



The Promise of Minimally Invasive Dentistry for dental caries: A Review

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التدخل المحافظ لعلاج التسوس في الاسنان :مراجعة

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الخلاصة

تتطوي رعاية الأسنان غير الجراحية التي تتسم بالحد الأدنى من التدخل على "احترام منهجي للأنسجة الأصلية". وهذا يشير إلى أن مجتمع طب الأسنان يدرك أن الأنسجة الصحية الأصلية لها أهمية بيولوجية أكبر من الأداة الصناعية. يمكن تطبيق فكرة طب الأسنان الحد الأدنى من التدخل على كل جانب من جوانب هذا المجال. يعد الحفاظ على الأنسجة، من الناحية المثالية عن طريق تجنب المرض وإيقاف تقدمه، ولكن أيضًا عن طريق الإزالة والاستبدال مع الحد الأدنى من فقدان الأنسجة، هو العنصر المشترك. لا يُوصى بإزالة الأضرار الثالثة المدفونة التي لا تظهر أعراض جراحياً أو إجراء حشوات صغيرة لإصلاح الآفات البادئة كأعمال قياسية. لقد زادت الاهتمامات بطب الأسنان الحد الأدنى من التدخل بشكل كبير منذ ظهور تقنيات اللصق الموثوقة. تملأ هذه الفكرة الفجوة بين العمليات الجراحية والوقاية، وهو ما يحتاجه طب الأسنان في العصر الحديث إن البحث الذي يدعم قابلية بقاء الترميمات يُظهر بوضوح أن ترميم الأسنان هو حل مسكن قصير الأمد سيفشل إذا لم يتم علاج المرض الأساسي بشكل كافٍ. على الرغم من وجود إمكانيات ودوافع وموارد لطب الأسنان الأقل تدخلاً اليوم، إلا أنه لا توجد حوافز كافية بلا شك. يبدو أن الأطراف الثالثة والمرضى مقتنعون بأن البدائل هي العوامل الوحيدة التي تهم. بعبارة أخرى، هم مستعدون للدفع مقابل حشو، ولكنه ليس لعملية تمنع الحاجة إلى واحد

Abstract

Dental care that is minimally invasive involves "a systematic respect for the original tissue." This suggests that the dentistry community understands that the original healthy tissue has greater biological significance than an artifact. The idea of minimally invasive dentistry may be applied to every facet of the field. Tissue preservation,

ideally by avoiding illness and halting its progression, but also by removing and replacing with little tissue loss, is the common delineator. It does not recommend that we remove impacted third molars that are symptomless surgically or do little fillings to repair incipient lesions as standard practices. Interest in minimally invasive dentistry has skyrocketed since the advent of reliable adhesive technology. The idea fills the gap between surgical operations and prevention, which is exactly what dentistry needs in the modern day. The research supporting the survivability of restorations makes it abundantly evident that tooth restoration is a short-term palliative solution that will fail if the underlying illness is not adequately treated. Although there are possibilities, motivations, and resources for minimally invasive dentistry today, there are unquestionably insufficient incentives. Third parties and patients appear to be persuaded that replacements are the only factors that matter. In other words, they are willing to pay for a filling but not for a process that precludes the need for one.

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.^١Introduction In dentistry, the use of diamine silver fluoride in the early 1970s marked the beginning of minimally invasive treatment (Alyahya, 2024, Kalra, R., 2022). The invention of the atraumatic restorative therapy (ART) (Convissar, 2022) in the 1980s, the preventative resin restoration (PRR) (Choudhary et al., 2022, Convissar, 2022) in 1978, and the chemo-mechanical caries elimination ideas (Leon et al., 2016) in the 1990s came next. In order to preserve as much dental tissue as possible and provide better care to patients who are afraid, the ultra-conservative therapy approaches are used. Preparing to achieve cavity access through air-abrasion, laser therapy, or sono-abrasion (Ricucci et al., 2020, Frencken, 2017), excavating infected tooth tissue by laser treatment or selective caries removal (Ricucci et al., 2020, Frencken, 2017), and restoring the cavity using different protocols (Choudhary et al., 2022, Convissar, 2022, Ricucci et al., 2020, Ritter, 2017) are some examples of minimally invasive, long-term dental cavity repair. MI restorations are often smaller and their treatments are thought to be more painless, frequently requiring no local anesthetics, as compared to the conventional amalgam treatment technique. However, computer-controlled local anesthetic administration devices can be used to provide local anesthetic less invasively if necessary (Nyvad and Takahashi, 2020). Instead of being replaced, failed restorations are fixed (Fenoll-Palomares et al., 2004). The terms "minimal intervention," "minimally invasive," and "preservative dentistry," which were once known as "Prophylactic Odontomy," were used by Martin et al. (2000). "A philosophy of professional care concerned with first occurrence, earliest possible cure of disease on micro (molecular) levels, followed by minimally invasive & patient friendly treatment to repair irreversible damage caused by such disease" is how MID is defined (Singh and Garg, 2013). According to MI's viewpoint, dental caries is a multifactorial illness that causes lesions in the hard tissues of the teeth (Fenoll-Palomares et al., 2004). The Extended-Ecological Plaque Hypothesis has provided a good explanation of the disease process.

