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Original Article

CHEMOMECHANICAL CARIES REMOVAL: AN OVERVIEW

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Abstract

Minimal caries excavation is the recent demand of dentistry and it includes chemomechanical caries removal methods and various agents. Based on existing evidence, conventional rotary instrument methods are outdated and the currently available chemomechanical caries removal methods are viable alternatives, as later could be extremely useful in very anxious, disabled and paediatric patients. It does seem some of these agents would still benefit from quicker excavation times in order to achieve more universal acceptance but these recent methods are much more useful in conserving the caries-affected dentin, than conventional rotary instrumentation.

Keywords: Carisolv, Papacarie, Carie care

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INTRODUCTION

Due to fear and anxiety of children and their parents, dental treatment including restorative treatment of carious teeth in children with conventional drill is considered traumatic. (Scott et al., 1984).¹ Avoidance of dental treatment due to fear factor leads to delay in treatment which results in progression of caries which itself is an emergency situation.² With advances in operative dentistry, the management of dental caries has drastically evolved from G.V. Black's "Extension for prevention" to "Construction with conservation" (Tandon, 2008).³

Chemomechanical caries removal concept includes the early detection of lesions, individual caries risk assessment, non surgical interventions and modified surgical approach which includes smaller tooth preparations with modified cavity designs and adhesive dental materials and repair rather than replacement of failing restorations. The goal is to preserve the natural tooth structure.⁴

Chemomechanical caries removal (CMCR) is a noninvasive technique of removal of caries via eliminating infected dentin and preservation of affected dentin and healthy tissue via a chemical agent avoiding pulpal irritation and patient discomfort. This is a dissolution based caries removal method where a chemical agent assisted by atraumatic mechanical force is used for removal of soft caries. This procedure selectively removes carious dentin but avoids the painful and unnecessary removal of sound dentin.⁵

Materials used for restoration are mainly GIC and composite resin which bond to the dentin surface rather than materials such as amalgams which involve cutting a cavity

designed to mechanically retain the restoration (Goldman et al., 1976).⁶

DISCUSSION

Although the use of burs in both high speed and low-speed handpieces for caries removal conventionally allows faster treatment, they may remove sound tooth structure as well which may weaken the remaining tooth structure as well as cause pulpal trauma.⁴ The chemo-mechanical caries removal technique has generated great interest among dental researchers due to its concept of saving unaffected tooth structure while guaranteeing the removal of the denatured collagen stage of carious dentin.⁷ Although the two layers i.e. infected and affected dentine can be differentiated by Fuschin staining, the removal of infected dentin is operator and technique sensitive method. Similarly, the caries detector dyes cannot specify correctly dentin removal in the cavity preparations on the pulpal surface of deep cavities and at the amelo-dentinal junction.⁸ Further, in this present era of esthetic and adhesive dentistry, any remaining color or stain is unacceptable. Thus, the best alternative is preserving remineralizable tissue and prevention of overexcavation of the cavity.⁹

Importance of CMCR Agents in Pediatric Dentistry

Chemomechanical caries removal is characterized by removal of infected tissue via gentle excavation and the use of a material that acts on the pre-degraded collagen of the lesion, promotes its softening, doesn't affect the adjacent healthy tissues and avoids pain stimuli (chemical action) thus results in reduced fear and anxiety which are known barriers to the

receptivity of dental treatment and in detriment to oral health.¹

Advantage Over Conventional Method

Less pain perception, Comfortable, Indicated in treatment of deciduous teeth, dental phobic's and medically compromised patients, Removes only infected layer, Preserve affected dentin and normal tissue, No pulpal irritation, Better caries removal in uncooperative patients and physically handicapped patients, Useful in patients with T.B like infectious diseases (prevent droplet infection).¹⁰

Journey from GK 101-caridex to Carisolv

Habib et al (1976) introduced a method using 5 percent sodium hypochlorite to remove carious tissues but it was known to be toxic and aggressive to adjacent healthy tissues.¹¹

***GK 101*¹**

A new solution named GK 101 was developed adding sodium hydroxide, sodium chloride and glycine to the 5 percent sodium hypochlorite and also comprises of N-monochloroglycine.

