Molar incisor hypomineralisation (MIH) - an overview

Molar incisor hypomineralisation (MIH) – an overview

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Key points

- Highlights different aspects related to molar-incisor hypomineralisation.
- Provides some up-to-date information about molar-incisor hypomineralisation.
- Discusses management and treatment options.

Recent data indicates that molar-incisor hypomineralisation (MIH) is a frequently – encountered dental condition worldwide. The condition could be associated with dental complications that might affect patients' quality of life as well as create treatment challenges to dentists. The affected teeth are more prone to caries and post-eruptive enamel breakdown, therefore, it is believed that this condition might be responsible for a substantial proportion of childhood caries since the condition has high prevalence. MIH is common, and as such it should be diagnosed and managed in primary care wherever possible. Early diagnosis can lead to more effective and conservative management. This article aims to highlight different aspects related to MIH, from its prevalence to treatment options in young patients.

Introduction

The term molar-incisor hypomineralisation (MIH) was first introduced in 2001 by Weerheijm *et al.*[1] and it was defined as 'hypomineralisation of systemic origin, presenting as demarcated, qualitative defects of enamel of one to four first permanent molars (FPMs) frequently associated with affected incisors.' Earlier nomenclature included non-fluoride enamel opacities, internal enamel hypoplasia, non-endemic mottling of enamel, idiopathic enamel opacities and cheese molars.[2] In 2003, MIH was further described as a developmental, qualitative enamel defect caused by reduced mineralisation and inorganic enamel components which leads to enamel discolouration and fractures of the affected teeth.[3] Initially, the condition was described as affecting the FPMs and incisors but more recently it has been noted that these defects could affect any primary or permanent tooth.[4] In MIH, the FPMs show rapid caries progression starting shortly after eruption in the majority of cases, which causes serious problems to patients as well as treatment challenges to dentists.[2] Although this condition is frequently encountered in dental clinics,[5,6] recent studies[5,7,8] have shown that dentists experience significant difficulties in diagnosis and management. Therefore, the aim of this article is to highlight the most important aspects of MIH from its prevalence to treatment options in young patients.

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Prevalence

Epidemiological studies from different parts of the world show a wide variation in the prevalence of MIH which can range between 2.8 to 40.2%,[9] however, this variation may be due to a lack of standardised tools to record MIH leading to underestimation of the prevalence.[9–11] In response to this finding Ghanim *et al.*[12] have introduced a standardised scoring system based on the European Academy of Paediatric Dentistry (EAPD) evaluation criteria. A manual has also been recently published[9] to facilitate and standardise its use in future epidemiological studies. Elfrink *et al.*[10] suggest that at least 300 subjects should be involved in such studies. Currently, it is estimated that this condition affects one in six children worldwide.[6]

Aetiology

The causative mechanism of MIH is still unclear,[7,13] but the clinical presentation of localised and asymmetrical lesions suggests a systemic origin with the disruption in the amelogenesis process most probably occurring in the early maturation stage or even earlier at the late secretory phase.[2] In general, the condition seems to be multifactorial and systemic factors such as acute or chronic illnesses or exposure to environmental pollutants during the last gestational trimester and first three years of life have been suggested as causative or contributing factors.[13,14] The number of affected teeth was associated with the time when the potential systemic disturbance occurred; children with prenatal, perinatal and postnatal problems showing more affected teeth in increasing order.[14] Multiple possible causes have been suggested in the literature, for instance, respiratory tract infections, perinatal complications, dioxins, oxygen starvation, low birth weight, calcium and phosphate metabolic disorders, frequent childhood diseases, use of antibiotics and prolonged breast feeding.[2] In addition, some studies[15,16] raise the possibility of a genetic role in the aetiology of MIH, indicating that a genetic variation may interact with systemic factors leading to MIH.

Diagnosis

The ideal time to diagnose MIH is as soon as it is clinically apparent either in primary or permanent dentition. The examination should be performed on clean wet teeth. The clinical presentation of MIH depends on its severity and can range from white-creamy opacities, yellow-brown opacities, post-eruptive enamel breakdown to atypical caries located on at least one FPM with or without incisor involvement.[2] The lesions should be larger than 1 mm to be recorded as MIH.[17] When such clinical signs exist during examination, the dentist should ask the parents about any illness that occurred in prenatal, perinatal, postnatal or the first three years of life to support the diagnosis. Figures 1 to 7 show some examples of different clinical presentations of MIH.

Mathu-Muju and Wright[18] had classified MIH into three severity levels:

1. Mild MIH: the demarcated opacities located at non-stress bearing areas, no caries associated with the affected enamel, no hypersensitivity and incisor involvement is usually mild if present
2. Moderate MIH: the demarcated opacities present on molars and incisors, the post-eruptive enamel breakdown limited to one or two surfaces without cuspal involvement, atypical restorations can be needed and normal dental sensitivity
3. Severe MIH: post-eruptive enamel breakdown, crown destruction, caries associated with affected enamel, history of dental sensitivity and aesthetic concerns.