.^٢The objectives and goals of minimal intervention

The main objectives of MID are the following:

- .^١Avoid dental cavities .^٢A decrease in microorganisms that cause disease .^٣Early lesions remineralization .
- .^٤Minimal cavitated lesion surgical intervention .^٥Fixing damaged restorations rather than replacing them.

Among the goals are:

- .^١Identification .^٢Prevention .^٣Control

.^٢.^١Identification

Identification involves :

.^١Salivary evaluation As long as the pH of the environment remains constant, saliva's calcium and phosphorus supersaturation relative to the enamel surface inhibits hydroxyapatite from dissolving in the oral environment (Maltz et al., 2020, Havsed et al., 2021). Saliva plays an important role in dental health, and numerous measures are employed to assess its preventive properties. One important measure is salivary flow rate, which normally ranges from 0.10 to 2.0 ml/min (Li et al., 2020, Khan et al., 2020). A flow rate of less than 0.1 ml/min shows xerostomia (dry mouth), which increases the likelihood of acquiring dental caries. This disease reduces the mouth's natural capacity to wash and neutralize acids, making it more susceptible to caries (Schön et al., 2024, Moores et al., 2022). Another important parameter is salivary pH, with a median value of 6.7903 and a range between 5.86 and 7.54. A pH level below 5.5 is concerning, as it makes the oral environment acidic, creating favorable conditions for enamel demineralization and increasing the likelihood of tooth decay. A slightly acidic or neutral pH, on the other hand, is beneficial for maintaining enamel integrity and preventing caries (Fenoll-Palomares et al., 2004, Blancas et al., 2021, Scharfe and Flöter, 2020)

.^٢The test for caries activity The rate at which a carious lesion progresses is known as caries activity. Various caries activity tests assess the presence of cariogenic bacteria and the risk of tooth decay. The Lactobacillus count

test and Dentocult lactobacilli test categorize caries activity based on bacterial levels, with >10,000 CFU indicating high caries activity. The Snyder test measures pH changes, with pH <4.1 suggesting marked caries activity, while the Streptococcus mutans test indicates high caries risk when >100,000/ml is present in saliva (Elamin., 2021, Cameron and Widmer, 2021). Tests like the Fosdick calcium dissolution test measure calcium loss from teeth, directly correlating to caries activity, with higher dissolution indicating increased caries susceptibility. Other tests like the Albans and Swab tests use color changes to assess caries activity, where a shift to yellow indicates a higher risk of caries (Chen et al., 2020, Lin et al., 2021).

• Evaluating the occlusion and other dental aspects Decreasing the occurrence and prevalence of caries, which also depends on the morphology, composition, and occlusion of teeth, has been the main focus for several decades. Other elements: Pattern of heredity-Systemic conditions such as xerostomia, protein, and vitamin deficiencies (Su et al., 2021).

• Dietary counseling and analysis Caries-promoting factors include: those high in sugar and low in starch that are quickly removed from the mouth may be less acidogenic than those high in starch that are retained (Khan et al., 2020, Elamin et al., 2021). Regular snacking in between meals (Ntovas et al., 2023, Cho et al., 2021). Drinking soft drinks slowly in between meals raises the incidence of dental cavities (Chen et al., 2020, Jardim et al., 2020). Plaque levels are also influenced by the order in which foods are ingested. For example, coffee conclusion of a lunchtime is more harmful than unsweetened food consumed after consuming sugared coffee (Lin et al., 2021, Ntovas et al., 2023).

• Prevention It is better to prevent than to cure. The dentistry profession has been focusing more on preventing dental caries by implementing a number of strategies, such as: Tussling bacteria that cause dental caries, changing nutrition, increasing tooth resistance to decay (Ntovas et al., 2023). Table 1: has a detailed discussion of each of these. Table 1: A discussion of the prevention elements (Lin et al., 2021).

