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Minimal Invasive Dentistry: Literature Review

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ABSTRACT

Minimally invasive procedures are the new paradigm in health care. Everything from heart bypasses to gall bladder, surgeries are being performed with these dynamic new techniques. Dentistry is joining this exciting revolution as well. Minimally invasive dentistry adopts a philosophy that integrates prevention, remineralization and minimal intervention for the placement and replacement of restorations. Minimally invasive dentistry reaches the treatment objective using the least invasive surgical approach, with the removal of the minimal amount of healthy tissues. This paper reviews in brief the concept of minimal intervention in dentistry.

Key words: Air abrasion–Lasers–Minimal invasion–Remineralization–Sealants

1 INTRODUCTION

Minimum (or minimal) intervention dentistry (MI) is defined as a philosophy of professional care concerned with the first occurrence, earliest detection and earliest possible cure of disease on micro (molecular) levels, followed by minimally invasive and patient-friendly treatment to repair irreversible damage caused by such disease. [1] It helps in tissue preservation by preventing disease and intercepting its progress, this means performing treatment with as little tissue loss as possible. [2] It expresses a very precise excision of what has to be removed, without causing any damage to adjacent tissue. [3] With the available new techniques, we can aim for both an early diagnosis and a minimally invasive therapy. [4]

2 DISCUSSION

Dr. G.V. Black the father of modern dentistry, in late 1800s invented the rules for dentistry. He gave the concept of "extension for prevention". [5] The minimally invasive approach in treating dental caries incorporates the dental science of detecting, diagnosing, intercepting and treating dental caries at microscopic level. [6] This has evolved from increased caries process understanding and the development of biomimetic and adhesive restorative materials. [3] With minimally invasive dentistry, dental caries is treated as an infectious condition. Now "extension for prevention" is not practiced and has changed to "constriction with conviction". [7]

Minimally-invasive treatment in dentistry was pioneered in

1. 1970s by application of silver diamine fluoride
2. 1978 by Preventive resin restoration (PRR)
3. 1980s by Atraumatic restorative treatment (ART)
4. 1990s by Chemo-mechanical caries removal concepts [8]

Golden triangle of MID

- Histology of dental subsurface being treated
- Chemical handling of dental adhesive materials used for restoration

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- Consideration of practical operative techniques available to excavate caries minimally [9]

Principles of Minimal Intervention *[3, 8]*

- Disease risk assessment and early caries diagnosis
- Classification of caries depth and progression using Radiographs
- Reduction of cariogenic bacteria, to decrease the risk of further demineralization and cavitation
- Arresting of active lesions
- Remineralization and monitoring of noncavitated arrested lesions
- The placement of restorations in teeth with cavitated lesions, using minimal cavity designs
- The repair rather than replacement of defective restorations.
- Assessing disease management outcomes at pre established intervals

Early Diagnosis *[10]*

To stop caries as early as possible, future caries risk and present caries activity should be established. [11] Caries risk may be assessed from a number of predictors such as *Streptococcus mutans* levels, salivary buffering capacity and flow rate baseline caries prevalence as well as fissure retentiveness. [12] Various new diagnostic aids have been mentioned in Table 1. [3, 13]

Remineralization of early lesions and reduction of cariogenic bacteria

It is possible to arrest and reverse the loss of minerals associated with caries at an early stage, before cavitation. In early carious lesions, there is subsurface demineralization of the enamel. As caries progresses into dentin, the surface of the enamel eventually cavitates. Once cavitation begins, it becomes difficult to control plaque accumulation. [14] In difficult access areas, plaque hinder the availability of phosphate, calcium and fluoride ions, which may decrease the remineralization potential. Therefore, surgical treatment-caries removal and restoration is indicated for the cavitated lesion. In non-cavitated lesion, one must first alter the oral environment to take advantage of the tooth's capacity to remineralize and to tip the balance in favor of remineralization and away from demineralization. [15]

This includes:

- Decreasing the frequency of intake of refined carbohydrates
- Optimum plaque control
- Optimum salivary flow
- Conducting patient education [8]

Chlorhexidine and topical fluorides can be applied to encourage remineralization. Chlorhexidine acts by reducing cariogenic bacteria number. Topical fluorides increases the fluoride ion availability for remineralization and fluoroapatite formation, with its increased resistance to demineralization. [16]

