REVIEW ARTICLE

# Minimal invasive dentistry – An emerging trend in pediatric dentistry: A review

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## Abstract

Modern dentistry has evolved into minimally invasive approach. Natural human enamel and dentin are still the best dental materials in existence and thus "minimally invasive procedures" that conserve a great part of the original, healthy tooth structure, are being focused on. The application of "minimally invasive restorative dentistry" can be justified on the grounds that no restorative material can adequately replace natural tooth structure for the long-term and hence its preservation is of paramount importance. Dentistry has witnessed an era of development of new techniques and instruments that make conservative dentistry in true sense - A practical possibility, and ultra conservative dentistry a reality.

**Keywords:** Diagnosis of early carious lesion, minimal invasive dentistry, new techniques and instruments in conservative dentistry

## Introduction

Dental caries is a multifactorial disease that has many contributing factors, including biological, genetic, socioeconomic, cultural, and environmental issues. It is the most common childhood disease and is five times more prevalent than asthma and seven times as common as hay fever.[1] Preservation of a healthy set of natural teeth for each patient should be the objective of every dentist. Conservative dentistry, a treatment procedure wherein a minimum of healthy tooth structure is removed along with a decayed portion during the restorative process, is inherently a desirable dental objective. Minimally invasive dentistry (MID), has developed a new approach for addressing dental decay through minimally invasive technique and the preservation of tooth. It is a conservative philosophy that reduces restorative procedure time, pain and stress, and results in decreased patient anxiety.[2]

It is a dental care concept based on the assessment of a patient's caries risk and the application of the current therapies to prevent, control and treat the disease. It is often referred to as treating dental caries with a biologic, therapeutic, or medical model.[3]

## Evolution of MID

G.V. Black was the first dentist to propose treating dental caries using minimal intervention. During his time surgical model continued to drive dentistry: The clinical symptoms were addressed by tooth extraction or restoration. Restorations of that time used an alloy that corroded rapidly and experienced problems with expansion. Several events occurred that allowed for the improvement of dental amalgams and the introduction of bonded restorations. In 1955, Buonocore described a technique for etching enamel surfaces to make them retentive for a restoration and Bowen in 1962 invented an adhesive materials, which lead to the invention of minimally invasive preparation.[4]

| Dental caries | Old model | New model |
|---|---|---|
| | Drilling and filling | Risk assessment |
| | Mechanical retention | Preventive care |
| | Extraction | Adhesive dentistry |

MID: Minimal intervention dentistry

## Principles of MID[5]

A. Early caries diagnosis
B. Classification of caries depth and progression
C. Assessment of individual risk
D. Optimal caries preventive measures
E. Remineralization of early lesions
F. Minimal surgical intervention of caries lesions
G. Repair rather than a replacement of defective restoration
H. Assess disease management outcomes at intervals.

## Early caries diagnosis

In children, long before capitation occurs, caries disease starts as a result of exposure to risk factors such as increased sugar consumption and eating frequency or the breakdown of protective saliva properties. These changes can be measured using chair side tests. Evaluation of saliva is done by testing quality and quantity of saliva, pH of saliva, buffering capacity of saliva and various tests for oral bacteria levels.[6]

### *Initial carious lesion*

It is a primary lesion, which has not reached the stage of an established lesion with cavitation. The purpose of the examination is to detect visually changes of color, translucency and structure of the enamel. An initial inspection, tooth by tooth, on wet surfaces can spot cavities and brown or white stains. Periodontal status and restorations may also be checked initially. At this stage, caries activity must be evaluated by checking the build-up of plaque biofilm and the gingival pathology at suspect sites. A blunt/rounded probe (a periodontal probe is appropriate) may be used, with gentle force. Clinical parameters that indicate and quantify the activity state of a single carious lesion are: [7]

- The appearance of the lesion correlated with its severity
- The position of the lesion (in an area in favoring plaque build-up or not)
- Tactile perceptions on probing (used to assess the presence of surface deposits and the roughness of the enamel)
- The status of the gingival margin in relation to the areas of interest (assessed by the absence or presence of bleeding caused by a careful probing).

### *Extensive clinical observation*

Changes in color and translucency that indicate the state of demineralization should be noted. These visible signs indicating caries have been rationalized in a classification system i.e., the International Caries Detection and Assessment System (ICDAS). The classification includes six codes. Initial lesions are mainly covered by Codes 1 and 2.[8]

- ICDAS II Code 0: The tooth is healthy
- ICDAS II Code 1: The tooth has a lesion visible only after drying and histology reveal that the lesion is limited to the external half of enamel
- ICDAS II Code 2: The lesion penetrates the full thickness of enamel. Clinically, an opacity or discoloration distinctly visible without air-drying is apparent but without cavitation.

