



Minimal Invasive Dentistry- A Comprehensive Review

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ABSTRACT

Minimal intervention dentistry initiates from the traditional surgical approach to the elimination of caries lesions seen as radiolucencies in the inner half of the enamel, at the dentin-enamel junction (DEJ), and slightly into dentin, with the removal of the minimal amount of healthy tooth structure. Dental adhesives and restorative materials; changes in remineralisation, caries process and prevalence have revolutionized the caries management from G.V. Black's "extension for prevention" to "minimally invasive." The benefit for patients from Minimal invasion lies in better oral health, minimizing the restoration cycle and reducing the patient dental anxieties. Minimal invasion includes clinical procedures such as assessment of caries risk, early detection of the disease followed by restoration of fissure caries with maximum retention.

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1. INTRODUCTION

Dental caries is defined as the microbial disease of the calcified tissues of teeth that are characterized by demineralization of the inorganic substance and destruction of organic substance of tooth. Minimum Invasion Dentistry (MI) is defined as a philosophy of professional care, concerned with the occurrence, early detection and earliest possible cure of disease on a micro level, followed by minimally invasive treatment in order to repair irreversible damages caused by such disease [1]. The benefit of Minimal invasion lies in better oral health through disease healing and not entirely on symptom relief. It also assists in reducing patient dental anxieties. Minimal invasion has the potential for the more conservative approach to caries treatment and it also offers patients less invasive, health orientated treatment options [2]. From the last few years, an increase in interest has been there in recreating the natural appearance of dentition. Preservation of the teeth with minimally invasive care is essential in today's dentistry. The current philosophy of Minimal Invasive Dentistry is to combine aesthetics, prevention, healing, adhesion, and restoration to remove a carious lesion in the least invasive manner [3]. Preservative dentistry is based on [1]:

- Accurate caries diagnosis
- Classification of the caries severity by using radiographs
- Assessment of individual caries risk (high, moderate or low)
- Arresting active lesions
- Monitoring of cavitated arrested lesions
- Placement of restorations in cavitated lesions with minimal cavity designs
- Assessing disease management outcomes (that is, change in various decayed/missing/filled indices) at predetermined time intervals.

1.1 Principles

- Remineralisation techniques for early lesions.
- Reduction in cariogenic bacteria, either chemically or mechanically, to reduce and prevent future carious lesions.
- When tooth restoration is necessary, using minimal restorative intervention of cavitated lesions.

- Caries controls as an infective communicable disease.
- Repairing defective restorations.

A recent Federation Dentaire International Commission project review of minimal intervention dentistry concluded that the most important principles include:

- A delay in surgical intervention as long as possible.
- Recognition of caries is an infection that should be controlled by altering the oral environment.
- Maximum preservation of tooth structure when required.

It is suggested that these principles be followed in the modern approach to dealing with the disease of caries.

2. CONCEPT OF MINIMAL INTERVENTION DENTISTRY

The concept of minimal intervention dentistry initiates from the traditional surgical approach to the elimination of caries lesions seen as radiolucencies in the inner half of the enamel, at the dentin-enamel junction (DEJ), and slightly into dentin, but with little or no evidence of cavitations [1].

Preservation of natural tooth structure should be the guiding factor for the smallest, as well as the largest cavity. Cavity preparation design and restorative material selection depend on occlusal load and wear factors. The life cycle of a restored tooth from natural eruption to extraction via multiple restorative procedures has been described for many years (Fig. 1).

