

NON ROTARY CARIES REMOVAL TECHNIQUES: A REVIEW

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ABSTRACT

Caries removal is one of the important criteria in restoration of the tooth to its proper health and function. The techniques used in caries excavation have been developed since 1983 by G.V. Black, who initially proposed the principle of "extension for prevention" in the treatment of carious lesions. This was the most apt method considering the restorative materials used at that point of time. With the advances in the restorative materials, especially adhesive restorative materials has led to the change in treatment from conventional cavity design to conservative cavity design leading to minimize excessive tissue loss. The non-rotary caries removal techniques developed for removal of carious tissue is an attempt to minimize excessive tissue loss. This paper reviews the non-rotary caries removal techniques.

KEYWORDS: caries, caries end point, infected dentin, effected dentin, demineralized dentin

INTRODUCTION

In recent years, with the invention of the adhesive restorative material, the widely accepted principle "extension for prevention" has been challenged and questioned. Theories regarding the rationale of the caries removal have begun to question the amount of tissue that need to be excavated in order to successfully treat a carious lesion.¹ Traditionally, the clinicians tends to rely on the consistency of the tissue but now they may use auto fluorescence as a marker for detection.^{1, 2, 3, 4} So no definite diagnostic tool is available to

clinically define the caries removal end point, enabling complete removal of infected tissue

without over extending cavity preparation. Newer caries removal techniques have been introduced such as chemomechanical, mechanical, air abrasion, air polishing, ultrasonics etc. They are all aimed to remove carious infected tissue as minimally invasive as possible. Each technique has its own specific carious removal end point. They also reduce the use of the local anesthetic which usually causes discomfort to the patients.

CARIOUS TISSUE REMOVAL TECHNIQUES:

There are number of caries removal techniques. Some of them claim to remove demineralized dentin selectively whereas others may not be able to make distinction and may not even be able to remove softened tissue effectively. So it is important for the clinician to know for what to be expected of each technique.

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

1. Comfort and ease of use in the clinical environment.
2. The ability to discriminate and remove diseased tissue only.
3. Being painless, requiring only minimal pressure for optimal use only.
4. Not generating vibration or heat during periods of operation.
5. Being affordable and easy to maintain.

ATRAUMATIC RESTORATIVE TREATMENT:

Atraumatic restorative treatment is based on the minimal invasive concept in removing carious tissue in addition to the restoration for controlling dental caries. The principle of atraumatic restorative treatment is to remove soft dentinal caries with hand instrument and to fill cleaned cavity with glass ionomer cement to release fluoride. Unlike the other conventional methods, atraumatic restorative treatment is non-threatening, not painful, therefore doesn't need anesthesia, doesn't use expensive electrically driven equipment and can be provided at low cost. Only hand instruments are needed to perform atraumatic restorative treatment. These are mouth mirrors, explorers, pair of tweezers, spoon excavators, hatchets or hoes and carvers. Atraumatic restorative treatment is based on modern concepts of cavity preparation where minimal intervention and invasive is emphasized. So this approach is applicable to industrial countries, special groups such as physically and mentally handicapped and the elderly. It is carried out in small cavities where hand instruments are accessible. It is contraindicated in abscess near the carious teeth, when pulp of the tooth is exposed, cavity not accessible to hand instruments. Atraumatic restorative treatment is a perfect alternative method to approach a large population, but is not practiced now a days due to advancements in dentistry.