Association between MIH and other hypomineralised teeth

The same demarcated defects that present on some molars and incisors in MIH have also been observed on other teeth such as second primary molars and tips of permanent canine cusps in some MIH cases.[17,19] Mittal *et al.*[20] have investigated the association between hypomineralised second primary molars (HSPMs) and MIH and they found that approximately half of the FPMs with MIH were associated with HSPMs. Furthermore, Negre-Barber *et al.*[21] found that HSPM can be considered a predictor for MIH, indicating the need for monitoring, but the absence of HSPM does not rule out the appearance of MIH. A significant association between MIH and hypomineralised permanent canines has

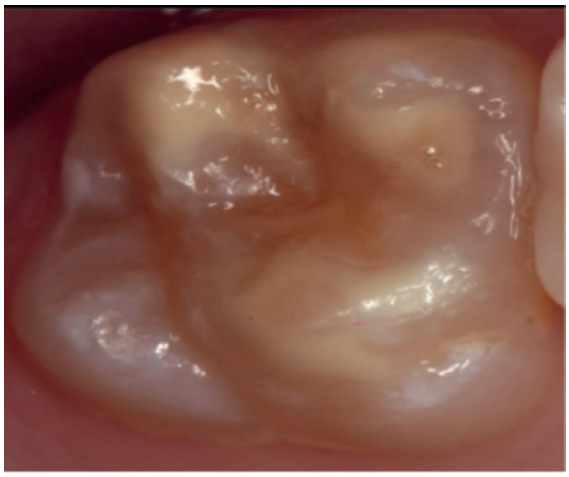

Fig. 1 Hypomineralised FPM with demarcated opacities. Reprinted by permission from Springer Nature, European Archives of Paediatric Dentistry, Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice, A. Ghanim, M. J. Silva, M. E. C. Elfrink *et al.*, 2017

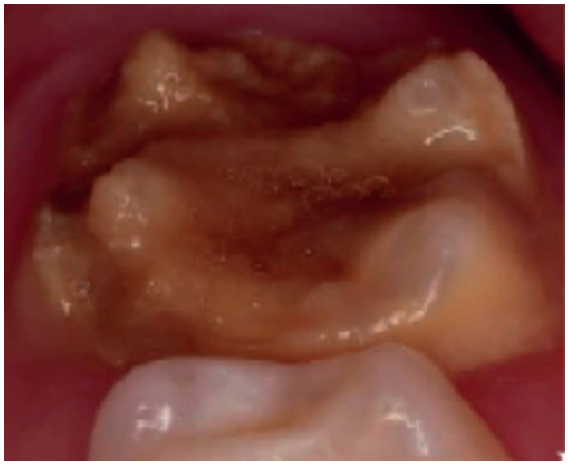

Fig. 2 FPM having severe hypomineralisation; note the post-eruptive enamel breakdown at palatal wall. Reprinted by permission from Springer Nature, European Archives of Paediatric Dentistry, Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice, A. Ghanim, M. J. Silva, M. E. C. Elfrink *et al.*, 2017

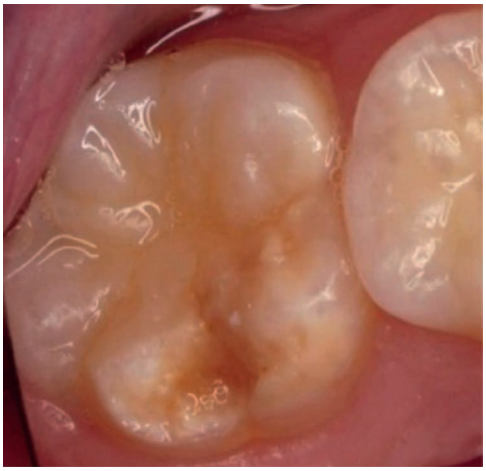

Fig. 3 FPM with post-eruptive enamel breakdown at the MIH lesion. Reprinted by permission from Springer Nature, European Archives of Paediatric Dentistry, Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice, A. Ghanim, M. J. Silva, M. E. C. Elfrink *et al.*, 2017

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also been described in a paper by Schmalfuss *et al.*[19] where they found approximately one quarter of MIH-affected individuals had one or more permanent canines with signs of hypomineralisation.

Differential diagnosis

Conditions which can present with hypomineralised lesions and should be distinguished from MIH include:[9,22]

Fluorosis

This is associated with history of fluoride ingestion during enamel development. Clinically, fluorosis presents as diffuse, linear, patchy or confluent white opacities without a clear boundary. The severity can range from barely perceptible striations in the enamel to gross disfiguration with almost complete loss of the external part of the enamel. It affects teeth in a symmetrical, bilateral pattern unlike MIH which is asymmetrical. Moreover, teeth affected by fluorosis are caries-resistant while in MIH they are caries-prone.

Enamel hypoplasia

This is a quantitative defect with reduced enamel thickness. The borders of hypoplastic enamel lesions are mostly regular and smooth, indicating developmental and pre-eruptive lack of enamel. The margins in MIH with post-eruptive enamel breakdown are sharp and irregular due to post-eruptive shearing of weakened enamel.