In traditional treatment, patients with caries are assumed to be at high risk of both lesion progression and new lesion formation, and restorations are often planned at the first appointment. The main principles are to delay operative intervention for as long as possible, to assess progression through one-third or more of the thickness of dentin. Placement (and replacement) of restorations is avoided until the disease is controlled. Infection control is applied first, and then caries risks status and evidence of lesion remineralization can be monitored over

extended periods of time. Demineralizing acids producing bacteria should be controlled to arrest demineralization and to initiate remineralization. To determine if infection control is effective, outcomes must be measured, such as the change in the size of caries lesions and white spot lesions. In order to assess radiographic changes in proximal radiolucencies, a suitable classification is as follows:

- E1 = outer half of enamel
- E2 = inner half of enamel
- D1 = outer third of dentin
- D2 = middle third of dentin
- D3 = inner third of dentin

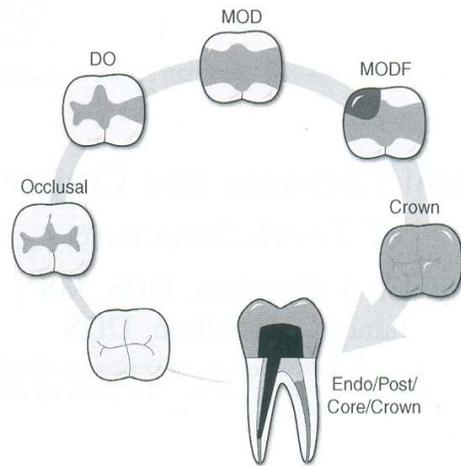


Fig. 1. Life cycle of restored tooth

A tooth or surface with no carious lesion is designated E0. MID aims to empower patients through information, skills, and motivation of their own oral health so they require minimum intervention from the dental profession. MID has the potential to apply a more conservative approach to caries treatment and simultaneously offer patients less invasive, health-oriented treatment options [2].

2.1 The Minimal Intervention Approach

It includes:

- 1) Caries Diagnosis
- 2) Early Restoration
- 3) Caries Control

2.1.1 Caries diagnosis

The word diagnosis originates in Greek and refers to the decision or distinction regarding the nature of the disease. Diagnosis is the art of

identifying a disease from its signs and symptoms [4]. The diagnosis forms the basis for making informed treatment decisions. The fundamental purpose of using caries diagnostic methods is to be able to identify, detect and classify the lesions to select most appropriate intervention for the patient.

It includes:

- A. CARIES RISK ASSESSMENT
- B. EARLY DETECTION OF CARIES

2.1.1.1 Caries risk assessment

Dental caries has a multifactorial etiology in which there is the interplay of three principal factors: the host (saliva and teeth), the microflora (plaque), and the substrate (diet), and a fourth factor: time [5]. Caries-risk assessments aid in the success of the treatment. Since caries is preventable, the diagnosis of caries as a lesion in a tooth is not sufficient for a treatment plan. For this, a proper 'medical' diagnosis is required based on certain components. Firstly, caries must be recorded on each surface as either initial lesions (reversible) or cavities (irreversible). Secondly, it should be assessed to estimate the severity of caries. Thirdly it assesses the future caries activity. Determination of caries-risk is important so as to access etiological factors of existing carious lesions, to modify preventive measures and to select an individual preventive programme to minimize the development of caries [6].

The caries-risk assessment tool (CAT) is used to assess the level of risk for caries (cavity) development in infants, children and adolescents based on a set of clinical, environmental and general health factors. The presence of a single risk indicator in any area of the "High Risk" category is sufficient to classify a child as being at "High Risk"; The presence of at least one "Moderate Risk" indicator and no "High-Risk" indicators results in a "Moderate Risk" classification; and a child designated as "Low Risk" would have no "Moderate Risk" or "High Risk" indicator [7].

2.1.1.2 Early detection of caries

Detection of the carious lesion is an important aspect in the diagnosis of caries. Visual and tactile examination and dental radiographs are commonly used methods for caries detection. Dental radiographs are recommended primarily for the detection of proximal carious lesions and

the occlusal surfaces for pit and fissure caries. In recent years, newer caries detection methods and devices have been developed as traditional caries detection procedures do not detect caries until they have progressed through at least the thickness of enamel [8]. This include:

1. Laser fluorescence
2. Fiber-optic transillumination
3. Digital imaging fiber-optic transillumination
4. Ultraviolet illumination
5. Electronic caries detector
6. Dye penetration method
7. Quantitative light-induced fluorescence (QLF)
8. Ultrasound imaging
9. Endoscope / Videoscope

3. CARIES REMOVAL AND RESTORATION

Rotary instruments used for the treatment of carious lesions have often resulted in a considerable removal of tooth structure. Caries removal and cavity preparation by using turbine and a handpiece result in an unpleasant perception of drilling to the patient. Newer techniques for removal of carious dentin have been developed to minimize this excessive tissue [9].

