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Minimal invasive operative dentistry

A Project Submitted to the College of Dentistry, University of Baghdad, Department of Restorative & Esthetic Dentistry in Partial Fulfillment for the Bachelor of Dental Surgery

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Certification of the Supervisor

I certify that this project entitled "**Minimal invasive dentistry**" was prepared by the fifth-year student **Hadeel Ali Hekmat** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor’s name:

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B.D.S., M.Sc.

Dedication

To the spirit of my father who gave his soul to protect the country "I will make you proud as you did to me I promise".

To my eyes that stays the nighs awake, wilt and lost part of them to reach this moment.

To my brain that kept me calm, patience and received all that huge informations.

To my heart who trusted me and gave me the peace in times of overthinking.

To my artistic hand that cured her patient with creativity.

To my feet that carried my shaking body in the moments of stress.

To my backbone that bowed for me.

myself the one and only supportive who has struggled , lost and lifted me when I bented down for 26 years.

It is the end of the first road and the beginning of ambition and goals

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Introduction

Minimal intervention is a concept introduced by Mount and Hume in 1997, they suggested to the dental profession that it was time for changes in the principles of operative dentistry. Minimal intervention in relation to dental caries covers a vast area of diagnosis, risk assessment, prevention, and control **(Murdoch-Kinch and Mclean,2003).**

The concept of minimal intervention dentistry has evolved as a consequence of our increased understanding of the caries process and the development of adhesive restorative materials **(Tays *et al.*, 2000)**. Over the years clinicians have used the G.V. Black cavity design and the ‘‘extension for prevention’’ surgical approach to oral disease management has been the cornerstone of 20th century dentistry **(Osborne and Summitt, 1998)**.

In this concept the clinicians’ approach was purely surgical. It was thought that the only effective method of eliminating disease was to completely remove all the demineralized areas of the tooth structure and rebuild the tooth with an inert restoration that would simply obdurate the cavity **(Mount and Ngo, 2000).**

Minimal intervention approach starts with diagnosis and risk assessment of the disease in order to allow for proper treatment decision. Different techniques for management of initial carious lesion include non-invasive management and operative care. Advancements in management of caries has started a trend toward the conservation of tooth structure and also bonding techniques which provide an alternative to mechanical retention. The main goal of minimal intervention is to increase the life of the teeth, which was restored with less intervention. Now the concept is “prevention of extension” rather than “extension for prevention **(Shivana and Ramakrishna, 2002).**

Aim of the study

This review aims to tissue preservation (preferably by preventing disease and intercepting its progress), this means performing treatment with as little tissue loss as possible. It expresses a very precise excision of what has to be removed, without causing any damage to adjacent tissue.

Chapter one

Review of literature

1. 'Golden triangle' of MID (Banerjee, 2013):

A thorough understanding and appreciation of the interplay between three critical factors is required to achieve success clinically when using a minimally invasive operative caries management strategy (MI OCMS):

1. The histology of the dental substrate being treated.
2. The chemistry/handling of the adhesive materials used to restore the cavity.
3. Consideration of the practical operative techniques available to excavate caries minimally.

2. Goals of minimal invasive dentistry include (Gujjar and Sumra, 2013):

1. Prevention of caries.

2. Reduction in cariogenic bacteria.

3. Remineralization of early lesions.

4. Minimum surgical intervention of cavitated lesion.

5. Repair rather than replacement of defective restorations.

3. Principles of Minimal Intervention are based on (Fairaq *et al*., 2019):

1. Disease risk assessment & early caries diagnosis.

2. The classification of caries depth and progression using Radiographs.

3. The reduction of cariogenic bacteria, to decrease the risk of further demineralization and cavitation.

4. The arresting of active lesions.

5. The remineralization and monitoring of noncavitated arrested lesions.

6. The placement of restorations in teeth with cavitated lesions, using minimal cavity designs.

7. The repair rather than replacement of defective restoration.

8. Assessing disease management outcomes at pre established intervals.

4. Dental caries:

Dental caries is the disease that results from an ecologic shift in the bacteria within the dental plaque biofilm. An initially balanced population of commensal micro-organisms in a healthy plaque biofilm alters as an increasingly favourable environment for aciduric and acidogenic microflora develops within the stagnating biofilm, after stimulation by frequent consumption of fermentable dietary carbohydrates. The resulting shift in biofilm activity brings about an imbalance in de- and re-mineralisation, leading to net mineral loss within dental hard tissues; the earliest sign and symptom is the carious lesion **(Fejerskov *et al*., 2008)**.

4.1. Enamel caries:

Long-term, repeated episodes of bacterial acid demineralization instigated at a susceptible tooth surface by the residing plaque biofilm results in the growth of subsurface structural porosities, eventually enlarging, if not controlled at the earliest stages by remineralization/oral hygiene procedures, coalescing and ultimately causing cavitation. Carious enamel with its unsupported prismatic structure is weak under stress from compressive/ shear occlusal loads or from tensile shrinkage forces from photo-cured resin-based adhesive materials **(Banerjee, 2010).**

Figure (1) Histopathology if caries in enamel

4.2. Dentine caries:

4.2.1. histopathological zones of Carious dentine:

4.2.1.1. The peripheral caries-infected zone: (close to the enamel-dentine junction [EDJ]), irreversibly damaged, necrotic and softened by long standing bacterial contamination and proteolytic denaturation of collagen and acid demineralization of the inorganic component

4.2.1.2. The deeper caries-affected zone: reversibly damaged by virtue of carious process, which has the potential to repair under the correct conditions as the collagen is not denatured **(Banerjee *et al*., 2000)**.The soft, wet, necrotic nature of caries-infected dentine means it is an inferior chemical and physical substrate for adhesion and seal formation, whereas the potentially repairable caries-affected dentine has been shown to exhibit adequate adhesive bonding potential, especially when surrounded by a periphery of sound dentine and enamel.Affected dentine within a lesion is a rather subjective process at present. Caries-infected dentine is sticky and soft to a sharp dental explorer whereas caries-affected dentine is a little more tacky ('scratchy and sticky') in nature and blends to the hard, scratchy consistency of deeper sound dentine **(Banerjee and Watson, 2011).**

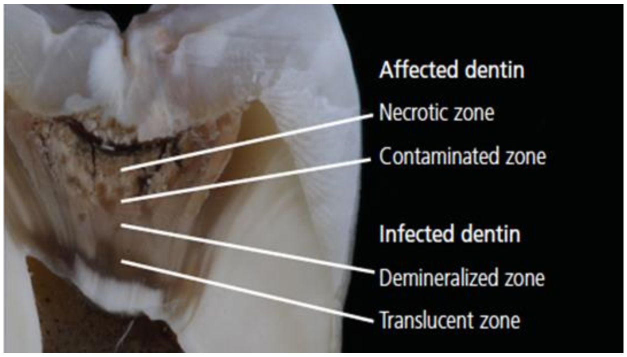

Figure (2) Zones of carious dentin

4.2.2. Clinical presentation of carious dentine (Banerjee and Watson , 2015)

4.2.2.1. Soft dentine : Soft dentine deforms when a dental explorer (sharp probe) is pressed onto it, with a latent "stickiness". It can be easily scooped up (e.g. with a sharp hand excavator) with little force being applied. This dentine consistency is often described as caries-infected dentine and can appear moist in consistency.