AIR ABRASION

Air abrasion system for cavity preparations uses the kinetic energy of abrasive particles to cut tooth structure in less invasive way while rounding off the internal and cavosurface angle to direct the benefit of the subsequent adhesive restoration. Air abrasion was developed by R. V. Black in 1945 who instigated preliminary investigations into a pseudo mechanical method for tissue removal which involved bombarding the tooth surface with high velocity particle (conventionally aluminum oxide (Al_2O_3)) carried in a stream of air.⁵ It has been said that this technology can be used to diagnose both early diagnosis of surface caries and treating them with minimum invasive technology. In 1951, the Air dent air abrasion unit was introduced by S. S. White Company. Depending on the nature of the abrasive, this technique has the ability of

removing efficiently both soft dentin and enamel. Several parameters can be altered in order to adjust the characteristic of the instrument, such as the type and size of the abrasive particle will affect the coarseness of the abraded particle. Larger the particle size the greater the kinetic energy to the surface thus rougher the final finish. The speed of the particles can be altered by varying the air pressure, distance between the nozzles and the tooth surface and length of the cutting tissue. These factors play a role in managing the effectiveness of the instrument. Decrease in the velocity of the particle will reduce the kinetic energy to the tooth surface thus reducing the overall abrasiveness.^{6,7,8} Aluminium oxide abrasive particles removes sound enamel and dentin very efficiently whereas clinically soft carious dentin is not removed due to difference in hardness of carious substrate when compared with aluminum particles.¹ A mixture of alumina and hydroxyapatite in a volume ratio of 3:1 with particle size ranging from 3 to 60 μm is shown to be as effective as conventional hand excavation with dental spoons.⁹ Vanleewen and Rassona in 1952 concluded that on basis of count, particle size ($> 40 \mu\text{m}$ diameter) and the normal use of the air abrasion presents little or no health hazard to both patient and dentist.¹⁰ This technique has full USFDA approval for clinical use of 27.5 μm alumina particles. This method of cutting teeth reduces the problem of heat generation,^{8,11} vibrations and other mechanical stimulation, resulting in pain free and comfortable procedures compared to dental drill.^{6, 12, 13} This technique can be managed by patients without the use of local anesthesia. It removes less tooth structure than drilling. Any caries removed with air abrasion minimally opens in the pits and fissures for visualization and access of caries. Air abrasion has different application in dentistry including removal of extrinsic stains and calculus, minimum cavity preparation, crown preparation and preventive resin restoration placement.^{12,14,15,16,25,31} The major disadvantage is loss of tactile sensation during cavity preparation because the nozzle does not touch the tooth surface. Care should be taken while working close to the soft tissues due to the increased risk of laceration, air dissection and emboli. Air abrasion is not used for the removal of amalgam and gross caries, because air abrasion of amalgam

releases vapors in excess as of OSHA standards, Air abrasion produces an irregular imbricate surface pattern and a thin smear layer when compared to rotary cavity preparation. New advances in micro abrasion technology allow a metered flow of alumina particles, higher opacity pressures and an immediate initiation and termination of abrasive stream. E.g.: polycarbonate resin or alumina hydroxyapatite is more selective in carious dentin removal as they are capable of removing tissue of equivalent hardness leaving healthier sound tissue virtually unscathed.^{4, 6, 26}

AIR POLISHING:

Air polishing is the process by which water soluble particles of sodium bicarbonate, to which tricalcium phosphate (0.08% by weight) has been added to improve the flow characteristics is applied onto the tooth surface using air pressure, shrouded in a connecting water jet. It is the main difference between air abrasion and air polishing.²⁶ The abrasive is water soluble so it does not escape far from the operating field. The bombardment of the hard tooth surface by these particles resists in continuous mechanical action which removes surface deposition. When the air pressure exceeds the clinical pressure the mass flow of the particles is decreased thus limiting the surface abrasiveness. Due to its non-selective detrimental abrasive surface attack on restoration, sound enamel and dentin, its overuse removes an amount of healthy tooth structure specifically at the cervical margin.³⁰ So the removal of carious dentin should be done at the end of cavity preparation. This technique is generally used to remove enamel stains, plaque and calculus away from the gingival margin of the teeth.⁷

Ultrasonics: Investigations of this technique have been carried out in 1950 by Nielsen et al.^{33, 34} He designed a magnetostrictive instrument with an oscillating frequency of 25kHz. This is used in combination with thick slurry of aluminum oxide and water. The mechanism of action is the kinetic energy of water molecules transferred to the tooth surface via abrasive through the high speed oscillation of the cutting tip.

