

Molar Incisor Hypomineralisation: State-of-the-Art on Early Diagnosis and Preventive Strategies



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Abstract

Aim To provide an updated, evidence-based guidance on preventive strategies for MIH management.

Study design Narrative review.

Methods The search process was conducted on PubMed®/MEDLINE and included the most recent (last 10 years), highest-quality English-language dental literature focused on preventive strategies in MIH patients (<18 years).

Results Preventive measures – including fluoride-, casein-, calcium glycerophosphate-, arginine-based products; bioactive glasses; biomimetic hydroxyapatite; self-assembling peptides; ozone and laser therapies; silver diamine fluoride; resin infiltration; and fissure sealants are presented.

Conclusions Early diagnosis is essential for the implementation of preventive strategies. Given the absence of a standardised treatment protocol for MIH, therapeutic interventions should be carefully customised based on the severity of the condition, the patient’s age, level of cooperation, and specific clinical needs. Adopting a combined preventive approach may significantly improve long-term outcomes.

KEYWORDS Behaviour guidance techniques, dental anxiety, Italian practitioners, paediatric patients.

Introduction

Molar incisor hypomineralisation (MIH) is a qualitative developmental defect of dental enamel, defined as a “hypomineralisation of systemic origin affecting one or more permanent first molars (PFMs), with or without involvement of one or more permanent incisors (PIs)” [Weerheijm et al., 2001]. With an overall prevalence estimated at 13.5% [Lopes et al., 2021] and a significant burden of care, MIH is currently considered a global public oral health problem [Lardani et al.,

2025]. Teeth affected by MIH exhibit marked clinical variability and may present with complications such as caries, post-eruptive enamel breakdown (PEB), and dentin hypersensitivity (DH). These conditions can significantly impair mastication and hinder effective oral hygiene practices, thereby elevating the risk of caries and negatively influencing the child’s oral health-related quality of life (OHRQoL). MIH is also associated with reduced adhesive bond strength, difficulties in anesthetising hypersensitive teeth, as well as aesthetic and psycho-social concerns, all of which complicate its management [Villani et al., 2023; Lygidakis et al., 2021; Lardani et al., 2025]. It therefore becomes evident that early diagnosis and preventive strategies are crucial for avoiding further complications and promoting oral health. Although extensive research on prevention has been conducted over the past 20 years, a standardised clinical protocol for MIH management has yet to be established.

This review aims to provide dental professionals with comprehensive guidance on evidence-based preventive strategies for managing MIH, ensuring that treatment decisions are informed by the most recent and highest-quality evidence.

Methods

An extensive electronic bibliographic search was conducted using PubMed®/MEDLINE with the keyword string: “((molar incisor hypominerali*ation) OR (MIH) OR (enamel hypominerali*ation)) AND ((prevention) OR (preventive strategies) OR (management) OR (treatment))”. The following additional filters were applied: publication date (10 years), text availability (full text), article type (clinical study, clinical trial, controlled clinical trial, guideline, meta-analysis, observational study, practice guideline, randomised controlled trial, review, scoping

Preventive Measure	Remineralisation	Desensitisation	Caries Prevention	PEB Prevention
Fluoride-based agents	Yes	Yes	Yes	Potential
Casein-based systems	Yes	Yes	Yes	Potential
Calcium glycerophosphate-based products	Yes	Potential	Potential	Not detected
Arginine-based formulations	Potential	Yes	Potential	Not detected
Bioactive glasses	Yes	Yes	Yes	Not detected
Biomimetic hydroxyapatite	Yes	Yes	Yes	Not detected
Self-assembling peptides	Potential	Potential	Not detected	Not detected
Ozone therapy*	Potential	Yes	Yes	No
Laser therapy*	Potential	Yes	Not detected	No
Silver diamine fluoride	Yes	Yes	Yes	Not detected
Resin infiltration	No	Yes	Potential	Yes
Resin-based fissure sealants	No	Potential	Yes	No
Glass ionomer fissure sealants	Potential	Yes	Yes	No

TABLE 1 Effectiveness and level of evidence of the main preventive measures for MIH.

* Combined use with remineralising and desensitising agents.

■ Strong evidence

■ Limited evidence

■ Evidence not available

attention to predisposing environmental factors, including maternal illnesses during pregnancy, low birth weight, need for oxygenation at birth, general illnesses (primarily respiratory), high fever, and prolonged medication use (especially amoxicillin and corticosteroids) before the age of three.

