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Application of Modern Technology in Minimal Invasive Dentistry - A Narrative Review



Abstract: - Preserving human anatomy and physiology is the ultimate goal of all health-related endeavours. The conservation of healthy tooth structure is the goal of minimal-intervention dentistry. The concept of "minimum/minimal intervention dental care" first appeared in the early 1980s. From its origins in general medicine, the minimum intervention philosophy in dentistry was created, focusing patient-oriented oral and dental care to prevent and treat oral disorders and maintaining overall oral health. A more conservative approach to tooth preparation and restoration in operative dentistry is called minimally invasive restorative dentistry. This terminology is relatively new. It comprises prompt identification prior to the onset of cavitation, sealing fissures and pits in uninfected areas, fluoride administration, minimum surgical repair of carious lesions, caries risk evaluation, and patient education regarding self-care. A wide range of methods are used, from initial identification of any demineralized tooth structure to evaluation and therapy, including air abrasion, laser cavity preparation, chemo-mechanical caries removal, and hand instrumentation. Adopting the current advanced method requires sufficient knowledge. The trio that comprises tissue histology, dental biomaterials science and professional patient care and management of materials are considered by the "golden triangle" of minimally invasive treatment options for dental caries in order to enable the successful application of minimally invasive dentistry in all patients. The term "minimal intervention dentistry" (MID) was first used in the early 2000s in a policy statement. Maintaining the greatest amount of healthy tooth structure and keeping teeth functional for life are the goals of MID. This approach is endorsed by the World Dental Federation (FDI) as the modern approach to dental caries management.

Keywords: minimal intervention dentistry, golden triangle, dental caries

I. INTRODUCTION

Numerous investigations are underway globally to identify avant-garde tools and methodologies that will yield advantages for both patients and dentists. To ensure universal access to superior healthcare, ongoing medical and dental research endeavors persistently seek innovations to enhance accessibility and diminish the invasiveness of procedures. The umbrella term "minimally invasive dentistry" encapsulates the entirety of this multifaceted domain [1].

Minimal Intervention Dentistry (MID), also known as micro dentistry, represents a modern medical methodology for caries management, employing caries risk assessment and emphasizing early prevention and intervention to proactively address issues at their inception. The overarching objective is to promptly mitigate dental concerns, adhering to the proverbial principle of "nipping the evil in the bud" [2].

The foundational tenets of Minimal Intervention Dentistry (MID) encompass prompt diagnostic measures, disease prevention, and judicious surgical intervention. The primary objective of the MID technique is to sustain tooth functionality for an extended duration. Facilitating the preservation and remineralization of dental structures, MID entails the selective removal of irreversibly denatured and heavily infected dentin tissue. The predominant bacterial aggregation resides in the soft, moistened decayed dentin lesions, necessitating meticulous excavation.

This excavation process should be pursued until the point where the tissue attains a discernible hardness, signifying the presence of demineralized dentin with the potential for remineralization [3].

Redirecting focus from dental restoration allows for optimal intervention with minimally invasive procedures [2]. The evolution of cavity preparation concepts has markedly surpassed the prescribed principles articulated by Dr. G.V. Black, widely acknowledged as the progenitor of operative dentistry. Dr. Black's renowned axiom advocating "extension for prevention" in the excavation of caries lesions necessitated the removal of intact dental tissues for

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retentive purposes. This methodology, deemed imperative during its era due to constraints imposed by the then-available dental materials and an incomplete comprehension of dental caries disease, is now regarded as a detrimental approach in contemporary caries management [3].

Dental caries is now regarded and addressed as an infectious condition rather than being perceived as a mere byproduct thereof, particularly within the framework of minimally invasive dentistry. Contemporary dental practices have transitioned from the erstwhile radical approach of "extension for prevention" to the more nuanced strategy of "constriction with conviction" [4].

II. GOLDEN TRIANGLE OF MID

The comprehensive oral healthcare team adopts a minimum intervention care approach, prioritizing prevention and patient-centered care plans, while meticulously managing patient expectations to ensure enduring oral health. Dental caries, a malady associated with lifestyle choices, necessitates the patient's active engagement in its control, with the support of the dental profession. This comprehension holds paramount significance for both patients and dental practitioners. Complete team involvement is imperative, encompassing the practice manager, therapist, hygienist, nurse (a trained oral health educator), and receptionist. Each team member should actively reinforce the dentist's personalized, long-term preventive care recommendations. Figure 1 delineates the interconnected phases of the minimum intervention care plan [5].

