CLINICAL DOCTORATE IN PAEDIATRIC DENTISTRY (DDENT)

DEVELOPMENT AND ASSESSMENT OF A MOLAR INCISOR HYPOMINERALISATION (MIH) PROGNOSIS GUIDE TO BE USED IN THE PRIMARY CARE SETTING

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DECLARATION

I, Mees Alkandari, hereby declare that this project is my own original work. Any content, ideas, or materials that are not my own have been clearly referenced and credited to the original sources. I understand the importance of academic integrity and have ensured that all external contributions are properly acknowledged.

Signed,

Mees Alkandari

Title of project:

Development and assessment of a Molar Incisor Hypomineralisation (MIH) prognosis guide to be used in the primary care setting

Examination: Doctorate Degree in Paediatric Dentistry, University College London.

ABSTRACT

AIM:

This study aimed to develop, (or refine) a clinical toolkit for prognosis of Molar Incisor Hypomineralisation (MIH) which would aid clinicians in primary care. This would help general dentists to manage patients locally or when referring to specialists, where required.

METHODS:

The project was conducted in four parts. First, a scoping review identified and evaluated existing MIH prognostic tools and indices. Next, qualitative interviews with general dentists explored their knowledge, experiences, and decision-making processes related to MIH prognosis. The third part incorporated the findings of the first two where the prognostic toolkit was developed. Finally, the toolkit was piloted and refined through another set of qualitative interviews to ensure clinical applicability, ease of use, and reproducibility.

RESULTS:

The scoping review revealed a lack of prognostic tools for MIH affected first permanent molars (FPMs), but it highlighted the clinical characteristics that are essential to determine the severity of MIH lesions which include lesion colour, location, and presence of post-eruptive breakdown (PEB), as well as symptoms such as

hypersensitivity and tooth restorability. These factors were also mirrored in the results from the thematic analysis of the qualitative interviews. The developed toolkit was structured and easy to use. After piloting, the feedback from the interviews confirmed that it would increase the confidence amongst general dentists when assessing the prognosis of FPM with MIH and that it was a clear guide which would support treatment planning and referrals, where required.

CONCLUSION:

This MIH prognosis toolkit offers general dentists a practical tool to support prognosis assessment and treatment planning in primary care. It brings together the key clinical characteristics in a simplified way that's easy to use and aims to improve management of MIH. Further validation is needed to ensure its effectiveness in practice and possible integration in MIH teaching and training.

IMPACT STATEMENT

Paediatric patients presenting with MIH require early assessment and diagnosis to determine if early management is required. MIH may be challenging to manage due to changes in the structure of the enamel, which is more porous, and associated hypersensitivity (William et al., 2006). With MIH affected FPMs, the prognosis may be less predictable than normal enamel due to the risk of PEB (Almuallem and Busuttil-Naudi, 2018). This in turn has implications for the timing and type of intervention, as well as factors such as the patient's orthodontic development and cooperation for treatment, possibly initiating an early restorative cycle and resulting in a long-term treatment burden for the child and their family. As a result, general dentists who initially see children with MIH in primary care may opt for referring to a specialist or consultant led clinic (Humphreys et al., 2021a). Management includes taking into consideration the long-term prognosis of the teeth involved to provide the best long-term outcomes tailored to the patient (Eachempati et al., 2024).

In the absence of available guidance on assessing the prognosis of MIH affected FPMs, this project aims to develop a guide for general dentists in primary care through a multi-phase process. The first part entailed an investigation of the available MIH prognostic guidelines and toolkits through a scoping review. In the second part, qualitative interviews highlighted the understanding of general dentists on prognosis of MIH and what characteristics are important when determining prognosis. The third part of the project involved the development of the toolkit, which was piloted in part four of this project, with another set of qualitative interviews with general dentists to ensure the toolkit is reliable, concise, and reproducible. Hence, the toolkit has the potential to enhance the long-term oral health and wellbeing of patients with MIH.

ACKNOWLEDGMENTS

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KEYWORDS

Molar-incisor hypomineralisation, MIH, dental prognosis, enamel hypomineralisation, dental anomalies, paediatric dentistry.

