

CURRENT CONCEPTS OF CARIES REMOVAL - A BRIEF REVIEW WITH A NOVEL APPROACH OF CHEMOMECHANICAL CARIES REMOVAL USING PAPAIN AS A CASE REPORT

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Abstract

As dental caries is the most common disease affecting the teeth, the aim of this article is to emphasize on different methods of caries removal from past to the present including, mechanical, rotary, chemomechanical methods and lasers. Among the chemomechanical agents papain appears to be more advantageous because of its properties like excellent efficacy, ideal consistency, quick action, conservation of tooth structure and economic. Since papain has all these advantages over other agents, it was chosen for caries removal in this case with deep dentinal caries which is briefed here with a short review of the other caries removal methods.

Key words: Caries, Chemomechanical method, Papain, α 1-anti trypsin, Tissue preservation.

Introduction

Caries continues to affect a significant proportion of world population. Dental caries is an infectious disease caused by disequilibrium in the process of demineralization and remineralization of hard dental tissues. This disequilibrium is induced by proliferation of cariogenic bacteria and consequent increase in acid production, causing the saliva pH to drop to a critical level.¹ The earliest attempts to remove caries involved the use of hand drills which were later replaced by modern high speed drills. However the inherent fundamental drawbacks of the drilling approach like excessive tooth structure loss and discomfort to the patient still remains.

To overcome the disadvantages of rotary system, other procedures of caries removal have evolved. Moreover, with the advent of adhesive restorative materials & subsequent developments in cavity designs, the widely accepted principle of "Extension for Prevention" has been challenged and is now considered too destructive a method of caries removal.

This article presents an overview of the past, present and future of various caries removal methods with special emphasis on tissue preservation.

Tissue Removal Techniques²

There are a number of techniques available for cutting tooth tissue

Category	Technique
Mechanical-rotary	Hand pieces –burs
Mechanical-non rotary	Hand excavators, Air-abrasion, Air-polishing, Ultrasonics
Chemomechanical	Caridex, Carisolv, Enzymes, Papacarie
Photoablation	lasers

The ideal cutting instrument should fulfill certain factors to satisfy both operator and patient. These factors might include:

- Comfort and ease of use in clinical environment
- The ability to discriminate and remove diseased tissue only
- Being painless, silent requiring only minimal pressure for optimal use
- Not generating vibration or heat during periods of operation and
- Being affordable & easy to maintain

Mechanical Method

Conventional caries removal and cavity preparation entail the use of burs. In current practice, having gained access to the carious dentine using the high-speed air turbine hand-piece and the slow-speed hand-piece and bur or hand excavator can be used for carious dentine excavation. As the hand excavator will remove softened tissue with more sensitive tactile feedback than a bur, this method is more self limiting of the two.

Disadvantages of mechanical (rotary) method include³

- (i) Unpleasant perception of drilling,
- (ii) Frequent requirement of local anesthesia,
- (iii) Deleterious thermal effects,
- (iv) Pressure effects on the pulp, and
- (v) The use of a hand piece may result in the removal of softened, but uninfected dentin, resulting in an excessive loss of sound tooth tissue. As a result there is a growing demand for procedures or materials that facilitate caries management.

Air –Abrasion

This method of cutting teeth seemed to dramatically reduce the problems of heat generation, vibration and other mechanical stimulation resulting in relatively pain-free procedures when compared with drill. There have been reports to indicate that there were no significant differences in pulpal response between air abrasion and high speed bur preparation using copious water spray.

Disadvantages

- The total loss of tactile sensation whilst preparing the cavity because the nozzle does not touch the surface of the tooth.
- This coupled with the fact that the operator must be able to envisage the position of the cavity boundaries prior to cutting, leads to the significant risks of cavity – over preparation and inadequate caries removal.
- It must be emphasized that the aluminum oxide abrasive particles will remove sound enamel and dentine very efficiently, whereas clinically soft, carious dentine is not removed due to reduced hardness of the carious substrate when compared with the alumina particles themselves.
- There is also the potential of inhalational problems.

Recent advances in air abrasion technology allow a metered flow of alumina particles, higher operating pressures and almost instantaneous initiation and termination of the abrasive stream. Further investigation into the use of alternative abrasive mixtures has indicated that softer particles, eg. Polycarbonate resin or alumina-hydroxyapatite mixtures might be more selective in carious dentine removal as they are only capable of removing tissue of equivalent hardness, leaving healthier, sound tissue virtually unscratched. These factors, coupled with the use of protective rubber dam, barrier masks for the clinical team, more efficient suction units to expel the unwanted dust.

