

## Chemomechanical Caries Removal: An Insight into the Agents' Development and the Clinical Efficiency

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### Review Article

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**Abstract:** Chemomechanical caries removal is a minimally invasive technique which is gaining attention in dental practice. The agents are either sodium hypochlorite- based such as GK-101, GK-101E (Caridex™) & Carisolv™, or enzyme/papain-based agents like Papacarie® and Carie-Care™. This review outlines the historical development of the chemomechanical caries removal methods and their clinical efficiency based on recently published laboratory and clinical studies. Based on the existing evidence, the available chemomechanical caries removal methods are promising alternatives to the conventional rotary methods. Chemomechanical methods could be more useful in very anxious, special need and pediatric patients. These agents would still benefit from quicker excavation times in order to achieve more universal acceptance.

**Keywords:** Dental caries; Papain; Carisolv™; Papacarie®; Carie-Care™; Chemomechanical Caries Removal; Minimally Invasive Dentistry

### INTRODUCTION

Dental caries removal in practice, whether partial or complete, can be performed using different methods. Conventional caries removal methods involve the use of sharp-edged hand instruments (excavators) and/or burs on high-speed and a low-speed rotary handpieces [1].

Chemomechanical caries removal is a method for minimally invasive, dentin caries removal based on biological principles which involves the chemical dissolution of carious/infected dentin followed by its removal by gentle mechanical excavation with hand instruments [4,5]. The chemical agent selectively degrade the demineralized collagen in carious dentin [3,6,7].

In the literature, various studies evaluated and compared their clinical efficiency and investigated various variables on primary and permanent carious teeth.

### Chemomechanical caries removal agents

The chemomechanical agents rely on the action of proteolytic agents such as synthetic agent (sodium hypochlorite) or natural agent (papain) to further degrade the partially demineralized and altered dentin matrix that has been previously exposed to bacterial action (infected dentin), thus facilitating its removal and preventing damage to the underlying demineralizable tissues (affected dentin) [3].

### GK-101 and GK-101E (Caridex™)

The idea of chemomechanical system was initially introduced in 1970s, in the form of the original GK-101 solution. The GK-101 formula consisted of N-monochloroglycine and 5% sodium hypochlorite (NaOCl) [8]. However, GK-101 was too slow in caries removal rate and evolved into GK-101E; Caridex™ (National Patent Medical Products Inc., New Jersey, USA) which was approved by the United States Food and Drug Administration (FDA) in 1984. Caridex™ contained N-monochloro-DL-2-aminobutyric acid, instead of N-monochloroglycine, although same principles of the previous product [9].

There were major drawbacks with the clinical effectiveness of Caridex™. These include large volume of solution needed, its short shelf life, and a special applicator instrument was required. To overcome these issues, a new product; Carisolv™ was introduced [6,9].

### Carisolv™

Carisolv™ (MediTeam Dental AB, Sweden) is a gel-based system which has gained popularity and considered as the gold standard for several years since

its launch in 1998. It consists of two gel syringes, one contains carboxymethylcellulose and amino acids (glutamine, leucine, and lysine); while the other syringe contains 0.5% NaOCl [8,10].

Its effectiveness is based on the proteolytic action of NaOCl, which dissolves the infected dentin, and on the action of amino acids, which enhance the effect of NaOCl on denatured collagen/proteins; carious dentin, thus minimize damage to healthy tissue [2,11].

Carisolv™ gel claims to remove infected, degraded, and demineralized dentin only, leaving the unaffected dentin layer. It also has an antibacterial effect on the carious dentin, and has been shown to be biocompatible with the dental pulp [11].

Carisolv™ requires volumes of 0.2–1.0 ml and has been developed for use with specially designed, non-cutting hand instrument (Maillefer curette) to abrade the carious dentin surface following its application [6].

The previously mentioned agents; GK-101, Caridex™, and even Carisolv™, failed to be practical alternatives to the conventional rotary method of caries removal due to their high cost, need of special instruments, more time consumption and unpleasant smell and taste of chlorine [12].

Considering the above disadvantages, a new formulation based on a natural component (papain) was introduced under the commercial name, Papacarie® [8,13].

