Dentistry 3000

Vol 14, No 1 (2026)
ISSN 2167-8677 (online)
DOI 10.5195/d3000/2026.1102

Molar Incisor Hypomineralization with Emphasis on the Current Treatment Evidence

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Abstract

MIH is a common developmental defect that affects both the permanent incisors and first molars, which has significant esthetic, functional along with psychological implications. The condition has a complex etiology that includes genetic, environmental, and systemic factors, but its precise mechanisms are currently unknown. The diagnosis and treatment of MIH are difficult due to its clinical manifestations, which include opacities, hypersensitivity, post-eruptive breakdown, and atypical restorations. As the lesion severity, patient's age and cooperation are the guide for preventive, non-invasive, and restorative therapies. Advancements including AI-assisted imaging and photobiomodulation provide encouraging opportunities for specific, individualized conservative treatment. Standardizing the treatment protocols, establishing long-term durability, and incorporating new materials into daily practice remain difficult tasks despite the emerging advancements. The clinical management of MIH with a focus on evidence is the main topic of this study.

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Citation: Khammas SM et al. (2026) Molar Incisor Hypomineralization with Emphasis on the Current Treatment Evidence. Dentistry 3000. 1:a001 doi:10.5195/d3000.2026.1102
Received: November 12, 2025
Accepted: November 13, 2025
Published: February 5, 2026

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Introduction

MIH is a common global problem and an increasing cause of restorative and orthodontic treatment needs in children and adolescents [1,3]. It is considered multifactorial. Epidemiological evidence implicates prenatal, perinatal and early childhood systemic insults (eg, high fevers, respiratory disease, complications at birth), certain medications and environmental factors during the enamel mineralization window; genetic susceptibility and gene–environment interactions are increasingly reported but no single causal pathway has been definitively proven [4-6]. Enamel affected by MIH shows reduced mineral density, altered protein content, and compromised mechanical properties compared with normal enamel. Microscopic and chemical analyses confirm that MIH lesions are structurally weaker and more porous, explaining their tendency to opacities, rapid breakdown under occlusal load, and difficulty achieving durable adhesion for restorations [9,10]. Clinically MIH is diagnosed by recognition of well-demarcated opacities on first permanent molars and often incisors, with recording of severity (mild opacity vs moderate/severe with post-eruptive breakdown). The European Academy of Paediatric Dentistry (EAPD) and subsequent training manuals outline standardized criteria and field survey protocols to improve diagnostic consistency [9,11]. Children with moderate-to-severe MIH commonly experience hypersensitivity, aesthetic concerns, repeated restorative failure, and dental anxiety; systematic reviews of oral-health related quality-of-life studies confirm measurable negative impacts for affected children and families. These outcomes highlight the importance of early detection, preventive and behavioral management [1,10,12,13].

Classification Systems and Severity Indices

There have been various classification systems to standardize MIH diagnosis. The European Academy of Paediatric Dentistry (EAPD) 2003 criteria, that determined MIH as the presence of opacities in one to four permanent first molars, and sometimes with incisor involvement,

are the most commonly used. [14]. Subsequent efforts were undertaken to improve the severity evaluation. The Wetzel and Reckel classification differentiated mild MIH (demarcated opacities without sensitivity or PEB) from severe MIH (hypersensitivity, enamel breakdown, and restorative complications) [15]. Similarly, the Mathu-Muju and Wright index incorporated both clinical and behavioral factors such as hypersensitivity and treatment need [16].MIH Treatment Need Index (MIH-TNI) has been developed to link severity with treatment planning. It considers extent of enamel breakdown, hypersensitivity, and child cooperation, offering a practical approach for clinical decision-making [17]. In addition, MIH Severity Scoring System (MIH-SSS) has been proposed to quantify lesion extent, PEB, and caries involvement, providing a reproducible method for clinical research [18]. Although Molar Hypomineralisation Severity Index (MHSI) is an old but still a relevant system and remained in comparative studies of newer indices (e.g. MIH-TNI vs MHSI) for its predictive value [19].

