European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 08, Issue 03, 2021

MINIMAL INVASIVE DENTISTRY- A NARRATIVE REVIEW

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Conflict of interest statement: Nil

ABSTRACT

Background and Objectives: Scientific advances in cariology, dental products, and diagnostic systems have altered dentistry's approach to the diagnosis and management of dental caries over the last few decades. The review was undertaken to discuss the scientific rationale for early diagnosis, a modified classification of caries based on the location and size of lesion remineralization, the reduction of cariogenic bacteria, and the design, techniques, and material selection for minimally invasive cavity preparation. Materials and Methods: Literature survey was carried out in April 2021 in electronic databases such as PubMed, SCOPUS, EMBASE, COCHRANRE library, Science Direct and manually using key words such as "Minimally Invasive Dentistry," "ART," "MID," "Minimum Intervention Dentistry". The searches revealed 911 articles out of which 34 were selected after reading the full text articles. Conclusions and Practice Implications: Scientific advancements have led to the development of minimally invasive dentistry. Emerging technology will aid the transition to primary caries prevention, but there are still technological, cultural, and economic barriers to their full adoption in clinical practice.

Keywords: ART, Minimal invasive dentistry, Minimum intervention, cariology

INTRODUCTION

Minimal Invasive Dentistry (MID), a modern medical paradigm, is a conservative philosophy that decreases restorative procedure time, discomfort, and stress while also lowering patient anxiety. In order to overcome the G.V. Black's "extension for prevention" and to reduce the size of cavity preparation, the minimal intervention paradigm stresses the use of adhesive restorative materials[1]. Minimal interference philosophy was adopted in dentistry beginning with the application of silver diamine fluoride[2] to prevent and arrest caries, in early 1970s. The conservative restoration was followed by preventive resin restoration (PRR) in 1980s, and in the 1990s by atraumatic restorative treatment (ART) [1].

The medical model of caries management focuses on identifying and eliminating the caries-causing factors, alongside repairing the damage caused by caries[3]. This differs from the traditional surgical model in that the disease is treated as an infection rather than a lesion, with the goal of reducing or eliminating pathogens[4]. Using new technologies, the medical model synthesizes knowledge of the disease process into a simple conceptual model and focuses on the early stages of caries and the underlying causes of the disease [4].

Public Health Dentistry (PHD) focuses on the early diagnosis, prevention, control of dental diseases, as well as the promotion of oral health through coordinated community efforts. The Department of Public Health Dentistry (PHD) provides services to the community through advanced scientific knowledge, health promotion, education, and dental care programmes. Therefore, PHD is the logical dental specialty to be at the forefront of the dissemination of the new approach to caries management.

Despite the advent of MID to caries care and the leading role of Public Health dentists in advocating prevention, no published studies have evaluated the awareness, attitudes, or behaviours of public health dentists regarding MID.

The review highlights the techniques for early caries diagnosis and assessment of caries activity; the classification of caries depth and progression using radiographs; the assessment of individual caries risk; the reduction of the risk of further demineralization; arresting of active lesions; and the remineralization and monitoring of active lesions.

MATERIALS AND METHODS

Search strategy:

A literature survey was carried out in various electronic databases in April 2021 to identify the articles required for review on Minimal Invasive Dentistry. MeSH terms/keywords such as “Minimal Invasive Dentistry,” “ART,” “MID,” “Minimum Intervention Dentistry” were used to search in the electronic databases such as PubMed database, SCOPUS, EMBASE, COCHRANRE library, Science Direct and a manual search was also done using the cross

references and textbooks. Articles published in English language from 2000 to April 2021 which fulfilled the objectives of the study were included.

Article selection criteria: The articles required for the review were selected based on the inclusion and exclusion criteria. Quality assessment was also carried out to select the articles required for this review.

Inclusion principles:

1. Studies on characteristics of Minimally Invasive Dentistry.
2. Studies on ART
3. Studies on Minimum Intervention
4. Clinical trials, randomized controlled studies, Investigative reports.