Amelogenesis imperfecta

This is a genetic condition which results in enamel that is hypoplastic, hypomature, or hypomineralised. In this condition, all teeth in both dentitions are affected and a familial history is often present.

White spot lesion

This is the earliest clinical sign of caries. The lesions appear chalkier, matt or more opaque than the adjacent sound enamel. They can be distinguished from MIH because they occur in areas of plaque stagnation, such as the cervical margin of the tooth.

Traumatic hypomineralisation

This is associated with a history of dental trauma to the primary predecessor tooth. Periapical infection of the primary tooth can disturb mineralisation of the underlying tooth germ. It has a wide variety of clinical presentations differing in shape, outline, localisation and colour. It is often limited to one tooth and asymmetrical.

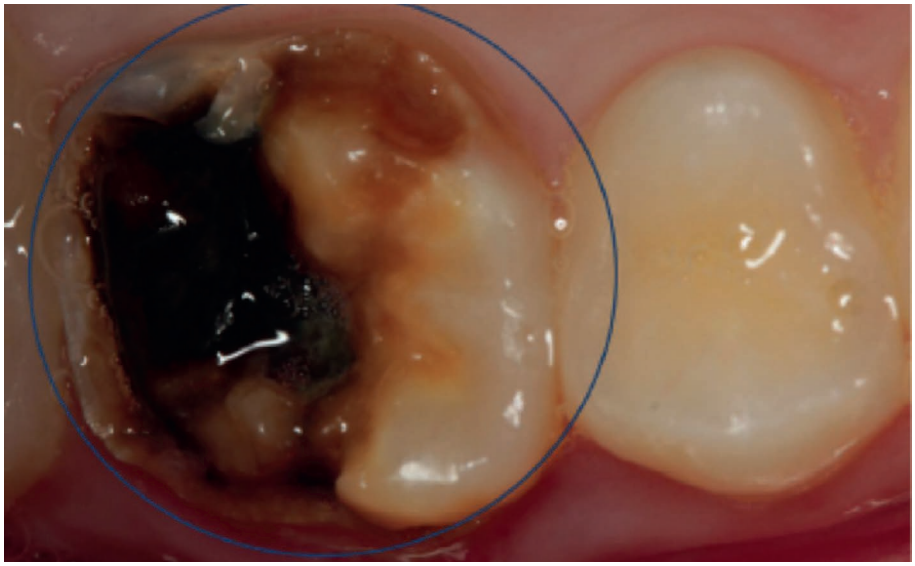

Fig. 4 FPM with atypical caries due to MIH. Reprinted by permission from Springer Nature, European Archives of Paediatric Dentistry, Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice, A. Ghanim, M. J. Silva, M. E. C. Elfrink *et al.*, 2017

Anatomopathology

The histopathological data relating to MIH, reveals that, unlike other types of enamel defects, hypomineralisation in MIH begins at the amelodentinal junction (ADJ) and not at the surface of the enamel.[22–24] In mild MIH the hypomineralisation remains limited to the inner enamel while the outer surface is intact. In severe MIH the whole enamel layer is hypomineralised. The affected enamel has 20% less mineral concentration according to an investigation by Fearne *et al.*[23] while the protein content in MIH enamel is three-fold to 15-fold higher than that of sound enamel.[25]

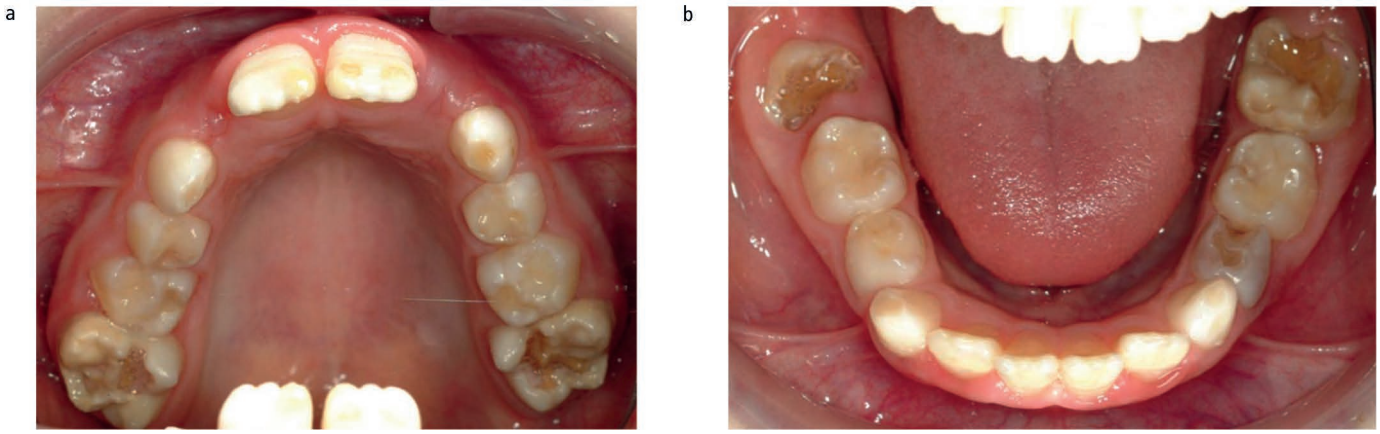

Fig. 5 Patient with severe MIH affecting all FPMs and causing atypical caries and post-eruptive enamel breakdown