Category		Details
Tussling	Caries-Inducing Microorganisms	- Bisguanides (e.g., Chlorhexidine)
		- Triclosan
		- Delmophinol Hydrochloride
		- Replacement Therapy: Replacing cariogenic bacteria with non-cariogenic bacteria.
Blocking Plaque Build-Up		The development of compounds that: 1. Block the activity of glycosyl transferase 2. Prevent bacterial adhesion and coaggregation 3. Serve as potent antimicrobials.
Modifying Diet		- Avoidance of cariogenic foods - Increase intake of foods that support oral health.
Increasing	Resistance of Teeth to Decay	-Demineralization by Nature Fluorides in drinking water are an example of an inhibitor.
		-Polyphenols, which are present in milk, cheese, and oat hulls, are protective food ingredients.
		-The calcium phosphate complex, which includes the phosphopeptides found in casein in milk.
Sugar Substitutes (Tooth-Friendly)	- Xylitol: Not fermented by dental plaque microflora.	
	- Xylitol + Chlorhexidine: Effective adjunct in antimicrobial therapy for caries reduction.	
	- FDA-Approved Sugar Substitutes:	
	1. Stevia	
	2. Aspartame	
	3. Sucralose	
4. Neotame		
5. Acesulfame		
6. Saccharin		

Category	Details
Side Effects of Sugar Substitutes	- Xylitol: Possible gastrointestinal side effects (e.g., osmotic diarrhea) when consumed in large amounts. - Observed during a 55-day xylitol consumption period.

The foundation of minimal intervention involves the following :

.) Prioritizing disease prevention over restoring damaged structure and function is the aim of MI. Present caries risk and caries activity should be determined in order to prevent dental cavities as soon as feasible. Table 2 (Leal et al., 2022) provided by the American Academy of Pediatric Dentistry (AAPD) can be used to evaluate caries risk (Leal et al., 2022). Table 2: American Academy of Pediatric Dentistry (AAPD) for caries risk evaluation.

Clinical or Conditions	No carious teeth within the last 24 months; no demineralization of the enamel; no evident plaque gingivitis	- One region of 12 months; many areas of demineralized enamel - Gingivitis (white spot lesion); and - Carious teeth visible plaque on the front teeth during the last 24 months
	The ideal level of topical and systemic fluoride exposure	Optimal topical fluoride exposure combined with streptococci titres suboptimal Using orthodontic or dental devices
Environmental Characteristics	High socioeconomic position of caregivers; frequent use of dental care in a recognized dental home; and consumption of simple sweets or meals significantly linked to the onset of caries, particularly around mealtimes	Hypoplasia of the enamel Frequent (3 or more) exposures to simple sweets or foods that are highly linked to dental cavities in Periodically (1-2) between meals; low in between meals, socioeconomic position of caregivers; and no regular provider of dental care are highly linked to dental cavities The mother has active caries.
	General Health - Optimal systemic & topical fluoride exposure	Children who require particular medical attention - Suboptimal systemic fluoride exposure with optimal topical exposure - Suboptimal topical fluoride exposure - Conditions impairing saliva composition/flow

Caries diagnosis The demineralization of enamel and dentin is not an ongoing, irreversible process. Depending on the microenvironment, the tooth alternately loses and acquires calcium and phosphate ions in a sequence of demineralization and remineralization cycles. Subsurface enamel or dentin will demineralize if the pH falls below 5.5 (Jardim et al., 2020). Fluoride can create fluoroapatite and improve the absorption of calcium and phosphate ions (31). Fluoroapatite is more resistant to demineralization following an acid challenge than hydroxyapatite because it demineralizes at a pH lower than 4.5. One must first change the oral environment to tilt the scales in favor of remineralization and away from demineralization in order to benefit from the tooth's ability to remineralize in the noncavitated lesion (Su et al., 2021- Cho et al., 2021). This strategy consists of: - Reducing the frequency of consumption of refined carbs; - Ensuring optimal management of plaque; Facilitating optimal salivary flow Patient education is being carried out (Foros et al., 2021). To promote remineralization, agents such topical fluorides and chlorhexidine might be used (Wang., 2023). By lowering the quantity of cariogenic bacteria, chlorhexidine works (Mohamad Saberi et al., 2022). Particularly in patients exposed to

fluoride, topical fluorides enhance the availability of fluoride ions for remineralization and the production of fluoroapatite, which has a higher resistance to demineralization (Frencken, 2017, Elamin et al., 2021). Table 3 lists many techniques for reducing cariogenic microorganisms (Hund et al., 2024, Abduraxmanovich et al., 2021).Table 3: Various methods used for the reduction of cariogenic bacteria for different patient scenarios.