Air Polishing

Air-polishing is the process by which water soluble-particles of sodium bicarbonate, to which has been added tricalcium phosphate (0.08 % by wt) to improve the flow characteristics, are applied onto a tooth structure using air pressure, shrouded in a concentric water jet. This is the important difference between this technique and that of air-abrasion. The fact that the abrasive is water soluble means it does not escape too far from the operating field. The bombardment of the hard tooth surfaces by these particles results in a continuous mechanical abrasive action which removes surface deposits.

The commercially recommended use of this technique is to remove surface enamel stains, plaque and calculus well away from the gingival margin of healthy teeth. However, due to the non-selective, abrasive, detrimental surface attack of restorations and sound enamel and dentine, overzealous use could easily remove a considerable amount of healthy tooth structure especially at the cervical margin. It has been suggested that air- polishing could be used for the removal of the carious dentin at the end of cavity preparation.

Ultrasonic Instrumentation

Investigation of this technique has been confined to work carried out in the 1950s where studies by Nielsen et al. indicated the possibility of using an ultrasonic instrument to cut tooth tissue. He designed a magnetostrictive instrument

with a 25 kHz oscillating frequency. This, used in conjugation with thick aluminium oxide and water slurry, created the cutting action.

Mechanism of Action

Kinetic energy of water molecules being transferred to the tooth surface via the abrasive through high speed oscillations of the cutting tip. It was found that the harder the tissue, the easier it was to cut. Soft, carious dentine apparently could not be removed, but the harder, leathery, deeper layer was more susceptible. However, in light of current knowledge regarding the structure of the carious lesion in dentine, it is a debatable point as to whether this harder, leathery deeper surface should actually be removed as it probably represents the dentine that has been affected by the carious process but only minimally infected, with a collagen structure permitting remineralization. This technique has been found to be favourable in terms of the reduced vibration and sound generated when compared with dental drill.

Sono Abrasion

A recent development from the original ultrasonics mentioned above is the use of high-frequency, sonic, air-scalers with modified abrasive tips-a technique known as 'sono-abrasion'. It is based upon the Sono -iflex 2000L and 2000N air scaler hand pieces that oscillate in the sonic region (<6.5 kHz). The tips describe an elliptical motion with a transverse distance of between 0.08-0.15mm and a longitudinal movement of between 0.005-0.135. They are diamond coated on one side using 40 um grit diamond and are cooled using water irrigant at a flow rate between 20-30ml/min. the operational pressure for cavity finishing should be around 3.5 bars. There are currently three different instrument tips: lengthways halved torpedo shape (9.5mm long, 1.3 mm wide), a small hemisphere (1.5mm diameter) and a large hemisphere (2.2mm diameter). The torque applied to the instrument tips should be in the region of 2N. If the applied pressure is too great, the cutting efficiency is reduced due to damping of the oscillations. This technique was initially developed, using different shaped tips, to help prepare predetermined cavity outlines but also works well in removing hard tissue when finishing cavity preparation. Favourable results from laboratory studies using sono- abrasion to remove softened, carious dentine have indicated another possible use for this technique in the future.

Lasers

Since the development of the first ruby laser by Maiman in 1960, researchers postulated that it could be applied to cutting both hard and soft tissues in the mouth. The efficacy of the lasers will depend on numerous factors including the wavelength characteristics, pulse energy, repetition rate and the optical properties of the incident tissues. Lasers that are currently being investigated for more selective hard tissue ablation include:

- Er:YAG and Nd:YAG- mid-IR to IR emissions

- Carbon di oxide lasers-IR emission
- Excimer lasers (ArF (Argon:Freon) and XeCL(Xenon:Chlorine) - UV emission
- Holmium lasers
- Dye-enhanced laser ablation- exogenous dye, indocyanine green in conjunction with a diode laser.
- Er,Cr:YSGG: Erbium, Chromium: Yttrium-Scandium-Gallium-Garnet: laser system used in conjunction with an air-water spray has been shown to be efficacious in vitro for cavity preparation and caries removal⁴

In terms of carious dentin removal, the UV emission of Excimer lasers (377 nm) has the potential to be more selective in the ablation of carious dentine and there may be a possible use of dye- enhanced laser ablation to develop this selectivity further. In addition to caries removal, studies have shown that, in the presence of a suitable photosensitizer, low-power laser light has the ability to destroy *streptococcus mutans*. Lasers have also been used to cut and seal dentinal tubules, reducing the possibility of post-operative sensitivity. At present, there is significant interest in these instruments but the problems still persist regarding thermal irritation to the pulp, the control of the procedure and the possible alteration or destruction of the adjacent sound tissue. These factors coupled with the expense and size of the equipment have meant their use in general practice as a hard tissue cutting tool has been effectively limited to date.

Enzymes

Studies have examined the possibility that carious dentine might be removed using certain enzymes. In 1989, Goldberg and Keil successfully removed soft carious dentine using bacterial *Achromobacter collagenase*, which did not affect the sound layers of dentine beneath the lesion. Also, a more recent study has used the enzyme pronase, a non-specific proteolytic enzyme originating from *streptomyces griseus*, to help remove carious dentine. This might have significant clinical implications but further laboratory research is required for validation of this technique.