4.2.2.2. Leathery dentine: Leathery dentine does not deform when an instrument is pressed onto it. Without much force, it can still easily lifted – a latent "tackiness" can be elicited. There may be little difference between leathery and firm dentine with leathery being a transition on the spectrum between soft and firm dentine. This dentine consistency is often described as caries-affected dentine.

4.2.2.3. Firm dentine: Firm dentine is physically resistant to hand excavation requiring some pressure to be exerted through an instrument to lift it.

4.2.2.4. Hard dentine: A pushing force needs to be used with a dental explorer instrument to engage the dentine and only a sharp cutting edge or a bur will lift it.

A scratchy sound or 'cri dentinaire' can be heard when a straight probe is taken across the dentine. This consistency classically signifies sound dentine.

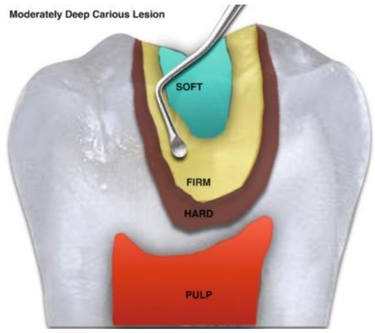

Figure (3) Clinical presentation of carious dentine

4.2.3. methods of caries removal:

4.2.3.1. nonselective removal of carious tissue: which consists of the removal of all softened dentin, not only from the surrounding walls but also from the cavity bottom, is the technique most used and preferred by dental surgeons **(Schwendicke *et al*., 2013; Casagrande *et al*., 2017)**. It is hypothesized that this technique completely eliminates bacteria, but it is has been reported that 25–50% of bacteria persist after nonselective removal of carious tissue (**Casagrande *et al*., 2017**; **Bitello-Firmino *et al*., 2018)**. Moreover, in deep lesions, nonselective removal of carious tissue can lead to accidental pulpal exposure and/or postoperative symptoms.

4.2.3.2. Selective removal of carious tissue:

A-Selective Removal to Firm Dentine: leaves 'leathery' dentine pulpally; there is a feeling of resistance to a hand excavator whilst the cavity margins and peripheral dentine are left hard (scratchy) after excavation is complete. "Selective Removal to Firm Dentine" is the treatment of choice for both dentitions, in shallow or moderately deep cavitated dentine lesions (i.e. lesions radiographically extending less than the pulpal third or quarter of dentine). In deeper lesions, “Selective Removal to Firm Dentine” puts the pulp at risk of “physiological stress” or exposure, which is why other strategies should be considered in these cases.

B- Selective Removal to Soft Dentine: is recommended in deep cavitated lesions (i.e. extending into pulpal third or quarter of the dentine). Soft carious tissue is left over the pulp to avoid exposure and “stress” to the pulp, encouraging pulp health, whilst peripheral enamel and dentine are prepared to hard dentine, to allow an adhesive seal to be achieved by placement of a durable restoration. “Selective Removal to Soft Dentine” reduces the risk of pulp exposure in deep lesions significantly compared with “Non-Selective Removal to Hard Dentine” or “Selective Removal to Firm Dentine.

4.2.3.3. Stepwise caries removal:

Consists of the nonselective removal of carious tissue over two sessions. In the first session, all carious dentin is removed from the surrounding walls of the cavity, and then, only the most necrotic and contaminated dentin is removed from the pulp wall, with a temporary sealing (2–6 months) then applied. After this period, the cavity is reopened, remineralization is evaluated, the softened remaining carious tissue is completely removed, and the final restoration is performed. The purpose of this treatment is to reduce the risk of pulpal exposure by stimulating the deposition of tertiary dentine **(Maltz *et al*., 2012).**

5. 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 once cavitation begins, it becomes difficult to control plaque accumulation **(Cury and Tenuta, 2009)**. 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 **(Neel *et al*., 2016).**

This includes:

• Decreasing the frequency of intake of refined carbohydrates.

• Optimum plaque control.

• Optimum salivary flow.

• Conducting patient education **(Fairaq *et al*., 2019).**

5.1. Remineralizing Agents:

5.1.1. Casein Phosphopeptide-Amorphous CalciumPhosphate (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 **(Walsh, 2009).** 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 **(Frencken *et al*., 2012).**

5.1.2. 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 pasteand then CPP-ACP paste **(Jingarwar *et al*., 2014).**

5.1.3. 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 fluids **(Cury and Tenuta, 2009).**The products containing this formula has desensitization as their use and is available in varnish, toothpaste and root desensitizer form **(Pradeep and Rao, 2011).**

5.1.4. TiF4 technology:

Titanium ion readily hydrolyze H2O to expel proton (H+) and render the solution of low pH value **(Wahengbam *et al*., 2011).** 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) **(Jingarwar *et al*., 2014).**

5.1.5. 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 **(Kielbassa *et al*., 2009).** The RI/CR approach increases the initial quality of fissure sealing and is recommended f or the clinical control of occlusal caries **(Frencken *et al*., 2012).**

5.1.6. Tri calcium phosphate:

Chemical formula of TCP is Ca3(PO4)2 and exists in alpha and beta forms. It is relatively insoluble in aqueous oral environment **(Walsh, 2009)**. The organic coating prevents undesirable interactions with fluoride, but dissolves away when particles come in contact saliva **(Jingarwar *et al*., 2014).**

5.1.7. 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 ZnCO3 is equally effect **(Pepla *et al*., 2014).**

5.1.8. Enamelon:

Enamelon consists of unstabilized calcium and phosphate salts with sodium fluoride in toothpaste Technical **(Kielbassa *et al*., 2009).** issue with EnamelonTM is that phosphate and calcium are unstabilized, which allows combining of two ions into insoluble precipitates before they contact enamel or saliva **(Jingarwar *et al*., 2014).** 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 **(Sathe *et al*., 2014).**

6. Minimal Cavity designs:

Cavity preparation design and restorative material selection depend on occlusal load and wear factors **(Murdoch- Kinch CA and Mc Lean, 2004).** 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 **(Mount and Hume, 1997).** 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 **(Murdoch- Kinch CA and Mc Lean, 2004).**The new classification system is based on site and cavity size Table[1] **(Mount and Hume, 1997).**

Table (1) 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

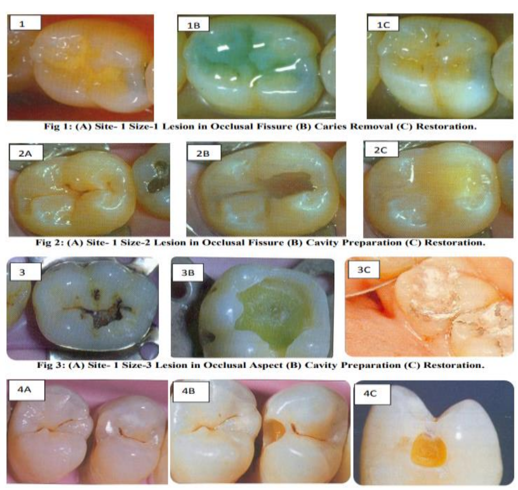

Figure (4): Caries classificationsystem based on lesion site and size (A) Site- 2 Size-1 Lesion in Proximal Aspect (B) Slot Cavity Preparation Occlusal View (C) Slot Cavity Preparation Proximal View.