Patient Sample	Toothpaste	Product	(0.12% Mouthrinse Chlorhexidine)	Fluoride (22,600 ppm)
Low risk	One thousand ppm two times daily	Not needed	No need	0-1 times annually
Low caries risk & hypersensitivity	1,000 ppm two times daily	After brushing and/or tray at night, use MI Paste Plus and/or gum many times a day.	Not needed	0-1 times annually
Low caries risk & hypersensitivity due to home bleaching treatment	1,000 ppm two times daily	Use MI Paste Plus 1-2 times per day on the days when bleaching is taking place, and for two weeks prior to and following bleaching.	Not needed	0-1 times annually
High risk for dental cavities, frequent consumption of carbohydrates and beverages, gastro-esophageal reflux illness, poor oral hygiene due to drug usage, treatment of salivary dysfunction, and prevention of demineralization prior to, during, and following head and neck radiation and chemotherapy	1,000 ppm two times daily (morning & night)	Use MI Paste Plus several times daily, especially after brushing and using trays, to strengthen enamel, neutralize acid, and combat saliva dysfunction; apply a pea-sized amount to your teeth and let it sit for 2-3 minutes without rinsing. Complement this by chewing sugar-free gum with xylitol multiple times daily, particularly after meals, to stimulate saliva production and maintain oral pH. Consistent use of both can significantly improve oral health by reducing dry mouth and lowering the risk of dental caries.	Use MI Paste Plus once daily after lunch for four weeks, applying a pea-sized amount to your teeth and allowing it to sit for 2-3 minutes without rinsing. Combine this with chewing sugar-free xylitol gum after meals to stimulate saliva and maintain oral pH. After four weeks, review oral bacteria levels and, if improvements are noted, reduce the frequency of use as advised by your dental professional.	Monthly initially, then reduce to several times annually

٣٥. Various different mid-techniques for the caries treatment .The initial step in treating caries is to determine the optimum method of treating cavitated or non-cavitated lesions in addition to identifying risk factors and the existence of demineralized regions (Bernabe and Marcenes, 2020). While non-cavitated lesions are treated with

non-invasive techniques, cavitated lesions require an intrusive approach. Table 4 provides an explanation of each of these methods (Foros et al., 2021, Desai et al., 2021). Table 4: various methods used for dental treatment, focusing on techniques like air abrasion, lasers, chemo mechanical agents, pit & fissure sealants, remineralization, and Alternative Restorative Treatment (ART), with their indications and contraindications:

Technique	Method	Indications	Contraindications
Air Abrasion	Air abrasion is a minimally invasive dental technique that uses a controlled stream of air mixed with superfine abrasive particles, such as aluminum oxide, to remove tooth structure by brittle microfractures. It operates with particle sizes of 27–50 µm, pressure between 40–160 psi, and an operating distance of 0.5–2 mm from the tooth, providing precision and reducing the need for traditional drilling.		Air abrasion is not recommended for patients who are allergic, asthmatic, or medically compromised, as the airborne particles may exacerbate their conditions. Additionally, it should be avoided in cases where there is a risk of pulp exposure, as the heat generated during the process could damage the pulp tissue.
Lasers	Uses Erbium, Yttrium-Aluminium Garnet (Er:YAG), Erbium, Chromium: Yttrium-Scandium-Gallium Garnet (Er,Cr lasers) to cut dental hard tissue.	Newly erupted primary molars & permanent bicuspid and molars Teeth in question erupted less than 4 years ago & fissures Stained pits & fissures with minimal decalcification	- Not recommended for individuals with no previous caries experience - Not used on wide & self-cleansable pits - Not effective for teeth that are caries-free for 4+ years
Chemomechanical Agent	Chemical agents like Caridex, Carisolv, Papacarie are used in combination with mechanical force to remove soft carious tissue.	- Incipient caries - Disabled children - Patients with reduced salivary flow rate due to medication	- Not effective for deep carious lesions - Not indicated for medically compromised patients - Not recommended in cases of significant tooth decay beyond initial stages
Pit & Fissure Sealants	Made of plastic resin, these fit into the grooves and depressions of teeth, acting as a barrier to protect against acid and plaque.	that are caries-prone Stained or decalcified pits Newly erupted or	- Not recommended for wide, self-cleaning pits - Not used for caries-free pits for 4 years longer

