



Research Article

MINIMAL INVASIVE DENTISTRY

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ABSTRACT

**Objective:** Minimally Invasive Dentistry (MID) emphasizes conservative caries management strategies resulting in less destruction of tooth structure. The primary focus in the medical model of caries management is identifying and eliminating the causative factors for caries, along with repairing damage caused by caries. This is a departure from the traditional surgical model because the disease is viewed as an infection rather than as a lesion and its treatment objective is to reduce or eliminate pathogens. The medical model synthesizes knowledge of the disease process into a simple conceptual model using new technologies. **Overview:** This section should include a brief summary of the findings of the review. **Conclusions:** The dentist role in MID is recognizing, intercepting and prevention of demineralized sites. Furthermore, assessing the caries risk and maintaining a state of oral health followed by monitoring over extended period of time. Thus, with the philosophy of extension for prevention would lead to extension for ruining teeth. With old challenges at hand to which applying minimally invasive techniques leads to maximum preservation with minimal removal of tooth structure. Technological innovations in materials and techniques gives better results and higher patient acceptance and an easier practice.

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INTRODUCTION

The aim of MID is to halt the disease first and then to restore the lost tooth structure and to keep teeth healthy and functional for life. A most important element is achieved through implementing the important strategies for keeping teeth free from carious lesions. These strategies are considered to be:

1. Early caries detection and risk assessment
2. Remineralization of demineralized enamel and dentin
3. Optimal caries preventive measures
4. Minimally invasive operative interventions
5. Repair rather than replacement of the restorations.<sup>1</sup>

The four core principles of MID can be summarized as follows:

1. **Recognition-** To identify and assess any potential caries risk factors early, through lifestyle analysis, saliva testing and using plaque diagnostic tests.
2. **Reduction-** To eliminate or minimize caries risk factors through altered fluid balance reducing the intake of dietary cariogenic foods addressing lifestyle habits.
3. **Regeneration-** To arrest and reverse incipient lesions using appropriate topical agents including fluorides and Casein Phosphopeptides-Amorphous Calcium phosphate (CPP-ACP).

4. **Repair-** When cavitation is present and surgical intervention is required. Bioactive materials are used to restore the tooth and promote internal healing of the dentine particularly in cases of deep dentine caries where the risk of iatrogenic pulpal injury is high.<sup>2,3</sup>

An accurate diagnosis of the disease is mandatory.

Early Caries Detection

In order to conserve tooth structure and perform minimally invasive dentistry, carious lesions must be detected at the earliest possible time.

Various Methods of Diagnosis of Dental Caries

Visual-tactile method

Conventional methods

1. Tactile examination
2. Visual examination

Advances in visual method

Illumination

1. Ultrasonic illumination
2. Ultrasonic imaging
3. Fiber optic transillumination (FOTI)
4. Wavelength dependent FOTI
5. Digital imaging FOTI (DIFOTI)

- a. Dyes
- b. Endoscopy filtered fluorescence (EFF) method.

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**Radiographic methods**

**Conventional methods**

- a. Intraoral periapical x-rays (IOPA)
- b. Bitewing radiographs
- c. Panorex radiography
- d. Xeroradiography

**Recent advances in radiographic techniques**

- a. Digital imaging
- b. Computerized image analysis
- c. Subtraction radiography
- d. Tuned aperture computerized tomography
- e. Magnetic resonance micro imaging (MRMI)

**Electrical conductance measurement**

**Lasers**

- 1. Argon laser
- 2. Diode lasers
- 3. Qualitative laser fluorescence
- 4. Diagnodent (Quantitative laser fluorescence)
- 5. Optical coherence tomography
- 6. Polarization sensitive optical coherence tomography (PSOCT)
- 7. Frequency-domain laser-induced infrared photo thermal radiometry & modulated luminescence (PTR/LUM)
- 8. Dye enhanced laser fluorescence.

The accuracy of any diagnostic test is measured according to its "sensitivity" and "specificity".

**Caries Risk Assessment**

Caries-risk is "the probability of future caries disease development."

Disease development includes both primary disease (new carious lesions) and secondary disease (lesion progression or re-activated carious lesions).