Exclusion principles:

1. Animal based studies
2. Narrative reviews on Minimally Invasive Dentistry.

The searches revealed 911 articles out of which 109 were selected after reading the titles and abstracts. 12 articles were added from hand searching to obtain a total of 81 articles. After reading the full text articles and applying the inclusion and exclusion criteria 34 articles were selected for the review fulfilling the criteria of the study.

HISTORICAL BACKGROUND

The use of silver diamine fluoride[2] as a minimally invasive procedure in dentistry was pioneered in the early 1970s. Soon after, many innovations came forth with the objective of prevention of caries. In the 1980s, preventive resin restoration (PRR)[5] was developed, followed by atraumatic restorative treatment (ART)[6] in the 1980s, and chemo-mechanical caries removal concepts[7] in the 1990s. The ultraconservative treatment concepts used in MID, as seen in Figure 1, are used to conserve as much tooth tissue as possible while also providing more patient-friendly care to anxious patients. Preparation to achieve cavity access and excavation of contaminated carious tooth tissue by selective caries removal or laser treatment[8-10], as well as cavity restoration using ART, PRR, or sandwich restoration treatment protocols[5,6] are all examples of minimal invasion. MI restorations are typically smaller and procedures are known to be relatively painless, even without the need for local anesthetics, as compared to conventional amalgam care. However, computer-controlled local anesthetic delivery systems[11] can be used to administer local anesthesia in a less invasive manner. Restorations that have failed are restored rather than replaced[12,13].

The Extended- Ecological Plaque Hypothesis, as shown in Figure 2, explains the disease mechanism by demonstrating the relationship between acidogenic and aciduric shifts in the composition of dental biofilm microflora and changes in the mineral balance of dental hard tissues[14].

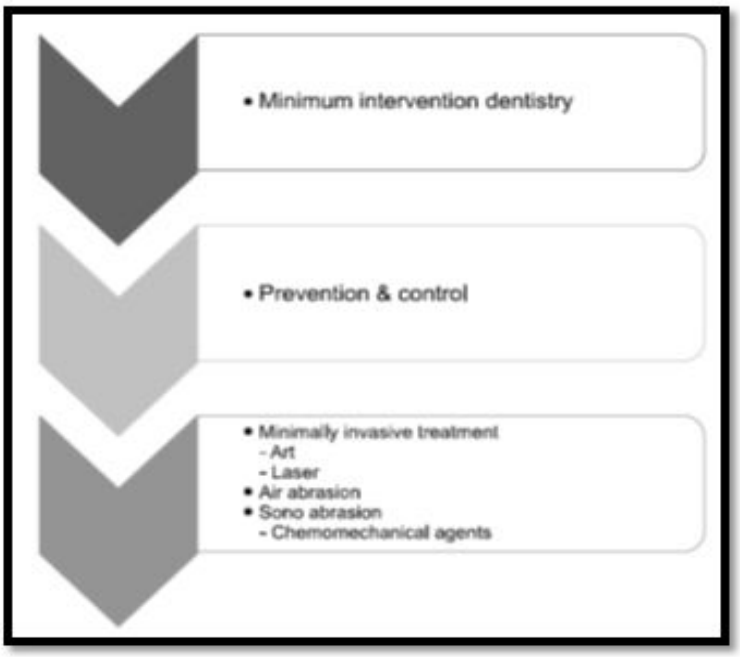


Figure 1: Ultraconservative treatment concepts in MID.

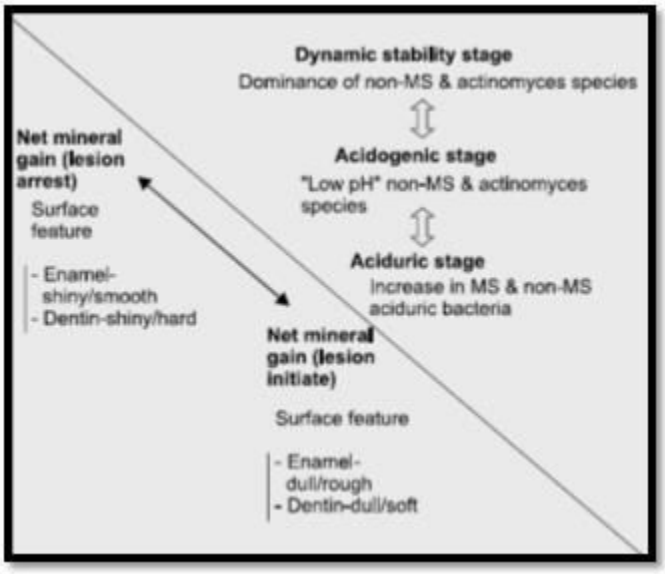


Figure 2: Extended ecological plaque hypothesis.