### *New diagnostic aids*

There are various recent diagnostic aids such as electrical conductance measurement, quantitative light induced fluorescence, dye enhanced laser fluorescence, diagnodent, fiber optic trans illumination, digital radiology, digital subtraction radiography, optical coherence tomography, tuned aperture computed tomography, electrical impedance tomography that can be used for early detection of caries.[9]

## Classification of caries depth and progression

A new classification that encourages the profession to see operative dentistry in a new light has been proposed by recently. In spite of the relatively hostile oral environment, there are restorative materials capable of long term adhesion to tooth structure, both to enamel and dentin and the instruments available for cavity preparation have changed. It was therefore suggested that the profession adopt new classification systems based on the site and size of a lesion and on radiographic evaluation.[2]

### *Classification based on site and size of the lesion*

A new classification of the carious lesion was proposed by Mount and Hume in 1997. Proper access to the lesions, which are infected and broken down to the point where remineralization is no longer possible, was the main aim behind this classification.

The classification is linked to the stage of progression of the lesion and is not related to cavity design.[3]

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

### *Radiographic evaluation of proximal caries*[2]

Early proximal lesions are those which have been identified as radiolucencies in the inner half of enamel, at dento enamel junction or even slightly into the dentin, but with little or no evidence of cavitation. The radiographic changes in proximal lesions can be assessed on the following classification given by Ben and Dankel *et al*.

$E_1$ = Radiolucency in outer 1/2 of enamel
$E_2$ = Radiolucency in inner 1/2 of enamel
$D_1$ = Radiolucency in outer 1/3 of dentin
$D_2$ = Radiolucency in middle 1/3 of dentin
$D_3$ = Radiolucency in inner 1/3 of dentin

## Assessment of individual risk

Risk is the probability that some harmful event will occur. Caries risk is defined as "the probability of future caries disease development."[5] American Academy of Pediatric Dentistry recognizes that caries-risk assessment and management protocols can assist clinicians with decisions regarding treatment and are essential elements of contemporary clinical care for infants, children, and adolescents.[10]

It includes both primary and secondary disease. There are some factors, which are related for the assessment of individual risk. Direct factors are the amount of plaque, type of bacteria, type of diet, frequency of carbohydrate intake, saliva secretion, saliva buffer capacity, and exposure to fluorides. Indirect factors, which may help to assess individual risk, are socioeconomic

circumstances and general health of the child. Identification of caries risk at early stage can be done by recording patient history, clinical examination, nutritional analysis, salivary analysis and by using accurate caries diagnostic methodologies.

### Risk assessment[10]

- Fosters the treatment of the disease process instead of treating the outcome of the disease
- Gives an understanding of the disease factors for a specific patient and aids in individualizing preventive discussions
- Individualizes, selects and determines frequency of preventive and restorative treatment for a patient.

### Optimal caries preventive measures

Proper and intelligent use of antiseptics to destroy the bacteria or at least to limit their number and activity could be a way to counteract or limit the ravages of dental caries. There are some basic methods by which prevention can be done in children.

#### *Diet counseling and sugar substitutes*

High risk individuals that do not use fluoride agents will benefit from dietary control measures.[5] Frequency of intake of sugars is an important factor in managing carious lesion development. van Loveren and Duggal stated the interplay between consumption of cariogenic food, oral hygiene, availability of saliva and fluoride.[11] Use of sugar substitutes i.e. xylitol and sorbitol, are sugar free products. As per the evidence available, immediately after meals, the use of sugar-free chewing gums reduces carious lesion progression.[12,13]

#### *Pits and fissure sealants*

Complex morphology of pits and fissures make them an ideal site for retention of bacteria and subsequent caries development.[14] Sealing of patent pits and fissures aim to protect them from bacterial colonization and exposure to fermentable substrate and can be cleaned easily. It is the preventive measure, in arresting non-cavitated enamel carious lesions.[15]

#### *Antimicrobial agents and chemotherapeutic approaches*

Mouthrinses deliver chemotherapeutic agents, and it is widely accepted in school fluoride rinsing programs both by self-administration and under supervision. Chlorhexidine, essential oils, triclosan, cetylpyridinium chloride, sanquinarin, sodium dodecyl sulfate, and various metal ions such as tin, zinc, copper are the active ingredients present in mouthrinses, which has an ability to reduce mutans streptococci. Chlorhexidine is the gold standard for plaque and gingivitis control in children.[16]