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Clinical problems in MIH

The following are the most commonly reported clinical problems for patients with MIH:[5,9,26]

- Post-eruptive enamel breakdown leading to dentine exposure and this makes the tooth at risk of pulp involvement
- Tooth sensitivity, which might lead to poor oral hygiene and therefore, caries susceptibility increases
- Local anaesthesia problems which are possibly related to chronic pulp inflammation
- Behavioural management problems due to dental fear and anxiety which is related to the pain experienced by the patients during multiple treatment appointments
- Aesthetic problems in anterior teeth
- Tooth loss
- Occasional eruption difficulties of molars due to enamel roughness
- Negative impact on the child's school performance due to the absence from school
- Financial concerns for families.

Management and treatment options

Identification of patients at risk of MIH and early diagnosis can lead to more effective and conservative management.[21,27] Based on the available evidence, children at risk of MIH are those with poor general health during early childhood and/or those with HSPM(s).[17,20,21,27] There are currently no guidelines available for the management of MIH, however, the EAPD published a consensus paper in 2010 as 'best clinical practice guidance for clinicians dealing with MIH.'[17] The authors noted that there was a limited number of evidence-based research papers on this topic at that time and they suggested some areas that required further investigation. In recent years, this topic has received a lot of attention by researchers, for example in Australia in 2013 'The D3 Group' (a translational research and educational network by a group of scientists and practitioners who are interested in the developmental dental defects) has launched an official website to provide education resources and updates especially about MIH and they aim by their research to develop guidelines for MIH management. More recently, the Würzburg MIH work group (an international working group with representatives from universities in Germany, Austria and Switzerland) introduced a treatment need index for MIH (MIH TNI).[28] The MIH TNI is unique as it is not only based on the extent of the destruction of tooth structure but also the possibility of hypersensitivity.[28] The index can be used for epidemiological studies as well as for individual patients for assessment and treatment planning. Creation of a standardised approach for dental treatment for MIH could be possible after validation of this index.[28] There are six measurements for index reference. These measurements are as follows: maxillary right; maxillary front; maxillary left; and the same thing for the mandible.[28] The index values are shown in Table 1. In a recent article[6], Dr M Hubbard (the founder and the director of the D3 Group) stated that MIH is a common dental problem (affects one in six children on average worldwide) and affected molars may face more than a ten-fold higher risk of developing caries when severely hypomineralised. Therefore, MIH accounts for a substantial proportion of childhood caries due to its high prevalence. Further research into better clinical management and ultimately medical prevention is needed and recommended.[6]