6.1. Cavity design principles (Neena *et al.*, 2015):

1. Gaining access to the body of the lesion without being destructive.

2. Removal of tooth structure that is infected and incapable of regeneration.

3. Avoiding the exposure of dentine unaffected by the caries process.

4. Retaining and reinforcing sound, but undermined enamel.

5. Reducing perimeter of the restoration.

6. Keeping the margins of the restoration away from the gingiva.

7. Reducing occlusal stress on the final restoration.

6.2. Specific designs for approximal lesions:

I. Tunnel preparation.

II. Microchip cavity preparation.

III. Minibox cavity preparation.

IV. Full box cavity preparation.

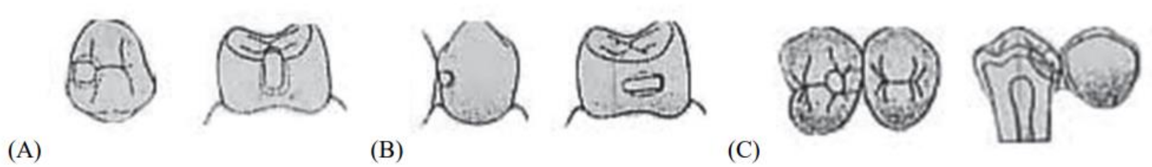

Figure (5) (A) showing Microchip and Minibox cavity design (B) Tunnel Preparation (C) Full box cavity.

6.2.1. Tunnel Preparation:

The tunnel preparation is performed by accessing the carious dentin from the occlusal surface, while preserving the marginal ridge. Tunnel preparations are technically difficult to do because of access and visibility and the small amount of tooth structure removed. Internal preparations preserve the marginal ridge and the proximal surface enamel **(Peters and McLean, 2001; Tyas *et al.*, 2000, Summitt, 2002).** A recent study showed that after three years, tunnel preparations had better results than did slot class II restorations. After five years, conventional amalgam class II restorations exhibited better survival rates than tunnel or slot preparations **(Tyas *et al.*, 2000).**

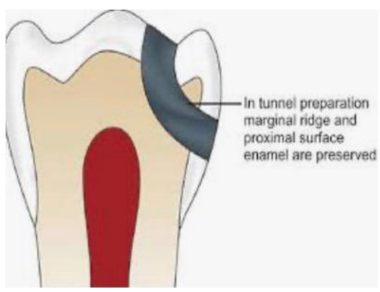

Figure (6)TunnelPreparation

6.2.2. Minibox cavity preparation:

Minibox or slot preparations involve the removal of the marginal ridge, but do not include the occlusal pits and fissures if caries removal in these areas is not necessary. These cavities may have either a box or a saucer shape and may be restored with resin-based composite or amalgam **(Peters and McLean, 2001; Tyas *et al.*, 2000; Summitt, 2002) .** Clinical studies of these conservative restorations have shown 70% survival at an average of seven years **(Tyas *et al.*, 2000).**

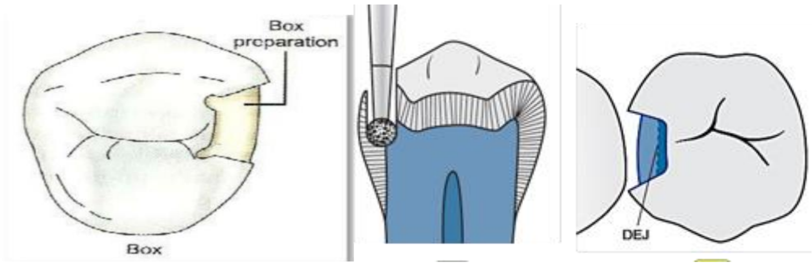

Figure (7) Mini Box preparation

7. Minimal invasive preparation techniques

Nowadays, the adhesive restorative materials in conjunction with increased knowledge on the pathology of caries and effective preventive methods allow for MI techniques. Atraumatic restorative and chemo-mechanical techniques have been developed as alternative methods for caries removal. The desire for preparation of small dimensions and microcavities has stimulated new approaches for cavity design and tooth cutting concepts, such as oscillating, kinetic, and hydrokinetic cavity preparation systems **(Petcu et al., 2016; Tyas *et al.*, 2000).**

7.1. Rotary – High / Low-Speed Bur

Though rotary bur being used universally, there are problems that need to be overcome. The rotating bur easily cuts through carious dentin to eventually open up healthy tubules deeper in the tissue and in conjunction with water stimulation of odontoblastic processes that will result in pain associated with cavity preparation using this technique **(Tyas *et al.*, 2000).**

a) Polymer burs

Polymer bur, a single-use self-limiting bur, was first described by Boston in 2003. **(Boston, 2003).** The development of selflimiting caries removal technique would be of greater clinical importance, as it is strictly restricted to the infected part of carious dentin, without extending into sound dentin. Hence, the possibility of pup exposure is infrequent even in deep carious lesions.The polymer burs have the potential to prepare cavities without the need for local anesthesia **(Allen *et al.*, 2005).**

Unlike the spiral cutting edge of conventional carbide burs, the polymer bur has shovel-like straight cutting edges and is made up of medically graded polyether ketone-ketone with a Knoop hardness value of 50 kg/mm2 which is greater than that of infected dentin (0 kg/mm2 -30kg/mm2) and lesser than that of healthy dentin (70 kg/mm2 - 90 kg/mm2)**(Allen *et al.*, 2005).** Accordingly, on encountering healthy dentin, the bur loses its cutting efficiency and the blades will abrade instead of abrading health/ affected dentin. These burs are described as “dentin safe” and “self-limiting burs”**(Boston DW, 2003).**

Figure (8) polymers burs

The bur blades are primarily designed to remove carious dentin by plowing, during which carious dentin is first locally compressed by the blades then the compressed wall of softened carious dentin is pushed along the sound dentin surface with the blades rupturing eventually at this surface level and the loosened fragments are carried to the surface**(Freedman, 2003; Hauman and Kuzmanovic, 2007).** Polymer bur is a more patient-friendly conservative approach in dentinal caries removal along with instilling a positive attitude of children towards dentistry.