An important concept, that governed the development of MID, is the 'Repeat Restoration Cycle'. The definition emphasized the importance of combining preventive or non-operative actions with restorative treatment, as well as the importance of assessing carious lesion growth and progression in providing appropriate oral health care. The invention of various adhesive materials and adhesive systems has greatly aided in the achievement of MID's primary goal. When compared to conventional restorative concepts, the potential to minimize the need for

cutting away healthy tooth tissues when using adhesive materials has resulted in much smaller and less destructive cavity preparations[15].

By the early 1990s, studies had shown that instead of using a conventional surgical approach, dentists should use a "biological" or "medical" approach to treat dental caries. The findings suggested a radically new approach to carious lesion management. Mount was the first to mention the need for 'Minimal Treatment' of dental caries, as far as we know. Davis and Makinson[16,17], who coined the word "Minimal Intervention Dentistry" in the literature, went on to expand on this new approach. The first International Association for Dental Research (IADR) symposium on minimal intervention techniques for dental caries was held in 1995 and was almost entirely devoted to the developments of one of the MID approaches, namely Atraumatic Restorative Treatment (ART)[18].

BENEFITS OF CONSERVING TOOTH SURFACE

Traditional or surgical treatment is used to handle caries at the tooth level, while the medical model of treatment is used to manage caries at the total patient level[19]. Carious lesions and tooth preparations were identified by G.V. Black according to their position in permanent teeth[20]. This classification defined a set of designs based on the needs for specific restorative materials[21].

These models promoted a surgical approach in which carious lesions were removed entirely and the tooth preparation was expanded into caries-resistant areas[13]. Dr. Black's definition did not take into account the scale and complexity of the lesion, so it might no longer be applicable to today's caries challenges[22].

Despite recent advancements and research in the field of minimally invasive dentistry, it has yet to gain widespread acceptance among private practitioners due to cost-effectiveness, patient attitudes, and technique-sensitive tools. There are new advanced technologies and instruments available for detecting caries at an early stage, but the findings of these tools vary from one clinician to the next due to technique differences. Air abrasion had a variety of disadvantages. It is, however, still in operation. But it also demonstrates improved enamel bonding.[23] Also, local anaesthesia is not needed for preparation that extends into the dentin and patients experience less discomfort as a result of the reduced sound and vibrations.[24] Since adhesive dental materials do not involve the inclusion of mechanical retentive features, it is possible to preserve tooth structure with minimal cavity preparation. GICs have the advantage as it is adhesive to the tooth structure and is anticariogenic as well due to the release of fluoride ions. Its brittle property, on the other hand, decreases when used alone. Combination of resin based composites and GICs called lamination or sandwich technique takes advantage of physical properties of both.

CONCEPT OF MINIMUM INTERVENTION

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[12].

Preservation of natural tooth structure should be the guiding factor. Cavity preparation design and restorative material selection must 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. 3).

Restorations are not placed (or replaced) until the disease is under control. First, infection management is implemented, and then the caries risk status and proof of lesion remineralization can be tracked over time. To stop demineralization and start remineralization, bacteria that produce demineralizing acids should be monitored. The change in the size of caries lesions and white spot lesions, for example, must be tested to see if infection control is successful. A appropriate classification[1] for assessing radiographic changes in proximal radiolucencies 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