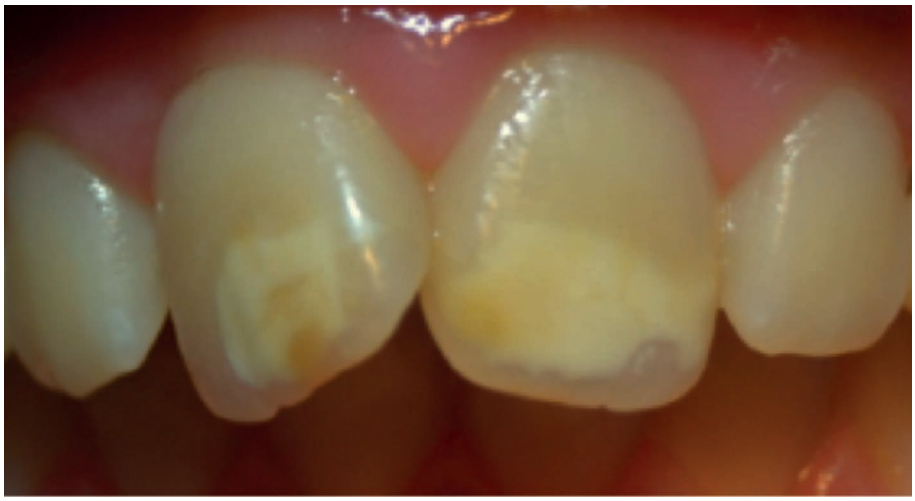

Fig. 6 Demarcated opacities at both upper central incisors

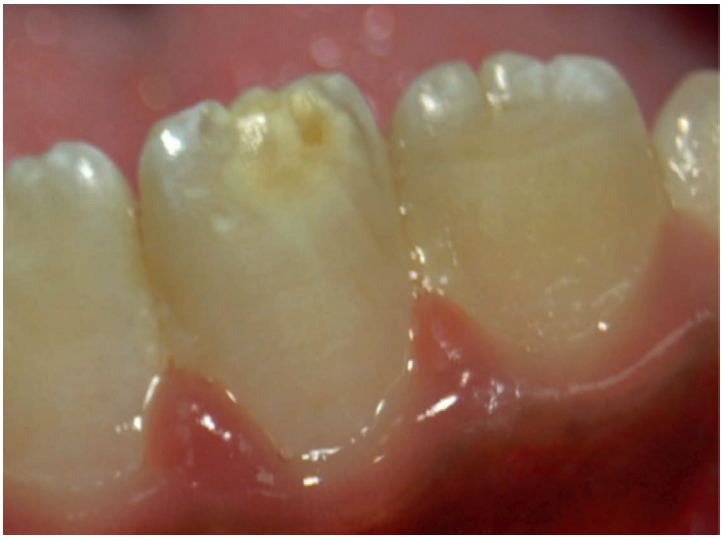

Fig. 7 Demarcated opacity affecting lower left central incisor

The following, however, are some management and treatment options, which have been suggested in the literature so far:

Enhanced prevention, remineralisation and sensitivity management

It is very important to commence enhanced prevention as soon as MIH teeth erupt as they are prone to post-eruptive enamel breakdown and caries due to the greater porosity of enamel and its lower mechanical resistance especially in severe MIH lesions.[9] Affected children and their parents should be provided with the appropriate dietary and preventive advice. They should be encouraged to use fluoridated

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toothpaste with at least 1450 ppm F to reduce caries risk and tooth sensitivity.

Improving the mineralisation of MIH teeth after eruption is possible according to some *in-vivo* and *in-vitro* studies; though, a complete resolution seems to be difficult due to the depth and/or the thicknesses of these lesions.[29–31] In an effort to remineralise the MIH teeth, the long-term use of products containing casein phosphopepetide amorphous calcium phosphate (CPP-ACP) is recommended especially at early stages where the surface enamel of newly erupted teeth is not completely matured.[13,30–32] The CPP-ACP ingredient helps to increase the bio-availability of calcium and phosphate within saliva and therefore encourages remineralisation and desensitisation of MIH teeth.[9,26,33] The CPP-ACP has the ability to bond strongly with the biofilm on teeth and also can stabilise calcium, phosphate and fluoride ions within saliva by the presence of CPP which prevents spontaneous precipitation and allows penetration of these ions deep into the subsurface lesion; these factors are effective in improving the remineralisation process throughout the body of lesion whereas the fluoride-alone products tend to mainly remineralise the surface layer.[31,34,35] Tooth Mousse (GC Corporation, Tokyo, Japan) and MI Paste Plus (GC Corporation, Tokyo, Japan) are the most commonly used dental products containing CPP-ACP. Tooth Mousse has a 10% CPP-ACP while MI Paste Plus has 10% CPP-ACP plus 0.2% NaF (900 ppm F). The combined use of fluoride and CPP-ACP has been shown to give enhanced benefits than using either agent alone.[35,36] It should be noted that CPP-ACP products are contraindicated in children who are allergic to milk protein due to the presence of casein.[31] Sugar-free chewing gum and lozenges containing CPP-ACP are also available and can be recommended.[9,37] Pasini *et al.*[33] found significant improvement in tooth sensitivity of MIH teeth after four months use of Tooth Mousse and, therefore, these products can also be recommended to patients with mild pain to external stimuli.[9,33]

Another effective product that can be used is Enamelon Treatment Gel (Premier Dental, USA), it contains both fluoride (970 ppm F) and amorphous calcium phosphate (ACP). Studies have shown that this product provides substantive amounts of fluoride and ACP ions to enhance remineralisation with similar benefits when compared to 5,000 ppm fluoride products.[32,38] Another product that has been found to enhance remineralisation and reduce sensitivity is NovaMin containing toothpaste.[39] NovaMin, a very fine Bioglass particulate (NovaMin Technology, GlaxoSmithKline, Florida, UK), with a particle size of ~18 µm is used as an active repair agent in toothpaste. This material mineralises tiny holes in the dentine leading to decreased sensitivity.[39] Multiple studies suggest that, NovaMin containing toothpastes have better remineralisation capability than CPP-ACP Tooth Mousse as the former attaches to the enamel surface more compactly.[40–42] These can be applied in Essix-style retainers overnight.

As a part of prevention at the dental clinic, it is recommended to fissure seal MIH molars. If the enamel surface of MIH molars is intact, resin-based fissure sealants can be used with adhesive application before placement as this will increase fissure sealant retention.[9,43] Some researchers indicate that enamel pre-treatment with deproteinising agents such as 5% sodium hypochlorite or papain-based papacarie gel for 60 seconds after etching increases bond strengths significantly.[44] If the MIH molars are partially erupted, hypersensitive or have post-eruptive enamel breakdown, it is recommended to fissure seal them with glass ionomer cement,[9,26] these will serve as a temporary management option as retention of such material is poor. It has to be noted that the intention here is different from conventional fissure sealants. Entire occlusal surface coverage, with glass ionomer cement, flowable or filled composite is often desired up to cusp level. Generally, all applied fissure sealants should be regularly monitored and replaced when lost.[26] Moreover, patients should receive regular professional applications of fluoride varnishes/gels as a part of the enhanced prevention protocol and to reduce tooth sensitivity.[9]