Soft carious dentin could not be removed but the harder, deeper layer was susceptible.^{33, 34} It is a controversial point that this hard leathery deeper surface layer should be removed as it

represents the dentin that has been affected by the caries with a collagen permitting remineralisation. Nielsen attempted to analyze the outcomes by altering the pressure applied, duration of use, the powder: water ratio in the slurry, the nature of the material used and the type of the abrasive used.³⁴ Due to erratic and unpredictable performance of the instrument, results were inconclusive. In a clinical trial, they found this to be favorable in terms of the reduced vibration and sound generation when compared with dental drill.³⁷

Sono Abrasion: It is the modification of ultrasonics which uses high frequency, sonic air scalers with modified abrasive tips. The sonic system micro unit designed by Dr. Hugo, Unterkirch and Mismosele in a venture between Ivoclar Vivadent and KaVo (KaVo dental Ltd, Amersham, U.K) is based upon the sonic flex 2000L and 2000N air scaler hand pieces that oscillate in the sonic region. The tip has an elliptical motion with a transverse distance of between 0.08- 0.15mm and a longitudinal distance of between 0.55-0.138mm. They are diamond coated on one side using 40µm grit diamond and are cooled using water irrigant at flow rate between 20-30ml/min. The operational air pressure for cavity cutting is around 3.5 bar (nominal pressure with coupling). It has three instrument tips 1). A lengthways halved torpedo shape (9.5mm long, 1.3mm wide). 2). A small hemisphere (1.5mm diameter). 3). A large hemisphere (2.2 mm in diameter). The torque applied to the instrument tip should be 2N. If the pressure applied is greater, the cutting efficiency is affected due to damping of the oscillations.⁸ This technique was developed to prepare predetermined cavity outlines but also works in removing hard tissues when finishing cavity preparation. Sono abrasion excavation with diamond coated tips appeared more efficient as conventional hand excavation using dental spoons.⁷ Positive results from laboratory studies using sono abrasion to remove softened carious dentin have indicated a further advanced use of this technique in the future.⁴ Some authors speculated that the oscillations of the diamond coated tip is transferred to only a slight vibration at the dentin surface, imparting effective tissue cutting and resulting in a compacting effect on the carious dentin substrate.⁷ According to another study, any smear layer produced tends to be

thinner than the one yielded by diamond/carbide burs which may be beneficial for the bonding effectiveness.^{11,22,39}

CHEMICO MECHANICAL METHODS

Sodium hypochlorite based agents: The first attempt to develop a chemical solubilizer that would selectively act on carious dentin turned out in a sodium hypochlorite solution buffered with an amino acid containing a mixture of amino butyric acid, sodium chloride and sodium hydroxide. In 1976, Goddman and Kromann reported the removal of carious tissue using N-monochloroglycerine (NMK, GK-101).²³ Subsequently after modification the Caridex system containing N-mono chloro amino D 1, 2-aminobutyrate (NMAB, GK10E) was introduced. Sodium hypochlorite is a non-specific deproteinising agent, the carious tissue removal capacity was attributed to burying effect of amino acid mixture, which was added to reduce the aggressiveness of sodium hypochlorite on sound dentin and to enhance the disrupting effect on degenerated collagen with carious dentin.⁴¹ The GK-101 material softens only the infected layer of carious tissue by selective attack on the degenerated collagen fibers. The attack causes breakdown of the polypeptide chain and hydrolysis of the cross links of collagen fibrils. The advantages of this system are increased patient compliance and a decreased need of local anesthesia.^{3,47} Brannstrom et al showed it as a successful way by removing soft carious dentin without any significant damage to underlying dentin but other studies showed no beneficial effects.¹⁶ This Caridex system (national patent medical products, New Brunswick, NJ, U.S.A) was not fully successful in clinical practice. Its efficacy in carious removal was contested but technical problems such as need of a specific apparatus to deliver into the cavity, short shelf life etc. was a reason why it failed in the clinical practice.¹¹ Renewed interest in chemico mechanical caries removing agents was associated with the developing concept of minimally invasive dentistry. A new caries removing system of sodium hypochlorite was introduced in the form of a gel (Carisolv, Medi Team Dental; Sanedalem, Sweden) which contained 0.5%w/v sodium hypochlorite, 0.1mg of an amino acid mixture (glutamic acid, Levine

and lysine) and water. This method effectively removes caries and was readily accepted by the patients.²¹ The steps in the chemico mechanical carious excavation is