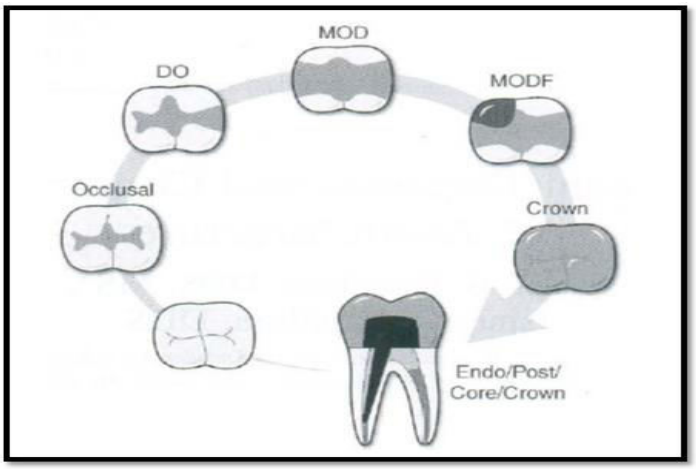


Figure 3: Life cycle of restored tooth

E0 refers to a tooth or surface that is free of caries. MID aims to empower patients by providing them with knowledge, skills, and inspiration about their own oral health so that they much invasive procedures can be prevented. MID has the ability to take a less invasive, health-oriented approach to caries care while still providing patients with less invasive, health-oriented treatment options[25].

MID for dental caries is classified into two major categories. The first is Caries Risk Assessment (CRA), which focuses on disease-causing causes, and the second is restorative, which focuses on maintaining and conserving tooth structure in order to reduce the irreversible effects of caries in terms of tooth structure breakdown.[26] As soon as caries is detected, we will recover and conserve as much as possible using a minimalist approach in the restorative process. A range of technologies, such as a caries detector dye, CAMBRA risk assessment tool, plaques and saliva test, loupes, laser fluorescence and auto fluorescence, electric current/ impedance, tomography imaging, and image processing, are used in processes aimed at detecting carious lesions in the early stages with the highest sensitivity and specificity.[27] Since this is such a crucial phase in the MID, clinicians should allot enough time for a thorough examination. Caries risk assessment is a vital step of the procedure that should be given enough time.[28]

MATERIALS

Since adhesive dental products do not have mechanical retentive features, tooth structure may be preserved with minimally invasive cavity preparations. Some of the products that can be used are glass ionomer cements, or GICs; resin-based composite/dentin bonding agents; and a layered mixture of resin-based composites and GICs applied with a method called lamination[1].

Glass ionomer cements.

Advantages of GICs

- It includes adhesion to tooth and release of fluoride and other ions.
- They perform well in low stress areas.
- GICs release fluoride, calcium and aluminum ions into the tooth and saliva.
- Also, set glass ionomer is “rechargeable,” meaning it can take up fluoride from the environment, which is provided by exposure to fluoride treatments and toothpaste.
- Theoretically, this fluoride uptake and slow release can have an anticariogenic effect, though clinical studies have not proven it to be clinically significant.

Disadvantages of GIC

- It includes technique sensitivity.
- The handling properties and brittleness of the material can be overcome by adding resin to the material.
- The resulting resin-modified glass ionomer cements, or RMGICs, are easier to place, are light-cured, and have improved esthetic qualities.
- GICs and RMGICs are appropriate for cervical restorations, fissure sealants, proximal lesions in anterior permanent teeth and proximal lesions in anterior and posterior primary teeth

Resin-based composite/ Dentin Bonding Agents.

The ability of resin to adhere to enamel is a critical consideration in the selection of these products. Cavity preparations that preserve as much enamel as possible will reduce the need for macro mechanical retention. Though etching dentin and enamel and forming a hybrid layer have improved bond consistency, polymerization shrinkage and marginal leakage remain a problem when margins are in dentin, but technology is constantly improving. Newer flowable resin-based composites have a low viscosity and are often used in preventive resin-type preparations and class V cavities[1].

Lamination.

The sandwich procedure, also known as lamination, takes advantage of both the GIC and the resin-based composite's physical properties. Because of its adhesion to dentin and fluoride release, the GIC is placed first. The GIC is then laminated with a resin-based composite for better occlusal wear or aesthetics[1].