Povidone iodine is known as a powerful germicidal agent effective against a wide range of bacteria, viruses, fungi, protozoa, and spores and 10% solution can be used for topical oral applications and a moderate suppression of mutans streptococci in plaque and saliva, which can be used in cases of early childhood caries.[17] Use of essential oils can also help to reduce caries at a greater level. As per the evidence available, significantly reduced levels of *Streptococcus mutans* had been demonstrated from in situ bactericidal activity, which can be suggestive of its daily use as an adjunct to mechanical oral hygiene regimens. It seems that the addition of fluoride to essential oil mouthwashes has further enhanced its appeal as a "broad-spectrum" mouthrinse with multiple benefits for patients combined with an extremely easy method of delivery via simple oral rinsing.[18]

### Remineralization of early lesions

Remineralization delivery methods materials include toothpastes, mouthrinses, gels, pastes, chewing gums, lozenges, foods, and beverages. There are certain requirements of an ideal remineralization material.[19]

- It should deliver calcium and phosphate by diffusing into the subsurface
- It should not deliver excess of calcium
- It should not favor calculus formation
- It should work at an acidic pH
- It should boost the remineralizing properties of saliva
- It should benefit over fluoride for novel materials.

#### *Saliva-natural reversal of demineralization*

Saliva contains calcium and phosphate ions as well as buffering agents, fluoride and other substances, which demineralize the initial lesions. Saliva has a pH of around 6.8-7 in healthy patients. If the level of acid present at the tooth surface is higher, it becomes more difficult for salivary buffering capacity to buffer the area and remineralization may also not be successful. If demineralization occurs, a lesion can develop.[20]

#### *Fluoride[21]*

Incorporation of fluoride into the crystalline structure of the carbonated hydroxyapatite, during the remineralization/demineralization cycle not only decreases crystal solubility, but also increases the precipitation rate of enamel mineral in the presence of calcium and phosphate due to the lower solubility of fluorapatite. Decrease in enamel solubility by fluoride is due to:

i. Its stability in the crystal lattice than the hydrogen ion and
ii. Its interaction with the calcium ions on the crystal surface, interacting closely and binding strong.

#### *Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP)[22]*

CPP is a derivative of the milk protein casein which is unique in its ability to bind calcium and phosphate ions and stabilize ACP in metastable solution and thereby preventing precipitation. Anti-cariogenic mechanism for CPP-ACP is by the localization of ACP on the tooth surface, which buffers the free calcium and phosphate ion activities, thereby helping to maintain a state of supersaturation with respect to the tooth enamel and, thus, preventing demineralization and enhancing remineralization. CPP-ACP is a useful cario-static agent for the control of dental caries. It can be used as an adjunct preventive therapy to reduce caries in high-risk patients and to repair enamel in cases

involving white-spot lesions. Elsayad *et al*.[23] reported CPP-ACP has a synergistic effect with fluoride. He stated that combining remineralizing agents with fluoride enhance fluoride's anti-caries effectiveness and in a lower dose. Combination of remineralizing agents should be in a lower dose to avoid the possibility of dental fluorosis in young children.

***Novamin***

It is a bioactive glass compound which comprises of minerals that naturally occur in the body and reacts when it comes into contact with water, saliva or other body fluids and releases calcium, phosphorus, sodium and silicon ions that results in the formation of new hydroxycarbonate apatite crystals. The mineralized layer formed by it is mechanically strong and more resistant to acid.[24]

***Enamelon***

It's an unstabilized calcium and phosphate salt with sodium fluoride. Delivery of fluoride along with soluble calcium and phosphate occurs with the liquid calcium formula. Enamelon toothpaste is beneficial in the reduction of white spot lesions, and the repair as shown by earlier human studies and remineralization of tooth enamel compromised by acidic beverages.[19]

***Glass ionomer cements (GIC)***

It is proved to be more efficient compared with other materials like fluoride varnishes, fluoride-releasing sealants. Application of GIC, as a dressing over the white spot lesion, provides necessary mechanical protection of weakened enamel and with continuous release of fluoride encourages the remineralization process. Resin-modified GIC can also be used in which resin is infiltered in the lesion and prevents further demineralization, while the fluoride ions that are released from GIC boost remineralization mechanisms.[25]

## Minimal surgical intervention of carious lesions

Principles of minimally invasive restoration are:[26]

- Shape of cavity is dictated by the caries and unique for each carious lesion (conservative cavity preparation)
- Only demineralized enamel and infected dentine are removed, affected dentine can be left
- Macromechanical retention not required
- Undermined enamel cavity can be restored with adhesive materials.

