Minimally invasive dentistry a short review of the concepts

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Abstract—Dental Caries is a common dental disease which can cause tooth decay and loss. Traditional methods of treating caries involved removing large amounts of tooth structure, which lead to discomfort, pain, and prolonged healing time. Minimally invasive dentistry (MID) is a newer approach to treating caries which aims to preserve as much tooth structure as possible. MID techniques include laser dentistry, air abrasion, and minimally invasive filling materials. This review summarizes the general principles of Minimally Invasive Dentistry and talk about all the methods and modifications which are practiced currently. Throwing a light to the advancements as well.

Index Terms - MID, Minimally Invasive Dentistry

I. INTRODUCTION
Dental caries is described as localized degradation of the structure of tooth by bacterial invasion in dental plaque which ferments the carbohydrates and leads to production of acids which causes degradation. It’s a multifactorial disease triggered microbiologically by changes in biofilm. It is influenced by a number of variables including: Oral hygiene, fluoride exposure, salivary contents and stream and sugar intake frequency. Dental caries is one of the most prevalent disease which affects children with one of the main etiological features being diet which mediates the cariogenic bacteria and leads to demineralization. Earlier concepts for management of such included extensive tooth preparation. Cavity preparation techniques have changed greatly from black’s principles to more conservative approaches. These approaches not only remove caries with minimal trauma too tooth structure but also prevent excessive loss of tooth structure. Minimal invasive dentistry was coined where ‘minimal’ means very small extent and ‘intervention’ means an action undertaken in order to prevent something. [1]

II. EVOLUTION OF THE TECHNIQUE [2]

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Evolution of MID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1923</td>
<td>Hyatt</td>
<td>Introduced Prophylactic Odontotomy</td>
</tr>
<tr>
<td>1928</td>
<td>prime</td>
<td>Designed a class II cavity that included a narrow, shallow occlusal step and narrow gingival walls inclined to the axial for retention.</td>
</tr>
<tr>
<td>1936</td>
<td>McGhee</td>
<td>In his “Textbook of operative dentistry” advocated a class II cavity in which the buccal and lingual margins converged towards the occlusal</td>
</tr>
<tr>
<td>1955</td>
<td>Buonocore</td>
<td>Developed Acid-etch technique for adhesion of resins</td>
</tr>
<tr>
<td>1963</td>
<td>Jinks</td>
<td>Introduced tunnel preparation</td>
</tr>
<tr>
<td>1965</td>
<td>Owen</td>
<td>Developed Bis-Gma resin</td>
</tr>
<tr>
<td>1975</td>
<td>Goldman and kronman</td>
<td>Made first attempt to use chemomechanical removal of caries</td>
</tr>
<tr>
<td>1997</td>
<td>Graham mount</td>
<td>Proposed a new cavity classification to take into account the changes in cavities activity. Carious lesion occurs in 3 sites on the crown or root of the tooth. (site-1, site-2 and site-3) with severity of lesion in 5 sizes (size-0 to size-4).</td>
</tr>
</tbody>
</table>

III. PRINCIPLES OF MINIMALLY INVASIVE DENTISTRY [1,3]

- Early detection of lesion and disease control through reduction of cariogenic flora
- Remineralize early lesions
- Perform minimal intervention surgical procedure
- Development of new classification system
- Repair rather than replace defective restorations

Early detection
Detection of the carious lesion is one of the most important aspect in the diagnosis of dental caries. Caries activity assessment is another important aspect but is difficult to detect. Caries activity cannot be determined at one point in time and must be determined by examination of the lesion over time. Radiographs and clinical information usually are used to make this determination. [3]
Early detection of Carious lesions can be done through a number of methods. In 2007, consensus statement was published supporting a new method, Caries risk management by risk assessment (CAMBRA) in clinical practice rather than only the cavitated end stage lesion. Recently International Caries Classification and Management System (ICCMS) is introduced which also incorporates principles of minimal intervention dentistry.

