

## Review Article

**A Review on Agents for Chemo-mechanical Caries Removal**Nidhi Dhamija<sup>1</sup>, Prachi Pundir<sup>2</sup><sup>1</sup>MDS, Pedodontics and Preventive Dentistry<sup>2</sup>Consultant, Scaling up RMNCH+A Interventions, IPE Global Ltd., New Delhi.**\*Corresponding author**

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**Abstract:** Chemo-mechanical caries removal was introduced to dentistry as an alternative to conventional drilling methods (which was the most frequently used method for caries removal). Chemo-mechanical caries removal is primarily indicated to overcome the inconvenience of using burs and local anesthesia, hence preserving healthy dental structure and causing less discomfort to patients. It complies with the concept of the minimal invasive dentistry. Caridex, Carisolv, Papacarie and Carie-care are some of the chemo-mechanical organic caries removal agents. The review will address systems of chemo-mechanical caries removal and their advantages by comparing within the various chemo-mechanical caries removal agents.

**Keywords:** Chemo-mechanical caries removal, Caridex, Carisolv, Papacarie, Carie-care

**INTRODUCTION**

The word 'caries' is derived from the Latin word for 'rot' and the Greek 'ker', which means 'death'. Dental caries has affected humans since prehistoric times. According to the definition by Shafer, 'Dental caries is an irreversible microbial disease of the calcified tissues of teeth characterized by demineralization of inorganic portion and destruction of organic substance of tooth.' It is one of the most prevalent oral diseases and is of great public health concern.

The earliest attempt to remove caries used hand drill, which was soon succeeded in 1871 by treadle instrument invented by James Morison. Since that time, various drills have been developed to improve the efficiency of rotary instruments [1]. Conventional caries removal and cavity preparation involves the use of burs. Disadvantages of this system include [1] perception of patients that drilling is unpleasant[2], frequent requirement of local anesthesia [3] probable deleterious thermal effects of drilling, [4] probable pressure effects of drilling on the pulp, and [5] the use of a hand piece may result in removal of softened, but uninfected dentin, ensuing an excessive loss of sound tooth tissue. This resulted in a growing demand for materials or procedures that help in caries management.

The chemo-mechanical method for caries removal was developed to overcome these shortcomings. It is comfortable for the patient and

preserves the healthy tissue causing less discomfort to patients and preserving healthy dental structure [2]. It complies with the concept of the minimal invasive dentistry [3]. Fear and anxiety are barriers to dental treatment among children which may be a cause of discomfort due to conventional drilling method[3]. The initiators of anxiety may be many, including local anaesthesia, rotary instruments and previous experience; with the magnitude of this problem, use of chemo-mechanical caries removal is necessary to improve dental treatment experience of children. Caridex, carisolv, papacarie and carie-care are some of the chemo-mechanical organic caries removal agents which are discussed in this review.

**Evolution of Chemo-mechanical caries removal agents**

The principle of chemo-mechanical caries removal is based on studies done by Habib *et al.* in the decade of 1970[3-4]. They reported the effect of a non-specific proteolytic agent called sodium hypochlorite on the removal of carious dentin. They noticed that 5% sodium hypochlorite was too corrosive for use on healthy tissue and incorporated Sorensen's buffer into it. Sorensen's buffer contained glycine, sodium chloride and sodium hydroxide. Later it was found that form N-monochloroglycine (NMG), which was prepared by chlorination of glycine, was more efficient in caries removal and was made available as the first chemo-mechanical caries removal agent, GK-101 in 1972. Limitation of GK-101 was, it had a slow action

and softened only the first layer, but not the second layer [3-5].

In later studies, it was found that the system was more effective if amino butyric acid replaced glycine, hence the product N-monochloroaminobutyric acid (NMAB) was formulated which was also called GK-101E. In 1975, the NMAB system was patented in the United States and received US Food and Drug Administration approval for use in 1984 and later marketed with the name Caridex[4,5].

#### CARIDEX

It consists of two solutions:-

- a) Solution I: 1% NaOCl
- b) Solution II: Glycine, Aminobutyric acid, NaCl and NaOH

The two solutions are mixed immediately before use to give the working reagent [pH 12] which is stable for 1 hour [3].

#### Delivery system

Delivery system available for Caridex consists of a reservoir for the solution, a heater and a pump which pass the liquid, warmed to body temperature through a tube to a hand piece and an applicator tip (in various shapes and sizes).

The solution is applied to the carious lesion by means of this application which is used to loosen the carious dentin by a gentle scraping action, the debris together with the spent solution being removed by aspiration. Application is to be continued until the remaining dentin is deemed sound by normal clinical tactile criteria. With suitable accessible soft lesions, after 15 to 20 min treatment, only clinically sound dentin remains.