Table 1 MIH-TNI by Steffen et al. Reprinted by permission from Springer Nature, *Eur Arch Paediatr Dent*, The Würzburg MIH concept: the MIH treatment need index (MIH TNI), R. Steffen, N. Krämer, K. Bekes, 2017

Index	Definition
0	No MIH, clinically free of MIH
1	MIH without hypersensitivity, without defect
2	MIH without hypersensitivity, with defect
2a	<1/3 defect extension
2b	>1/3 <2/3 defect extension
2c	>2/3 defect extension or/and defect close to the pulp or extraction or atypical restoration
3	MIH with hypersensitivity, without defect
4	MIH with hypersensitivity, with defect
4a	<1/3 defect extension
4b	>1/3 <2/3 defect extension
4c	>2/3 defect extension or/and defect close to the pulp or extraction or atypical restoration

Local anaesthesia

Difficulty to anaesthetise the MIH molars is well reported in the literature.[2,45] The hypomineralised enamel is a poor insulator and therefore, the pulp is not well protected from external thermal stimuli. As a result, the tooth becomes hypersensitive to hot and cold temperatures.[45] This chronic stress on the pulp leads to an inflammatory response within the pulp and pH changes at periapical tissue level leading to hypersensitive pulp nerve tissue which excite with less stimulation than normally necessary.[45] The clinical implication of this is a hypersensitive tooth that is difficult to anaesthetise even with increasing the local anaesthetic dose.[45] For restorative treatment of MIH teeth, it is important for the dentist to achieve adequate local anaesthesia in order to perform good quality restorative treatment as well as to reduce behaviour management problems.

To overcome this difficulty, multiple options have been suggested in the literature. Some researchers suggest the use of inhalation sedation to increase the pain threshold during dental treatment.[18,27,46] The use of anaesthetic adjuncts such as intraligamental, intraosseous and palatal anaesthesia is also an effective option.[45,47] Different types of local anaesthetics (LA) are available and the 2% lidocaine HCL and 4% articaine HCL are possibly the most frequently used LA agents. Studies that compare

the effectiveness of these LA agents in inferior alveolar nerve block, found that none has been shown to have a superior effect over the other,[48–50] while studies that compare their effectiveness in infiltration anaesthesia showed that articaine was significantly more effective.[51] Moreover, buccal infiltration with articaine as a LA adjunct to inferior alveolar nerve block was found to be effective in achieving more profound anaesthesia.[51] Providing the dental treatment under rubber dam isolation can prevent sensitivity from other teeth during procedures which are not anaesthetised and the use of saliva ejector instead of high-volume suction could be a more gentle option for hypersensitive tooth.

Some preoperative management techniques have also been described, such as the use of desensitising toothpaste before the restorative appointment.[45] Fayle[46] recommended the application of fluoride varnish at a pre-restorative appointment. Sedative interim restorations such as glass ionomer cements can be used in case the pain is uncontrollable and it is difficult to complete the restorative treatment.[45] Glass ionomer cements have sedative properties in cases of hypersensitivity and they help by soothing the highly sensitive tooth.[52] After one to two weeks, the restorative treatment could be completed. This two-step technique can offer shorter and more comfortable appointments for young patients.[45]

Finally, in cases where there is extreme difficulty to perform the proposed treatment and all the options have failed, general anaesthesia could be the last option, however, in these situations a more radical treatment should be planned.

Treatment options for molars

It has been reported that these teeth have five to ten times more dental treatment need than molars without MIH.[26] When managing these teeth, the first clinical consideration is whether to restore or extract. This depends on factors such as: child's age; severity of MIH; pulp involvement; presence of third molar germ(s); restorability of the tooth/teeth; expected long-term prognosis; and long-term treatment cost.[26]

Resin infiltration

Also known as erosion-infiltration, this technique uses a very low viscosity resin which is capable of penetrating demineralised enamel.[22,53] Icon by DMG (Hamburg, Germany) is the only material available for this procedure. Its manufacturer recommends this material to treat incipient caries and/or carious white spot lesions reaching up to the outer third of dentine. The Icon system consists of: Icon-Etch (15% hydrochloric acid), Icon-Dry (99% ethanol) and Icon-Infiltrant (Methacrylate-based resin). The hydrochloric acid is used to eliminate the relatively intact surface layer and open access to the body of the lesion, then the fluid resin is infiltrated into the broad channels of communication. Although this product has no bioactive properties, so it does not allow for future mineral augmentation of the lesion, researchers suggest that it could protect against acid attack, improve enamel micromechanical properties and decrease post-eruptive enamel breakdown and/or possible improvement in bonding and restorative outcomes.[32,53] Crombie *et al.*[53] suggest that in MIH molars, the resin infiltrant has the potential to penetrate surfaces like hypomineralised cuspal inclines which are susceptible to post-eruptive enamel breakdown without interfering with occlusion or being broken by occlusal forces so this material can be effective if used as 'fissure sealant', but the material here will be infiltrated into the hypomineralised enamel therefore this procedure, if done, is irreversible and it requires excellent isolation.[53] Crombie *et al.*[53] also suggest a possible benefit of this material, if it is applied before composite restoration, in improving bonding by increasing surface hydrophobicity and the area of the resin-enamel interface.