Cavity Designs for Minimal Intervention[29]

Cavity design principles

1. Gaining access to the body of the lesion without being destructive
2. Removal of tooth structure that is infected and incapable of regeneration
3. Avoiding the exposure of dentine unaffected by the caries process
4. Retaining and reinforcing sound, but undermined enamel
5. Reducing perimeter of the restoration
6. Keeping the margins of the restoration away from the gingiva
7. Reducing occlusal stress on the final restoration.

Designs of cavity preparations

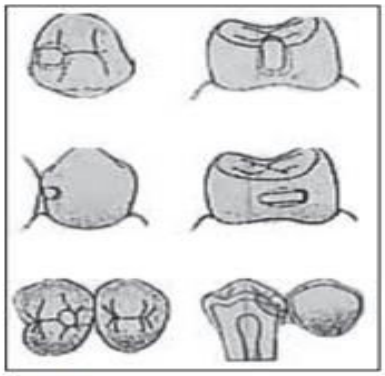
Specific designs for approximal lesions:

I. Tunnel preparation

II. Microchip cavity preparation

III. Minibox cavity preparation

IV. Full box cavity preparation.



Designs of cavity preparations

Rotary – high/low speed

Though the rotary bur is in universal use, there are still problems that need to be overcome. Five factors are potentially responsible for discomfort and pain associated with cavity preparation.

1. The sensitivity of vital dentine
2. Pressure on the tooth (i.e. Mechanical stimulation)
3. High pitched noise of air turbine handpiece and
4. Development of high temperature at the cutting surface (i.e. thermal stimulation).

RECENT ADVANCES IN MINIMALLY INVASIVE DENTISTRY

Caries management techniques have progressed well beyond "drilling and filling" tooth, which does little to stop the underlying disease mechanism. Silver diamine fluoride (SDF), the most recent addition to the caries prevention arsenal, was approved by the US Food and Drug Administration (FDA) in 2014 to treat tooth sensitivity and entered the market in 2015.If a patient will not be able to return for subsequent dental care for any reason, it is preferable to use a minimally invasive procedure rather than nothing at all, placing SDF and GIC on the same appointment is particularly useful. By placing a chemically sealed restoration that will arrest and remineralize the caries lesion, maintaining tooth structure and improving pulp vitality, you destroy bacteria and cut off the nutritional supply for any remaining bacteria [30].

The preventive aspect includes numerous remineralizing agents, such as fluorides, xylitol, nanohydroxyapatite, and other calcium and phosphate based remineralizing agents; however, in order to achieve a biomimetic remineralization, the long-standing use of calcium-phosphate based remineralizing agents ceased, and newer agents, such as P11-4, Bioactive Glass, emerged in the preventive field.

When topical fluoride is used, low levels of calcium and phosphate will slow down the remineralization process. Casein phosphopeptide–amorphous calcium phosphate complex (CPP-ACP) is a calcium phosphate complex made up of casein phosphopeptide and amorphous calcium phosphate. CPP casein has the ability to adapt to an acid-base environment. ACP separates from CPP at an acidic pH, resulting in a rise in calcium and phosphate levels in saliva and aiding in the maintenance of a state of supersaturation with respect to the site. The CPP-ACP complexes have been shown to prevent demineralization and enhance remineralization in the presence of fluoride. CPP-ACPF, which contains 0.2 percent F, has been shown to have a higher remineralization potential than CPP-ACP.

A calcium and phosphate-dependent remineralizing agent based on Anticay technology is made up of a mixture of calcium sucrose phosphate and inorganic calcium phosphates, containing 10-12 percent calcium and 8-10 percent phosphorous by weight. On the tooth surface, calcium and phosphate ions are easily adsorbed. By virtue of their common ion influence, these ions are primarily responsible for the remineralization of tooth enamel. The phosphate ion of sucrose slows the acid degradation of hydroxyapatite and prevents tooth enamel demineralization [31].

Glycine-guided remineralization mimics the natural biomineralization process, which results in the formation of well-oriented rod-like hydroxyapatite crystals that restore the mechanical properties of demineralized enamel. When xylitol is added to the demineralized surface of enamel, it releases calcium and phosphate into the saliva, which prevents acid production by reducing bacteria fermentation. This causes saliva to be stimulated, and the increased pH of saliva remineralizes the carious lesion. By disrupting their energy production processes, xylitol lowers the levels of mutans streptococci (MS) in plaque and saliva, resulting in cell death.