Chemo-Mechanical Methods

The chemo-mechanical method of caries removal was developed to overcome these shortcomings. It is not only more comfortable for the patient but also able to better preserve the healthy tissue.⁴

The chemo-mechanical method is an effective alternative for caries removal because it brings together (i) atraumatic characteristics, (ii) bactericide & bacteriostatic action (iii) the active ingredient would soften the pre degraded collagen of the lesion without pain & undesirable effects to adjacent healthy tissues.

The chemomechanically treated carious dentin becomes brittle, and is easily removed by curettage with hand instruments.⁵

In 1975, Habib et al introduced a method of using 5% Sodium Hypochlorite to remove carious tissues. Sodium Hypochlorite is a non specific proteolytic agent, on the removal of carious material from dentin. Since then, many studies have attempted to improve this early technique.

GK-101

The sole use of sodium hypochlorite was to be toxic and aggressive to adjacent healthy tissues. Therefore, a new solution was developed adding sodium hydroxide, sodium chloride and glycine to 5% Sodium Hypochlorite. This modified formula was known as GK -101 and it was comprised by N-monochloroglycine. It was more effective than the hypochlorite alone but was very slow in carious tissue removal.³ Its modus operandi has been described as a chlorination of free amino groups and possibly, the amino groups of the peptide bonds of protein, thus forming -chloroprotein compounds, NMG solutions were also found to have the ability to convert hydroxyl-proline, an important factor of collagen fiber stability. The partially degraded collagen in carious dentin was chlorinated by NMG solutions and the chlorination affected the secondary and quaternary structure of collagen, by disrupting hydrogen bonding.⁶ At the time of introduction of GK -101, the use of adhesive dental materials was not common, and the dentists still prepared teeth according to Black's cavity design. Therefore, the use of a method that only removed carious dentin could not significantly reduce the need of drilling to create mechanical retention.

Caridex™

Caridex™ was later developed from a formula made of N-monochloroglycine and amino butyric acid. Caridex™ disrupted the carious dentin collagen making it easier to remove. Despite its effectiveness, Caridex™ had certain clinical limitations, among them (i) it was expensive, (ii) it required a large reservoir with pump, (iii) it required large quantities of solution, (iv) it presented several problems during heating, and (v) it had a short life.

Carisolv™

Carisolv™ reached the market promising to be more effective and easy to manipulate. The key difference to other products already in the market was the use of three amino acids- lysine, leucine and glutamic acid. Despite its effectiveness, Carisolv™ was not a blockbuster mainly because it required (i) extensive training & registration of professionals and (ii) customized instruments which increased the cost of solution.

Papacarie®

With the intension of presenting a chemomechanical caries removal product that cost less than Carisolv® in 2003 Papacarie® a material composed of papain, chloramines, toluidine blue was launched.⁷

Papain

Papain is a proteolytic enzyme. It has bactericide, bacteriostatic and anti-inflammatory characteristics.

Similarly to the human pepsin, papain acts as a debridant anti inflammatory agent which does not damage the healthy tissue and accelerates cicatricial process. Papain comes from the latex of the leaves & fruits of the green adult papaya.

Chloramines

Chloramines are formed during a reaction between chlorine and ammonia. Chloramines are amines which contain at least one atom chlorine atom, which is directly bonded to nitrogen atoms. Chloramines have bactericide and disinfectant properties. The disinfectant chloramines -T, a well known active chlorine compound, have been demonstrated to inactivate gram positive and Gram negative bacteria in vitro, and are also bactericidal in vivo when applied to contaminated wounds.

Chloramines are broadly use to chemically soften the carious dentin

Mechanism of Action

Papain acts on infected tissue because infected tissues lack a plasmatic anti protease called $\alpha 1$ -anti- trypsin. The $\alpha 1$ -anti- trypsin is only present in sound tissues and it inhibits protein digestion. The absence of $\alpha 1$ -anti- trypsin in infected tissues allows papain to break the partially degraded collagen molecules, contributing to the degradation and elimination of the fibrin "mantle" formed by the carious process. This mechanism affects the collagen structure, dissolving hydrogen bonds and thus facilitating tissue removal.⁸

Chloramine causes choramination of partially degraded collagen in carious dentin. This chloramination affects the secondary and /or quaternary structure of collagen, by disrupting hydrogen bonding and thus facilitating the carious tissue removal.

Material Presentation

Papacarie[®] is a gel syringes that have 3 ml of solution.