There are two Polymer burs commercially available, SmartBurs II (SS White, Lakewood, NJ, USA) and Polybur-1 (Komet, Mediteam, Sweden). They are available in different sizes. SmartBurs II is available on 004, 006, 008, and Polybur-1 is available on 014, 018, 023. SmartBurs II was designed to be used in a micromotor handpiece at a speed of 500-800 rpm whereas Polybur-1 is recommended to be used at 2000-8000 rpm **(Carounanidy and Ranjani, 2012) .**

b) Fissurotomy burs:

They are used particularly for pit and fissure dental caries treatment. The head length of these burs is 2.5 mm, which allows the dental practitioners to remove dental tissues just below the Dentino Enamel Junction (DEJ) and no more. Hence, their use is confined to the enamel structure. The tapered shape of these burs permits the cutting tip to confront fewer dentinal tubules. The flowable composite is considered a suitable restorative material to fill this type of cavity preparation . The burs tips are tiny and more conservative than those of a ¼ round bur. The head length of fissurotomy original and fissurotomy micro NTF is 2.5 mm, whereas the head length of fissurotomy micro STF is 1.5 mm. The fissurotomy original and micro NTF burs can be used to remove caries conservatively and ultra-conservatively, respectively, from molar pits and fissures, while the fissurotomy micro STF can be used for deciduous teeth, permanent premolars and enameloplasty.

Fissurotomy burs have many advantages including the following:

Often time without local anesthesia, low heat generation and vibration, fast treatment procedures associated with using these burs, familiar instruments to dental practitioners that do not demand the incorporation of a new device and enhancement of patient comfort **(Rajnekar *et al*., 2021).**

Fissurotomy burs have a few disadvantages including Exorbitant price must be used in conjunction with proper restorative materials.

Figure (9) Fissurotomy bur

7.2. Atraumatic restorative technique

Atraumatic restorative treatment (ART) is an alternative treatment for dental caries. Since MI requires no anaesthesia or electricity it was originally developed for use in underdeveloped countries, in rural areas. The increased interest in this technique was manifested in developed countries, because of its "atraumatic" approach in relation to the stress and pain experienced by patients **(Boitor, 2013).**

The ART principles are:

1) Removal of carious tooth tissue using only hand instruments.

2) Restoration of the cavity with a high viscosity glass-ionomer, along with concurrent sealing of the adjacent pits and fissures.

Advantages of ART (Morrow *et al*., 2000):

1.Easily available inexpensive hand instruments are used rather than the expensive electrically driven dental equipment.

2.As it is almost a painless procedure the need for local anesthesia is eliminated or minimized.

3.ART involves the removal of only decalcified tooth tissues, which results in relatively small cavities and conserves sound tooth tissues as much as possible.

4.Sound tooth tissue need not be cut for retention of filling material.

5.The leaching of fluoride from glass ionomer probably remineralizes sterile demineralized dentin and prevents development of secondary caries.

6.The combined preventive and curative treatment can be done in one appointment.

Disadvantages of ART (Morrow *et al*., 2000):

1.ART restorations are not long lasting.

2.The average life is two years depending upon the rate of caries activity of the individual oral cavity.

3.Because of the low wear resistance and low strength of the existing glass ionomer materials their use is limited.

4.The continuous use of hand instruments over long period of time may result in hand fatigue.

Figure (10) Atraumatic restorative technique

7.3. Air Abrasion

Air abrasion, as an alternative technique of cutting hard dental tissues, is an ultraconservative method in the following situations:

a. Incipient caries of pits and fissures, which are difficult to diagnose and which, despite preventive measures, still count for 90% of newly appeared caries in children and adolescents **(Brunelle, 1989**). In this uncertain diagnosis **(Liebenberg, 1994).** the practitioner may either to treat the lesion or only to monitor it, with questionable benefits in time **(Sheiham, 1997)**. In this specific lesiona stage, air abrasion is the method of election, as bur preparation of pits and grooves would remove a greater quantity of healthy dental tissues as compared to air abrasion, which is more conservative **(Hegde and khatavkar, 2010).**

b. In case of dental abrasion, erosion, and abfraction, air abrasion removes, without cutting dental structures, the shiny surface layer which is inappropriate for good adhesion. Thus,rough surface results **(Gerbo et al., 1993, Brauchli ,2011)**.adequate for the adhesion of restorative materials **(Hannig and Femerling, 1998; Sengun et al.,2008).**

c. In case of marginal repair or restoration resurfacing, air abrasion removes a small quantity of dental tissue or restoration material, respectively, increasing restoration's life span and esthetics.

-advantages of air abrasion:

• It does not require dental anesthesia.

• It does not produce noise, vibrations, pressure, or heat.

• It removes only the decayed tissues with minimal loss of healthy tissues.

• It eliminates the risk of microfracture and microcrazing at the level of enamel margins.

• Dentinal tubules remain clogged after air abrasion therapy.

• It improves bond strength of restorative materials to enamel and dentin.

• The method is fast and simple—in the same dental appointment several incipient caries can be treated.

-disadvantages of Air abrasion :

• It is not used in deep cavities, due to the risk of opening the dental chamber.

• It is not recommended in subgingival caries and also for removal of amalgam restorations, due to releasing mercury aerosols.

• An efficient protection is required for dental practitioners (mask, glasses, gloves) and patients (glasses).

• The risks of abrasive powder inhalation, emphysema, gingival, or smooth oral tissue lesions which might occur to patients are prevented by the use of rubber dam.

• The flow of abrasive particles and air pressure are controlled by the device; the narrow diameter of the ejecting needle, the position, and distance from where the abrasive flow is projected, all of these thus avoiding any possible accident.

• High-speed suction is required to remove the abrasive powder that accumulates during treatment.

• Patients with pathologies such as severe dust allergy, asthma, and chronic pulmonary disease should avoid air abrasion procedures **(Sambashiva *et al.*, 2011; Arora *et al.*,2012; Rainey, 2002).**

Figure (11) caries removal using air abrasio

7.4. Air Polishing

Air polishing produces a high-pressure jet which contains sodium bicarbonate; it is projected on the surface of teeth, producing a cutting/grinding effect. Air polishing is not a very selective procedure when grinding tooth structure and it can affect the health of dentin and cementum. Used for removing stains and in the final preparation of the tooth to remove the remaining altered dentin. Air polishing is accomplished by the propulsion of abrasive particles through a mixture of compressed air and water, with a handpiece, thus removing the stain and/or dental plaque. The abrasion rate is influenced by speed, pressure, time of abrasion, shape and hardness of the particles used **(Madan and Gandhi, 2010).**

Figure (12) Air Polishing

7.5. The Ultrasonic Instrumentation

High frequency ultrasonic vibrations have been recommended since the 1950s to remove proximal carious lesions in both anterior and posterior teeth, with the aim of achieving a more conservative cavity preparation. This technique does not physically excise the dentine, but abrades it using a diamond-coated tip oscillating at a frequency of about 6.5 kHz ranging to a maximum frequency of 20-40 kHz.