The three levels of prevention linked to the steps are:-

**Primary prevention (step 1)-** to prevent the intra family transmission of mutans streptococci and delay the establishment in infants, toddlers, and young children.

**Secondary prevention (step 2)-** to prevent, arrest, or reverse the microbial shift before any clinical manifestations of the disease occur.

**Tertiary prevention (step 3)-** focuses on limiting (stopping) the progression of caries process by initiating remineralization therapy of the existing lesions.

**Clinical examination for evaluation of caries activity**

A few important points for estimating caries activity are presented in table below:

**Table 1** Estimation of Carious Activity

Clinical finding	High Activity	Low Activity
Number of Teeth	Less than normal	Normal
Reason for extraction	Caries / perio treatment	Orthodontic treatment
When were teeth extracted	Recently	In the past.
Number of fillings	More than normal	Less than normal
When were fillings made	Recently	Long time ago
frequency	> 2 fillings each year	Very rare,
Filling material	Composites	occasionally

Number of enamel lesions and cavities	More than expected Appeared recently.	Gold glass ionomers None old , neglected
Localization	Smooth or lingual surfaces,	Predilection sites only Fissures.
Surface colour	lower incisors	Hard, Dark
X-rays	Soft, light Progression into dentin	Regression, still within enamel. Acceptable
Oral hygiene	Poor Crowded teeth Deep Fissures	Spaced arches shallow fissures
Aggravating factors	Marginal overchanges Orthodontic appliances	Perfect adaptation Removable appliances

**Caries-Activity Tests for the Dental Office**

Caries activity tests should reflect the three overlapping circles presented by Keyes in 1962: (1) the bacterial challenge, (2) the sugar content of the diet, and (3) tooth and host resistance (susceptibility) with remineralization potential. In the light of these requirements following tests should be suggested.

- **Bacterial challenge-** Determination of mutans streptococci as an indicator of relative risk.
- **Diet-** determination of lactobacilli as an indicator of sugar content in the diet.
- **Remineralization potential** - salivary flow rate and buffer capacity as an indicator of potential biological repair.
- **Host susceptibility** - caries experience as an indicator of past activity.

**Remineralization**

After the disease control, the loss of minerals from tooth hard tissues needs to be addressed and the oral balance between de and remineralization processes on the tooth surface should be regained. This may be done through "external remineralization" (on the tooth surface) and in cavity walls through "internal remineralization".<sup>4</sup>

**Reduction in Cariogenic Bacteria**

**Casein Phosphopeptide Amorphous Calcium Phosphate Complexes (CPP-ACP)**

These complexes of tryptic casein phosphopeptides have the ability to stabilize calcium phosphate in solution as amorphous calcium phosphate (ACP).<sup>5,6</sup> This complex is a nano cluster of ACP with four multiphosphorylated peptides that prevent its growth to the critical size required for nucleation, phase transformation and precipitation. Remineralization of enamel is correlated with the degree of saturation for dicalcium phosphate dihydrate (CaHPO4.2 H2O).<sup>7</sup>

**Flowable composites**

Flowable composites were developed mainly for special handling properties for composite resins. Because of low viscosity the composites are indicated for preventive resin restoration as pit and fissure sealants and for repair of porcelain or gold alloy restoration.<sup>8</sup>

**Indirect Composite Resin**

Here, the restoration is made on a die rather than directly on the tooth, the restoration has superior adaptation, contour and proximal contact. A number of highly improved indirect resin restorative systems have been introduced with unusually good properties like wear resistance, esthetics, marginal adaptation, control over polymerization shrinkage.<sup>9</sup>

**Nanocomposites**

Nanotechnology may provide composite resins with a dramatically smaller filler particle size that can be dissolved in higher concentrations and polymerized into the resin system. The molecules in these materials can be designed to be compatible when coupled with a polymer and provide unique characteristics (i.e., physical, mechanical, optical).<sup>10,11</sup>

**Antimicrobial Composite**

Antimicrobial properties of composites may be accomplished by introducing agents such as silver or one or more antibiotics into the material. Microbes are subsequently killed on contact with the materials or through leaching of the antimicrobial agents into the body environment.<sup>12</sup> Silver and titanium particles were introduced into dental composites, respectively, to introduce antimicrobial properties and enhance the biocompatibility of the composites.<sup>13</sup>

Several reports have described the incorporation of a methacryloyloxy-dodecyl-pyridinium-bromide monomer in composite resins that showed no release of the incorporated monomer but still exhibited antibacterial properties.<sup>14</sup>

**Stimuli Responsive Composite**

Stimuli-responsive materials possess properties that may be considerably changed in a controlled fashion by external stimuli like changes of temperature, mechanical stress, pH, moisture, or electric or magnetic fields.