Advantage: Effective than hypochlorite alone

Disadvantage: Slow caries removal, Cavity preparation according to Black's cavity design.

***GK 101-E / Caridex*^{1,12,13}**

Replacement of glycine by amino butyric acid and the product being formed is N-monochloroaminobutyric acid (NMAB) also designated as GK-101E in 1975.

Composition

It consisted of two solutions : Solution 1 containing sodium hypochlorite and Solution 2 containing sodium chloride, aminobutyric acid and sodium hydroxide. The two solutions were mixed immediately before use to give the working reagent [pH 12 (Gulcin et al., 2004)] which was stable for 1 hr.

Mechanism Of Action

Chlorination of partially degraded collagen and conversion of hydroxyproline to pyrrole-2-carboxylic acid that initiated disruption of the altered collagen fibers in the caries thus facilitating its removal.

Delivery System

1. Solution is applied to the carious lesion
2. Loosen carious dentin by a gentle scraping action
3. Application continued until dentin remaining deemed sound
4. After 15 to 20 min treatment, only clinically sound dentin remained
5. Reagent removed carious dentin leaving many overhangs and undercuts

Limitations

Rotary and/or hand instruments cannot be completely eliminated, Removal of enamel overlying the caries, Removal of existing restorations and for cavity design when non-adhesive restorative materials are used, Slow procedure as time involved is around 10 to 15 min and costly as large volumes of solution were needed (200 to 500 ml).

Although there were studies on the efficacy of caries removal by the procedure, studies on the long term success of cavities restored after CMCR treatment were lacking.

Because of the time required for CMCR treatment, the large volumes of solution needed and the fact that the delivery system was no longer commercially available, the use of CMCR despite its potential became minimal.

Carisolv^{14,15,16}

New patented system for chemomechanical caries removal called Carisolv (Figure 1) was developed by Christer Hedwards and Lars Strid of MediTeam (Dentalutveckling Göteborg AB) in collaboration with Dan Ericson and Rolf Bornstein in Sweden in January 1998

Key difference to other products already in the market was the use of three amino acids - lysine, leucine, and glutamic acid—instead of the aminobutyric acid. These amino acids counteracted the aggressive behaviour of sodium hypochlorite on the oral healthy tissues.

Composition

The formulation of Carisolv involves :
Available as single mix or multi mix syringes
Syringe one: Sodium hypochlorite (0.5%)
Syringe two: Three amino acids (glutamic acid, leucine, lysine)
Gel substance: Carboxymethylcellulose
Adjunct: Sodium chloride/sodium hydroxide
The gel is available in two different packages:
Multi mix (Figure 2)
Single mix (Figure 3)

Mechanism of Action

1. After mixing cariosolv gel, chloramine forms when amino acid bind chlorine at high pH

2. Softening effect on carious tissue is the result of several reactions that act in concert to disrupt the fibre structure of collagen
3. The three amino acids are differently charged, which allow for an electrostatic attraction to different areas of proteins in the carious dentin
4. Peptide chains of all the proteins including collagen, are made up of hydrophilic and hydrophobic patches, so each of three chloramine amino acids in cariosolv electrostatically attract one of these patches
5. Chloramine formation reduces the chlorine reactivity without altering its chemical function. Moreover, chlorinated amino acids disrupt the several types of electrostatic bond holding the fibrous structure together.
6. Results in breakdown of degraded collagen found in the demineralized portion of a carious lesion
7. Gel softens only the carious dentin while healthy tissue is unaffected. The degraded collagen has an open structure therefore more susceptible for further breakdown by chloramines
8. Porous nature of demineralized dentin allows penetration of Cariosolv. The unaffected collagen is more resistant to degradation, but the framework of degraded collagen in the porous mineral is broken down and can easily be scraped off- sound and carious dentin become easily separable clinically: the carious dentin is easier to dislodge than the sound dentin