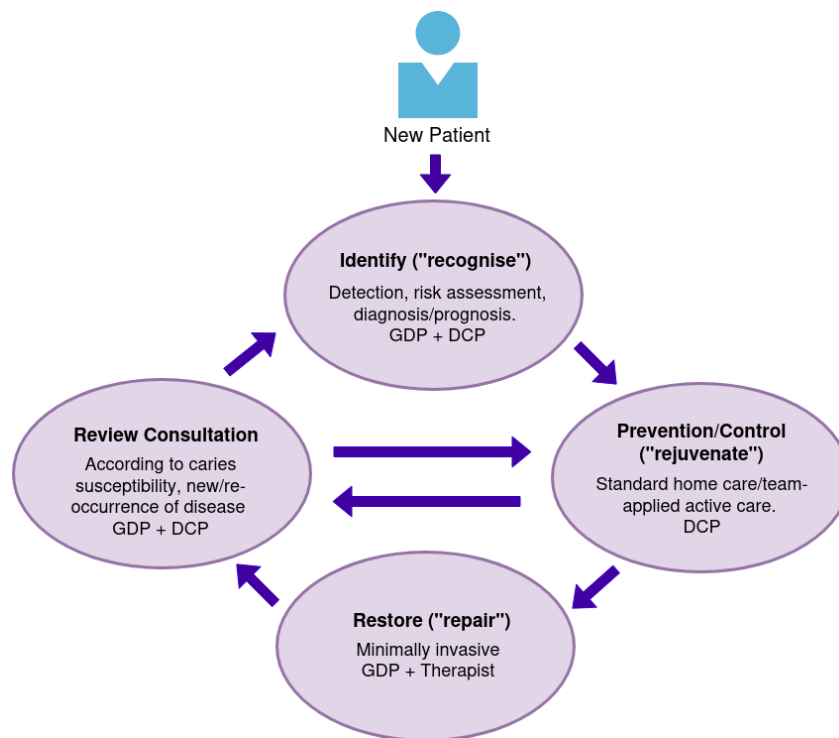


Figure 1: The directional orientation of patient progression within this cycle is denoted by an arrow, while each bubble encapsulates a roster of potential dental team constituents. Dental Care Professionals (DCP), encompassing individuals with specialized training in oral health education, such as nurses, hygienists, therapists, practice managers, and reception staff, constitute integral components of this framework.

The incorporation of MI (Minimal Intervention) dentistry within the broader framework of a comprehensive care plan is illustrated in Figure 1. Substantial progress has been made in comprehending the histopathological alterations occurring progressively in carious dental tissues, the delicate balance between demineralization and remineralization, the impact of the dentine–pulp complex on healing the demographics and spatial distribution of bacteria, and their collective contributions to the etiology and progression of caries [5].

The amalgamation of this knowledge with the progress in advanced adhesive, sealing, and potentially even "healing," "biomimetic" restorative materials implies that the management of caries may not indispensably demand

a paradigm akin to the treatment of gangrene, entailing complete surgical excision along with a substantial healthy margin. This departure from the traditional belief underpinning operative caries management protocols heralds a shift in perspective [5].

Encouraging the remineralization of carious tissues and adopting a biologically selective approach for caries removal upon detecting ongoing progression should be established as standard practice. This stands in stark contrast to the iatrogenic creation of overprepared, standardized cavity shapes, with their sizes dictated by the physicomaterial properties of conventional restoration materials. It is imperative to consider the "golden triangle" of MI operative caloric management, as illustrated in Figure 2. The synergistic combination of the three factors outlined therein is essential for the effective implementation of Minimal Intervention (MI) dentistry across all patient cases [5].