Clinical Features and Diagnostic Criteria

The most widely accepted diagnostic criteria were introduced by the European Academy of Paediatric Dentistry (EAPD, 2003), which include: Presence of demarcated opacities with clear boundaries; Evidence of post-eruptive enamel breakdown (PEB) not associated with trauma; Atypical restorations (size, shape, or position inconsistent with caries) and Exfoliation or extraction of PFMs due to enamel hypomineralisation [14]. Affected molars often present with rapid caries progression, posteruptive breakdown, and restorative difficulties due to poor bonding. Children may report hypersensitivity to thermal or mechanical stimuli, complicating oral hygiene and treatment [1,20]. Incisor involvement typically raises aesthetic concerns, especially when anterior teeth display yellow-brown opacities [21]. The Severity of MIH varied from Mild (isolated opacities with no breakdown or sensitivity) to severe MIH includes extensive enamel loss, hypersensitivity, atypical restorations, and high risk of pulp involvement [22]. MIH should be differentiated from other conditions including fluorosis, amelogenesis imperfecta, and enamel hypoplasia. MIH lesions are asymmetrical and well-defined, whereas dental fluorosis usually exhibits diffuse opacities. Instead of porous enamel, hypoplasia manifests as decreased enamel thickness [23]. In order to increase the early identification and repeatability of MIH diagnosis; recent researches investigate quantitative light-induced fluorescence (QLF), optical coherence tomography (OCT), and AI/assisted imaging. These supplements might help with treatment planning and standardizing epidemiological research [24–28].

Preventive Approaches in MIH Management

With the goals of reducing hypersensitivity, preventing post-eruptive breakdown, and enhancing collaboration for restorative therapy; preventive management continues to be the cornerstone of care for children with MIH. In order to strengthen the affected enamel and reduce the risk of cavities, high-concentrations of fluoride varnishes and gels are still frequently advised [29]. Recent research illustrated the function of hydroxyapatite and casein phosphopeptide–amorphous calcium phosphate (CPP–ACP) formulations as a biomimetic material, in improving the remineralization and alleviating symptoms in teeth afflicted by MIH [30]. Particularly in young or nervous children, the application of silver diamine fluoride (SDF) has drawn interest as a less invasive means of inhibiting enamel destruction along with controlling dental caries progression [31]. A randomized clinical trial studied the management of children with mildly affected MIH molars by using 38% SDF or CPP-ACP fluoride varnish; the researchers found that SDF was more effective than CPP-ACP varnish in reducing both the incidence and progression of dental caries, even though both methods had similar results in enamel breakdown and sensitivity [32]. Furthermore, research on photobiomodulation therapy (PBM) as a supplement to remineralizing agents has shown promise in 2024 for lowering hypersensitivity and improving patient comfort [33]. These preventive practices were enhanced by behavioral strategies, such as early diagnosis, usage of desensitizing paste and food counseling which also improve long-term results [34].

Restorative Strategies & Minimally Invasive Techniques in MIH

In order to preserve the dental structure while lowering hypersensitivity and treatment load, clinicians are progressively striking a balance between durability and pediatric-friendly methods, guided by current knowledge that directs toward material selection and procedure adaptation. Current studies and long-term research shows that in teeth compromised by MIH, glass-hybrid restorations, SMART, resin infiltration, and endocrowns are all effective substitutes for traditional crowns [35–41]. The study 134 first permanent molars with MIH that were treated using glass-hybrid restorations following selective caries removal revealed good clinical performance and longevity (>6 years), suggesting that glass-hybrid restorations were effective in conjunction with careful caries removal for moderate MIH molar [42]. However, in a randomized clinical study, prefabricated SSC and endocrowns made of two CAD-CAM materials (composite & lithium disilicate) were contrasted in children's f first permanent molars that have had endodontic treatment. After a year, the restorations' survival rates were similar, and in many instances, endocrowns demonstrated improved gingival response, reduced plaque buildup, and increased parental satisfaction [43]. Alongside A survey in Saudi Arabia with dentists of different specialties revealed that treatment choices for MIH differ by severity and tooth type: for mild/moderate MIH in anterior teeth, resin infiltration is preferred; for posterior molars, general/restorative dentists favor composite resins, whereas pediatric dentists often prefer stainless steel crowns for severe lesions. This reflects awareness but also variability in clinical application of minimally invasive vs full-coverage approaches [44]. GI cements, composite resins, and adhesive systems (direct restoration materials used in MIH) were the subject of a systematic review in 2024 that compared the results of the various materials. Important conclusions were found: "GI is frequently suggested as a temporary or interim material; composite resins are commonly used, but how well they work is largely dependent on the extent of the lesion, the pretreatment, and the adhesive technique" [45]. A clinical evaluation of the SMART (Silver-Modified ART) technique in children with MIH (age 6-12) involving class I and II cavity preparations suggested that SMART may be a good short-term minimally invasive approach, particularly in occlusal class I lesions [46].