Advantages

- Incorporation of 3 amino acids have improved the interaction with the

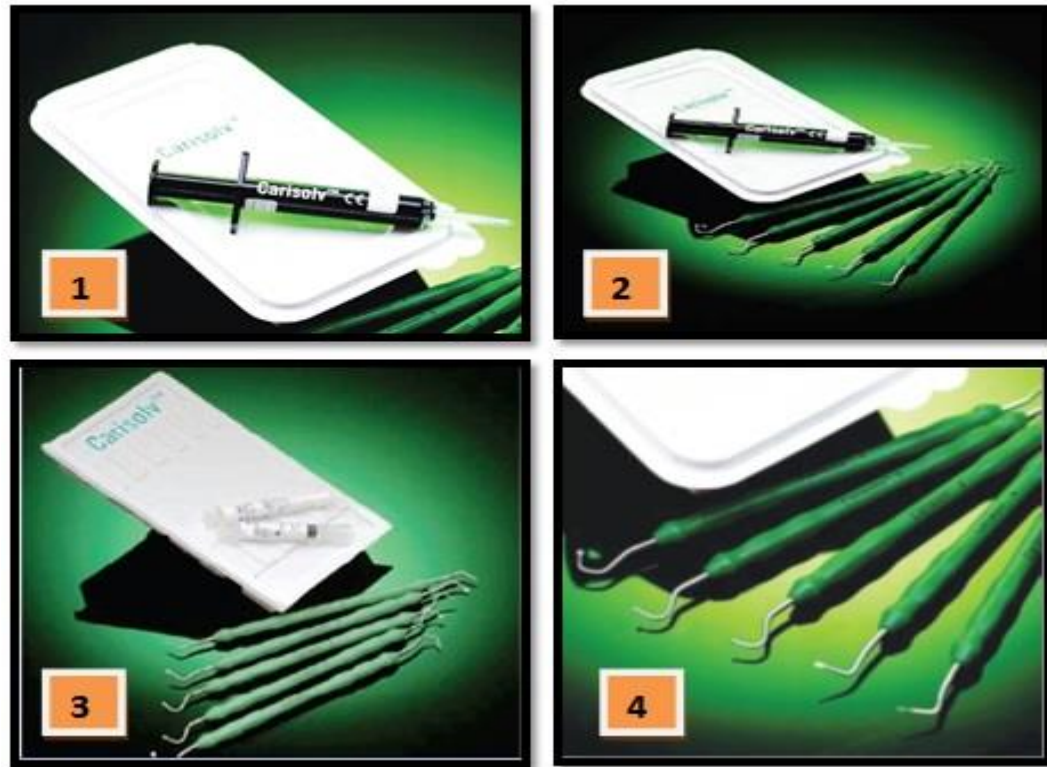


Fig. 1) Carisolv, 2) Multi Mix Carisolv, 3) Single Mix Carisolv, 4). Hand instruments for Carisolv

degraded collagen within the lesion, thus increasing the efficacy.

- Carisolv has a higher viscosity which allows for the application of higher concentrations of amino acids and sodium hypochlorite without increasing the total amount of fluid used, therefore reducing the total volume required.
- The solution does not need to be heated, or applied through a pump mechanism.
- Increased viscosity enhances precision placement.
- Overall increased stability, giving an improved shelf-life.

Disadvantages

Increased cost due to use of customized instrument and extensive training is needed.

Hand Instruments

To ensure the most effective removal when the Carisolv gel has softened the carious dentin, specially-designed instruments and tips (Figure 4) have been developed. They are atraumatic, help to preserve tissue and speed up the treatment. The tips have different shapes and sizes to suit cavities of all kind.

- Instruments with permanent tips: The instrument tips are paired together in double ended Carisolv instruments.
- Instruments with interchangeable tips: A single handle can be used with a range of

different interchangeable Carisolv instruments.