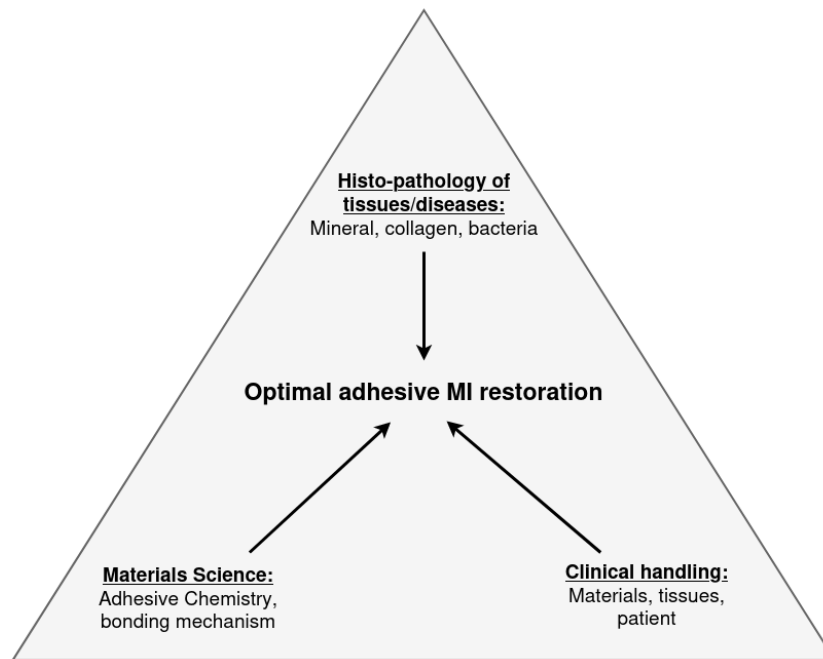


Figure 2: The proficient execution of minimally invasive operative caries management hinges upon a comprehensive comprehension of the 'golden triangle.' The successful and dependable placement of adhesive restorations is contingent upon a thorough understanding of the intricate interplay among three pivotal factors.

A. Banerjee's "Golden Triangle" of Minimally Invasive Dentistry (MID) underscores the equal significance of three pivotal elements in achieving successful minimally invasive restorations. These elements encompass the histopathology of the dental tissue requiring attention, the scientific principles governing materials (specifically bonding and adhesion mechanisms), and the dentist's clinical approach to patient treatment. The interplay of these factors within an equilateral triangle forms the foundation for optimal outcomes in MID procedures [6].

Comprehending these components will enable the dentist to embrace a biological approach to operative caries management, as practiced by contemporary oral physicians. This stands in contrast to the surgeon's mechanical endeavors in cavity preparation, wherein the predetermined shape is predominantly influenced by the properties of the chosen restorative material, rather than accurately reflecting the histopathology of the disease process and the preservation of tooth substance [7].

III. PREVENTION AND MID

A century ago, dental caries, akin to periodontitis, was perceived as an infectious malady. Due to its pervasive dissemination, unmanageable attributes, and the absence of proficient diagnostic tools and therapeutic alternatives, the predominant modality for addressing these dental afflictions entailed tissue excision. The transition from a surgical paradigm to preventive and minimally invasive dental methodologies has been facilitated by advancements

in operative techniques, technological innovations, and material sciences, coupled with an enhanced comprehension of the diseases and discernible shifts in their prevalence, scope, and severity [8].

Over the course of time, the maintenance of optimal dental hygiene, coupled with the utilization of natural implements such as "miswak" dating back to ancient eras, emerged as the primary defensive measure against various oral lesions. Subsequently, with advancements in chemical understanding, the potential of fluoride as a preventive agent found application in diverse forms, initially manifesting in mouthwashes and toothpaste. By 1984, an overwhelming 94% of oral care products incorporated fluoride for caries prevention.

The strategic initiative to fluoridate public drinking water aimed at ensuring accessibility across diverse nationalities and socioeconomic strata. This concerted effort resulted in a marked reduction in the epidemiology of dental caries during the 1980s. Furthermore, the integration of fluoride into cooking salt expanded the reach of preventive measures.

As time progressed, additional preventive techniques gained prominence, including the application of sealants and alternative fluoride delivery methods such as dietary supplements, fluoride gel, foam, varnish, and paste. Rigorous studies were conducted to validate the efficacy of these strategies within adult populations. In the realm of preventive oral care, non-fluoride chemical agents, namely chlorhexidine (present in mouthwash and varnish), xylitol (featured in candies, lozenges, and chewing gum), and polyol (incorporated into chewing gum), were also deployed [9].

An increasing number of dental professionals are directing their attention toward the prevention of dental caries by employing diverse strategies, including the eradication of caries-causing bacteria, dietary modifications, and enhancement of dental resilience against decay [10].

Before diagnosing active yet non-cavitated carious lesions, it is imperative for the clinician to meticulously assess the disease's extent and caries risk. Subsequently, the formulation of a patient-specific preventive plan takes precedence, with a particular focus on arresting caries and impeding its progression. The dentist is afforded the discretion to choose from a spectrum of non-invasive procedures, such as fluoride varnish, silver diamine fluoride (SDF), resin infiltration, and pit and fissure sealants, tailored to the specific needs of each case. In instances where cavitated lesions are active, the implementation of minimally invasive interventions may become imperative [11].