Technique	Method	Indications	Contraindications
Remineralization	Fluoride treatments (e.g., 2% NaF, 1.23% APF) and ACP (amorphous calcium phosphate) are used to restore minerals to demineralized enamel and strengthen teeth.	primary molars and permanent bicuspid molars - Short time post-eruption - Incipient caries - High caries risk patients - Children with frequent acidic beverage consumption - High fluoride exposure recommended	- Not recommended for partially erupted teeth - Not effective in severe caries lesions - May not be sufficient for cases of significant enamel degradation or deep caries
		- Small Class I & V cavities - Pit and fissure caries - Caries-active children - Medically compromised patients - Ideal for non-cooperative patients	- Not ideal for patients without previous caries experience - Not used for large or deep cavities - Not effective if there is advanced pulp exposure or infection
ART (Alternative Restorative Treatment)	A method using hand instruments and adhesive materials to restore cavities, often used in conjunction with fluoride varnish.		

4. Fixing faulty restorations rather than replacing them Globally, it is estimated that between 50 and 71 percent of a general dentist's work consists of maintaining pre-existing restorations (Ricucci et al., 2020). Larger restorations with progressively shorter lifespans than their predecessors are created as amalgam and resin restorations are replaced. Concerns regarding bond strength to previously placed materials, residual caries left behind, and recurrent caries around the margin of a restoration that suggests an increased risk of developing caries in other sites, including under existing restorations, are some of the reasons for replacing restorations rather than repairing them (Koç-Vural et al., 2024, Bagheri et al., 2010). For populations that degrade gradually, repairing broken restorations instead of replacing them is a valid and more conservative therapeutic option. Cavity preparations should offer resistant shape and independent retention for the repair (Prathap, 2024, Desai et al., 2021). Given the potential for fluoride leakage and the high adhesion of GICs, GIC repair may be preferred in cervical sites (Elraggal et al., 2024, Azzopardi et al., 2023). When choosing whether to repair rather than replace a restoration, always take into account the patient's caries risk, the professional's evaluation of the benefits and drawbacks, and conservative cavity preparation approaches (Razaghy, 2023).

5. Control Healing the caries lesion and controlling the illness must come first in any intervention, whether primary or secondary, such as restoration-replacement. Any replacement will fail due to ongoing disease activity if disease control is not implemented (Rainey, 2002, Prathap, 2024). Treatment for MI begins at the molecular or micro level, such as by preventing bacterial activity and repairing reversible carious lesions. Bacterial activity can be decreased by a variety of treatment methods, including the use of triclosan, diamine silver fluoride, chlorhexidine, or cavity closure by chemical substance adhesion (Prathap, 2024, Maheshwari et al., 2020, Eltahlah, 2021, Tao et al., 2021). Both the loss of minerals from the tooth's hard tissues and the oral balance between the de- and remineralization processes on the tooth surface need to be restored after disease therapy. Both "external remineralization" on the tooth surface and "internal remineralization" in cavity walls can do this (Maheshwari et al., 2020). Water, a pH higher than 6.5, and the presence of minerals like calcium and phosphate are frequently necessary for remineralization (Frencken et al., 2008, Eltahlah, 2021). Increased fluid intake and

the use of sugar-free chewing gum can help enhance saliva flow, which is necessary for the remineralization of the tooth surface. By lowering the availability of substrates for bacterial metabolism, good mouth hygiene and dietary changes aid in lowering acidic environments and bringing the pH down to neutral values. The use of dentifrice that contains fluoride and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) can support mineral availability (Al-Germ et al., 2023, Gürcan and Şişmanoğlu, 2023).

MI's advantages Better dental health via disease repair, rather than just symptom treatment, is the advantage for MI patients. Additionally, MI can help lessen common dental anxiety in patients, which is typically brought on by traditional, extremely invasive dental treatments (Gürcan and Şişmanoğlu, 2023, Frencken and van Amerongen, 2008, Eltahlah, 2021, Tao et al., 2021, Hunwin et al., 2024) .

Conclusion An adept dentist should embrace the principles of Minimally Invasive Dentistry (MID) to manage dental caries in a way that conserves healthy tooth structure. This approach not only prioritizes patient comfort but also aligns with modern dental care philosophies, offering less invasive and more preventive treatments. By focusing on early detection and intervention, dentists can provide patients with more holistic, health-conscious options that promote long-term oral health and reduce the need for extensive restorative procedures.

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