REVIEW ARTICLE

CHEMOMECHANICAL CARIES REMOVAL AGENTS - AN OVERVIEW

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ABSTRACT

Minimally invasive dentistry is a conservative philosophy based on sound scientific principles.[9] It is the need of the hour as the conventional 'extension for prevention' is being challenged and the more conservative forms of operative intervention are being recommended. An innovative approach called **"chemomechanical 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

KEY WORDS

Minimal Invasive Dentistry, Chemicomechanical caries removal, CARISOLV, CARIDEX.

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INTRODUCTION

Chemomechanical caries removal (CMCR) is a non-invasive technique eliminating infected dentine via a chemical agent. This is a method of caries removal based on dissolution. Basically, the principle of chemomechanical caries removal is the use of a solution to chemically alter carious tooth tissue to further soften it, thus facilitating its easy removal. It was introduced to dentistry as an alternative method of caries removal and is mainly indicated to overcome the inconvenience of using burs and local anesthesia, causing less discomfort to patients and preserving healthy dental structure, there by complying the concept of the minimal invasive dentistry (MID). Various agents with their methods have been used in the past for CMCR, but only a few have got into a stable clinical practice.[1]

THE BACKGROUND

The principle on which chemomechanical method for caries removal work are based on studies by Goldman and Kronman working in New Jersey, U.S in the early 1970's. Goldman (1970) an endodontist first developed the chemicomechanical caries removal method by using sodium hypochlorite (NaOCl).[2] Since then, many studies have been attempted to improve this century old technique. The sole use of 5% sodium hypochlorite was known to be toxic and aggressive to healthy and sound tissues.

A new solution was developed by adding sodium hydroxide, sodium chloride and glycine to the 5% sodium hypochlorite solution. This modified formula was known as **GK-101** and it was comprised of N- **monochloroglycine (NMG)**.[3]

GK-101

The chlorination of glycine to form N-Monochloroglycine (NMG) led to the formation of the first chemomechanical caries removal agent (Goldman et al., 1976), which was marketed as **GK-101**. Few studies evaluated the GK-101 solution; however, Goldman and Kronman reported that the mean caries excavation time for GK-101 was 8.5 minutes and using burs remained an essential subsequent step in order to achieve ideal finishing of the excavated sites.[3]

Composition

GK-101 contains:

- 0.05% N-monochloroglycine (NMG) and sodium

hypochlorite (NaOCl), and was prepared by mixing two solutions.

- Solution A consisted of 25 ml each of 2M sodium chloride (NaCl), 2M sodium hydroxide (NaOH) and 2M glycine, and
- Solution B consisted of 10 ml of 4–6% NaOCl.[3]

Mechanism of action

GK-101

↓

Conversion of hydroxyproline (essential factor of the stability of collagen) to pyrrole-2-carboxyglycine

↓

Chlorination of the denatured collagen

↓

Removal of carious tissue

Armamentarium required

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.[3]

Caries removal and effect on pulp

In an in vitro study conducted by Kurosaki et al[4], it was found that GK- 101 softened the outer dentinal caries layer by 2 to 10 Knoop Hardness numbers in all teeth. The pulp response was found to be either non-existent or slight.

GK-101 has been found in vitro to be more effective in removing carious dentine in comparison to saline controls.[5]

Limitations

- It had an slow action
- Softened only the first layer, but not the second layer [6]
- Need for special delivery equipment

These findings led to improvements in the formula of GK-101 to GK-101E.

CARIDEX

GK-101E is the ethyl derivative [N-monochloro-DL2 amino butyrate (NMAB)] of GK-101 (NMG). It was claimed this formula increased the specificity of the solution towards denatured protein of caries infected dentine.[4] It was marketed as 'Caridex' (National Patent Dental Products, Inc., New Brunswick, NJ, USA) and received FDA approval in 1984.[7]

Composition

The system was granted in the form of two bottles

a) Solution I: 1% sodium hypochlorite (NaOCl)

b) Solution II: Glycine, Aminobutyric acid, sodium chloride (NaCl) and sodium hydroxide (NaOH)

The two solutions are mixed immediately before use to give the working reagent [pH 12] which is stable for 1 hour. [6]

Mechanism of action

The mechanism of action of N monochloroglycine and N-monochloroaminobutyric acid on collagen is unclear.