1) Application of the solution. 2) Scrapping of the carious dentin with the possible change of instrument size. 3) Rinsing, 4) repetition of the procedure till all the caries are removed.^{21, 29}

Carisolv's clinical efficacy was described by Ericsson et al in 1999. Carisolv has proved its efficiency in establishing the end point of caries excavation by removing carious dentin to the same extent as the auto fluorescence of carious tissue when measured by confocal microscopy.⁷ After caries excavation with Carisolv microstructure and chemical composition doesn't seem to be significantly altered. Carisolv excavated lesions are deeper in dentin as compared to when caries was removed with a conventional bur guided by a caries staining dye.⁴⁶ Carisolv excavated dentin has a good bonding tendency, meaning that it is not covered by a smear layer, exhibit patent dentinal tubules²⁷ and an irregular surface topography with improper wetting potential.^{7,19} Carisolv has some bactericidal activity due to the formation of chloramphenicol compounds. The presence of the bacteria and absence of smear layer can be explained when Carisolv is used, presumably because of pushing the bacteria into the dentinal tubules. Carisolv has proven to be superior in reducing the viable bacteria count in residual dentin as compared to conventional bur excavation. This technique may be useful in certain lesion e.g.: exposed caries, buccal, cervical root lesions, deep lesions. The drawbacks of the method may include prolonged operating time (when compared with rotary instrumentation) and the simple fact that the more conventional methods are still used in order to gain access to the carious tissue to allow the solution to function.

Papain based agents: A new experimental gel consisting of pepsin in phosphoric acid/sodium bisphosphate buffer is considered as an alternative chemico mechanical caries excavation agent (SFC VIII, 3MESPE, Seefeld, Germany). The phosphoric acid dissolves the inorganic component of carious dentin while it also gives access to pepsin to the organic part of caries biomass to selectively dissolve the denatured

collagen.²Heavily pigmented, arrested carious dentin is resistant to pepsin digestion.⁴⁰ An x ray micro CT evaluation of caries excavation with SFC V reveals that the new enzymatic caries removing gel is able to remove equivalent volumes of caries dentin as Carisolv. The main advantage of this technique is that it could be more specific by digesting only denatured collagen (after the triple helix integrity has lost) than sodium hypochlorite agents. Studies have found partially demineralized intertubular collagen fibrils and some tubule occlusion upon treatment of artificially formed dentin caries with a pepsin based agents. Further laboratory studies and clinical trials are still lacking.

LASERS

Since the development of first ruby laser by Naiman in 1960, researchers postulated that it could be applied to cutting hard tissues and soft tissue in the mouth. The field of lasers has been developed considerably and new types of lasers are available to cut dental hard tissues. The efficiency of lasers depends on the factors including the wavelength characteristics, pulse energy, repetition rate and optical properties of the incident tissue.

Lasers available for more selective hard tissue ablation are:

- Er:YAG (erbium, yttrium aluminum- garnet) and Nd: YAG(neodymium -YAG) - mid IR – IR emission.
- Carbon dioxide lasers (CO₂) - IR emission.
- Excimer lasers -ArF (argon: Freon) and XeCl (xenon:chlorine) - UV emission.
- Holmium lasers.
- Dye enhancer laser ablation - exogenous dye, indocyanine green in conjugation with a diode laser.¹