- 2) Assessment of the family history of MIH, considering its complex and multifactorial etiology involving both genetic inheritance and early childhood environmental influences [Juárez-López et al., 2023; Alrehaili et al., 2024].
- 3) Identification of signs of hypomineralisation in the primary dentition, with particular focus on the second molars. Hypomineralised second primary molars (HSPM) are predictive of MIH (OR = 10.90, 95% CI, $p < 0.05$); however, not all MIH cases present with HSPM [Zhang et al., 2024].

Early diagnosis

Early diagnosis of MIH, made around the age of 6 as soon as PFMs erupt, is key to facilitating early intervention to prevent complications and support a minimally invasive approach. Paediatricians should also be involved [Paglia, 2018]. To diagnose MIH, the European Academy of Paediatric Dentistry (EAPD) recommends using standardised clinical criteria, which include:

- Presence of well-demarcated opacities larger than 1 mm with variable coloration (ranging from creamy white to yellow or brown) on one to four PFMs – an essential criterion – with possible involvement of PIs;
- Enamel PEB – especially in molars, which are exposed to greater masticatory forces than incisors;
- DH of varying severity, ranging from mild discomfort to spontaneous pain;
- Atypical restorations differing in size and shape from conventional caries;
- Early extraction of one or more PFMs when opacities are present on at least one of the others.

Clinical examination should be performed on clean, moist teeth with proper lighting. Excluding other DDE in differential diagnosis with MIH such as enamel hypoplasia, amelogenesis imperfecta, white spot lesions, and dental fluorosis, allows for accurate and targeted treatment of MIH. Severity should be assessed using the EAPD criteria, classifying MIH as mild (demarcated opacities without PEB, occasional DH to air/water, mild aesthetic concerns) or severe (opacities with PEB, caries, persistent DH affecting function, significant aesthetic and psychosocial impact) [Lygidakis et al., 2021].

With a view to the future, research should focus on developing pre-eruptive diagnostic methods based on risk assessment [Lygidakis et al., 2021].

Preventive strategies

The goals of preventive strategies are to prevent or minimise DH and chronic pulpal inflammation, avoid the development of caries and/or PEB – or at least postpone restorative treatments. Optimising oral hygiene practices, providing dietary advice, promoting remineralisation and desensitisation, and applying FS on PFMs are the essential measures to improve the structural integrity of affected enamel, reduce the need for invasive interventions, and enhance the OHRQoL of patients [Lardani et al., 2025; Lygidakis et al., 2021]. Remineralisation and desensitisation are influenced by three key factors: the thickness of the enamel surface layer covering the defect, which may limit a deep mineralisation; the porosity of the hypomineralised enamel; and its protein content, which cannot be directly measured *in vivo*. Findings from *in vivo* mineral density

measurements should therefore be interpreted with caution, as the available optical methods – i.e., quantitative light fluorescence and laser fluorescence – provide indirect assessments of remineralisation and should always be interpreted in conjunction with clinical examination and the patient's symptoms [Cavalcante et al., 2024]. Likewise, DH is complex to evaluate, as pain perception is subjective and can be influenced by emotional and psychological factors, particularly in children [Cavalcante et al., 2024].

Current evidence does not clearly support the long-term superiority of any specific remineralisation or desensitisation approach, due to moderate to high risk of bias, short follow-up periods, and limited sample sizes. A synergistic approach combining different agents may enhance therapeutic outcomes, and their effectiveness is greater with earlier implementation. However, the need for continued use of the intervention may limit its applicability to individuals who can regularly access or afford the necessary products, or who are sufficiently cooperative [Enax et al., 2023; Cavalcante et al., 2024].

The main at-home and chairside preventive strategies are discussed below.

Fluoride-based agents

Twice-daily brushing with toothpaste containing at least 1000 parts per million (ppm) fluoride for minimum two minutes is recommended. However, clinical evidence supporting its remineralisation efficacy remains limited, with few studies focusing primarily on fluoride varnish (FV) applications. Chairside application of FVs, such as 5–6% NaF varnish (22,600–27,000 ppm F-), with and without tricalcium phosphate, in combination with individualised 3- to 6-month recall visits and reinforced oral hygiene and dietary advice, has been shown to promote remineralisation, enhance resistance to PEB, prevent caries, and reduce DH in MIH-teeth [Lygidakis et al., 2021; Inchingolo et al., 2023; Jimenez et al., 2023; Enax et al., 2023; Alrehaili et al., 2024; Hjertberg et al., 2025]. Four applications of 5 % NaF varnish applied at 1-week intervals, showed no significant remineralising effect in MIH lesions of varying severity [Restrepo et al., 2016]. 5% NaF varnishes supplemented with tricalcium phosphate appears to be more effective in improving mineral density in mild lesions, whereas standard 5% NaF varnishes shows greater efficacy in moderate cases [Biondi et al., 2017].