**Fiber Reinforced Composite**

Fiber reinforced composites have numerous industrial and aerospace applications because they are light, strong and non flammable.<sup>15,16</sup>

**Self-healing Composite**

One of the first self-repairing or self-healing synthetic materials was an epoxy system which contained resin filled microcapsules. If a crack occurs in the epoxy composite material, that microcapsules are destroyed near the crack and release the resin. The resin subsequently fills the crack and reacts with a Grubbs catalyst dispersed in the epoxy composite, resulting in a polymerization of the resin and a repair of the crack.<sup>17</sup>

**Atraumatic Restorative Treatment**

Ultraconservative treatment approaches are recommended for treating cavitated dentin lesions, which includes preservation of as much sound tooth structure as possible.<sup>18</sup> ART is an example of MID.<sup>19</sup>

**It consists of two components:** sealing of caries prone pits and fissures with a sealant, and use of a sealant in combination with restoring cavitated dentin lesions.<sup>20</sup> The main difference between the ART approach and other minimally invasive operative interventions is that ART uses hand instruments only in conjunction with adhesive materials or systems.

The instruments used in ART are; mouth mirror, a probe, tweezers, a dental hatchet, excavators, and an applier / carver. The consumable materials required are cotton wool rolls, cotton wool pellets, petroleum jelly, tumbler/cup, wooden wedges, and matrix bands or plastic strips.

In practice, Glass-Ionomer Cement (GIC) has become the most predominantly used material mainly because of its delayed

setting reaction that allows handling of the material before it is completely set.

**Step-by-Step procedure of ART for use with glass-ionomer restorative material is**

1. Isolation of the tooth.
2. Cleaning of the tooth to permit examination of the carious lesion.
3. Access to the caries is achieved using a hatchet or other suitable instrument.
4. Caries is removed with excavators.
5. The cavity and adjacent pits and fissures are further cleaned with a conditioner.
6. The glass-ionomer is mixed according to the manufacturer's instructions.
7. The cavity and pits and fissures are slightly overfilled with the mixed glass-ionomer.
8. A gloved index finger is placed over the top of the filling material and pressure is applied to press the filling material into the cavity and the pits and fissures.
9. The finger is removed carefully.
10. Excess filling material is removed.
11. The occlusion is checked and the filling adjusted.

The term "modified ART" refers to ART which is performed in places where traditional dental equipment is available instead of in field situations. This modification uses rotary equipment, the drill, to open the tooth cavity, followed by the normal ART procedure in cleaning and restoring the cavity. The use of rotary equipment makes the total procedure quicker and easier.

**The management of ART failures follows principles of restoration repair instead of replacement**

**Table 2** Principles of Restoration Repair

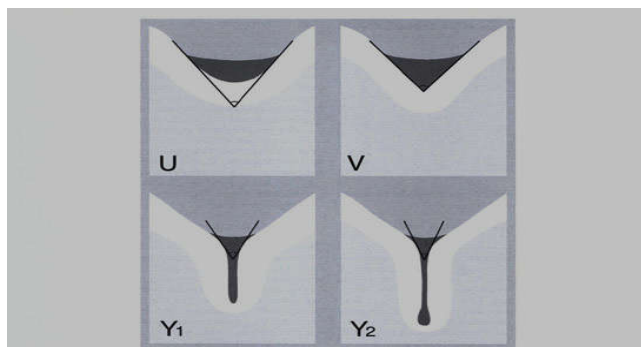
ART Failure	Management
Material wear >0.5mm	Cleaning of GIC surface, Application of dentine condition. Placement of new GIC Layer
Partial material loss	Cleaning fracture surface, Application of dentin conditioner Placement of new GIC layer
Complete material loss	Cleaning cavity surface, Application of dentin condition Placement of new GIC layer Caries removal using hand excavator Cleaning GIC surface
Caries related to restoration margin	Application of dentin conditioner Placement of new GIC layer