In caries dentin removal the UV emission excimer lasers (377nm) has the potential to be more selective in ablation of carious dentin.⁴⁵In the presence of a suitable photo sensitizer, lower power laser light has the ability to destroy *streptococcus mutans*.¹⁷The erbium loaded yttrium aluminum garnet (Er; YAG) and the erbium chromium; yttrium-scandium gallium garnet lasers are two types of erbium based laser devices available in the market.⁴³Both devices have similar wavelength (2.78um for Er Cr; YSGG and 2.94 um for Er: YAG). Mechanism by

which enamel and dentin are removed during Er;YAG irradiation consists of explosive subsurface expansion of water interstitially trapped within the dental hard tissues. During irradiation, the water molecules absorb the radiation causing sudden heating and water expanation. High stream is formed including a violent, yet controlled explosion and ejection of dental hard tissue components.²⁸ Er:Cr; YSGG laser system is known as laser powered hypokinetic system which delivers photons straight into the target tissue. This phenomenon induces micro explosive forces into the water droplets which contribute to the mechanism of hard tissue removal. Lasers can be used for caries diagnosis, disinfection of periodontal pockets or root canals, photodynamic therapy of oral tumors, soft tissue surgery, caries removal and cavity preparation.⁴³Lasers can be used to cut and seal the dentinal tubules reducing the possibility of post-operativesensitivity.³²Advantages of lasers are a more conservative design, an alleged anti-bacterial activity and a significant decrease in enamel solubility therefore also possible in playing the role of prevention of recurrent caries. Laser ablation gives more comfort to the patient due to the absence of vibration and lower pain sensation compared to the use of the conventional method. The main drawback is its relatively longer time needed for cavity preparation. The factors such as thermal irritation to the pulp,possible destruction of the adjacent soft tissues and size of the equipment has led its limited use in clinical practice till date. An improvement in the caries removal ability of erbium lasers is to combine it with laser florescence technology for caries detection.

ENZYMES

In 1989, Goldberg and Kiel successfully removed soft carious dentin using bacterial achrombacter collagenase which didn't affect the sound layers of the dentin beneath the lesion. The enzyme prognase, a nonspecific proteolytic enzyme from *Streptomyces griseous* helps to remove carious dentin.³⁵A further lab research is needed for the valuation of this technique.

OZONE

The word ozone was introduced by schonbein in 1940. Ozone consists of three atoms of oxygen

and normally present in the outer layers of atmosphere in abundance. The word ozone was introduced by Schonbein in 1940. Ozone consists of three atoms of oxygen and normally present in the outer layers of atmosphere in abundance. Ozone therapy has been used in many countries throughout the world for many years it's recently gaining interest in the medical community. In dentistry three forms of ozone application is seen i.e., ozonated water, ozonated olive oil and ozone gas. Ozonated water and olive oil forms an ideal delivery system to entrap and then release oxygen and ozone. They are either used alone or in combination for treatment. Ozone is a powerful antioxidant, capable of interacting as metabolic and immune modulation as well as antimicrobial agent. Ozone attacks many biomolecules such as the cysteine, methionine and histidine, residue of proteins and change the surface ecology of the carious lesions. The average concentration of ozone used in the treatment is 25g of ozone. The therapeutic goals of the ozone therapy in dentistry is the removal of pathogens, restoration of proper oxygen metabolism, induction of friendly ecological environment, increased circulation, immune modulation and stimulation of the humoral anti-oxidant system. Many studies have shown that low concentration of ozone gas causes inhibition of pit and fissure caries, root surface caries, and interproximal carious lesions. And they have also shown that reversal of decay in carious lesion with the exposure of ozone as little as 10 seconds. The proper use of this therapy is necessary to avoid inhalation of the gas which causes irritation to the eyes and the mucosal lining of the respiratory tract.

CONCLUSION

This paper gives overview of various non-rotary caries removal techniques. All the techniques removes carious dentin with different levels of efficiency but still there is a debate that these technique discriminate between highly infected zone and low infected zone. The failure in discriminating these zones will lead to the over preparation of the cavities with little control over the tissues. So it is important for a clinician to know the pros and cons of each technique and its efficiency in caries removal.

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