9% sodium hexametaphosphate addition to a gel with reduced fluoride concentration (4500F) significantly enhance the remineralization of artificial carious lesions *in vitro* when compared to 4500F, reaching protective levels similar to an acidic formulation with ∼3-fold higher fluoride concentration. SDF used at a high concentration (38%, 44,800ppm fluoride) is effective in arresting caries among children. [17]

Minimal Cavity designs

Cavity preparation design and restorative material selection depend on occlusal load and wear factors. [6] It has been proposed that the G.V. Black classification of cavity designs be replaced by a new classification system advocated by Mount and Hume. [18] The rationale behind the cavity classification system proposed by Mount and Hume is that it is only necessary to gain access to the lesions and remove areas that are infected and broken down to the point where remineralization is no longer possible. [6] The new classification system is based on site and cavity size Table 2. [18]

Remineralizing Agents *[3]*

1. Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP)
2. Combination of CPP-ACP and fluoride
3. Novamin
4. TiF4 technology
5. Resin infiltrant technology
6. Tricalcium phosphate
7. Nano hydroxyapatite
8. Enamelon

1. Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP)

Researchers from Melbourne University have identified CPP as an anticaries milk component. 0.5-1.0% of CPP-ACP solution cause remineralization effect equivalent to 500ppm of fluoride. [19] CPP-ACP binds readily to tooth surface. Under acidic conditions, CPP-ACP buffers free calcium and phosphate ions, substantially increasing the calcium phosphate level in plaque and therefore, maintains a state of supersaturation which enhances remineralization and inhibits enamel demineralization. [20]

2. Combination of CPP-ACP and fluoride

CPP-ACP when combined with fluoride show synergism in remineralizing potential. CPP-ACPF varnish showed the greatest remineralization, followed by CPP-ACPF paste and then CPP-ACP paste. [3]

3. Novamin

Chemically, Novamin is known as calcium sodium phosphosilicate. It is a bioactive glass consist of minerals that have been found naturally in the body and reacts when comes into contact with saliva, water, saliva or other body

Table 1. NewDiagonostic Aids for dental Caries

Enhanced visual techniques	Fluorescent techniques	Laser-Induced Fluorescence	Detection systems based on electrical current measuremnt	Ultra-sound tech-niqus	Chemo-mechani-cal removal of caries
1.Fibre optic transillumination (FOTI) 2.Digital Imaging Fiber-Optic TransIllumination (DIFOTI)	Quantitative Light Induced Fluorescence (QLF)	1.Diagnodent 2.FluorescenceCameraVista Proof) 3.LED technology (Midwest Caries I.D.)	1.Vangaurd electronic caries detector 2.Caries meter L 3.Electronic caries monitor (ECM)	The Ultra-sonic Sys-tem	Carisolv, Papacarie

Table 2. Caries classificationsystem based on lesion site and size

Location	Classification 1 = Minimal	2 = Moderate	3 = Advanced	4 = Extensive
Pits and fissures	1.1	1.2	1.3	1.4
Proximal surfaces	2.1	2.2	2.3	2.4
Cervical surfaces	3.1	3.2	3.3	3.4

fluids. [14] The products containing this formula has desensitization as their use and is available in varnish, toothpaste and root desensitizer form. [21]

4. TiF4 technology

Titanium ion readily hydrolyze H_2O to expel proton (H+) and render the solution of low pH value. [22] The affinity of titanium ion to oxygen imparts a strong tendency to form titanium phosphate complex (i.e. titanium ion reacting with the oxygen atom of the phosphates of the tooth structure). [3]

5. Resin infiltrant technology

Resin infiltration technology in combination with substantial caries remineralization program may provide therapeutic benefits and reduce long term restorative costs and needs, thus complementing the minimal intervention dentistry concept. [23] The RI/CR approach increases the initial quality of fissure sealing and is recommended for the clinical control of occlusal caries. [20]

6. Tri calcium phosphate

Chemical formula of TCP is $Ca_3(PO4)_2$ and exists in alpha and beta forms. It is relatively insoluble in aqueous oral environment. [19] The organic coating prevents undesirable interactions with fluoride, but dissolves away when particles come in contact saliva. [3]

7. Nano hydroxyapatite

Nano-hydroxyapatite (n-HAp) is considered one of the most biocompatible and bioactive materials, and has gained wide acceptance in medicine and dentistry in recent years. Nano-sized particles are similar in morphology to apatite crystals of tooth enamel and crystal structure. Combination of nanohydroxyapatite and $ZnCO_3$ is equally effect. [24]