The reagent selectively removes carious dentin leaving a surface with many overhangs and undercuts. The procedure avoids the painful removal of sound dentin, but is ineffective in the removal of hard parts of the lesion (eburnated dentin). Recently, it has been shown that discoloration in carious dentin results from the Maillard reaction which modifies amino acids in collagen, making them more resistant to proteolytic attack and inhibiting lesion progression in discolored dentin [3].

#### Mode of action

The mechanism of action of N-monochloroglycine and N-monochloroaminobutyric acid on collagen is unclear. Originally, it was thought that the procedure involved chlorination of the partially degraded collagen in the carious lesion and the conversion of hydroxyproline to pyrrole-2-carboxylic acid. Further work suggests that cleavage by oxidation of glycine residues could be involved[3]. This causes

disruption of the collagen fibrils which become more friable and can then be removed[6].

#### Limitations of caridex system

1. Rotary or hand instruments may still be needed for the removal of tissue or material other than degraded dentin collagen- access to small or interproximal carious lesions, removal of enamel overlying the caries, removal of existing restorations as well as for cavity design when non-adhesive restorative materials are used.
2. The system requires large volumes of solution – 200-500ml and the procedure is slow and costly.
3. Because of the time required, the large volumes of solution needed and the fact that the delivery system was no longer commercially available, the use of caridex, despite its potential, became minimal[7].

#### CARISOLV GEL

Carisolv gel is commercially available in two different packages:-

- Carisolv gel – Multimix
- Carisolv gel – Single mix

Carisolv gel is marketed in 2 syringes. Equal parts of the two are mixed to form the active gel substance.

- a) **Syringe I:** 0.5% NaOCl
- b) **Syringe II:** Amino acids- Lysine, Leucine and glutamic acid, Carboxymethyl cellulose, Erythrocinand NaOH



Fig- 1: Carisolv gel (Source: Ozident website)

#### Properties

The first marketed version of Carisolv gel was red, but in recent years the gel has been colorless, being prepared at the University of Goteborg, Sweden. Increased amount of free chloramines were needed to improve its efficacy, which in turn required a higher concentration of sodium hypochlorite. Effect of higher concentration of sodium hypochlorite is that the color agent is removed, and the gel is uncolored [3].

#### Mode of action

The principal mode of action is based on the use of a non-specific proteolytic agent called sodium

hypochlorite, and effectual interaction of three amino acids (0.1M Amino butyric acid glycine, 0.1M NaOCl and 0.1 NaOH) with carious dentin, removing organic components at room temperature. The gel is effective one minute after mixing. The gel is repeatedly applied to the carious dentin and softened caries dissolved by the Carisolv gel is gently removed with specially designed hand instruments, thus preserving the remineralizable layer of dentin, let alone underlying sound dentin.

The mechanism of gel is based on the proteolytic effect of sodium hypochlorite. It dissolves infected dentin, as chlorine breaks down degraded collagen. The amino acids intensify the effect on the denatured collagen. They have no detrimental effects on healthy, hard dental tissues[8].

- When complete caries removal is achieved by this technique, the cavity surface has been shown to be as sound as it remains after conventional drilling.
- Toxicity studies have shown the solution to be safe and to have no adverse effects on pulp or healthy tissue, although, a few patients find the taste unpleasant. Generally this is not a problem and a patient acceptance is high.
- The gel has been reported to have an antibacterial action, but this action has yet to be thoroughly documented.
- The Carisolv treated dentin surface appears to be compatible with restorative adhesive technique.
- No reduction in bond strength has been observed allowing adhesive restorations to be placed. It is widely accepted that Carisolv potentially increases adhesion to dentin, but does not eliminate the need for pre-treatment with etchant or self etching adhesive system prior to restoration.

#### Advantages

The advantages include reduced need for local anesthesia, conservation of sound tooth structure and reduced risk of pulp exposure. It is well suited to the treatment of anxious or medically compromised patients and pediatric patients. This method causes less discomfort compared to drilling, but takes longer to perform[8-9].

#### Advantages over Caridex

The Carisolv system is much easier to use than Caridex.

1. As it involves a gel rather than a liquid, there is better contact with the carious lesion and the quantity required is very less which enhances precision placement.
2. Three amino acids are incorporated instead of one and different charges have improved the interaction with the degraded collagen within the lesion, thus increasing efficiency.

#### Indications

- All forms of carious dentin.

- Root caries.
- Medically compromised patient.
- Anxious patients.

#### Disadvantages

- Extensive training and customized instruments required, which increases the cost of the solution.