Emerging Therapies (Photobiomodulation, Biomimetic materials)

Management of MIH continues evolving toward combining preventive, minimally invasive, and restorative strategies, with increasing emphasis on symptom control (hypersensitivity) and patient comfort rather than only structural repair. Previous evidence showed that multimodal management (CPP-ACPF mousse, photobiomodulation therapy) is more effective than single interventions as it yields greater and more sustained reduction in hypersensitivity [47]. As the biomimetic materials (nanohydroxyapatite (nano-HAp), zinc-substituted hydroxyapatite, bioactive glass, and scaffold-based formulations) are designed to enhance remineralization, occlude porosities, and reduce sensitivity. It could be promising strategy in the management of MIH. For instance, a clinical trial demonstrated that a hydroxyapatite-based toothpaste significantly improved the remineralization of MIH-affected teeth, offering a fluoride-free alternative for sensitive patients [48]. Additionally, the incorporation of

bioactive glass particles into adhesive systems has shown promise in enhancing the mechanical properties and longevity of restorations in MIH-affected teeth [49]. Furthermore, a comparative study indicated that fluoride bioactive glass toothpaste exhibited superior remineralization effects compared to conventional fluoride toothpaste, suggesting its potential in preventing further demineralization in MIH-affected teeth [50]. These findings underscore the increasing interest toward the application of biomimetic materials in the management of MIH, offering innovative solutions that align with the natural features of the dental tissues.

Prospects

The treatment of molar-incisor hypomineralization (MIH) is about to undergo a major transformation due to recent developments in materials science, diagnostic tools, and individualized therapy plans. In addition to restoring dental function and aesthetics, the new innovations prioritize minimally invasive, patient-centered techniques that address the underlying enamel deficiencies. Innovations such as biomimetic materials, artificial intelligence-aided imaging, and photo-bio-modulation treatments, along with the use of multimodal therapies, have the potential to improve early diagnosis, enhance remineralization, and lessen hypersensitivity.

However, longer-term follow-up studies are required to assess the outcomes of the restorative procedures and the emerging biomaterials, enhancing PMB procedures (for example, figuring out the optimal energy density, wavelengths, the perfect time either after restoration or before anesthetic administration). The use of artificial intelligence-based imaging as a diagnostic tool to help with caries diagnosis, severity assessment, and modeling of breakdown risk prediction. Similarly, more extensive multicenter randomized clinical studies of combination treatment (such as using desensitizing agent besides with PBM and biomimetic material) are required in order to determine the optimal protocols regarding doses, timings, and intervals for varying severity levels.

Conclusions

MIH continues to remain a serious clinical issue that requires early diagnosis and individualized care. The use of preventative treatments, such as fluoride, CPP-ACP, and sealants, is essential to safeguard the affected teeth. Resin infiltration, GI restoration, SMART, and endocrowns are examples of minimally invasive restorative procedures that can preserve tooth structure while improving aesthetics and functionality. The use of biomimetic materials and revolutionary approaches like PBM and AI-assisted imaging offers promising support for enhancing treatment outcomes.

Ultimately, an integrated strategy that combines preventive, minimally invasive, and innovative biomimetic solutions offers the best path to achieve healthier, stronger teeth and a brighter smile for children with MIH.

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