3.1 Preventive Resin Restoration (PRR)

PRR is indicated in teeth with minimal teeth and fissures decay. In this minimal cavity preparation is required to prevent unnecessary removal of healthy tooth structures for retention. If the decay is limited to enamel then no local analgesia is required. After etching, rinsing and drying the cavity is condensed with a normal composite or GIC.

3.2 ART (Atraumatic Restorative Technique)

ART approach involves the removal of only soft, demineralized tooth tissue with hand instruments, followed by filling the cleaned cavity & associated pits & fissures with adhesive restorative materials [10].

3.2.1 Recent advances in caries removal techniques

3.2.1.1 Air abrasion

The instrument was first developed in the 1940's by Dr. Robert Black. In 1951- S.S. White Technology introduced Air-Dent the first

commercially available unit for preparing cavities in teeth air abrasion. It has changed tooth preparation requirements and eliminated the need for mechanical retention [11]. It removes tooth structure using a stream of aluminium oxide particles generated from compressed air or bottled carbon dioxide or nitrogen gas. The abrasive particles strike the tooth with high velocity and remove a small amount of tooth structure. The efficiency of removal is relative to the hardness of the tissue or material being removed. Generally, gas pressures range from 40 to 160 pounds per square inch. The most common particle sizes are either 27 or 50 micrometers in diameter. The speed of the abrasive particles when they hit the tooth depends on the gas pressure, nozzle diameter, particle size, and distance from the surface. Operating distances from the tooth range from 0.5 to 2 millimetres. Farther distances produce a more diffuse stream that results in a diminished cutting ability.

3.2.1.2 Lasers

Early use of infrared lasers, such as carbon dioxide (10.6µmwavelength) and ruby lasers, to remove carious dentin results in a slow removal of tissue and excessive heat transfer to the dental pulp. In 1997, the Food and Drug Administration approved the use of Erbium: Yttrium Aluminium Garnet laser for caries removal in the USA. It operates at a wavelength of 2.94 µm and is used for the caries removal, cavity preparation in both enamel and dentine and for the preparation of root canals.

The Er:Cr:YSGG lasers operates at a wavelength of 2.78 µm, with an extinction length in water of 1.0 µm (a measure that translates into a depth of 90 percent absorption). The waveform for the Er:Cr:YSGG laser is pulsed and is used for enamel etching, caries removal [12] and for cavity preparation. With this laser, enamel etching produces bonds with a wide range of strengths, which can be unreliable. To minimize leakage in resins, enamel is acid-etched after preparing cavities with the Er:Cr:YSGG laser. However, experimental results with the Erbium: YAG laser have been disappointing [13] because laser irradiation weakens the surrounding dentin.

3.2.1.3 Polymer bur

Polymer bur remove softened and infected dentin and not normal dentin. The cutting elements of the bur were made of a softer polyamide/imides

polymer material than the traditional carbide bur [14].

3.2.1.4 Micropreparation burs

The Fissurotomy Bur (SSWhite Burs, Lakewood, NJ, USA) is designed so as to explore the fissure with minimal removal of enamel. It is 1.5–2.5mm in length and tapers to a fine carbide tip so that only one-sixth to one-tenth of the intercusp width is removed. The Brasseler 889M-007 bur (Brasseler USA, Savannah, GA, USA) allow minimally invasive preparation of the tooth occlusal surface, and for slightly wider preparation, the Micro-Diamond 838M-007 can be used. Micro instruments (such as the Micro preparation set 4337, by Brasseler, Germany) require low contact pressure (< 2N) to avoid instrument breakage. The instruments are manufactured using a special high-tensile steel to produce a thin neck.