#### **Papacarie®**

Papacarie® - a papain gel (Formula & Acao, Sao Paulo, SP, Brazil) is a Brazilian formulation for chemomechanical caries removal, which was introduced in 2003 [8,14].

Papacarie® is constituted of papain, a papaya extract, which is a natural proteolytic enzyme and has collagen degradation features, antibacterial and anti-inflammatory properties [8,15–17].

Papacarie® gel based on papain is additionally contain chloramine and toluidine blue and considered as a biocompatible gel with conservative, antibacterial, and atraumatic properties, which could reduce the risk of pulp exposure and not damage healthy tissue [2,18].

Papacarie® has further advantages of ease of application and no need for special instruments [12]. The new version of this product is Papacarie Duo™, which was released in 2011 and has the same efficacy plus a number of additional properties, such as a longer shelf life and no need for refrigerated storage [4].

#### **Carie-Care™**

Recently, to develop a cost-effective material, a newer product was introduced into the market under the name of Carie-Care™ (Uni Biotech, Pharmaceuticals Pvt, and India). Carie-Care™ gel was developed by Vittal Mallya Scientific Research Foundation, India in 2011 [5]. It is also a papain-based gel and consists of papaya extract, clove oil, colored gel, chloramines, sodium chloride (salt), and sodium methylparaben [3,8].

The advantages of Carie-Care™ are its ease of application which does not need special instruments, the preparation does not contain sodium hypochlorite and has most of the ingredients derived from natural sources [11,13]. In addition, it has anti-inflammatory and mild anesthetic effect due to the added of the essential therapeutic oils from plant sources [11,18,19].

#### **CHEMOMECHANICAL versus ROTARY METHODS**

Since the release of chemomechanical caries removal systems, many studies have been conducted to evaluate their clinical efficiency compared to the conventional rotary methods in both primary and permanent carious teeth.

There is agreement in the literature that chemomechanical caries removal methods are less traumatic to the dentinal tissue (more conservative), less pain and anxiety, less need for local anesthesia, more patient comfort and less pulp irritation, when compared to the rotary methods [19–24].

However, as the chemomechanical gel only works on carious dentin, rotary instruments may be still required to gain access to the dentin, unless the lesion is already cavitated.

Chemomechanical method provides effective caries removal, preservation of healthy structures, and bacterial reduction [10,16,21]. The Carisolv™ showed increase of pulp survival rate compared to the rotary method in a recent randomized clinical trial [25].

In two systematic reviews published in 2014 and 2015, it was concluded that there was no significant difference regarding the complete caries removal rate between Carisolv™ and the rotary method [1,22]. An *in-vitro* study used Papacarie®, found no significant difference in the completeness of caries removal when compared to the rotary method [14].

However, the rotary method tends to overprepare cavities due to lack of sensitivity of the tactile feedback, but based on the operator's subjectivity. This would result in gross removal of tooth tissue [3,5].

The micro hardness value of dentin following caries removal was significantly higher in the rotary group compared to Carie-Care™ group [3]. In another study, dentin hardness of the cavity floor after Papacarie® application was significantly lower compared to the rotary method [14].

In studies with microbiological evaluation of the remaining dentin after caries removal, it was observed that both the mechanical and chemomechanical methods produced statistically significant reduction on counts of viable cariogenic bacteria [12,23,26].

In a recent microbiological analysis and clinical study by Moimaz *et al.* [27], there was no statistically significant difference in the reduced amount of *Streptococcus mutans* and *Lactobacillus* between the mechanical and chemomechanical caries removal methods.

The rotary method results in a smear layer over the dentin and occludes the dentinal tubules, which may interfere with adhesion of the following restoration if not fully removed. The cavity surface prepared with rotary instruments has usually smooth and flat appearance [14,28].

On the contrary, dentin surface following chemomechanical treatment was irregular with remained very minimal smear layer and most of the dentinal tubules were opened, which would be well suited to bonding with adhesive restorations [3,6,28].

A study by Chittem *et al.* [13], found no difference in microshear bond strength and the type of failure of an adhesive system to caries-affected dentin when compared rotary *versus* Carie-Care™. Some other studies also showed that the chemomechanical methods did not adversely affect the bond strength or the survival of the restorations compared to the conventional rotary method [8,10,26,29].