Casein-based systems

Daily application of a pea-sized amount of 10% casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) crème creates a supersaturated environment of calcium and phosphate ions on the surface of MIH-enamel, promoting remineralisation, reducing porosity, increasing physical strength and alleviating DH. Daily use of 10% CPP-ACP paste has been reported to more effectively reduce DH in hypersensitive teeth after 4 months, compared to fluoride toothpaste (1000 ppm F-) [Pasini et al., 2028]. 10% CPP-ACP combined with 0.2% sodium fluoride (900 ppm F-), resulting in casein phosphopeptide-amorphous calcium fluoride phosphate (CPP-ACFP), has demonstrated superior remineralising and desensitising efficacy compared to CPP-ACP alone. Its use is recommended for managing severe MIH cases and in individuals at high risk of caries. Casein-based products exhibit excellent biocompatibility and are safe if ingested; however, they are contraindicated in individuals with milk protein allergies [Lygidakis et al., 2021; Enax et al., 2023; Alrehaili et al., 2024; Cavalcante et al., 2024; Hjertberg et al., 2025]. A recent, randomised clinical trial reported faster and marked long-term improvements (over 24 months)

in yellow-brown MIH lesions treated with CPP-ACP and CPP-ACFP pastes, compared to 5% NaF varnishes [Olgen et al., 2022].

Calcium glycerophosphate (CaGP)-based products

Twice-daily use of a 0,25% CaGP paste in a pea-sized amount after brushing has been reported to improve mineral deposition in MIH lesions over 3 months, with no significant differences compared to CPP-ACFP and 1450 ppm fluoride toothpaste [Sezer and Kargul, 2022]. The increase in mineral content did not differ significantly between white-creamy and yellow-brown enamel opacities [Sezer et al., 2022; Jimenez et al., 2022; Enax et al., 2023; Inchingolo et al., 2023].

Arginine-based formulations

An 8% arginine and calcium carbonate-containing paste, applied once professionally and followed by twice-daily at-home use for 8 weeks, has proven effective in reducing DH in MIH-teeth [Bekes et al., 2017]. Arginine penetrates the porosity of the affected enamel and seal dentinal tubules, inhibiting sensory nerve signals triggered by external stimuli [Hjertberg et al., 2025].

Bioactive glasses

Calcium sodium phosphosilicate toothpaste has demonstrated effectiveness in the remineralisation and desensitisation of MIH-teeth. This effect can be enhanced by applying bioactive glass products such as gels or mousses, using a vacuum-formed retainer worn overnight [Lygidakis et al., 2021].

Biomimetic hydroxyapatite (HA)

At-home-use of biomimetic zinc-nanoHA-based paste (30% weight/volume), applied in a retainer worn for 10 minutes once a day for one week per month over a 9-month period, has reported to have a potential in desensitising mild MIH-teeth and improve enamel integrity [Butera et al., 2022]. Findings from a previous trial, however, indicated similar effectiveness between HA and amine fluoride toothpastes – used twice daily – in reducing DH in MIH-teeth after 8 weeks [Ehlers et al., 2021]. Further research with long-term follow-up is necessary, especially in severe cases. Biomimetic HA has gained increased attention in recent years thanks to its ability to facilitate enamel surface repair by forming a protective layer that acts as a reservoir of calcium and phosphate, and its capacity to inhibit bacterial biofilm formation. Given the reduced HA content in MIH-enamel, the use of HA-containing products is reasonable, as the particles can integrate with the enamel surface by forming mineral bridges that enhance remineralisation. Current knowledge is limited, as this field is still in its nascent stages [Jimenez et al., 2022; Inchingolo et al., 2023; Enax et al., 2023].

Self-assembling peptides (SAPs)

The application of SAPs to intact yellow-brown MIH opacities, following deproteinisation with 5% sodium hypochlorite, demonstrated effective remineralising potential over 1 month [Singh et al., 2021]. SAPs are short amino acid sequences that, in response to specific environmental triggers, form well-defined tridimensional scaffolds mimicking enamel matrix proteins, serving as template for enamel regeneration. These agents are emerging remineralisers with demonstrated efficacy in treating early caries [Enax et al., 2023]; however, their preventive use in MIH management remains largely unexplored, with this study being the only pilot trial available.