3.2.1.5 Carisolv gel

Carisolv (MediTeam Dental, Göteborgsvägen, Sweden) is a chemo-mechanical method of removing dental caries that is minimally invasive. It constitutes amino acids and 0.5% sodium hypochlorite and is applied to the dentin. This forms high-pH chloramines (pH 12) that react with the denatured collagen in the carious dentin for easy removal. The softened dentin is removed by scraping the surface with special hand instruments. The technique is useful for the removal of root or coronal caries where access is easily obtained, but repeated application is required. Use of Carisolv Gel may be an inefficient method of removing caries at the enamel-dentin junction as carious dentin may go unnoticed beneath the overhanging enamel [15].

3.2.1.6 Caries detector dyes

In caries removal during cavity preparation, only the soft, heavily infected outer dentin must be removed, whereas the demineralized, uninfected inner dentin should be left. Caries-detecting dyes

(e.g.1.0% acid red in propylene glycol) have been developed in distinguishing between the two types of caries [16].

3.2.1.7 Ozone

Ozone is part of a natural gas mix that surrounds the earth at high altitude and protects world's population from excessive UV radiations. The fresh wonderful smell on mountains after the thunderstorms is ozone. This ozone is an oxidizing agent, used to purify water. The O₃ technology was developed by Prof. Dr. Edward Lynch. This technique utilizes O₃ gas which is applied to the tooth surface in a controlled manner with the use of heal ozone delivery handpiece. This O₃ gas eliminates decay-causing bacteria. Once the bacteria are eliminated the treated surface can be restored or left to re-mineralize.

4. NEW CAVITY CLASSIFICATION SYSTEM

This new system defines the site, extent, and complex of a cavity and at the same time encourages a conservative approach to the preservation of natural tooth structure. This new system is designed to utilize the healing capacity of the lesion [17] (Table 1).

5. THE THREE SITES OF CARIOUS LESIONS (ANATOMIC SITES)

Cariou lesions occur at three sites on crown or root of a tooth: that is, in those areas subject to the accumulation of plaque.

- **Site 1** – pits, fissures and enamel defects on occlusal surfaces of posterior teeth
- **Site 2** – approximal enamel immediately below areas in contact with adjacent teeth.
- **Site 3** – the cervical one-third of the crown or, following a gingival recession, the exposed root.

Table 1. Cavity classification

No.	Site	Size			
		1=Minimal	2=Moderate	3=Enlarged	4=Extensive
1	Pits & fissures	1.1	1.2	1.3	1.4
2	Proximal surface	2.1	2.2	2.3	2.4
3	Cervical surfaces	3.1	3.2	3.3	3.4

6. THE FOUR SIZES OF CARIOUS LESIONS (ACCORDING TO EXTENT & COMPLEXITY)

- **Size 1** – minimal involvement of dentin just beyond healing through remineralization.
- **Size 2** – moderate involvement of dentin. Following cavity preparation, remaining enamel is sound, well supported by dentin and not likely to fail under normal occlusal load. The tooth is sufficiently strong to support the restoration.
- **Size 3** – the cavity is enlarged beyond moderate involvement. Remaining tooth structure is weakened to the extent that cusps or incisal edges are split or likely to fail if left exposed to occlusal load. The cavity needs to be further enlarged so that the restoration can be designed to provide support to the remaining tooth structure.
- **Size 4** – extensive caries and bulk loss of tooth structure has already occurred.

6.1 Site 1, Sizes 1, 2, 3 and 4 – PIT and Fissure Caries

- Cavity located on the occlusal surface of a posterior tooth or any simple enamel defect on an otherwise smooth surface of any tooth.
- Black's class I – the smaller size 1 could not be carried out previously because suitable restorative materials were not available, so Black's classification begins with Site 1, Site 2 (# 1.2).

