR gel. It consists of papain enzyme, toluidine blue, chloramine, stabilizers,

preservatives, a thickener, salts and deionized water (Rao, Panwar and Narula, 2020).

The main mechanism of action depends on the presence of the enzyme of papain which has a proteolytic, anti-inflammatory with bactericidal action. It is extracted from adult tree of *Carica papaya* (Hamama, Yiu and Burrow, 2014).

The previous study reported Papacarie to be easily manipulated, cheap and simple, as well as effective in infected tissues removal (Sahana *et al.*, 2016).

Mechanism of action:

The mechanism of Papacarie was based on the absence of α -1-anti-trypsin in the infected dental tissues (Chatterjee *et al.*, 2020).

Biological effect of Papacarie on the dental hard tissue and pulp:

A study conducted to examine the effect of Papacarie in comparison to carisolv, it was on subcutaneous tissue and cultured fibroblasts, revealed the biocompatibility of Papacarie CMCR gel and that it had similar animal implantation assays as Carisolv gel (Hamama, Yiu and Burrow, 2014).

Caries excavation time:

Laboratory studies and clinical trial (Singh *et al.*, 2011) had evaluated the time required for caries removal with Papacarie in comparison to Carisolv and rotary technique, revealed no difference between the rotary method and Papacarie. Although, Carisolv showed longer time than Papacarie.

Carie-Care™

It is developed by Uni-Biotech Pharmaceuticals Private Limited in India. The main active ingredient from papaya extract, chloramines and dye. Also, the gel contains percentages of essential oils such as clove oil, which has mild anesthetic and anti-inflammatory action. The preparation also contains a gelling agent to prevent the gel to be spill over when applied (Venkataraghavan *et al.*, 2013).

Effectiveness of cariecare in caries excavation and Microhardness of dentin following cariecare caries removal:

A previous research was conducted to evaluate the efficiency and efficacy of caries removal using Papacarie® and Carie-Care, revealed that they were conservative techniques in caries removal, but Papacarie was more efficient in bacteria reduction from the infected carious lesion in lesser time (Sahana *et al.*, 2016).

An in vitro study examined the effect of Carie-Care (CMCR) agent on dentin microhardness, and showed that the Carie-Care caused a change in normal and treated carious dentin microhardness (Ramamoorthi, Nivedhitha and Vanajassun, 2013).

Biosolv:

Biosolv is an enzyme based CMCR agent. It consists of pepsin enzyme in a phosphoric acid and sodium biophosphate (A. D. A. Neves *et al.*, 2011).

Biosolv instruments:

Biosolv manufacturers recommended a specific plastic instruments (MA, 2017). The

special plastic instruments hardness is between infected and sound dental tissues hardness.

Mechanism of action

It was supposed that the phosphoric component can affect the mineral contents of carious dentine, whereas allowing pepsin enzyme to destruct the degraded fibers of collagen. Meanwhile, these softened dental tissues can be removed easily without effect on sound dental tissues.

Biosolv effectiveness in caries excavation:

Banerjee *et al.* revealed that there were more caries-infected dentine tissues remained after Biosolv CMCR comparing with Carisolv CMCR and hand excavation techniques (Hamama, Yiu and Burrow, 2014). They related this to the buffering effect of dentin which counteracts with the function of the enzyme. On the contrary, the acidity of biosolv is the reason why it has an aggressive effect as it affect both sound and infected dental tissue (A. A. Neves *et al.*, 2011).

Brix 3000:

Brix 3000 was the recent enzyme-based CMCR agents. This CMCR gel introduced in 2012 by Brix Medical science, Argentina. The unique features of this product were the papain concentration which was increased in each 10% to 3000 U/mg, and the Encapsulated Buffer Emulsion technology. So, the Brix 3000 gel has the ideal pH to immobilize the enzymes, that enhance the proteolytic effect on the collagen fibrils in the carious dental tissues, resist the undesirable storage environment. As well, Brix 3000 didn't contain chloramines, and this enhances

its toxicological safety features (Inamdar *et al.*, 2020).

Caries excavation time of Brix3000

An invitro study evaluated the time required to caries removal with Brix 3000, conventional rotary method and sodium hypochlorite gel in deciduous molars, showed that the conventional rotary required less time compared to NaOCl gel and Brix 3000, although no difference was reported between NaOCl gel and Brix 3000 (Alkhouli *et al.*, 2020). Another in vivo study aimed to evaluate the time required to Brix 3000 caries removal compared with Carie Care gel and smart burs, the authors concluded that caries excavation time was lesser in Brix3000 group than Cariecare and smart burs (Inamdar *et al.*, 2020).

Conclusion

Whenever possible, dental tissues should be kept preserved; invasive surgical treatment should be kept to minimum and the natural dental tissues should be replaced with artificial substitutes only when its removal is definitely unavoidable. The best way to ensure maximum life for the natural teeth is to respect the sound dental tissues and protect it from damage by using minimally intervention techniques in the restorative dentistry.

According to the evidence, the available CMCR techniques are considered an effective method of caries removal. Although, it takes longer time for removal of caries but it is highly useful in very fearful and anxious patients so it can bring promising results in pediatric, as well as special health care need patients.

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