Recently, sono-abrasion has been developed as a modification of the original ultrasonic method. Sono-abrasion is a technique for the selective preparation of enamel and dentine offering excellent efficacy, quality and safety **(Decup and Lesfargue, 2014)**. This technique utilizes high frequency, sonic, airscalers with modified abrasive tips which describe an elliptical motion with a transverse distance of 0.08- 0.15 mm and a longitudinal movement ranges from 0.055 to 0.135 mm. These tips are diamond coated on the cutting side, cooled using water at a flow rate of 20-30 ml/min and operated by 305 bar air pressure for cavity finishing. Other tips shaped length ways halved torpedo, small hemisphere and large hemisphere are currently available.

Using the different shapes of the tips helps in preparing predetermined cavity outlines, and also works well in removing softened, carious dentine.

Advantages- The ultrasonic procedure has the advantage of minimising or eliminating noise, vibration, heat and pressure. The use of the ultrasonic technique can be helpful to modify the approximal preparation procedure in order to protect adjacent teeth against iatrogenic damage caused by the use of dental burs.

Disadvantages- of this system are the relatively low abrasion and high hub excursion (0.4 mm) of the tips and the weakening of enamel rods with the associating cracks adjacent to the prepared sites.

Systems Available- A new ultrasonic system now available on the market uses Chemical Vapour Deposition (CVD, São José dos Campos, Brazil) diamond tips which have better resistance and durability. This is because the diamond deposition occurs through a chemical bond providing the dentist with better visibility of the working area as its shank has an ideal angulation. Moreover, this system provides cavity preparation with better cleansing procedure and tissue conditioning.

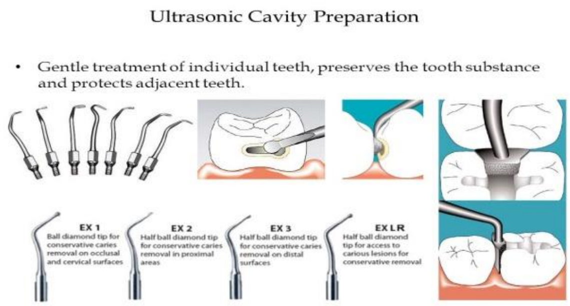

Figure (13) The Ultrasonic Instrumentation

7.6. Chemo-Mechanical Caries Removal

This is a method of caries removal based on dissolution. Instead of drilling, this method uses a chemical agent assisted by an atraumatic mechanical force to remove soft carious structure. The chemical-mechanical removal of caries has been studied and the success of this therapy is based on the selective removal of the lesion, which reduces the amount of bacteria inside the cavity without removing the tissue susceptible to remineralization. This method is also able to minimize the unpleasant perception by the patient during the manipulation of the lesion by the conventional method, and, therefore, it has been widely accepted among phobic patients, children and special needs patients **(Chowdhry et al,2015).**

7.6.1. CaridexTM

studying the effects of 5% sodium hypochlorite, found that it was capable of promote the dissolution of decayed dentin **(Beeley *et al*.,2000)**. Later, however, this material was noted to be too unstable and corrosive for use in healthy tissue **(Goldman and Kronman, 1976)**. In an attempt to minimize these problems, a solution known as Sorensen that contained glycine, sodium chloride and sodium hydroxide was incorporated into 5% sodium hypochlorite and the resulting product, 0.05% N-monochloroglycine (NMG) also called GK101, was shown to be effective in removing decayed tissue. which became known as CaridexTM. However, due to disadvantages such as high cost, short clinical validity and the need for large volumes of material (making it impractical), this product is no longer found in the market.

7.6.2. CarisolvTM

It consisted of two tubes, one containing a gel of lysine, glycine, leucine, acid glutamic, sodium chloride, erythrosine and carboxymethylcellulose, and one containing 0.5% sodium hypochlorite **(Ericson *et al*.,1999)**. Later, CarisolvTM was commercially available in a single syringe, the softening effect on the carious tissue is the result of several reactions that act in concert to disrupt the fiber structure of collagen, CarisolvTM requires specific instruments, increasing the cost of the product **(Martins *et al*., 2009).**

7.6.3. Papacárie Duo R

Faced with the need for a more accessible product for the application of the chemical- mechanical method to remove caries, a new formula was developed in 2003 in Brazil and improved over the years. Papacárie Duo R is a successor to the CaridexTM and CarisolvTM system and its composition is basically a proteolytic enzyme that interacts with the partially degraded collagen of the necrotic carious tissue. Papacárie Duo R (Formula & Ação, São Paulo, SP, Brazil) is composed of papain, chloramine, toluidine blue, salts and thickening vehicle, which provides anti-inflammatory, bactericidal and bacteriostatic actions to the product. The main component, papain, comes from the latex of papaya leaves and fruits **(Bussadori *et al*., 2005).**

Papacárie Duo R does not require specific instruments for its use, thus being a practical, accessible and low-cost product that has been shown to be effective for caries removal with less painful stimuli and superior patient acceptance when compared to conventional treatments **(Cardoso *et al*.,2020).**

7.6.4. Brix3000 and Carie-careTM (Cardoso *et al*.,2020).

Brix3000 presents a higher papain concentration (3000 U/mg) and bioencapsulation by buffer emulsion (EBE) technology **(Torresi and Besereni, 2017; Ismail and Al Haidar,2019).** These characteristics allows to remove the compromised tissue more easily without causing damage or pulp cytotoxicity. In addition Brix3000 presents anti-inflammatory properties which may favor the recovery of pulp tissue **(Santos *et al.*,2020).** Carie-careTM is composed of papain and clove oil, it acts paralyzing the activity of localized caries and preventing the advancement of lesions to the dental pulp. In addition, the clove oil has analgesic, antiseptic and antiinflammatory properties, which acts preventing the dental pulp damage **(Ramamoorthi S*et al*., 2013).**

The advantages of this method are its speed, ease of execution and patient comfort, as it does not generate anxiety and pain. These materials can be an excellent alternative in the context of the COVID-19 pandemics, as they reduce aerosols.

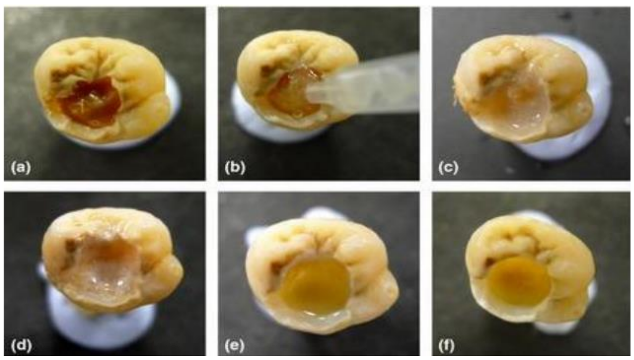

Figure (14) Chemo-Mechanical Caries Removal

7.7. Lasers

Lasers are devices that produce beams of coherent and very high-intensity light. A large number of current and potential uses of lasers in dentistry have been identified that involve the treatment of soft tissues and modification of hard tooth structures **(Tyas *et al.*,2000).** 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.