#### PAPACARIE

In 2003, a research project in Brazil led to the development of a new formula to universalize the use of chemo-mechanical method for caries removal and promote its use in public health. The new formula was commercially known as Papacarie[10-11].



Fig-2: Papa cariegel (Source- Ganesh *et al.*, [3])

Papacarie basically comprises of papain, chloramines, toluidine blue, salts, thickening vehicle.

#### Papain

Papain is a proteolytic enzyme. It has bactericidal, bacteriostatic and anti-inflammatory characteristics [10-14]. Similar to the human pepsin, papain acts as a debrindant, anti-inflammatory agent which does not damage the healthy tissue and accelerates the cicatricial process. Papain comes from the latex of the leaves and fruits of the green adult papaya.<sup>[11-14]</sup> Papain acts only in infected tissues because infected tissues lack a plasmatic anti protease called  $\alpha 1$ -anti-trypsin. The  $\alpha 1$ -antitrypsin is only present in sound tissues and it inhibits protein digestion. The absence of the  $\alpha 1$ -anti-trypsin in infected tissues allows papain to break the partially degraded collagen molecules [15-18].

#### Chloramine

It is a compound comprised by chlorine and ammonia and has bactericidal and disinfectant properties. It is widely used as an irrigating solution of radicular canals in order to chemically soften the carious dentin. The degraded portion of the carious dentine collagen is chlorated by the chloramine and is easily removed with excavator.

#### Toluidine blue

Initially, malachite green was used as coloring agent, however, after a few studies toluidine blue was found highly effective against *Streptococcus mutans*. It is a photosensitive pigment that fixes into the bacterial membrane.

**Mode of action**

When papacarie is applied on the carious teeth, within a minute it causes chemical debridement, which is due to the papain gel. Degradation and elimination of fibrin mantle (formed by carious process) followed by breakdown of collagen molecules. The degraded collagen is then chlorinated by chloramines, which also liberates oxygen, resulting in bubbling action and blearing of gel. The effervescence disturbs the hydrogen bond and affects secondary and quaternary structure which leads to softening of dentin and facilitating removal of carious tissue [14-18].

**Advantages**

1. Papacarie is a biocompatible gel with antibacterial properties that eliminates the need for anesthesia, removes only the compromised tissue and preserves the healthy tissue better.
2. The formation of a smear layer is not observed after using the gel.
3. The gel combines an atraumatic treatment with antibacterial properties without affecting healthy tissue and causing pain.
4. Papa carie was evaluated *in vitro* for cytotoxicity in fibroblasts culture at different concentrations (2, 4, 6, 8 and 10%) and was found to be safe and non-cytotoxic *in vitro* fibroblast culture.

Carie care system was introduced in India by Uni-biotech Pharmaceuticals Pvt. Ltd., which consists of papaya extract(papain) 100mg, clove oil 2mg, colored gel(blue), chloramines, sodium chloride, and sodium methylparaben, with similar properties as that of papa carie.



**Fig-3: Carie-care caries solvent (Source- Indian Dental Mart website)**

**Advantages**

1. It is lower in cost as compared to papacarie.
2. It is available commercially in India and is used in dental colleges widely.

**Comparison between various chemo-mechanical caries removal agents**

The various chemo-mechanical caries removal agents available are listed in Table 1. The agents vary and are hence compared based on properties to gain an insight into the process and requirements.

**CARIE-CARE**

**Table 1: Comparison between various chemo-mechanical caries removal agents**

	<b>Caridex</b>	<b>Carisolv</b>	<b>Papacarie</b>
Solution – I	1% NaOCl	0.5% NaOCl	Single gel
Solution – II	0.1 M aminobutyric acid glycine 0.1 M NaCl 0.1 M NaOH	0.1 M glutamic acid / leucine / lysine NaCl NaOH	Endoprotein- Papain and Chloramines
Dye	-	Erythrocin(pink)	Toluidine blue
pH	11	11	11
Physical properties	Liquid	Gel	Gel
Volume needed	100-500 ml	0.2 - 1.0 ml	0.2-1.0 ml
Time required	5-15 minutes	5-15 minutes	5-8 minutes
Equipment required	Applicator unit	None	None
Instruments	Applicator tips	Specially designed	No specific
Preparation remains active after mixing	1 hour	20 minutes	No mixing

**CONCLUSION**

Removal of decayed tissues with chemo-mechanical caries removal agents is efficient, easy to perform, comfortable and less destructive to the dentinal tissue. Variety of materials is available commercially, which increases the accessibility and affordability. Agents such as carisolv, papacarie and carie-care are widely used materials and hold a bright future in minimum invasive dentistry. Further research should be taken up on effectiveness of chemo-mechanical caries removal compared to conventional methods.

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