Enamelon

Enamelon consists of unstabilized calcium and phosphate salts with sodium fluoride in toothpaste. [23] Technical issue with Enamelon^{TM} is that phosphate and calcium are unstabilized, which allows combining of two ions into insoluble precipitates before they contact enamel or saliva. [3] Scanning Electron Microscope (SEM) images showed decrease in pore volume of the enamel in all the treatment groups compared to the control group indicating increase in resistance to demineralization in acidic pH. [25]

***MID Techniques** [26]*

- Mechanical Rotary High/Low-Speed Bur
- Atraumatic restoration
- Air abrasion
- Sono Abrasion
- Air Polishing
- Laser
- Chemomechanical agent
- Pit and fissure sealant
- Ozone Technology

1 Rotary – High/Low Speed Bur

Rotary bur is used universally. It easily cuts through carious dentin to open up healthy tubules deeper in the tissue and along with water stimulation of odontoblastic processes resulting in pain associated with cavity preparation. [27]

For ultraconservative dental treatment, Fissurotomy bur is a new approach. Three unique burs i.e. Original fissurotomy Micro STF and fissurotomy Micro NTF have been designed specifically for treating pit and fissure lesions. [28] The comparison of a fissurotomy bur to a traditional cutting bur demonstrates the lessened invasiveness of this new design bur. [16]

2. Atraumatic restorative technique

First evaluated in Tanzania in 1980s. Its principles rely on minimum intervention, minimum invasion. All the procedures are carried out only using hand instruments and adhesive restoration. [8] While MID concept involves using all possible technologies and instruments to achieve the best to save natural tissues, ART is helpful in eradicating or

controlling spread of caries in poor nations with minimally sophisticated technology. [29]

3.Lasers

Lasers produce beams of coherent and very high-intensity light. Lasers in dentistry have been involved in the treatment of soft tissues and modification of hard tooth structures. [16]

- Lasers that are currently being investigated for more selective hard tissue ablation include: Erbium: Yttrium-aluminum-garnet (YAG) and neodymium: YAG – Mid-infrared (IR) to IR emission
- CO2 laser – IR emission
- Excimer lasers
- Holmium lasers
- Dye-enhanced laser ablation – exogenous dye, indocyanine green in conjunction with a diode laser

4. Chemomechanical Preparation

Carisolv

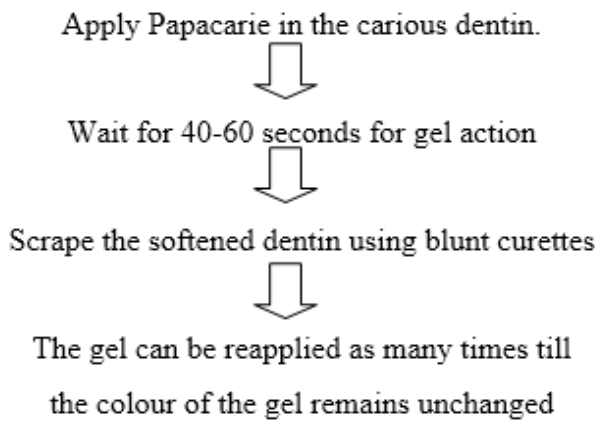
This material consists of a clear liquid (NaOCl) and a red gel (3 amino acids – Leucine Lycine, Glutamic acid, Carboxymethyl-cellulose gel, Na(OH)2, and coloring agent) which are mixed together. [30]

Papain Gel

To overcome the disadvantages of carisolv system, in 2003 in Brazil a new formula was developed to universalize the use of chemo-mechanical caries removal method and promotion in public health. [31]

The new formula was commercially known as Papacarie. It is available in syringe form which contains blue-colored gel. It is basically composed of Papain, chloramines, toluidine blue, salts, thickening vehicle responsible for papacarie's bactericidal, bacteriostatic and anti- inflammatory characteristics. Papain comes from the latex of the leaves and fruits of the green adult papaya [32, 33] .