Focused on preserving dental structure to the greatest extent, minimal intervention dentistry prioritizes diagnosis, prevention, and employing less invasive procedures [12].

The foundational principles of minimally invasive dentistry encompass the following core concepts:

Recognition: Swift identification and assessment of potential risk factors associated with dental caries.

Regeneration: Application of appropriate techniques to arrest and reverse incipient lesions effectively.

Reduction: Mitigation or elimination of caries risk factors through lifestyle modifications and enhancement of the oral environment.

Repair: Utilization of conservative caries removal methods to preserve and restore tooth structure. [2]

IV. MINIMAL INTERVENTION TREATMENT PLAN (MITP)

The MITP framework encompasses four primary stages of patient-centered treatment. The initial stage involves MI identification, which includes a comprehensive assessment of the patient's disease experience, etiology, and individual risk factors. Subsequently, MI prevention focuses on averting the loss of tooth surface integrity and further disease progression. The third stage, MI restoration, emphasizes the application of non-invasive and minimally invasive therapies. Figure 3 provides a visual representation of the MITP framework. Notably, the fourth and critical stage is the MI recall phase, essential for sustaining oral health at a level tailored to the patient's specific requirements. This phase can be incorporated at any point during the treatment cycle, guided by the individual's ongoing oral health needs [13].

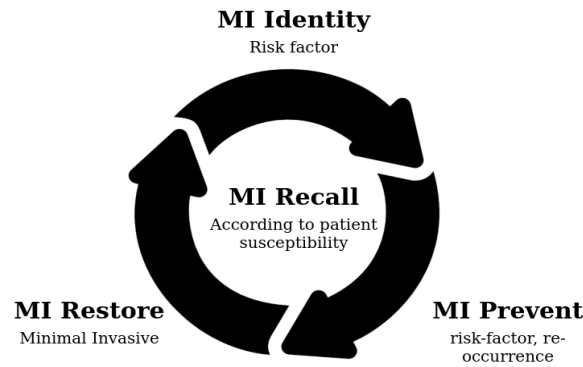


Figure 3: The Minimal Intervention Treatment Plan follows a patient-centered management cycle, allowing recall to be incorporated as needed for individual patient requirements.

A comprehensive flowchart detailing the practical implementation of MITP, aimed at enhancing the clarity and ease of understanding patient-centered management pathways for both dental teams and patients is illustrated in Figure 4 (13). Prior to implementing any form of intervention, be it primary or secondary such as restoration or replacement, it is crucial to ensure that the caries lesion undergoes a healing process and the disease is effectively brought under control. Without addressing ongoing disease activity, substitutive measures prove ineffective. Managing MI at the micro or molecular level begins with halting bacterial activity and rectifying reversible carious lesions. Various treatment techniques, including cavity sealing through chemical material adhesion, utilization of substances like triclosan, diammine silver fluoride, and chlorhexidine, are applicable for controlling bacterial activity [10].

Once successful disease control is achieved, the focus shifts to addressing mineral loss from the hard tissues of the teeth and restoring equilibrium between de- and remineralization processes on the tooth surface. This involves implementing both "internal remineralization" within cavity walls and "external remineralization" on the tooth surface. Remineralization requires conditions such as the presence of water, a pH exceeding 6.5, and the availability of minerals like phosphate and calcium. Augmented saliva flow, achievable through increased fluid intake and the use of sugar-free chewing gum, is vital for tooth surface remineralization. Effective dental hygiene practices and dietary modifications play a pivotal role in mitigating acidic environments and normalizing pH levels by limiting substrate availability for bacterial metabolism [10].

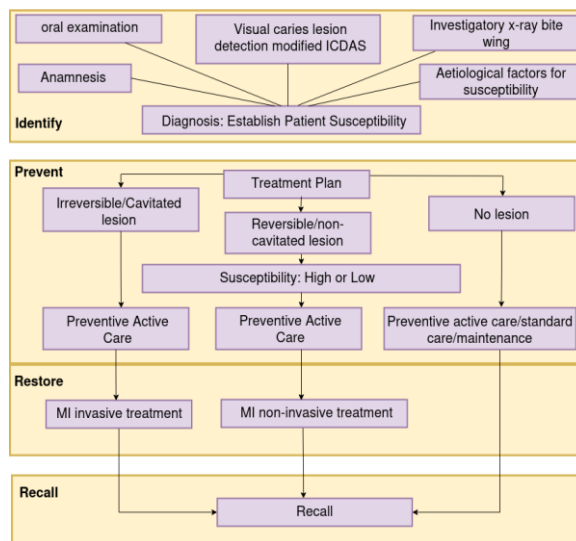


Figure 4: Shows treatment of Minimal Intervention Dentistry.