Conservation of tooth structure using minimally invasive cavity preparations is possible because adhesive materials do not require the incorporation of mechanical retention features. Biomimetic potential including the release of fluoride, calcium and phosphate ions can be of value in enhancing remineralization potential of the carious lesion. Several materials that can be used are GIC, composites etc.

Minimal surgical intervention possibilities have been further expanded by the introduction of certain technologies.

***Atraumatic restorative treatment (ART)***[27]

It was developed in Tanzania in mid-1980's. Principles of ART are:

1. Removal of carious tooth tissues using hand instruments only
2. Restoration of the cavity with a restorative material that sticks to the tooth.

ART restorations are not different from either comparable resin-composite restorations or amalgam restorations. ART includes the absence of noise and vibration and the reduced need to administer local anesthesia.[28] Studies have shown that ART restorations in single-surface cavities in deciduous posterior teeth survive as long as comparable to amalgam restorations. ART including multiple-surface restorations in deciduous posterior teeth survives for a short period as compared to single surface restoration.

***Chemo-mechanical method of caries removal***[29]

Chemomechanical caries removal is a modified hand excavation procedure utilizing a gel which acts as a lubricant to aid in the mechanical removal of caries and exerts a chemical effect on the infected carious dentine. Chemomechanical caries removal is based on the role of sodium hypochlorite in caries removal. Sodium hypochlorite is a non-specific proteolytic agent, which removes organic components at room temperature. It has a corrosive effect, so glycine, sodium chloride and sodium hydroxide were added to minimize this effect. This addition resulted in the formation of N-monochloroglycine, which is effective in the removal of carious dentine.

***Enamel cavity***[2]

Enamel rods at fissures collect at their tops centripetally and are supported at their bottom by dentin. Consequently, if amalgam is placed in a cavity limited to the enamel layer, the filling will be supported indirectly by the surrounding dentin with no need to fear the brittleness of enamel. The advantages of enamel cavity in children are that it is painless cavity preparation, which will reduce children anxiety and minimum tooth surface loss. Hence strength of the tooth is maintained.

***Mini-box or slot type preparation***[6]

Slot preparation as advocated by Wilson and McLean, which involves the removal of the marginal ridge but do not include the occlusal pits and fissures. Proximal approach is a rather unusual design because access is dependent upon the presence of a rather large size 3 lesion in the adjacent tooth. Though unusual, it is very conservative of tooth structure and will lead to preservation of the marginal ridge.

***Air abrasion***[30]

It is a pseudo-mechanical, non-rotary technique of caries removal which was originally developed in 1945 by Dr. Robert Black. Method of tissue removal involves the transfer of kinetic energy from the incident particles, traveling in high velocity to the softened dentine surface. It is an alternative means of cavity preparation by providing a truly conservative preparation for preservation of a maximal sound tooth structure. Bonded

restorations combined with air abrasion dentistry provide truly minimal intervention dentistry.

***Lasers***[31]

Lasers have been reported to have the ability to remove hard tissue and selectively remove caries leaving healthy enamel and dentine with an ability to destroy mutans streptococci. It has various advantages i.e. selectively removes caries, seals dentinal tubules to reduce sensitivity, well tolerated by pediatric patients, no need for LA, does not leave a smear layer-better bonding and conservation of tooth structure can be done.

***Hall technique - A new method***[32]

It may be helpful in reducing the treatment burden of cavitated dentine carious lesions A metal crown, which is prefabricated, is cemented over the cavitated tooth, using a low-viscosity GI. This crown is placed only after removing debris, but without removal of decomposed carious dentine. Still more research is required before the use of hall technique.

**Repair rather than replacement of defective restoration**[33]

Replacement dentistry' leads to:

- Weakening of tooth structure by increasing the surface area of the cavity
- The increased surface area tends to make more complex form of restoration
- Larger restorations which usually have a shorter life span than their predecessors
- Possible damage to adjacent teeth.

Decision to repair rather than replace a restoration always must be based on patient's risk of developing caries, conservative approach of the repair and professional's judgment of benefit versus risk.

**Assess disease management outcomes at intervals**[34]

Recall at various intervals should be done to reduce the recurrence of caries.

## Conclusion

It is important that our profession embraces modern science and move into the new era of "MID," which is based on a large body of scientific evidence. Dental professionals hold the responsibility to upgrade clinical practice from the maximal intervention approach to the minimal intervention one. The key to success of practicing MID lies in the clear understanding of balance between pathological and protective factors. Although further research is needed, MID has the potential for dentists to apply a more conservative approach to caries treatment and simultaneously offer patients a more friendly and health orientated treatment option.

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