**Preventive Resin Restoration**

Preventive sealant restoration is indicated primarily on the occlusal surfaces of permanent molars and premolars when occlusal caries has involved a minimal amount of dentin, and may also be indicated for primary molars.<sup>21</sup> They are used especially when the cavity in a pit or fissure is small and discrete. Larger cavities should be restored with amalgam or a posterior composite while smaller cavities may be restored with sealant alone.<sup>22, 23</sup>

**Sealants**

Sealants form a physical barrier between ecological niches in fissures with high caries susceptibility and the oral environment. Sealants are effective in preventing fissure caries and their success is related to the accuracy of the technique used for placement.



**Figure 1** Diagrammatic depiction of the morphological types of fissure system u, u shaped, v, v shaped, Y1 and Y2, deep narrow fissure systems.

Deep and narrow fissures (Y1 and Y2) are associated with a higher local caries risk, and should be sealed independent of general caries risk.

**Indications for fissure sealing<sup>24</sup>**

Local risk	General risk	Sealing
Low (shallow fissure)	low	no
High (deep fissure)	low	yes
Low (shallow fissure)	high	yes
High (deep fissure)	high	yes

**Table 3** Indications for the use of each of the four types of sealant restoration

Type of sealant restoration	Indications
Type-1	Stained and decalcified fissure
Fissure sealant alone	No radiographic sign of dentine involvement
Type-2	Less than two other carious lesions in the mouth. Stained and decalcified fissure
Composite plus sealant	More than two other carious lesions in the mouth
Type-3	Enamel biopsy shows lesions confined to enamel Enamel biopsy indicated
Glass ionomer cement plus cement	Cavity in dentine with minimal lateral spread
Type-4	Margins not in occlusal contact Enamel biopsy indicated
Laminate restoration	Lesions in dentine with lateral spread along DEJ
Amalgam restoration	Cavity margins in occlusal contact Enamel biopsy indicated
	Large radiolucency in dentin.
	Significant lateral spread along DEJ
	Few fissures remaining surrounding cavity.

**The "Tunnel" Restoration**

A tunnel preparation is made for removal of proximal caries by making an access through occlusal surface while leaving the marginal ridge intact. This technique was first used in primary molars by Jinks in 1963 and later on Hunt and Knight used this procedure for restoration of small proximal lesions. Most clinical studies report, silver-cermet glass ionomer as the preferred restorative material. This technique has fallen from favor because of the difficulty of completely removing the

caries, subsequent frequent collapse of the marginal ridge, and occlusal wear of the restorative material. **Hasselrot (1998)** reported a 50% survival rate of tunnel restorations in permanent teeth over a 6-year period.<sup>25</sup>

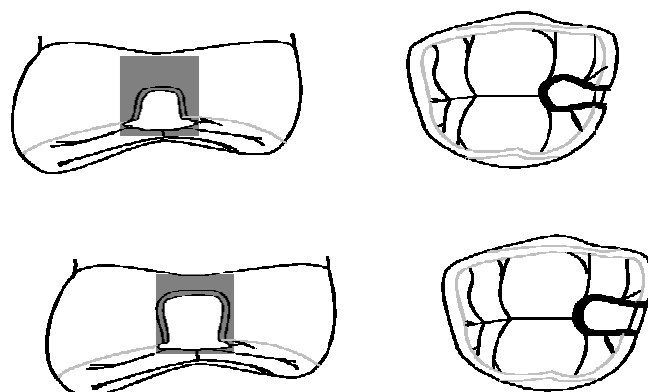


**Figure 2** The Tunnel Preparation

**The Proximal "Slot" Preparation**

In the "slot" preparation, access to the caries is gained through the marginal ridge, but preserving this structure wherever possible (Mount and Ngo 2000).