Ozone therapy

One randomised clinical trial compared the application of 5%

NaF varnish, CPP-ACP and CPP-ACFP pastes, and ozone on MIH-incisors with mild lesions, reporting that ozone prolongs the effects of all desensitising agents over 12 weeks [Özgül et al., 2018]. Ozone has antimicrobial anti-inflammatory, analgesic, antioxidant and bio-stimulant properties. Its use is especially beneficial in young or anxious children, as it is a pain-free and easy-to-use tool [Luppieri et al., 2022].

Laser therapy

Laser has anti-inflammatory properties, and its use combined with desensitising agents provides more sustained relief from DH in MIH-teeth [Inchingolo et al., 2023; Alrehaili et al., 2024]. Two sessions of diode low-level laser therapy (LLLT), administered 48 hours apart and combined with weekly application of FV for four weeks, resulted in a greater desensitising effect on MIH-teeth. LLLT produced an immediate effect, while 5% NaF varnish showed a delayed onset of action [Muniz et al., 2019]. Similarly, erbium-doped yttrium-aluminum-garnet (Er:YAG) laser therapy combined with a desensitiser reduced DH and improved the quality of life of affected children over 6 months [Zhao et al., 2023]. LLLT has proven effective in reducing DH prior to the application of a glass ionomer (GI) sealant, and again after 48 hours and 30 days, leading to better oral hygiene. However, it remains unclear whether the effect is attributable to the sealant or to photobiomodulation [Fossatti et al., 2025].

Silver diamine fluoride (SDF)

A randomised clinical trial with a split-mouth design showed that mildly MIH-molars treated with 38% SDF had a lower incidence of caries and a higher caries arrest rate compared to those treated with CPP-ACPFV (2% CPP-ACP + 5% NaF varnish) over 9 months. Both interventions showed promising results in reducing DH and preventing PEB. Currently, this is the only study evaluating the preventive efficacy of SDF in intact MIH-teeth [Al-Nerabieah et al., 2024]. Other trials have investigated its use in comparison to silver-modified atraumatic restorative treatment (SMART) sealants for managing decayed hypomineralised teeth; however, these are not addressed in this review as they fall outside its scope. SDF works by forming a silver-protein complex and a calcium fluoride-like layer, which have antibacterial properties, promote remineralisation and provide relief from DH. Although the technique is considered both safe and minimally invasive, its principal limitation lies in the black discoloration caused by the precipitation of silver ions. Applying a potassium iodide solution after the SDF treatment can reduce the discoloration caused by SDF. In 2014, the U.S. FDA approved its use for the treatment of DH [Alrehaili et al., 2024; Cavalcante et al., 2024].

Resin infiltration (RI)

RI has been shown to better preserve structural integrity by preventing PEB in MIH-teeth with yellow-brown opacities over 18 months compared to FVs (5% NaF varnish applied alone or after enamel pre-etching with 37% phosphoric acid) [Nogueira et al., 2021]. Moreover, this minimally invasive technique has demonstrated positive results in reducing DH to both thermal stimuli (e.g., cold air jet) and tactile stimuli (e.g., during oral hygiene or while eating ice cream) in hypersensitive MIH-teeth over a 12-month period [Murri dello Diago et al., 2021]. RI was particularly promising for managing severe cases, serving as a functional treatment to prevent caries and PEB, and reduce DH both chairside and in daily life over 3 months – ultimately contributing to an improved OHRQoL [Luppieri et al., 2022]. These are the only in vivo trials evaluating the use of RI as a

preventing strategy to avoid MIH-related functional issues. Studies investigating its use for initial caries treatment and aesthetic management of MIH-teeth are not considered in this review since not pertinent. The infiltrant resin is a low-viscosity, TEGDMA-based material that penetrates the lesion body by capillarity. By occluding the porosity of hypomineralised enamel, it creates a physical barrier against external stimuli and enhances its micromechanical properties. However, the infiltration pattern is erratic, and the changes induced in enamel microhardness are unpredictable [Lygidakis et al., 2021].