CAMBRA [4]

- Cambra was developed by Featherstone et in 2007
- It involves taking proper history and conduct clinical exam to assess the condition of tooth
- Risk assessment is done and a questionnaire is asked after which it is graded in low, medium, high moderate or extreme.
- Chemical therapy is done based on risk level that includes fluorides and antibacterial agents
- Minimally invasive procedures are performed to conserve tooth structure
- Caries risk level is reassessed and treatment is modified accordingly based on recalls and review

<table>
<thead>
<tr>
<th>Disease indicators</th>
<th>Biological risk factors</th>
<th>Protective factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of cavity, approximal lesions that can be assessed using radiograph, Number of restorations done in past 3 years</td>
<td>Visibility of plaque, snacking habits, salivary flow, dryness of mouth, medications that can lead to hyposalivation</td>
<td>Includes brushing habits using fluoride tooth paste</td>
</tr>
</tbody>
</table>

ICDAS [5]

The International Caries Detection and Assessment System (ICDAS) was developed in 2001 with the aim to create a caries detection method that might be universally used and allowing clinicians, researchers, and epidemiologists to measure caries disease at different stages.

- It was developed to bring forward the current understanding of the process of initiation and progression of dental caries to the field of epidemiological and clinical research.
- Examination is done by drying of tooth surface for detecting non cavitated surfaces, since water clogs the pores in the carious teeth and hampers the detection of early white spot lesions.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Sound tooth surface: No evidence of caries after 5 sec air drying</td>
</tr>
<tr>
<td>1</td>
<td>First visual change in enamel: Opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure seen after prolonged air drying</td>
</tr>
<tr>
<td>2</td>
<td>Distinct visual change in enamel visible when wet, lesion must be visible when dry</td>
</tr>
<tr>
<td>3</td>
<td>Localized enamel breakdown (without clinical visual signs of dentinal involvement) seen when wet and after prolonged drying</td>
</tr>
<tr>
<td>4</td>
<td>Underlying dark shadow from dentine</td>
</tr>
<tr>
<td>5</td>
<td>Distinct cavity with visible dentine</td>
</tr>
<tr>
<td>6</td>
<td>Extensive (more than half the surface) distinct cavity with visible dentine</td>
</tr>
</tbody>
</table>

Advantage of ICDAS

- The main advantage of ICDAS system was its ability to diagnose carious lesions at initial stages.
- It also allowed clinicians to evaluate and classify the progression of the lesion with a greater accuracy.
- The developed ICDAS system also allowed the clinician to evaluate the condition of the restoration in terms of validity and longevity.

Limitation of ICDAS

The limitation of ICDAS system was its low rate of reproducibility when compared to other methods like WHO-DMFT.

ICDAS 2

ICDAS 1 has criteria divided into two groups:

- Caries detection
- Caries activity criteria

It was reported that while ICDAS caries detection criteria are ready to wider use, caries activity criteria was still part of an expanding research agenda.

ICDAS 2 have two digit coding for detection criteria of primary coronal caries. The first digit is related to the restoration of teeth and has coding that ranges from 0 to 9.
<table>
<thead>
<tr>
<th>Code</th>
<th>Condition of restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>surface not restored or sealed</td>
</tr>
<tr>
<td>1</td>
<td>sealant, partial</td>
</tr>
<tr>
<td>2</td>
<td>sealant, full</td>
</tr>
<tr>
<td>3</td>
<td>tooth coloured restoration</td>
</tr>
<tr>
<td>4</td>
<td>amalgam restoration</td>
</tr>
<tr>
<td>5</td>
<td>stainless steel crown</td>
</tr>
<tr>
<td>6</td>
<td>porcelain or gold or PFM crown</td>
</tr>
<tr>
<td>7</td>
<td>Lost or broken restoration</td>
</tr>
<tr>
<td>8</td>
<td>temporary restoration</td>
</tr>
</tbody>
</table>

## Remineralize early lesions

Enamel and dentin demineralization is not a continuous, irreversible process. It takes place through a series of demineralization and remineralization cycles, where the tooth alternately loses and gains calcium and phosphate ions, depending on the environment of the oral cavity.

Featherstone proposed the concept of demineralization-remineralization cycle. It states that caries progression is greatly influenced by positive and negative factors which a tooth maintains a balance and caries can progress only if the balance. Therefore by reducing the acidic pH or reducing the cariogenic bacteria the demineralization can be reduced and by using remineralizing agents like fluoride and CPP-ACP remineralization can be increased. Other agents like chlorhexidine can be applied to encourage remineralization, which acts by reducing the number of cariogenic bacteria and promoting remineralization by preventing demineralization. [9]

## Perform minimal intervention surgical procedures

In 1960, a new understanding of carious dentin emerged where it was identified as two separate carious dentin layers, an outer infected dentin and an inner affected dentin by fusayama using fuschin dye.