The occlusal fissure is maintained intact and when the cavity is restored with resin composite, the fissure can be protected with sealant. The cavity design allows better visualization of the caries than the tunnel design, allowing the removal of unsupported enamel. The cavity can be restored with glass ionomer and a bonded surface laminate of composite resin to resist heavy occlusal contact. Slot preparations to be restored with amalgam require mechanical retention. Grooves 0.5-mm wide must be cut into the facial and lingual walls of the proximal box using the full diameter of a No. 1/4 round bur. They are placed 0.25mm from the enamel-dentin junction in the opposing facial and lingual walls, and parallel to the external surface of the tooth. The grooves should be quite distinct, extending from the gingival floor of the slot preparation to the occlusal surface



**Figure 3** Proximal Slot Preparation

**Chemomechanical Caries Removal (CMCR)**

Chemo mechanical caries removal is a method for minimally-invasive, gentle dentine caries removal based on biological principles (Zinc *et al.*, 1988).<sup>26</sup> CMCR involves the use of a gel (carisolv) that is applied to the caries affected area of the dentine, which selectively reacts with denatured collagen, thereby making the carious dentine softer. Specially designed instruments are used to remove the softened diseased portion of the tooth, while healthy tissue is preserved. The treatment is quiet and effective. Many patients and dentists call it "a silent revolution".

### **It has the following advantages over traditional drilling**

1. Less perception of pain and more comfortable for patient.
2. Less fear and anxiety to method, leads to less discomfort to patients especially in children.
3. Removes only infected layer and leads to more tissue preservation.
4. No pulpal irritation.
5. Well suited to the treatment of deciduous teeth, dental phobic's and medically compromised patients.
6. Better removal of caries in uncooperative patients.
7. Useful in physically handicapped patients.
8. Useful in patients with T.B like infectious diseases (prevent droplet infection).

Papacarie and Carisolv can be successfully used in special health care needs (SHCN) patients and phobic adults in pediatric dentistry and public health sectors.<sup>27</sup>

### **Papacarie**

In Brazil 2003, Formula ea cao by Sao Paulo, first time introduced papain gel as Papacarie for chemomechanical caries removal agent (Bussadori *et al.*, 2005).<sup>28</sup> Papacarie is a product which is patented, registered and approved by ANVISA in Brazil. Its main components are papain, chloramine and toluidine blue.

### **Chloramine**

A compound comprised by chlorine and ammonia has bactericidal and disinfectant properties widely used as an irrigating solution of radicular canals in order to chemically soften the carious dentine.

### **Toluidine Blue**

Initially, the malachite green was used as coloring agent, however, after a few studies toluidine blue was found highly effective against *Streptococcus mutans* that fixes into the bacterial membrane.

### **Ozone Therapy**

Ozone therapy can be defined as a versatile bio-oxidative therapy in which oxygen/ozone is administered via gas or dissolved in water or oil base to obtain therapeutic benefits.<sup>29</sup> Ozone therapy has a wide range of applications in treating various diseases owing to its unique properties including antimicrobial, immune stimulant, analgesic, anti hypnotic, detoxicating, bioenergetic and biosynthetic actions. Currently ozone finds its application in the management of inflammatory bowel disorder, specifically ulcerative colitis, Crohn's disease and chronic bacterial diarrhea, cancer, stroke and AIDS.

### **Lasers**

The term LASER is an acronym for 'Light Amplification by the Stimulated Emission of Radiation'. The most commonly used lasers in dentistry at present are Carbon Dioxide (CO<sub>2</sub>), Erbium: Yttrium, Aluminum, Garnet (Er:YAG), Erbium, Chromium: Yttrium, Scandium, Gallium Garnet (Er, Cr:YSGG), Neodymium: YAG and diode.

## **CONCLUSIONS**

G.V.Black introduced the concept of "Extension for prevention" which has gradually evolved in modern times into "prevention of extension" resulting in conservation of tooth

structure in which lies the basis of MID, either surgically or by remineralization procedures. Thus MID is directed at detecting, diagnosing, intercepting and treating dental caries on the microscopic level. Minimally intervention philosophy relies on identifying and assessing the risk factors early, preventing disease by eliminating the risk factors, and restoring the health of the oral environment.

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