Tips of Hand Instruments

Standard instrument classification:

- Carisolv hand instrument 1 (extra bend; star 3, flat 0): Primarily used for crown margins and areas that are difficult to access.
- Carisolv hand instrument 2 (multistar, star 3): The basic instrument to apply gel and start removing caries. The multistar tip promotes penetration of the gel. When getting closer to healthy dentin, use the star-shaped tip, scraping in all directions with its fourpronged design.
- Carisolv hand instrument 3 (star 2, star 1): To remove caries in smaller cavities; for example, root caries or deciduous teeth.
- Carisolv hand instrument 4 (flat 3, flat 2): To be used, for example, close to the pulp and to remove the softened carious dentin from the cavity.
- Carisolv hand instrument 5 (flat 1, flat 0): Flat 0 and flat 1 are used to remove caries at the dentino-enamel junction.

Clinical Procedure of Caries Removal with Carisolv

1. Mixing of two components (NaOCl and amino acid solution) is done according to instruction manual and put the required amount of gel into a suitable chamber
2. Carisolv instrument is used to pick up the gel and apply it to the carious dentin
3. Soak the caries generously
4. Wait for atleast 30 seconds, for chemical process to soften the caries

5. Select power drive TM tip a carisolv hand instrument to match the size, position and accessibility of the cavity
6. Scrape off the superficial softened carious dentin. The hand instrument with the multistar tip may facilitate the early penetration of the gel. Work carefully using scraping or rotating movements
7. Softened carious dentin is removed with the instrument .Avoid flushing or drying the cavity
8. Lesion is soaked and continue scraping. 30 seconds of waiting time needed
9. Repeat until the gel no longer turns cloudy and the surface feels hard using the instrument
10. Carefully check for caries at the DEJ. Adjust periphery before filling with drill when the gel is still in the cavity
11. When the cavity is free from caries, gel is removed and cavity is wiped with a moistened cotton pelletor. Rinse with lukewarm water, inspect and check it with a sharp probe
12. If caries still persist, apply new gel and continue scrapping
13. If necessary, the periphery of the cavity should be adjusted using hand instrument or the drill
14. Tooth restoration with a suitable filling material according to the manufacturer's instructions

Treatment of Children using Carisolv

The clinical procedure undertaken is the same but there are a few behavioral modifications that have to be made:

- Do not rush
- Be sure to give the gel 30 seconds to react
- During the treatment, patient should be well informed

- In case of pain, cavity coverage with gel is checked and consider the potential benefit of local anesthesia
- Do not work with too much force – use speed and not pressure in movement of the Carisolv instruments
- Rub/massage the gel into the carious lesion

Fluckiger L et al (2010) conducted a study on 22 freshly extracted teeth with varying degree of caries which were treated using Carisolv and Conventional hand excavation method and it was found that there was no significant difference in the amount of residual caries in the cavity walls treated using two methods. Carisolv™ was more time consuming than conventional preparation using hand excavator.¹⁷

Avinash A et al (2012) conducted a study on 30 carious teeth 15 deciduous and 15 permanent teeth having dentinal caries which were subjected to caries removal by mechanical and chemomechanical methods (Carisolv). Using stopwatch, time taken for removal of caries was recorded and samples were prepared and seen under the scanning electron microscope for the presence of bacterial colonies. No significant difference was found for the presence of bacterial colonies in both groups of deciduous and permanent teeth; however, time taken for caries removal by the chemomechanical method was twice than the mechanical method. Despite the insignificant presence of bacterial colonies and twice time taken as compared to mechanical method, chemomechanical method was easy to introduce, was painless, did not form smear layer and conserved the sound tooth structure.¹⁸

Papacarie^{1,4,16,19,}

Papain gel as papacarie for chemomechanical caries removal agent was introduced in Brazil 2003, Formula eacao by Sao Paulo for the first time (Bussadori et al., 2005). Papacarie (Figure 5) was approved by ANVISA in Brazil Its main components are : Papain, Chloramine and Toluidine blue.

Papain

It is an endoprotein similar to the human pepsin which has a bacteriocidal, bacteriostatic and antiinflammatory activity, and debriding agent. It 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.

Chloramine

A compound comprised by chlorine and ammonia 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 dentin collagen is chlorated by the chloramine and is easily removed with excavator.

Toluidine blue

Initially, the malachite green was used as colouring 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.