Instructions for Use

The use of Papacarie[®] for carious tissue removal must be done in accordance with the following methodology:

- Radiograph of the target tooth
- Prophylaxis of the region using rubber cup and slurry of pumice
- Rinsing with air/water spray or cotton pellet with water
- Isolation of target tooth
- Application of Papacarie[®] allowing the chemistry to work for 30 to 40 seconds
- Removal of the softened carious dentin using the opposite side of the excavator and promoting a pendulum movement.
- The softened tissue must be scraped, but not cut.
- Reapplication of gel, if necessary. There is no need for rinsing the cavity between applications.
- The vitreous aspect of the cavity indicates complete removal of infected dentinal tissue.

- Rinsing 0.12 %, 1 % or 2 % chlorhexidine or water spray
- Drying with moisture-free and oil-free air
- Restoration with a suitable filling material according to manufacturer's instructions

Case Report

A twenty year old male patient reported to the department of Conservative dentistry and Endodontics, College of Dental Sciences, Davangere for routine dental check-up. On clinical examination 36 was found to be discolored on the occlusal surface [Figure 1].



Figure 1: Pre-operative view of discolored occlusal surface of 36

An IOPA radiograph was taken for the same and it revealed radiolucency involving enamel and dentin approximating the pulp. [Figure 2]



Figure 2: Preoperative IOPA radiograph of 36 showing deep dentin caries approaching pulp

The involved tooth 36 was isolated using rubber dam. Since the occlusal enamel was intact, the undermined discolored enamel was removed by using a round bur. [Figure 3] Since the remaining dentin thickness was less, chemomechanical method using Papacarie[®] [Figure 4] was chosen for caries removal.

Once the access to the frank caries was gained, Papacarie gel was applied and left for 40 seconds. [Figure 5] Following which the tissue was removed using the opposite side of spoon excavator in a pendulous motion. In this case the gel was reapplied twice to facilitate the complete removal of the caries. At the end of three applications the cavity appeared to be clean and glossy. [Figure 6]



Figure 3: Removal of undermined enamel with round bur to expose the lesion



Figure 4: Papacarie® gel



Figure 5: Application of Papacarie® gel

The cavity was then irrigated with 0.12% chlorhexidine and dried. The tooth was then restored using composite (Z350 3M ESPE) after sufficient pulpal protection using Calcium Hydroxide paste and Glass Ionomer Cement liner. [Figure 6]

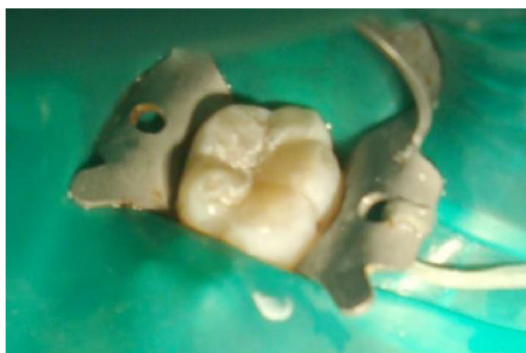


Figure 6: Tooth after composite restoration

Conclusion

Caries removal methods appear to have earned a new lease of life with the introduction of the new chemomechanical agent Papacarie® enjoying major advantages like (i) fast

action, (ii) ideal consistency, (iii) effectiveness, (iv) no sensitivity and (v) reduced risk of pulpal exposure. The advent of Papacarie® has revolutionized 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.

References

1. Motta LJ, Martins MD, Porta KP, Bussadori SK. Aesthetic retraction of deciduous anterior teeth after removal of carious tissue with Papacarie®. Indian J Dent Res 2009;20(1):117-20.
2. Banerjee A, Watson TF, Kidd EA. Dentine caries excavation: a review of current clinical techniques. Br Dent J 2000;188(9):476-82.
3. Bussadori SK, Castro LC, Galvao AC. Papain Gel: a new chemomechanical caries removal agent. J Clin Pediatr Dent 2005;30(2):115-9.
4. Hadley J, Young DA, Eversole LR, Gornbein JA. A laser-powered hydrokinetic system For caries removal and cavity preparation. J Am Dent Assoc 2000;131(6):777-85.
5. Carnerio FC, Nadanovsky P. Remocao quimicomecanica da carie. In:Carnerio F C; Nadanovsky P. Dentistica ultraconservativa. Sao Paulo:Santos 2003:59-71.
6. Maragakis GM, Hahn P, Hellwig E. Chemomechanical caries removal: a comprehensive review of the literature. Int Dent J 2001;51(4):291-9.
7. Beeley JA, Yip HK, Stevenson AG. Chemo-mechanical caries removal: a review of techniques and latest developments. Ned Tijdschr Tandheelkd 2001;108(7):277-81.
8. Silva LR, Motta LJ, Reda SH, Facanha RA, Bussadori SK. Papacarie- a new system for de chemomechanical caries removal- a case report. Revista Paulista de Odontologia 2004;6:4-8.

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