Fissure sealants (FSs)

FSs have a well-documented caries-preventive effect in MIH-molars, with their efficacy being directly proportional to material retention, which must be monitored periodically [Zöllner et al., 2024]. Resin-based FSs are indicated for fully erupted molars when isolation is adequate. If moisture control is poor, the tooth is hypersensitive, or patient cooperation is limited, low viscosity GI sealants are suggested as a temporary measure until eruption is complete and conditions improve. Moreover, flowable GI cements used as a varnish over partially erupted and highly hypersensitive molars are indicated for high-caries-risk patients as a short-term measure to stabilise porous enamel [Jimenez et al., 2022; Alrehaili et al., 2024]. Adhesion to hypomineralised enamel poses a clinical challenge due to its elevated protein content and reduced mineral density compared to sound enamel. A deproteinising pretreatment with 5% sodium hypochlorite (NaOCl) for 30 seconds, followed by the application of a bonding agent, has been suggested to improve bond strength and reduce material debonding when resin-based FSs are used [Lagarde et al., 2020; Luppieri et al., 2025]. Resin-based FSs applied to MIH-molars (n=77) after weekly application of 5% NaF varnish for four weeks showed a survival rate of 72% at 18 months, with no significant difference compared to sound molars (62%) [Fragelli et al., 2017]. A lower retention rate of 68% was observed at 12-month follow-up in MIH-molars (n=50) that did not receive any pretreatment. This randomised clinical study used a split-mouth design, where the contralateral MIH-molar was sealed with a GI sealant, showing a survival rate of 8%. The superior performance of resin-based FSs was attributed to their better bonding and retention, whereas the lower success of GI FSs was likely due to the inadequate etching ability of the self-etch primer used [Özgür et al., 2022]. A similar performance in terms of retention (93% for resin-based FSs and 78% for GI FSs) was observed for both materials at 12-week follow-up in MIH-molars (n=38) [Bekes et al., 2022]. Thanks to their ion release, GI sealants may provide immediate reduction in DH in hypomineralised molars (n=43), with stable outcomes over 12 weeks [Karim et al., 2025]. Despite their remineralisation potential, these agents have not demonstrated efficacy over a 12-month period in preventing post-eruptive breakdown (PEB) in MIH-affected molars, particularly those exhibiting darker opacities. [Schraeverus et al., 2021].

Strengths and limitations

This manuscript provides a broad overview of MIH preventive strategies, highlighting key trends and gaps in current knowledge by considering recent studies with various methodologies and it may serve as an educational tool for clinicians and researchers. The heterogeneity among the included studies, especially the lack of standardisation in protocols, assessment criteria, sample sizes, and follow-up durations, hampers meaningful comparisons and undermines both the generalisability and long-term reliability of the findings. Furthermore, the decision to limit the search to

only two databases, exclude in vitro studies and clinical reports, and restrict the selection to English-language publications may have compromised the comprehensiveness of the available evidence base.

Recommendations

MIH-affected individuals require a comprehensive preventive approach to protect and preserve tooth structure, prevent or control DH, and ultimately promote OHRQoL while reducing the burden of care. Clinicians should:

- Diagnose MIH early and classify the lesion severity according to the EAPD criteria.
- Educate and guide patients and their families on oral hygiene and dietary habits.
- Develop individualised short-, medium-, and long-term preventive strategies, including:
 - At-home and in-office remineralisation and desensitising treatments;
 - Placement on FSs on affected molars;
 - Management of dental anxiety and fear related to DH and frequent dental procedures;
 - Regular periodic evaluations to monitor and adapt preventive measures as needed.

Practical advices

- Oral hygiene: use a soft-bristled toothbrush and non-abrasive toothpaste, as hypomineralised teeth are susceptible to abrasion; lukewarm water should be used in cases of marked DH.
- Diet: avoid acidic foods and beverages as they can further erode hypomineralised enamel.
- Clinical evaluation: avoid drying hypersensitive teeth with cold air to prevent discomfort and maintain cooperation, especially in anxious children; use cotton pellets instead.
- Clinical procedures: perform indicated treatments under rubber dam isolation to prevent DH from other MIH-teeth, and use a saliva ejector over high-volume suction to avoid discomfort.

Conclusion

MIH represents a global challenge with a significant health burden. Interest in effective management strategies, beginning with prevention, is growing. Although the number of studies on MIH preventive strategies has increased in recent years, evidence-based research addressing long-term outcomes is still lacking. In the absence of a standardised management protocol, therapeutic decisions should be evidence-based and individually adapted, taking into account disease severity, patient age, behavioural compliance, and specific clinical needs. Successful MIH management relies on the proactive involvement of patients and their caregivers, who should be adequately informed and motivated to comply with therapeutic guidelines in order to maximise treatment efficacy and improve quality of life. A synergistic approach combining various preventive measures may improve therapeutic outcomes. Future research should focus on expanding the body of high-quality evidence, with particular emphasis on prospective clinical trials involving larger cohorts and extended follow-up periods. This approach is crucial to reinforce existing evidence and enhance clinical decision-making in the context of MIH management.

Authors' contributions

Writing—original draft preparation, V.L., Writing—review and

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