Dentifrices containing fluoride and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) can facilitate mineral replenishment. In cavity walls, the primary method of remineralization involves applying a therapeutic

biomimetic filler, such as glass ionomer cement (GIC). GICs, owing to their hydrophilicity, ensure a consistent release of fluoride and minerals, coupled with an effective seal due to chemical adhesion. During the caries treatment phase, recurrent patient recalls for diagnostic measurements, monitoring, and patient motivation may be imperative. Treatment should persist until bacterial infection is controlled, and reversible carious lesions have fully healed. Subsequently, patient-friendly and minimally invasive treatment options can be employed to address irreversible structural and functional loss, once the status of "absence of disease" has been attained [10].

V. TECHNIQUES OF MID

- Mechanical Rotary High/Low-Speed Bur
- Atraumatic restoration
- Air abrasion
- Sono Abrasion
- Air Polishing
- Laser
- Chemomechanical agent
- Pit and fissure sealant
- Ozone Technology

A. Mechanical Rotary High/Low-Speed Bur:

- Description: Traditional dental burs, operated at either high or low speeds, are used to remove decayed or damaged tooth structures [14].
- Benefits: Precise and efficient removal of affected areas while minimizing impact on surrounding healthy tooth structure.

B. Atraumatic Restoration:

- Description: This technique emphasizes gentle procedures and materials to preserve tooth structure. It may involve minimally invasive cavity preparations and adhesive restorative materials [18].
- Benefits: Reduced trauma to the tooth, often allowing for the preservation of more natural tooth substance.

C. Air Abrasion:

- Description: Utilizes a stream of abrasive particles propelled by compressed air to remove decay or prepare a tooth for restoration [19].
- Benefits: Minimal noise and vibration, reduced need for anesthesia, and preservation of healthy tooth structure.

D. Sono Abrasion:

- Description: Involves the use of ultrasonic vibrations to remove decayed tooth structure without generating heat [20].
- Benefits: Reduced discomfort, precision, and preservation of healthy tooth structure.

E. Air Polishing:

- Description: Utilizes a high-pressure stream of air and fine particles (usually sodium bicarbonate) to remove stains, plaque, and biofilm from tooth surfaces [21].

- Benefits: Effective cleaning with minimal impact on tooth structure.

F. Laser:

- Description: Involves the use of laser energy for various dental procedures, such as cavity preparation, soft tissue treatment, and teeth whitening [17].
- Benefits: Precision, reduced discomfort, and in some cases, a decreased need for anesthesia.

G. Chemomechanical Agent:

- Description: The use of chemical agents to selectively dissolve decayed tooth structure [16].
- Benefits: Conservative removal of decay without the need for drilling.

H. Pit and Fissure Sealant:

- Description: Application of a thin protective coating (usually a resin material) to seal the natural pits and fissures of teeth, preventing decay [15].
- Benefits: Prevents the initiation and progression of decay, avoiding the need for more extensive restorations.

I. Ozone Technology:

- Description: Utilizes ozone gas to disinfect and treat dental caries [10].
- Benefits: Non-invasive and can arrest early-stage decay, promoting remineralization.

VI. CONCLUSION

In 1896, Dr. Black foresaw a transformative era in dentistry, one where the focus would shift from repairing dental issues to preventing them – a prophetic vision that has now materialized. The imminent years are poised for a significant paradigm shift in dentistry, marked by the crucial theme of "Change." Recognizing that recurrent caries remains the primary cause of restoration failure, there is a compelling need to redirect clinical attention from the art and science of restoring decayed teeth to proactive disease prevention and early interception [2].

Attempting to precisely replicate natural tooth structure over the long term is deemed impractical, emphasizing the importance of preserving it to the greatest extent possible. While the acronym CAMBRA encapsulates one approach through Caries Management by Risk Assessment, the contemporary concept of Minimal Intervention Dentistry (MID) integrates both maximal intervention and minimally invasive treatments. However, the effective implementation of these technological advancements necessitates comprehensive retraining for clinical dentists, reshaping the way they approach diagnosis, intervention, treatment, and disease management [3].

Simultaneously, there is an equal imperative to educate the public on the advantages of modern diagnostic methods, preventive measures, remineralization, minimal intervention, and repair, in contrast to traditional restorative procedures. The long-term biological and financial savings for patients underscore the significance of disseminating this knowledge, as the landscape of dentistry undergoes a transformative evolution [2].

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