Fig 5: Papacarie

Clinical Procedure

1. Radiograph of tooth
2. Prophylaxis done using rubber cup and pumice
3. Rinse with air/water spray or cotton pellet with water
4. Isolation of tooth
5. Papacarie application, allowing the chemicals to work for 20 to 30 seconds
6. Papain acts by breaking the partially degraded collagen molecules, causing elimination and degradation of fibrin mantle formed by caries. Oxygen is freed and bubbles appear on surface and gel blearing is seen
7. Removal of soft carious dentin using opposite side of the excavator and promoting pendulum movement; softened tissue must be scrapped out
8. Gel application, if required
9. When cavity free from caries, vitreous aspect of cavity appears
10. Rinse with 0.12%, 1% or 2% Chlorhexidine or waterspray
11. Drying with oil free or moisture free air
12. Restoration with suitable material according to manufacturer's instruction

Advantages

Biocompatible, Antibacterial properties, No requirement of anesthesia, Preserves the healthy tissue, No smear layer formation
The gel combines an atraumatic treatment with antibacterial properties without affecting healthy tissue and causing pain.

Venkatesh Babu NS et al (2015) compared the efficacy of Carisolv and Papacarie in reducing cariogenic flora in primary molars employing bacteriological evaluation on 40 children aged 3-9 years. It was concluded that Papacarie can be an effective clinical alternative to Carisolv for the removal of dentinal caries in cavitated primary molars.²⁰

Lara et al (2014) conducted a trial of long term chemomechanical caries removal using Papacarie gel and low speed bur on 20 children aged 4 to 7 years, in 40 deciduous teeth and clinical evaluation was done at 6 and 18 months after treatment and it was concluded that Papacarie is as effective as the traditional method for the removal of carious dentin on deciduous teeth, but offers the advantages of the preservation of sound dental tissue as well as the avoidance of sharp rotary instruments and local anesthesia.²¹



Fig. 6: Carie Care

***Carie Care*²²**

Carie care - a product that has been locally introduced (Figure 6)

Ingredients

- Endoprotein, chloramines and dye (from papaya extract)
- Essential oils from plant source (has anti-inflammatory and mild anesthetic effect)
- Gelling agent in accurate percentage to give exact consistency to the gel so that when applied there is no spill over.

However present gel preparation does not contain sodium hypochlorite or any other strong chlorinating agent instead has most of the ingredients from natural sources. Essential oils (act as anti-inflammatory agent) have been incorporated in cariecare for the first time, none of earlier preparation consist of this ingredient.

Carie Care show anti-inflammatory activity and aroma alongwith softening of infected dentin

Mechanism of Action

1. Applied directly onto the tooth by disposable applicator tip.
2. Gel changes the color in the affected area
3. 1 minute after application of gel, the gel along with dissolved caries is removed by means of a Sharp Spoon Excavator.

Sahana S et al (2016) conducted a study on 30 extracted deciduous molars with proximal caries. The specimens were treated either using Papacarie or Carie-Care and it was concluded that both Papacarie and Carie-Care were found to be conservative in caries removal. Papacarie was more efficient in removing bacteria in lesser time from the infected carious lesion.⁸

Hedge et al (2014) conducted a study to determine the clinical evaluation of chemomechanical caries removal using Carie-Care system and conventional method on 64 teeth of 32 children with class I carious lesions and it showed that though Chemomechanical technique took a marginal increase in time compared to the

conventional technique, but was found to be more comfortable for all the children.²³

SUMMARY

It is well-known fact that traditional method of caries removal using the “dental bur” is the most common technique for caries removal in dental practice. However, this technique is always associated with many disadvantages. As a result, “quest” for newer materials and techniques is going on in the field of caries management. 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. This method of caries removal involves chemical softening of carious dentin followed by its removal with gentle excavation.

CONCLUSION

Chemomechanical caries removal could be an effective caries removal method for the treatment of patients seeking an alternative to conventional methods. Removal of carious tissue in primary teeth using these materials proved to be comfortable, inexpensive and showed promising results. However, further studies are highly recommended to obtain more clinical evidence for regular use of these methods in clinical practice.

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