6.2 Site 2, Sizes 1, 2, 3 and 4 – Approximal Lesion Commencing in Relation to Contact Areas

- Cavity located on the proximal surface of any tooth (anterior or posterior) initiated immediately below the contact areas.
- Black's class II – lesions occurring between posterior teeth only. Because of materials limitations, there was no equivalent of Size 1, so the Black's classification begins with Site 2, Size 2 (#2.2).
- Black's class III – cavity located between anterior teeth only. Because of materials limitations, there was no equivalent to Size 1, so the Black's classification begins with Site 2, Size 2 (#2.2).
- Black's class IV – an extension of a class III involving corner or Incisal edge of an

anterior tooth. An alternate cause would be a traumatic fracture of the Incisal corner. Now classified Site 2, Size 4 (#2.4).

6.3 Site 3, Sizes 1, 2, 3 and 4 – Gingival One-third of the Clinical Crown or Exposed Root Surface Following Recession

- Cavity located in the gingival one-third of the crown or exposed root. Black's class V – this classification does not differentiate lesions on the gingival one-third of the approximal surface (particularly root surface caries) from class II lesions. An erosion / abrasion lesion or a small carious cavity would be a Site 3, Size 1 (#3.1) or Site 3, Size 2 (#3.2) and interproximal lesions would usually be Site 3, Size 3, Size 4 (#3.4)

7. CAVITY DESIGNS FOR MINIMAL INTERVENTION

7.1 Tunnel Preparation

It is considered in small, proximal carious lesions and where aesthetics demands are high. Access may be gained through the occlusal surface with No. 2 bur about 2.0 mm from the marginal ridge. Due to limited access, caries disclosing solution is needed to improve visibility for caries removal. After the removal of dentinal caries, the proximal enamel lesion is evaluated. If enamel is to be removed, a matrix band is placed to protect the adjacent tooth. If the marginal ridge has been undermined the tunnel preparation can be converted to a traditional Class II preparation at this time. Resin-modified glass ionomer cement is the current material of choice for this restoration. They are radiopaque and have been shown to prevent microleakage.

7.2 Micro Chip Approximal Cavity Preparation

It is considered when the fracture in the enamel wall extends down from the marginal ridge to the porous region. An extension of the occlusal access is made to include the fractured portion of the marginal ridge. The cavity is filled with glass ionomer cement and the excess is being removed from the occlusal surface. The glass ionomer and enamel are then etched, and the posterior composite is placed to restore the deficiency (Fig. 2).



Fig. 2. "Micro Chip" cavity preparation

7.3 "Minibox" Approximal Cavity Preparations

In this preparation, the excavation of the dentin lesion is same as for the previous preparations. The design differs only in the handling of the enamel. Initially, the integrity of enamel wall needs to be preserved by extending the margins where it can be considered stable and durable. A full box needs to be developed. Later on, the enamel should be opened out to sound dentin until it can be considered stable. It is preferable to retain and reinforce this enamel even if it is unsupported by dentin by placing glass ionomer cement base (Fig. 3).

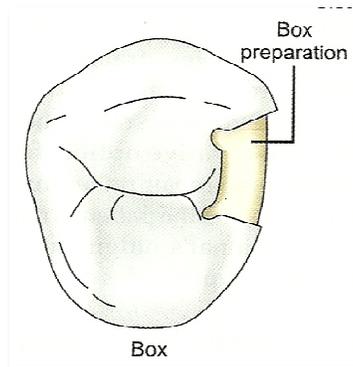


Fig. 3. "Mini Box" cavity preparation

7.4 "Full Box" Approximal Cavity Preparation

It is a very common procedure, where the enamel is in hopelessly poor condition and needs refining after eradicating the dentin lesion. The final refinement will depend on the type of restoration to be placed. For example, the preparation design for an amalgam or composite

restoration differs from the design for a porcelain or gold inlay (Fig. 4).