Procedure [30]



5. Air Abrasion

Air abrasion is a technique that uses kinetic energy to remove carious tooth structure. [27] A powerful narrow stream of moving aluminum oxide particles is directed against the surface to be cut. [26] It has been proposed that air abrasion technology can be used to both diagnose early occlusal-surface lesions and treat them with minimal tooth preparation. Air abrasion requires less time and energy consumption, it requires no anaesthesia and does not produce vibrations and heat. [34] The air abrasion system uses abrasive particles targeted mainly for the affected area of the cavity. Simple stains can be removed easily. Both stains and affected tissue can be removed easily using a strong jet of abrasive particles. [26] Alternative abrasive particles have been proposed, showing that software particles, such as polycarbonate resin or alumina hydroxyapatite mixtures can be more selective in removing carious dentin as they have the ability to remove only equivalent hardness tissue and the healthier one remained unaffected. [2]

6. Ultrasonics and Sono Abrasion

Since 1950s, ultrasonic vibrations with high-frequency have been recommended for the proximal carious lesions removal in both anterior and posterior teeth, with the aim of more conservative cavity preparation. To excise the dentin, diamond coated tip oscillating at a frequency of 6.5 kHz and maximum of 20-40 kHz frequency is used. [35]

Sono abrasion is used for selective enamel and dentin preparation, offering excellent quality, safety and efficacy. This utilizes high frequency, sonic, air scalers with modified abrasive tips with a longitudinal movement ranging from 0.055 to 0.135 mm and a transverse distance of 0.08–0.15 mm. [27]

The advantages are minimizing or eliminating noise, vibration, heat and pressure. The disadvantages are low abrasion and high hub excursion (0.4 mm) of tips and weakening of enamel rods with associated cracks adjacent to the prepared sites. [35]

7. Air Polishing

This procedure produces high-pressure jet containing sodium bicarbonate. It is projected on teeth surface thereby, resulting in a grinding/cutting effect. Air polishing is not a very selective procedure when grinding tooth structure and it can affect the health of dentin and cementum. [36] Used for removing stains and in the final preparation of the tooth to remove the remaining altered dentin. [37] Air polishing is accomplished by the propulsion of abrasive particles through a mixture of water and compressed air, alongwith handpiece, thus removing dental plaque and/or stain. Pressure, time of abrasion, speed, shape and hardness of the particles used influences the abrasion rate. [38]

8. Pits and fissure sealants

Pits and fissures morphology is believed to be one of the main caries risk factors with molars being more commonly affected as compared to premolars [20]. Sealants modify pits and fissures into smooth surfaces which have been protected from bacterial colonization and fermentable substrate exposure and can be easily cleaned. This is effective in arresting non-cavitated enamel carious lesions in pits and fissures

alongwith preventive measure. [39] Pit and fissure sealants have been proved to be superior than fluoride varnish application in the occlusal carious lesions prevention. [40]

Resin composites and glass-ionomer cements are the dental materials generally used to seal pits and fissures. A high-viscosity glass-ionomer is indicated for use with the ART sealant technique. It is generally accepted that resin composite sealants are retained longer than lowto medium viscosity glass ionomer sealants. [41, 42]

Based on extensive evidence, the use of dental sealants is strongly recommended for all at risk surfaces and shows good results for both high-viscosity glass-ionomer and resin composite material use with the ART approach. The latter can be used in situations where electricity and running water are unavailable. [20]

9. Ozone Technology (O3)

Ozone (O_3) is an energized form of oxygen. Ozone therapy has been extensively used in the medical professions for more than a century. [43] Ozone is one of nature's most powerful oxidant, which accounts for its ability to kill bacteria, spores and viruses. Ozone therapy is based on the premise that the primary carious lesions when exposed to ozone become sterile and re-mineralize after some time. [44]

Disease Control

There is a need to establish clear guidelines on the management of caries as an infectious disease. [6] Strategies include bacterial identification and monitoring [45] diet analysis and modification, use of topical fluorides [46] and use of antimicrobial agents [6]. Several strategies have potential to reduce caries prevalence in early childhood:

- Increasing access to care, educating patients and their parents
- Using targeted preventive therapies, including treating the family in hopes of decreasing transmission of virulent Streptococcus mutans and other bacterial species from caregiver to child. [47, 48]

3 CONCLUSION

It is not possible to really imitate natural tooth structure on a long term basis, so it is best that it should be retained as far as possible. Now the profession has a better understanding of prevention of dental disease, with the advent of adhesive and bioactive restorative materials but there is reluctance in a wide group of dental professionals to use these materials and techniques. The reasons can be traced to lack of knowledge and adequate training for use of these procedures. Moreover, cost of the equipment and the consumable materials and items also becomes a deciding factor for most practitioners. But what needs to be put into perspective is that these techniques and materials are not only true to the philosophy of "patient centred simplification" but also are practice builders.

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