Novamin's chemical name is calcium sodium phosphosilicate. It's a bioactive glass made up of minerals contained in the human body that responds when it comes into contact with saliva, water, or other bodily fluids. This formula is used in varnish, toothpaste, and root desensitizer products, and it is available in varnish, toothpaste, and root desensitizer form[32].

Titanium ions readily hydrolyze H_2O, releasing proton (H+) and lowering the pH of the solution. The strong propensity to form titanium phosphate complexes is due to the affinity of titanium ion for oxygen[32].

Resin infiltration technology, when combined with a comprehensive caries remineralization programme, provides therapeutic benefits while also lowering long-term restorative costs and needs, thereby complementing the minimal intervention dentistry principle. The RI/CR method improves the initial consistency of fissure healing and is recommended for occlusal caries clinical monitoring.

TCP has the chemical formula $Ca_3(PO_4)_2$ and comes in alpha and beta forms. In an aqueous oral setting, it is relatively insoluble. The organic coating prevents fluoride interactions, but it dissolves as particles come into contact with saliva.

Nano-hydroxyapatite (n-HAp) is a biocompatible and bioactive substance that has recently gained widespread acceptance in medicine and dentistry. Nanoparticles have a morphology and crystal structure identical to apatite crystals found in tooth enamel. When nanohydroxyapatite and $ZnCO_3$ are combined, they have a similar effect.

In toothpaste, enamelon is made up of unstabilized calcium and phosphate salts, as well as sodium fluoride. Enamelon™ has a technical issue in that phosphate and calcium ions are unstabilized, allowing two ions to combine into insoluble precipitates until they touch enamel or saliva.

Bioactive Glass air abrasion is a careful method of removing only the decalcified tissues of the teeth while maintaining tooth structure by mineral release. The abrasive particles interfere with the carious lesion, speeding up the remineralization process.

Chemo-mechanical caries removal relies on the application of a selective reagent that degrades and partially solubilizes the tooth's damaged dentin collagen. This approach has been explained for the care of patients who are looking for alternatives to traditional approaches. The violet light (370–420 nm) that is fed into the fiberoptics of a slow-speed handpiece illuminates the operating field during excavation in Fluorescence Aided Caries Excavation. The orange-red

fluorescence-producing areas are then selectively removed. In a darkened space, an operator observes these areas through a 530 nm yellow glass filter.

Dentinal caries are selectively removed using polymer burs and lasers. When these polymer burs approach sound dentin, they self-limit, retaining the sound tooth structure and thus being referred to as "dentin protected." For selective dentine caries elimination, smart-prep polymer burs are a relatively new and naval launch.

The ultra-conservative access cavity training, such as the NINJA endodontic cavity (NEC), is used in minimally invasive endodontics. In the conservative endodontic cavity (CEC) preparation, the premolar and molar teeth were accessed in the same way as in the NEC preparation. The chamber roof is kept as clean as possible here. On the occlusal plane, the access NINJA outline is derived from the oblique projection of the root canal orifices towards the central fossa. Since the endodontic access is parallel with the enamel cut at 90^0 or more to the occlusal table, it is possible to locate all of the root canal orifices from various visual angulations.

CONCLUSION

Minimally invasive dentistry necessitates a change in mindset when it comes to treating dental caries[29]. Caries can be avoided at an early stage by interrupting the disease process prior to cavitation by suppressing bacteria, improving the oral condition, and using fluoride and sealants to protect the teeth.

Minimally invasive procedures and materials should be used to preserve sound tooth structure because the carious process cannot be reversed. The new treatment modalities allow us to preserve as much healthy tooth structure as possible during caries removal. While further research is required, it can currently be concluded that Minimum Intervention has the potential to provide a more conservative approach to caries treatment as well as a health-oriented treatment choice. An astute dentist should use MID principles to handle dental caries conservatively while still providing patients with a more patient-friendly and health-oriented care choice for successful management. The aim is to make a transition from “Extension for Prevention” to “Prevention of extension”.

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