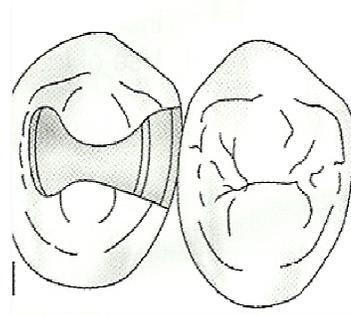


Fig. 4. "Full Box" cavity preparation

8. CARIES CONTROL

Restoration of carious lesions is the most effective method to control the progression of active, cavitated lesions. Caries control refers to an operative procedure in which multiple teeth are treated quickly by removing the infected tooth structure, by medicating the pulp and by restoring the defects with a temporary material [18]. Caries Control means "Initial treatment of caries and Maintenance". Initial treatment includes evaluation and documentation of lesion followed by temporization and specific Antimicrobial treatment. It also includes Plaque and Dietary Control. Maintenance includes Preliminary assessment and Follow-up care¹. Emerging technologies in this area include caries vaccines and bacterial replacement therapy which have been studied in rodents to date. In bacterial replacement therapy, gene manipulation yields a strain of *S. mutans* unable to produce lactic acid through fermentation of carbohydrates. It could be used to prevent dental caries by replacing wild-type *S. mutans* in humans with high caries risk [19].

9. RESTORATIVE MATERIALS USED IN MINIMUM INTERVENTION DENTISTRY

The restorative materials used in MID are biomimetic in nature. In other words, the material should be biocompatible, biologically acceptable and not rejected by adjacent vital tissues. The application of the biomimetic principle involves the preparation of dental tissues to allow functional stresses to pass through the tooth by the creation of a hard tissue bond resulting in biologically functional and esthetically acceptable crown [20].

The ideal tooth restorative material for MI should form a strong adhesive bond to dentin and enamel. It should resist fracture, compressive strength, wear resistance. It should not undergo shrinkage or expansion during the hardening reaction and have dimensional stability [21]. Materials satisfy the above requirements include Glass Ionomer Cements, Compomers, and Composites.

10. ADVANTAGES OF MINIMUM INTERVENTION

Minimal intervention applies a more conservative approach to caries treatment and simultaneously offers patients less invasive, health-oriented treatment options. The benefit for patients from MI lies in better oral health, minimizing the restoration cycle and reducing the patient dental anxieties. MI includes clinical procedures such as assessment of caries risk, early detection of the disease followed by restoration of fissure caries with maximum retention [11].

10.1 Significance of Minimum Intervention in Paediatric Patients

Prevention of dental diseases has been proven to be the best strategy so far. The newly erupted teeth in a child's mouth have to go a long way performing the functions of speech, esthetics and mastication, so conserving teeth at an early stage of life is desirable. This can be easily achieved with minimum intervention approach. MI helps in preventing the unnecessary tooth structure loss, reducing child's dental anxiety, by decreasing the cost viability and by avoiding the repair of the restoration at a later stage in life.

Patients in India are now switching over to the new concept of Conservative Approach i.e. Minimal invasive dentistry due to recent advances and the benefits of the modern methods of diagnosis, prevention, remineralization, minimal intervention and repair over the conventional restorative procedures [1].

11. CONCLUSION

Minimally invasive dentistry requires a change in philosophy in our approach to managing dental caries [22]. Dental caries should be viewed as a bacterial disease rather than the end product of that disease. Patients should be assessed for their caries risk. Caries should be prevented at its early stage by interrupting the disease

process prior to cavitation by suppressing the bacteria, by enhancing the oral environment and by protecting the teeth with fluoride and sealants. When the caries process cannot be reversed, minimally invasive techniques and materials should be used to conserve sound tooth structure. The new treatment modalities allow us to minimize loss of sound tooth structure during caries removal. Although further research is needed, it can so far be concluded that Minimum Intervention has the potential to apply a more conservative approach to caries treatment and health orientated treatment option [2].

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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