Bjorndal et al, 1997 treated deep/extensive dentinal carious lesions with selective (one step) or stepwise (two-step) seems advantageous compared with complete caries removal and found selective removable more efficient. In this approach, the surgical management of tooth with no cavity and demineralized teeth should be the last option.

### Step-wise excavation[6]
- Involves removal of infected dentin and preservation of a layer of deeper caries affected dentin if there is a risk of pulpal exposure.
- In first appointment, there is partial caries removal and indirect pulp capping using calcium hydroxide
- After 8 to 12 weeks, under the absence of signs of pulpal pathology, remaining caries is removed and tooth is restored.

**Advantage**
Preservation of tooth vitality and tooth structure which otherwise might go for endodontic procedure and may weaken the tooth structure.

**Disadvantage**
Requires more than one sittings and longer waiting periods.

## Development of a new classification system[7]

GV blacks’ classification is not suitable for minimal invasive dentistry because it requires large cavity preparation.

Newer classifications have been developed which doesn’t require removal of sound tooth structure and have a more conservative approach.

### Mount and Hume classification:

There are two parameters to determine the progression of caries:
- **Site**
- **Size**

There are three sites:
- Site 1- pit and fissure area- black’s class 1 lesions
- Site 2- contact areas- black’s class 2, class 3, class 4
- Site 3- cervical area- black’s class 5 lesion

There are four sizes:
- Size 1- minimal
Size 2- moderate
Size 3- enlarged
Size 4- extensive

**Repair rather than replace defective restorations**

The replacement of restorations results in bigger restorations with shorter life. Reasons for replacing restorations include concerns about bond strength of previously placed materials, caries left, and recurrent caries around margin of a restoration resulting in increased risk of developing caries. Defective restorations can be repaired more quickly with low operational costs that replacement. Studies have shown that removal of defective restoration may provide additional stress on the tooth with possible pulp reaction to thermal, chemical, bacterial or mechanical stimuli.

**IV. INDICATIONS AND CONTRAINDICATION OF MID**

**Indications**
- Shallow cavities without pulpal involvement
- Aims on prevention of caries
- Reduction in cariogenic bacteria
- To remineralize early lesions
- Minimal surgical intervention of cavitated lesion
- It aims on conservative approach which aims towards preservation of natural tooth surface and repair rather than replacement

**Contraindications**
- Deep carious lesions that require endodontic intervention
- Uncooperative patients
- Time consuming
- Customized instruments may be required for caries removal using chemical agents
- Air abrasion is contraindicated in patients having Dust allergy, Asthma, lung disorders, recent surgical interventions.

**V. MINIMALLY INVASIVE CONSERVATIVE APPROACHES**

- ART
- Cavity Preparation
- Halls Technique
- Preventive Resin Restoration
- Pit and Fissure Sealants
- Various modalities of caries excavation for management cavitated dentine carious lesions

**ATRAUMATIC RESTORATIVE TREATMENT**

**Procedure**
Step 1. Isolation- After achieving good isolation, tooth surface is dried and plaque is removed.
Step 2. Caries removal- A excavator is used to remove soft caries using a circular scooping motion along long axis of tooth.
Step 3. Pulpal protection- It is only used in case of deep carious lesions. Ca(OH)2 is used.
Step 4. Conditioning of the cavity- Conditioning increases the chemical bonding of GIC to tooth surface
Step 5. Mixing of GIC- Mixing is done according to manufacturers instructions without altering its powder-liquid ratio.
Step 6. Mixed material is inserted in small amounts with blunt instrument while proximal caries are restored with mylar strip to give the contour.
Step 7. Petroleum jelly is applied over the restoration to protect from saliva.
Step 8. Finally bite is checked with the help of articulating paper and patient is instructed not to eat or drink for 30 minutes.

**Advantages of ART**
- Uses easily available hand instruments alone
- No need for local anesthesia
- Retention is obtained by microtags produced due to etching and additional retention by adhesive material used
- Leaching of fluoride from GIC remineralized demineralized dentin and prevent secondary caries.
• Less expensive and less time consuming

Disadvantages of ART
• ART restorations are not long lasting
• Fundamental principles of cavity preparation
• Low wear resistance and low strength of GIC makes its use limited to very small and medium sized lesions
• Conditions use of hand instruments over long period causes hand fatigue.