Figure (15) Lasers caries removal

7.8. Ozone

During the last few years, reversal of caries using Ozone has also been suggested based on the fact that the remineralised tooth tissues are known to be more resistant to decay than sound tooth structure. Ozone therapy causes remineralisation of incipient pit and fissure caries as well as incipient root caries. Its usefulness in open lesions has also being demonstrated **(Arigbede *et al.*,2010).** Ozone readily penetrates through decayed tissue, eliminating the ecological niche of cariogenic microorganisms as well as priming the carious tissue for remineralisation. As ozone readily penetrates through decayed tissue, eliminating any bacteria, fungi and viral contamination, it would be expected that this 'clean' lesion would remineralise. The remineralisation process will then take place with the aid of a topically applied remineralising solution and the recommended patient's maintenance kit. Ozone has the effect, through its powerful oxidizing properties, of not only removing the protein protection and being bactericidal, but also oxidising the biomolecules that allow the niche to survive and expand. For example, the acid Pyruvate, one of the strongest naturally occurring acids manufactured by bacteria, and implicated in the progression of caries, is oxidised by ozone to acetate acid and carbon dioxide. Acetate acid is less acidic than pyruvate, and this de-carboxylation reaction leads to mineral uptake due to the more alkaline conditions in a carious lesion. The lesion will become populated with normal mouth commensals which do not produce acid, after ozone therapy.

This simple fast novel approach avoids the need for local anaesthesia, drilling and filling, however, its application is restricted to treat the superficial enamel and root caries.Heal Ozone was the first dedicated dental ozone unit. With the advent of new units with different delivery systems, dental treatment with ozone has become fast, predictable, and has now expanded into every facet of dental care. It must be stated that ozone is a substance that needs to be carefully controlled, as high concentrations at ground level have been known to cause respiratory distress.

Systems and Clinical Procedure- There are various dental ozone devices available (for example, the Heal Ozone and DentOzone unit.) Both these dental ozone units deliver ozone gas at pre-set concentration. At the end of a 30 to 60s ozone exposure, a mineral wash is placed over the treated area to kick-start the remineralisation process. Once ozone treatment has been completed as necessary, the patient is sent away with an ‘at-home care kit’.

One important factor that needs to be remembered is that during the initial stages, the treated areas of decay will be relatively soft and will not support any restoration. Therefore, if a restoration is planned after ozone treatment, it should be planned at the review appointment at 2-3 months after the initial ozone treatment by which time, the research data suggests, the remineralisation process will be well advanced, the lesion static and reversed, and the tissue hard enough to support a

transitional technology.

Figure (16) Ozone technology

7.9. Antibacterial Photodynamic Therapy (aPDT)

Antibacterial Photodynamic Therapy (aPDT) represents a perfect option for treating caries lesions in the deep dentin. The implementation of (aPDT) deactivates the carious lesions and decreases the level of the cariogenic bacteria in the dentin tissue and simultaneously lowers the possibility of iatrogenic pulp exposure, thus prohibiting the advancement of the bacterial activity, thereby promoting dental tissue mend. The outer layer and soft dentin tissues are excavated, thus preserving tooth structures. Generally, aPDT can help treat dental caries in a way that is not very invasive **(Reis *et al*.,2019, Santin *et al.*,2014).**

Advantages The use of antibacterial photodynamic therapy in minimally invasive cavity preparations offers the following advantages:

It is a painless, quick, easy and affordable procedure. It eradicates the micro organisms that are present in dentin tissue and preserves the adjacent tissues, no bacterial resistance will develop to this treatment and the PS is precisely designed to destroy microorganisms without affecting human cells **(Alves *et al.*,2019; de Melo *et al.*, 2013).**

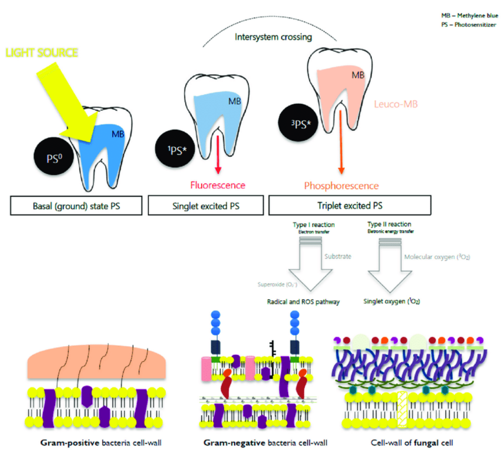

Figure (17) Antibacterial Photodynamic Therapy (aPDT)

7.10. Silver Diamine Fluoride

Silver Diamine Fluoride (SDF) is a liquid interim caries-arresting medicament Biannual application of 38% SDF has an 84.8% success rate in arresting caries **(Llodra, *et al.*,2005).** and its use to arrest cavitated lesions in primary teeth SDF is inexpensive **(Crystal and Niederman ,2016),** can be applied without the removal of infected soft dentin **(Chu *et al.*,2002).** and provides an effective treatment alternative in patients with behavioral issues and severe dental anxiety, medically fragile patients including those undergoing or having undergone radiation therapy and young pre-cooperative patients who need treatment under general anesthesia **(Antonioni *et al*.,2019)**.

SDF contains silver and fluoride ions dissolved in an ammonia solution, which aids in the stabilization of silver fluoride. Thirty-eight% of SDF contains 44,800 ppm of fluoride ion, and although its exact mechanism of action is unknown, it is found to be effective in inhibiting the demineralization of carious lesions, facilitating remineralization and preventing the degradation of the dentinal organic matrix **(Yu *et al*.,2018)**. It can increase the mineral density of enamel lesions and microhardness of dentinal carious lesions **(Liu *et al*.,2012).** Treatment with SDF has been shown to precipitate an insoluble surface layer of silver chloride, which acts as a protective layer and inhibits further demineralization by limiting the loss of calcium and phosphate ions

One of the major advantages of SDF is its ease of application and, as such, pre-cooperative patients, patients needing advanced behavior management techniques and those with limited access to dental care were deemed as good candidates for SDF treatment **(Nelson *et al.*,2016).** Clinically, SDF application causes a permanent black discoloration of the carious enamel and dentin and concerns about parental acceptance of the treatment due to the staining was reported to be the most common perceived barrier to its use amongst healthcare professionals **(Chhokar, *et al*.,2017; Nelson *et al.*,2016).**

7.11. Resin-Based Fissure Sealants

Methacrylate-based resin sealants have been used to prevent dental caries since the 1960s. Dental sealants form a mechanical barrier between the enamel and the pathogenic biofilm and have been shown to be more effective in preventing dental caries in permanent molars relative to unsealed teeth **(Wright *et al.*,2016).**

More recently, due to the paradigm shift in dentistry towards less invasive procedures, it has been recommended that the use of sealants be extended to include teeth with carious pits and fissures for the arrest of dental decay **(Crall, and Donly, 2015; Splieth *et al*.,2010).**