Originally, it was thought that:

GK-101E

↓

Conversion of hydroxyproline (essential factor of the stability of collagen) to pyrrole-2-carboxyglycine

↓

Chlorination of the denatured collagen

↓

Removal of carious tissue

Further work suggests that:

GK-101E

↓

Cleavage by oxidation of glycine residues

↓

Disruption of the collagen fibrils which become more friable

↓

Easy removal of the damaged collagen fibrils

Armamentarium required

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).

Caries removal and effect on pulp

The Caridex system was critically evaluated, demonstrating its caries removal efficiency,[6] biocompatibility[7] and pulpal safety.[8]

According to a SEM study by Goldman et al[9], NMAB removes the entirety of the decayed dentine, leaving a surface of sound dentine.

The histological examination, in a study conducted by Waltman et al[10] showed Caridex to be biocompatible with regard to the dental pulp.

Limitations

- Rotary or hand instruments may still be needed for the removal of tissue or material other than degraded dentin collagen access to small or inter proximal 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.
- The system requires large volumes of solution 200-500ml and the procedure is slow and costly.
- 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.

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 which led to the invention of **Carisolv**.

CARISOLV

Medi Team in Sweden continued to work on the Caridex system and resulted in the launch of chemo-mechanical caries removal agent known as Carisolv in January 1998. Carisolv reached the market promising to be more effective and easy to manipulate. The fundamental dissmilarity between Carisolv and other products already in the market during that time was the use of three amino acids – lysine, leucine and glutamic acid– instead of the amino butyric acid. These amino acids counteracted the sodium hypochlorite aggressive behavior at the oral healthy tissues.[11,12]

Composition

Original gel (before 2004):

(Syringe A: carboxymethylcellulose-based gels, colouring agent and amino acids (glutamic, leucine and lysine)

Syringe B: 0.25% NaOCl in the other

Modified gel (after 2004) Multimix syringe the red colouring agent was removed, the amino acid concentration was reduced by half and the NaOCl concentration was increased to 0.475%

New Carisolv System (2013) Incorporation of minimally invasive burs and special Carisolv caries detector dye to the modified Carisolv gel to shorten the caries excavation time

Armamentarium required

Non-cutting tip Carisolv hand instruments

New Carisolv System: Cera and Polymer Burs (Komet, UK)

Caries removal and effect on pulp

Ericson et al[13] investigated the in vitro effectiveness of Carisolv in 30 permanent and 20 deciduous freshly extracted human teeth. Complete caries removal, as determined by clinical criteria using a sharp probe, was achieved in all (30/30) permanent teeth treated with Carisolv.

In a study conducted by Mazumdar P et al[14], it was found that Carisolv is a complement to traditional caries treatment, which reduces or in some cases reduces the need of local anaesthesia.

Limitations

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

PAPACARIE

With the intension of presenting a chemomechanical caries removal product that cost less than Carisolv in 2003 Papacarie was introduced.

Papacarie is a Portuguese word meaning 'caries eater'. It is an enzyme (papain enzyme) based chemomechanical caries removal agent introduced by Bussadori et al [15]

The main action depends on the presence of the papain enzyme which is a proteolytic enzyme that causes degradation of proteoglycans in the dentinal matrix.[15] Papacarie is a gel syringe that have 3 ml of solution. Manufactured by Formula & Acao, Brazil

Composition

Papain enzyme, chloramine, toluidine blue, salts, preservatives, a thickener, stabilizers and deionized water.

Mechanism of action

The mixed gel is applied to the carious lesion for 30- 40 seconds and then the carious portion can be gently removed using specially designed, non-traumatic hand instruments.

Degrades and eliminates the fibrin "mantle" formed by carious process

↓

Breaks the partially degraded collagen molecules

↓

By digesting the dead cell, causes breakdown of the collagen molecules

↓

Degraded collagen is chlorinated by chloramines

↓

Disturb the hydrogen bond and affects the secondary and quaternary structure

↓

Chemically soften the carious dentin and facilitating removal of caries tissue

Armamentarium required

Manufacturer recommends using back of blunt spoon excavator.