Cavity preparation\[9\]
• For designing proximal lesions number of methods have been developed:

  • Tunnel cavity preparation
    o Indicated for small cavities less than 2.5mm
    o A small tapered cylindrical bur is used to approach dentin in a triangular cavity. After opening the cavity, a small bur is used to remove carious lesions keeping the proximal wall intact.
    o Final restoration can be done using Glass Ionomer Restorations.

  • Slot cavity/minibox restoration
    o Involves approaching the lesion through the crest or the outer surface of the marginal ridge.
    o Conservative entry is made without involving any more than the carious lesion.
    o It aims to retain as much tooth structure as possible.

  • Proximal approach
    o Indicated when adjacent tooth is missing or has a extensive cavity prepared on it.
    o A small round bur is used to remove the caries completely proximally and can be restored using a radiopaque filling material.

Hall’s Technique\[10\]
It was developed by Dr. Nora Hall who practiced this method on north east part of UK.
It involves placement of stainless steel crown without any removal of caries in tooth affected by multi-surface caries.

Step 1:
• Proper diagnosis is done for the asymptomatic tooth and radiographic examinations are done.
• Orthodontic separators are placed mesially and distally on the tooth.

Step 2:
• After 3-7 days the separators are removed.
• Crown selection is done blanching is adjusted and luted with Glass Ionomer Cement.

Follow up:
• Tooth is assessed for pain, sinuses, swelling and radiographically for signs of radiolucency or root resorption.

Preventive resin restoration
It integrates the preventive approach of the sealant therapy for caries susceptible pits and fissures with the therapeutic restoration of incipient caries with composite resin that occur on same occlusal plane.

There are three types of PRR based on the extent and depth of carious lesion:-
1. Type A- Comprised of suspicious pits and fissures where caries removal is limited to enamel
2. Type B- Comprises of incipient lesion in dentin that is small and confined
3. Type C- Characterized by the need for greater exploratory preparation in dentin.

Procedure:
The tooth is first inspected radiographically for any interproximal or occlusal caries. Then, the occlusal surface is investigated. Examination is done for an explorer catch and resistance to removal, soft or opaque areas, or discontinuity of the enamel surface. Next, occlusion is examined and marked with articulating paper. The tooth is perfectly isolated with cotton rolls or rubber dam. A small round bur is made worn at high or low speed to make less exploratory preparation into deep pits and fissures. If caries is experienced, good access should be gained using a pear-shaped bur. All unprepared pits and fissures, minimal exploratory preparations must be restored with a pit and fissure sealant.\[11\]

Pit and fissure sealants
In 1965, Buenocore described the acid etching technique as a method for increasing the adhesion off self curing methyl methacrylate resins to dentin-enamel using 85% phosphoric acid for 30 seconds.
Indications
- Permanent molars in children at medium or high risk of caries
- Premolars should be sealed in those children at high risk
- In children at low risk, only the fissures that are deep and retentive need to be sealed
- Primary posterior teeth in children at risk high of caries.

Method
Step 1. Isolate teeth with rubberdam
Step 2. Gross debris is removed with a blunt probe and occlusal surface is cleaned with pumice and water.
Step 3. Tooth is etched for 20 seconds and washed with copious water and air dried for 20 seconds.
Step 4. A thin coat of sealant is applied on the pits and fissures including the buccal extension and palatal extension in lower and upper molars.
Step 5. Polymerization light is applied for 20 seconds
Step 6. Occlusion is checked after removal of rubber dam.\[12\]

Various modalities of caries excavation for management cavitated dentine carious lesions: [1,2,13,14]
- Mechanical
- Chemical
- Sonic
- Kinetic
- Hydrokinetic