Since sealants can form a hermetic seal, the occlusal carious lesion can be isolated from the oral environment, depriving the biofilm of nutrient supply, resulting not only in fewer bacteria but also a less virulent and less diverse biofilm. The biofilm activity is consequently reduced or altered, slowing caries progression **(Fontana, and Innes, 2018).**

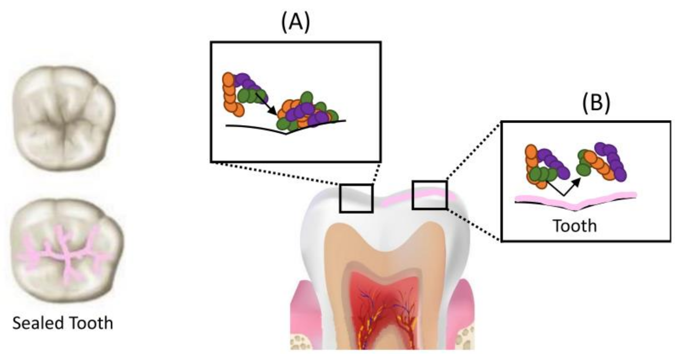

Figure (18) Resin-Based Fissure Sealants

8. Ultraconservative preparation (White Spot Lesion treatment)

The initial carious lesions are the so-called "white spot" lesions, which implies that there is a subsurface area with most of the mineral loss beneath a relatively intact enamel surface **(Toumba, 2005).**

While fluoride remains an important factor in the prevention and management of dental caries, widespread exposure from different sources has increased the risk of fluorosis in communities, regardless of whether or not the community uses a fluoridated water supply **(IIDA and KUMAR, 2009).** Unlike early caries lesions, dental fluorosis is a developmental disturbance caused by exposure to high concentrations of fluoride during tooth development, which leads to enamel with lower mineral content and increased porosity. As light refraction through enamel is directly related to the level of mineralization **(YETKINER *et al*.,2014).**

Compared to sound enamel, WSLs are clinically white and opaque, often observed on the labial surface of anterior teeth. In posterior teeth WSLs develop in the interproximal contact area as incipient class II lesions. Hydroxyapatite in sound enamel has a refractive index (RI) of 1.62. When a WSL is hydrated with saliva, the RI of saliva within the enamel porosities is 1.33. This discrepancy in RI between saliva and hydroxyapatite affects light scattering and makes the WSL look slightly opaque . When teeth are dried, saliva is replaced with air (RI = 1.0) within the WSL porosities. The difference in RI between air and hydroxyapatite is wider than that between saliva and hydroxyapatite, making the WSL more evident in dehydrated teeth.

Figure (19) White Spot Lesion

8.1. Tooth Whitening:

If a white spot lesion is an esthetic concern, tooth whitening should be considered in an attempt to blend the lesion in with the natural dentition. Tooth whitening involves diffusion of the whitening material into the enamel and dentin to interact with stain molecules. It also creates micromorphologic alterations on the tooth surface that affect its optical properties **(KWON and WERTZ, 2015).**

When properly monitored by a dental professional, tooth whitening is safe and effective in improving the appearance and color of teeth **(MONCADA *et al.*,2013).** Whitening will lighten the tooth color so that the white spot lesion naturally blends**.** Upon completion of the whitening process, patients can decide if further treatment, such as minimally invasive restorative procedures, is needed to meet their esthetic expectations.

Figure (20) Tooth Whitening

8.2. Enamel Microabrasion

It is indicated for intrinsic discoloration or texture alteration due to enamel hypoplasia, amelogenesis imperfecta or fluorosis **(SUNDFEL *et al*.,2007).**

Microabrasion is used for superficial defects, but is contraindicated in lesions with dentin involvement and deeper opaque stains associated with severe hypoplasia, which may require a restorative approach **(RESTON *et al*.,2011).**

It involves a combination of erosion and abrasion of the superficial enamel by a low concentration of hydrochloric acid, in conjunction with mechanical rubbing of abrasive silicon carbide particles in a water-soluble mixture **(CROLL and HELPIN,2000)**. When overall tooth color change is desired, microabrasion can be preceded or followed by tooth whitening to improve the overall esthetic outcome. Proper isolation with a rubber dam is necessary during microabrasion procedures to ensure patient safety. Furthermore, periodic evaluation of the enamel thickness labio-lingually with a mouth mirror is helpful in assessing the amount of enamel removed during the procedure. Upon completion of microabrasion, fluoridated prophylaxis paste should be applied to aid re-mineralization of the treated surface**.**

Enamel microabrasion is not indicated if the patient presents deficient lip sealing, as the teeth are always exposed to air and dehydrate more easily, thus a moistened film is not formed under the enamel. With this condition, the stained appearance of the tooth is more evident, and it may characterize the failure of the microabrasion. Therefore, these patients are encouraged to first seek orthodontic treatment and/or speech therapy **(SUNDFELD *et al*.,2014).**

The most important factors contributing the success of enamel microabrasion are the location and depth of the enamel stain or defect **(HEYMANN *et al.*,2014)** The alteration must be restricted to enamel tissue, without involvement of the dentin **(SUNDFELD *et al*.,2007).**

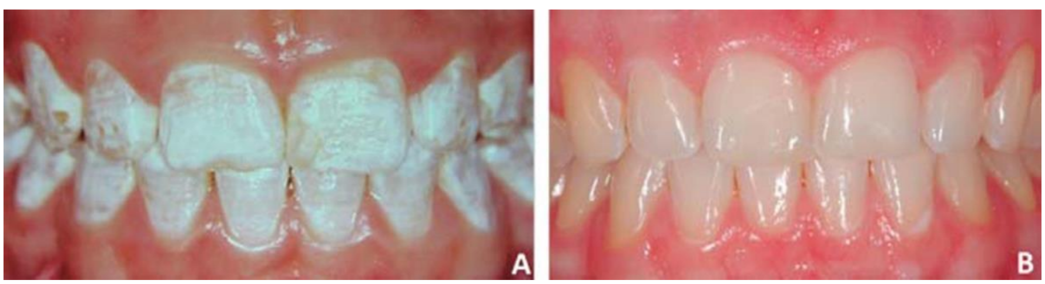

Figure (21) Enamel Microabrasion

8.3. Macroabraion

An alternative technique for the removal of localized, superficial white spots (not subject to conservative, remineralization therapy)and other surface stains or defects is called *macroabrasion*. Macroabrasion simply uses a 12-luted composite finishing bur or grit finishing diamond in a high-speed handpiece to remove the defect. Care must be taken to use light,intermittent pressure and to monitor the removal of tooth structure carefully to avoid irreversible damage to the tooth. Comparable results can be achieved with microabrasion and macroabrasion. Both treatments have advantages as well as disadvantages.