Effect on biological tissues

In a study conducted by Martin et al[16] that Papacarie was biocompatible and exhibited similar in vitro cytotoxicity and animal implantation assays as Carisolv gel.[16]

Limitations

• Caries removal using Papacarie gel is an expensive procedure.

The advent of Papacarie has revolutionarized the chemomechanical caries removal process and has proved to be a highly effective and excellent product in this field with added advantage of maximum preservation of healthy tooth tissue, especially in cases of deep dentinal caries.

BIOSOLV

It is manufactured by 3M-ESPE AG, Seefeld, Germany. The information about Biosolv remains very limited and is based mainly on the manufacturer's claims. It is basically an experimental material. In 2006, Clementino Luedemann et al.[17] evaluated SFC-V solution and comparing the results with Carisolv, reported that the SFC-V solution was not as effective as Carisolv. Since 2010, Banerjee et al.[18] and Neves et al.[19] evaluated the efficiency of caries excavation of two improved versions of SFC-V and SFC-VIII gels. However, no details about the difference were provided.[20]

Composition

It consists of pepsin enzyme in phosphoric acid/ sodium biophosphate buffer.[17,19]

Mechanism of action

Phosphoric acid in Biosolv

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Dissolve the inorganic components of caries-infected dentine

↓

Permitting the pepsin to selectively disrupt the denatured collagen fibres

↓

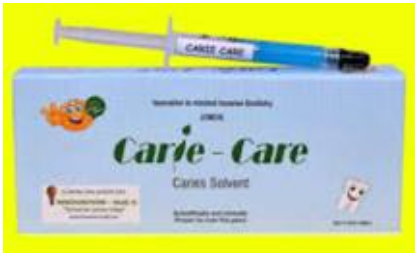
The softened mass can then be easily removed by the specially designed plastics instruments without affecting sound tissue.

Limitations

Biosolv is not available commercially, it is an experimental product.

CARIE-CARE

Carie-Care system was introduced with the intention of presenting a new agent that costs less than Papacarie and easy availability, a new chemomechanical caries removal system (Carie-Care). It was manufactured by Uni-biotech Pharmaceuticals Pvt. Ltd., in 2010, which consists of papaya extract (papain) 100mg, clove oil 2mg, colored gel (blue), chloramines, sodium chloride, and sodium methyl paraben, with similar properties as that of Papacarie. Manufacturer recommends using back of blunt spoon excavator. Compared to conventional method of caries removal using burs, a number of scientific studies have documented that carious dentin removal with Papacarie caused no painful sensitivity in most cases. Studies by Nagaveni et al[21] as well as Venkataraghavan et al[20] found the similar results using the Carie-Care , when used on primary teeth with carious lesions in the dentin.



Mechanism of action

Papaya extract in Carie-Care

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breaks peptide bonds in the denatured collagen and involves deprotonation (Deprotonation is the removal of a proton (H+) from a molecule, forming the conjugate base.)

↓

Facilitates easy removal of carious tissue

BRIX 3000

In 2012, the BRIX-3000 was released, a chemicalmechanical agent, also papain-base, with a proteolytic enzyme obtained from leaves latex and fruits of green papaya (Carica Papaya) that acts as a chemical debridant. The differential of this product according to the manufacturers is the amount of papain used (3,000 U/mg in a concentration of 10%) and the bio encapsulation thereof by EBE (Encapsulating Buffer Emulsion) technology, which gives the gel the ideal pH to immobilize the enzymes and liberate them at the moment of exerting its proteolysis on the collagen. Torresi and Bseremi[22] verified the efficacy of BRIX-3000 for the removal of carious tissue comparing 75 patients treated with the mechanical chemical agent (BRIX 3000) and 75 by the traditional rotary method. It was found that the gel was effective for 62 patients (82.7%) with a single application of the product.

CONCLUSION

Chemomechanical caries removal agent may not be able to replace the use of traditional instruments (drill) for caries removal, but can be an alternative to many cases especially in children who are anxious about dental procedures. The new system provide significant feature for the clinician to opt it as a routine practice for the painless and non-invasive approach thus ensuring a positive patient dentist relationship.

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