Regarding micromechanical properties, studies have reported improvement in enamel hardness of MIH lesions which were infiltrated with Icon resin infiltrant, however, there was only a 15% increase in hardness which does not reach the normal values.[53,54] Although, laboratory studies found that resin infiltrant is capable of penetrating developmentally hypomineralised enamel, this occurs in an inconsistent manner, not as extensively as reported in carious lesions and does not reach ADJ.[53,54] It seems that teeth with severe MIH can be infiltrated more than mild cases due to its greater porosity and reduced mineral density.[54] Increasing etching time could be needed in MIH cases as suggested by Kumar *et al.*[54]. Denis *et al.*[22] indicate that this technique seems inappropriate especially in mild MIH cases where the defect is located beneath the superficial two thirds of relatively healthy enamel. Therefore, this technique is not yet strongly recommended and requires further investigation.

Restorations

When restoring hypomineralised teeth, dentists frequently face difficulty in defining the cavity margins. Cavity design plays a critical role, as defective enamel remnants compromise the end result. It is recommended that the cavity design should involve removal of all the porous but not necessarily discoloured enamel, until resistance to the bur or to the probe is achieved.[9,26]

Glass ionomer cement (GIC) or resin modified GIC restorations can be considered only as an intermediate approach until definitive restoration is placed.[9,26] Resin composite is the material of choice and recommended for one to three surface restorations[9,26] and the pre-treatment with 5.25% sodium hypochlorite can improve the bond strength[55]. Amalgam should be avoided due to atypically shaped cavities in MIH molars so further breakdown often occurs at the margins, it is a non-adhesive so does not restore the strength of the tooth, and is a poor insulator.[9,26]

Full or partial coverage

Preformed metal crowns (PMCs) can be used successfully in severely damaged MIH molars with high long-term survival rates.[9,26] PMCs can prevent further post-eruptive enamel breakdown, manage sensitivity, are not expensive, can establish correct interproximal and occlusal contacts, require no/little tooth preparation, and can be done in single visit.[26] Non-precious metal, gold or tooth-coloured indirect onlays can be used in older children but the procedure is time-consuming, technique-sensitive and expensive,[9,26] however, studies found that this kind of treatment is clinically successful over five-year follow-ups. Preformed malleable composite temporary crowns that come in different sizes (Protemp Crown Temporisation Material by 3M ESPE) can offer an aesthetic option.[56] With this material some tooth preparation is required and the crown will require some adjustments but the process is considered easy and requires a single visit.[56] There are as yet no studies that assess the performance of these crowns in MIH molars.

Extraction of severely affected molars

For severely affected FPMs with poor prognosis, extraction might be considered at the dental age of eight to ten years.[57] This will give the second permanent molars (SPM) an opportunity to drift into the FPM position. Before a decision to extract the molars is made, full dental assessment should be carried out to check for

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the presence, position and normal formation of the developing permanent dentition to ensure favourable orthodontic conditions. Therefore, it is advisable to seek an orthodontic opinion before extraction and consideration should be given to further FPM extractions for balancing and compensation reasons.[57]

The spontaneous mesial eruption of SPMs is more likely to occur when the SPM follicle is still entirely within bone. It has been suggested that the ideal timing of FPM extraction is indicated radiographically by the calcification of the bifurcation of the roots of the lower SPMs. However, studies show that the stage of SPM development may not be as critical as current guidance suggests.[58] The chance of ideal positioning of the SPMs after the extraction of FPMs at the ideal time is 94% for upper SPMs and 66% for lower SPMs.[58] In the upper arch, complete space closure is mostly to be expected regardless of extraction timing while in the lower arch even when FPMs are extracted at what is generally accepted to be the ideal timing, a significant proportion of patients will still exhibit incomplete space closure or tooth malalignment.[58] Therefore, fixed appliance orthodontic treatment might be needed to close the residual space but this will take less time than if the extraction of FPMs were performed after eruption of SPMs.

Treatment options for incisors

Aesthetic concerns are common in patients with MIH with incisor involvement.[9] In young patients, these teeth should be treated in a conservative approach as they have immature anterior teeth with large and sensitive pulps.[9] Therefore, it is preferred to postpone the aesthetic treatment as the enamel opacities often become less profound in the long term.[9] In general, the yellow-whitish defects are less severe than the yellow-brownish defects[9] and the defects on the incisors are milder than those on molars,[2] however, the defects on the incisal edge tend to undergo post-eruptive breakdown more than those within the labial surface, and are thus clinically more difficult to manage. The following are some possible treatment options for anterior teeth with MIH, which could be used alone or in a combination of methods to achieve better aesthetic results.