Excavation by burs
- Smart burs
  - Developed based on Fusayams’s idea where only the infected dentin is removed and affected dentin is left
  - Constructed with medical grade polyether-ketone-ketone with hardness and wear resistance less than sound dentin.
  - Available in three ISO sizes- 010(round bur no.2); 014(round bur no.4); 016( round bur no. 6)
- Micro diamond prep system
  - Micro Prep diamond burs have been specially been designed with small abrasive heads to facilitate conservative tooth preparation and longer necks to enhance vision and control.
- Fissuretomy burs
  - These burs are scientifically designed for the treatment of hidden caries
  - Fissuretomy burs (ss white, USA) with the aid of magnifying loops allows precise tooth preparation.
- Chemo-mechanical caries excavation
  - Noninvasive technique for removing of caries by dissolution
  - Involves application of chemical agent on carious dentin which makes the infected dentin softened.
  - This softened dentin can be removed by gentle excavation.
- Caridex
  - Developed based on the idea of using sodium hypochlorite to remove organic materials from root canal.
  - Further it was diluted and a new preparation was made named as GK101
  - Has a two bottle system- sodium hypochlorite and the other one with glycine, aminobutyric acid, sodium chloride and sodium hydroxide.
- Carislov gel
- Consists of two syringes-
  - White syringe with sodium hypochlorite
  - Transparent syringe with amino acids, sodium chloride, sodium hydroxide and purified water.
- Papacarie
  - Introduced by Sao Paulo in brazil 2003.
  - Consists of papain, chloramines, toludinie blue dye, water, salts and thickeners.
  - Papain is a proteolytic enzyme- bacteriocidal, bacteriostatic and anti-inflammatory.
Carie-Care

- Consists of papain and therapeutic oil.
  - It not only softens dentin but gives additional advantage of essential oils, which provide anti-inflammatory and mild anesthetic effect.
- Consists of:
  - Colouring gel
  - Sterile water
  - Chloramine and sound chloride
  - Preservatives

Sonicflex system

- The sonic oscillating, SONI-flex system was developed to cut and finish proximal cavities.
- System uses highly frequent oscillating preparation instruments in an air driven oscillating handpiece.
- Safe-sided, diamond coated, round-ended preparation tips can minimize the damage to neighbouring teeth during proximal preparation and finishing.

Advantages-
This has the advantage of minimizing or eliminating noise, vibration, heat and pressure. This technique can be useful to modify the proximal preparation procedure protect adjacent teeth against iatrogenic damage caused by the use of dental burs.

Disadvantages-
Disadvantage 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.

Air Abrasion Excavation

- It was originally developed by Robert Black in 1945 as an alternative to pseudo-mechanical method for dental hard tissue removal and the first air abrasion unit marketed was called the Airdent by SS White.
- This technique involved bombarding the tooth surface with high velocity aluminum oxide particles (Alumina) carried in a stream of air.
- The technique uses fine abrasive particles fired at the decayed tooth surface powered by compressed air.
- The powder consists of aluminum oxide particles which after hitting the decayed area is sucked away by a powerful suction.
- This method of cutting is relatively painless however, the total loss of tactile sensation, and the ability of alumina particles to remove sound tooth structure rather than the carious substrate in addition to the potential risk of inhalation problem should also be considered at the time of selection.
- Quantity of tooth removal and depth of penetration depends on air pressure, particle size, nozzle diameter of handpiece and distance and time of exposure to the object.

Laser Excavation

- Laser is an active medium which produce protons of energy that are delivered in a beam with an exact wavelength.
- Soft tissues laser and hard tissue lasers have different wavelengths.
- When it is targeted at on decayed tissue, it removes the decayed dentine and dentof affects the sound tooth.
- It not selectively targets caries but also has an bactericidal effect and dosent require anesthesia because of its numbing effect.
- After a period of uncertainty concerning the use of lasers in dentistry at the end of the 1990s, three wavelengths available for clinical use in hard dental tissue management were developed. These included the 1. Erbium:yttrium-aluminum-garnet Er:YAG (\(\lambda = 2.94 \mu m\))
  2. Erbium:chromium:yttrium-scandium-gadolinium-garnet Er,Cr: YSGG, (\(\lambda = 78 \mu m\))
  3. Er:YSGG (\(\lambda = 2.79 \mu m\)).

VI. CONCLUSION

There is constant development of new restorative materials and in the field of adhesive dentistry. The understanding of management of dental caries has changed drastically from the conventional G.V Black’s approach to a minimally invasive approach. MID is based on several variables showing remarkable scientific evidence that has been summarized and discussed. In future further evolution waits toward a more preventive approach, facilitated by emerging technological advancements for diagnosis, prevention and treatment. [3]
REFERENCES