The roughened surface created by chemomechanical caries removal would offer better prerequisites for micromechanical retention and resin penetration which results in higher bond strength [13].

Regarding the time taken for caries removal, most of the studies in the literature indicated that chemomechanical caries removal methods required a significant longer time for effective treatment than the rotary methods [10,30].

The conventional rotary method required significant less time for caries removal when compared to Carisolv™ [1,22,31], Papacarie® [14,16,23], or Carie-Care™ [7,32].

However, few other studies found no difference with regards to the time spent for caries removal. Interestingly, we noted that these studies were using the papain-based gel; Papacarie® [12,21,27].

The manufacturer of Papacarie®, recommended 60 s application of papain gel. However, at the end of a single application, complete caries removal may not be evident, which required two to three repeated applications [13].

Additionally, it was observed that time taken with initial few cases was much higher than the conventional rotary method. However, with time and development of expertise, no difference in time spent to remove caries with papain gel [33,34].

In addition, advantages of chemomechanical methods such as reduced pain, need for anesthesia outweigh the longer time requirement and would make it the preferred method for caries removal [31].

Removal of caries is subjective to the operator experience and also use of local anesthesia in conventional rotary method would increase the total time and would be comparable to the chemomechanical method. The measured time required for caries removal in some studies did not usually include the time required for local anesthesia administration, and probably less time needed due to patients' perception of more comfort with the chemomechanical methods [24,26]. Thus, considering the factor of time efficiency should be interpreted with caution [24].

#### **Carisolv™ versus Papacarie®**

In the literature, several studies compared several variables between sodium hypochlorite (NaOCl) and enzyme (Papain) -based agents, with contrary results.

The enzyme-based chemomechanical caries removal (Papacarie®) had more antibacterial effect, higher efficiency, more reduction of the residual cariogenic bacteria in the dentin, fewer applications required, and more patient acceptance than the sodium hypochlorite-based method; Carisolv™ [20,30,35–38].

However, on the other hand, other studies found comparable efficacy for complete caries removal between the two agents; Carisolv™ and Papacarie® [2,39], and both have similar antibacterial efficacy with no statistical significance for the total viable bacterial counts [40]. Recently, Moimaz *et al.* [27], reported lack of difference in reducing bacterial count, treatment acceptability, or pain between the use of Carisolv™ and Papacarie®.

Regarding the time required for caries removal, there were controversy results of the studies compared Carisolv™ with Papacarie® agents. While

some studies reported that Papacarie<sup>®</sup> required less time [20,30,38], other studies found no significance [2,27].

### Carisolv<sup>™</sup> versus Carie-Care<sup>™</sup>

Carie-Care<sup>™</sup>, a gel based on papain, is inexpensive, and has a similar caries removal efficiency compared with Carisolv<sup>™</sup> [13].

Both Carisolv<sup>™</sup> and Carie-Care<sup>™</sup> gels showed significant antibacterial activity and reduction of the total viable count for *Streptococcus mutans* and *Lactobacillus acidophilus*, but no difference between them [11].

However, the smear layer removal showed to be significantly higher in the sodium hypochlorite-based gel (Carisolv<sup>™</sup>) than in the papain-based gel (Carie-Care<sup>™</sup>) [41].

### Papacarie<sup>®</sup> versus Carie-Care<sup>™</sup>

Comparison between the two papain-based gels; Papacarie<sup>®</sup> and Carie-Care<sup>™</sup> is limited in the literature. Though both agents showed the minimal smear layer over the dentinal tubules, Carie-Care<sup>™</sup> showed a clearly exposed peri-tubular and inter-tubular collagen network; better surface morphology [18].

### CONCLUSIONS

Chemomechanical caries removal method is a promising alternative procedure as efficient in removing infected dentin selectively without altering the healthy dentinal tissue.

These agents have considerable attractions in dental practice for selected cases such as children and anxious patients, but may need to be faster in action to increase their popularity.

With further and continuous development, well-designed, randomized trials investigating the most relevant outcomes are needed.

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