High-speed instrumentation used in macroabrasion is technique sensitive and can have catastrophic results if the clinician fails to use extreme caution.Macroabrasion is considerably faster and does not require the use of a rubber dam or special instrumentation **(HEYMANN *et al.*,2014).**

8.4. Resin infiltration of enamel white spot lesions

A technique to stop the progression of initial caries without the use of drilling has been proposed: the inhibition of caries by resin infiltration, that is, stopping the active carious process at its site without any invasive procedure **(KUGEL *et al*.,2009).**

The ability of replacing air in the demineralized enamel of WSLs with a material with an RI similar to that of hydroxyapatite, such as a methacrylate resin, has been shown to mask the WSL by preventing light from scattering inside the WSL **(Denis *et al.*,2013).**

In addition, filling the porosities with an adhesive resin reinforces the unsupported enamel crystallites in the body of the WSL.1 This reinforced enamel becomes mechanically stronger and more resistant to acid dissolution**.(Kielbassa *et el.*,2009; Paris and Meyer ,2010).** Both enamel structural reinforcement and cariostatic properties have been accomplished by infiltrating enamel WSLs using 15% HCl etching to make the mineralized surface layer more porous, followed by a drying step with ethanol to remove excess water, and application of a low-viscosity light-cured resin (tetraethylene glycol dimethacrylate [TEGDMA]

(Meyer and Paris, 2008, 2009).Studies have confirmed the effectiveness of the technique clinically and in vitro, not only as an esthetic treatment but also as microinvasive cariostatic procedure**.(Senestraro *et al.*,2013).**This resin infiltration technique has also been shown to be more effective than fluoride or amorphous calcium phosphate in improving the esthetic appearance of WSLs **(Yuan *et al*.,2014).**

Table (2) Composition of materials used in Resin infiltration

Commercial name (manufacturer)	Composition	Instructions for use
Icon-Etch (DMG)	15% hydrochloric acid, water, pyrogenic silica, surfactant, pigments	• Apply the gel and leave it for 2 min • Remove excess material with a cotton roll • Rinse with water for 30 s • Dry with oil-free and water-free air
Icon-Dry (DMG)	Ethanol	• Apply an ample amount of material and let it set for 30 s • Dry with oil-free and water-free air • When wetted with Icon-Dry, the whitish-opaque coloration on the etched enamel should diminish. If this is not the case repeat the etching step once or twice for 2 min each, and rinse and dry the teeth again as above
Icon-Infiltrant (DMG)	TEGDMA-based resin, initiators and stabilizers	• Apply an ample amount of Icon-Infiltrant onto the etched surface • Let Icon-Infiltrant set for 3 min • Remove excess material with a cotton roll and dental floss • Light-cure Icon-Infiltrant for 40 s • Screw a new Smooth Surface-Tip onto the Icon-Infiltrant syringe, repeat the application and let set for 1 min • Remove excess material with a cotton roll and dental floss, and light-cure for a minimum of 40 s
Filtek Supreme Ultra flowable Restorative (3M Oral Care)	TEGDMA, BisGMA, silane-treated ceramic, silane-treated silica, ytterbium fluoride, diphenyliodonium hexafluorophosphate, reacted polycaprolactone polymer, substituted dimethacrylate	• An increment of 2 mm was applied and light-cured for 40 s

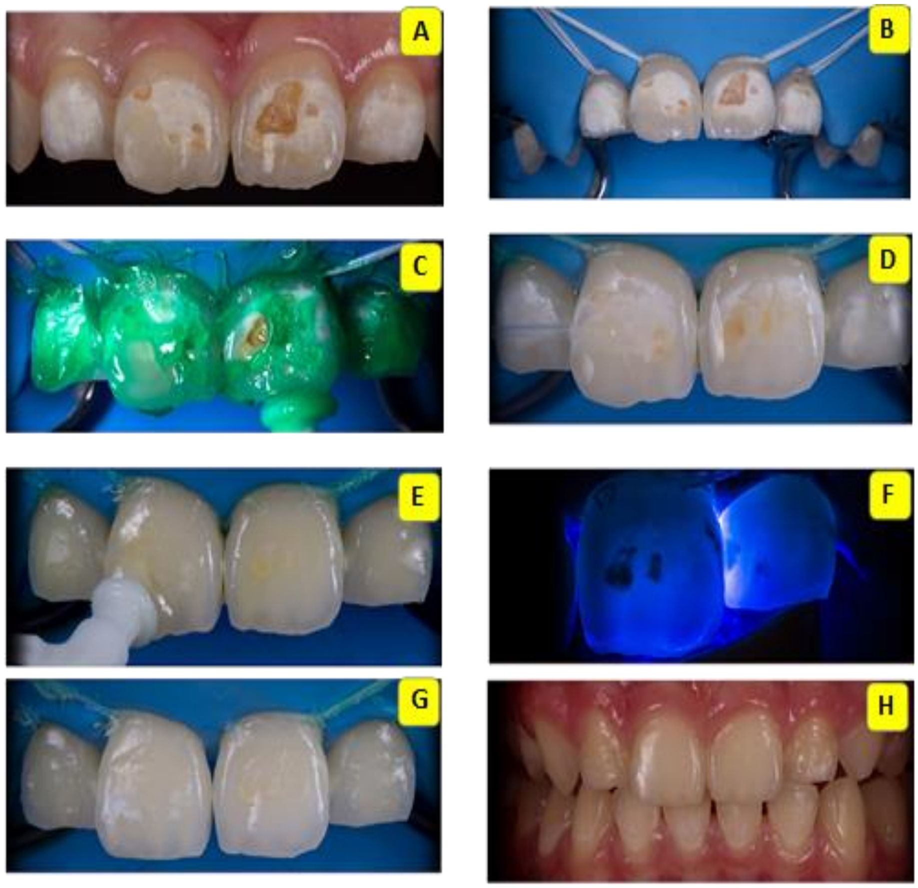

Figure (22) Clinical case treated with ICON system, DMG (A) Pre-op with hypomineralized lesions (B) Rubber dam isolation (C) Application of hydrochloric acid (ICON-etch) (D) Visual inspection after 30 second application of ethanol (ICON-Dry) (E) Application of the infiltration resin (ICON infiltrant) (F) Light curing of each tooth for 40 seconds (G) Final view of infiltrated lesions (H) View of teeth at two-week recall.(Guerra *et al.*, 2015)

Chapter two

CONCLUSION

CONCLUSION

MI may assist in reducing widespread patient dental anxieties, which are usually caused by conventional, highly invasive dental procedures. This evolution of minimum intervention in the history of dentistry have taken the dental professionals to a point where the patients can be treated quickly, easily and comfortably. It is apparent that it is time for a change in operative dentistry. It is not possible to really imitate natural tooth structure on a long term basis, so it is best that it be retained as far as possible. Therapeutic methods for the control of the disease are available, and these should be the first line of defense. In the presence of early carious lesions, there is no justification for removal of tooth structure simply to provide a theoretic resistance to further carious attack or to develop mechanical retention for restorative materials.

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