Microabrasion

This involves the removal of a small amount of surface enamel (no more than 100 µm (0.1 mm)) through abrasion and erosion using 18% hydrochloric or 37.5% phosphoric acid with pumice.[59] The process abrades the surface enamel while also polishing it which leads to changes in optical properties and this may improve the aesthetics.[60] Microabrasion is indicated when the discolouration is limited to the outer surface of enamel and it is more effective at eliminating brown mottling.[46,59] This technique was suggested in the literature for aesthetic management of MIH incisors with limited benefit if used alone due to the anatomopathology of MIH lesions.[17,22,46] Some researchers suggest this technique to remove a hypermineralised superficial layer of enamel followed by home application of CPP-ACP products as this was found to improve remineralisation outcomes.[60,61]

Tooth bleaching

The aim is to camouflage white opacities by increasing the overall brightness of the teeth.[22] This option is indicated for adolescents.[9] The possible side-effects of bleaching are: sensitivity, mucosal irritation, and enamel surface alterations.[26] Home bleaching through daily placement of 10% carbamide peroxide gel into custom fitted trays is the gentlest bleaching option prescribed by the dentist, but for more protection, the combined use of CPP-ACP Tooth Mousse and bleaching gel is recommended.[62] The CPP-ACP Tooth Mousse will protect the tooth structure and remineralise the MIH opacities during the bleaching process without interfering with bleaching effect.[62] The combined use of hydrogen peroxide and CPP-ACP, could be done with a ratio range from 1:6 to 3:4, depending on the opacity response to the bleaching agent.[62]

Etch-bleach-seal technique

This technique was suggested by Wright[63] to remove yellow-brown stains. The affected tooth should be etched first with 37% phosphoric acid for 60 seconds, followed by continuous application of 5% sodium hypochlorite as the bleaching agent for five to ten minutes. Then the tooth should be re-etched and covered with a protective layer such as clear fissure sealant or composite bonding agent.[26,63] With this technique the yellow-brown stains can be eliminated leaving a white mottled appearance which is more aesthetically acceptable.[63]

Resin infiltration

This technique was discussed earlier in 'treatment options of molars.' Additionally, it can have some benefits in aesthetic management of MIH incisors as well. Since the refractive index of the resin infiltrant (1.52) is close to that of healthy enamel (1.62), this can improve the optical properties by improving the translucency and therefore improving the aesthetics.[53,64] As mentioned earlier, this technique seems inappropriate especially for mild MIH cases where the defect is located beneath the superficial two thirds of relatively healthy enamel, Attal *et al.*[64] suggested a modification in this technique for aesthetic management of MIH incisors and this was introduced as 'deep resin infiltration technique.' The technique involves preparing the affected tooth by an intraoral sandblasting device to ensure that the infiltration can indeed reach the full extent of the lesion in case of MIH. This should remove no more than 500 µm from surface enamel and after resin infiltration, some composite could be added to tooth surface.[64] The bonding between resin infiltrant and composite is of very good quality.[65,66] Studies assessing the longevity of the aesthetic result found stable results for at least six months with the main drawback being material discolouration.[67,68] Paris *et al.*[69] suggest that well-polished infiltrated enamel is resistant to discolouration. However, these findings are related to the regular resin infiltration technique, as in the situation of deep infiltration the resin infiltrant is not in contact with the external environment.[64] In general, the use of resin infiltration technique in MIH teeth requires further investigation, improvement in material properties and/or technique modifications to be strongly recommended in MIH cases.[54]

Composite restorations or veneers

Composite restorations involve removal of defective enamel and composite resin build-up using opaque resins to avoid excessive enamel reduction,[9,26] while composite veneers could be a more conservative approach as it can be achieved with no tooth preparation that is, no removal of even defective enamel. These options could be indicated for large enamel defects that require treatment due to exposed dentine or chipped enamel.[26] The bond strength to hypomineralised enamel can be improved significantly by pre-treatment with 5.25% sodium hypochlorite for one minute after etching.[55] The composite resins are susceptible to discolouration, wear and marginal fractures, therefore, long-term maintenance is required.[26]

Porcelain veneers

These are indicated for patients aged 18 years and above when the gingival margin has matured. It can be an option when the other techniques failed to produce satisfactory results.[26,59]

Conclusion

Children with poor general health in early childhood or with hypomineralised second primary molars should be considered at risk of MIH. Therefore, they should be monitored more frequently during eruption of the FPMs. Management of these teeth should consider their long-term prognosis, as well as management of the presenting features such as pain. Aesthetic management of MIH incisors should be as conservative as possible and the extent of treatment depends on the patient's age, aesthetic concern and lesion severity. The remineralisation and resin infiltration techniques are possible effective conservative approaches in managing MIH teeth but these treatment modalities require further investigation to introduce the best technique/protocol in using them for MIH cases.

Since MIH is considered common, it should be diagnosed and managed in primary care wherever possible. Automatic referral to a dental teaching hospital or salaried service is a frequent approach. If MIH is as common as we think it is, it is illogical to expect the problem to be routinely managed in a specialist setting.

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