LIST OF ABBREVIATIONS

AAPD	American Academy of Pediatric Dentistry
AI	Amelogenesis Imperfecta
AMBN	Ameloblastin
AMELX	Amelogenin, X-linked
BSPD	British Society of Paediatric Dentistry
CBCT	Cone-beam computed tomography
CCLAD	Computer-controlled local anaesthesia delivery
CPD	Continuing professional development
CPP-ACFP	Casein phosphopeptide-amorphous calcium flluoride phosphate
CPP-ACP	Casein phosphopeptides-amorphous calcium phosphate
DBOH	Delivering Better Oral Health
DDE	Developmental defects of enamel
DDent	Doctorate of Dentistry
DMFT	Decayed, missing, filled teeth
DPO	Data Protection Office
DPT	Dental panoramic tomograph
EAPD	European Academy of Paediatric Dentistry
EDI	Eastman Dental Institute
EDJ	Enamel-dentine junction
ENAM	Enamelin

FAM20A	Family with sequence similarity 20, member A
FAM83H	Family with sequence similarity 83, member H
FDI	World Dental Federation
FPM	First permanent molar
GDC	General Dental Council
GIC	Glass ionomer cement
HSPM	Hypomineralised second primary molar
IAPD	International Association of Paediatric Dentistry
JBI	Joanna Briggs Institute
LMS	Life and Medical Sciences
MA	Mees Alkandari
MAC	Minimum alveolar concentration
MIH	Molar Incisor Hypomineralisation
MIH-SSS	Molar Incisor Hypomineralisation severity scoring system
MIH-TNI	Molar Incisor Hypomineralisation treatment need index
MIHSI	Molar Incisor Hypomineralisation severity index
MMP20	Matrix-Metalloproteinase-20
MSc	Master of Science
NHS	National Health Service
OHRQoL	Oral health related quality of life
OPG	orthopantomogram
PA	Paul Ashley

PCC	Participants, concept, context
PEB	Post-eruptive breakdown
PMC	Preformed metal crown
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
RCS	Royal College of Surgeons of England
RCT	Root canal treatment
RMGIC	Resin-modified glass ionomer cement
SDCEP	Scottish Dental Clinical Effectiveness Programme
SP	Susan Parekh
SPM	Second permanent molar
TEGDMA	Triethylene glycol dimethacrylate
TF	Thylstrup-Fejerskov
TPM	Third permanent molar
UAE	United Arab Emirates
UCL	University College London
UHC	Universal Health Coverage
UK	United Kingdom
USA	United States of America
WHO	World Health Organization

CHAPTER 1 : TOPIC INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

MIH is a dental anomaly of systemic origin presenting as hypomineralisation of at least one FPM with frequent involvement of the permanent incisors (Weerheijm et al., 2001). The hypomineralised enamel lesions may present as white/creamy, yellow, or brown and affect the overall enamel structure, placing the tooth at a higher risk of developing caries or PEB (Almuallem and Busuttil-Naudi, 2018). MIH may also be seen on incisors which has further implications with management of PEB and dental aesthetics, this possibly has further psychological implications on their oral health related quality of life (OHRQoL) and self-perception (Silva et al., 2020; Jälevik et al., 2022). Therefore, teeth affected by MIH require a more demanding long-term management plan and regular dental reviews which start at a young age.

The British Society of Paediatric Dentistry (BSPD) has published a Policy Statement on MIH which indicates that primary care dentists should have the skill set needed to manage most MIH patients, this includes general dentists. Where there is a possible future need of orthodontic treatment, it is recommended to plan the treatment alongside an orthodontist; either by referring to paediatric specialist who would liaise with an orthodontist directly, or to refer straight to an orthodontist around the age of 8-9 years (BSPD, 2020).

The European Academy of Paediatric Dentistry (EAPD) developed a guideline which helps clinicians in diagnosing and managing MIH. It specifies how to classify the severity of the lesions, proposed aetiology, and different management options suitable for anterior and posterior teeth that are suitable for the paediatric patient considering patient-level, oral-level, and tooth-level factors (Lygidakis et al., 2022). Despite the available guidelines, general dentists are often faced with challenges on decision making in primary care when managing MIH affected teeth, especially where there is a need for specialist input (Osborne et al., 2024).

A critical part of decision making when formulating a treatment plan is the assessment of a tooth's restorability and long-term prognosis. The prognostic assessment considers the periodontal health and bone support, the pulp vitality and periapical health, the restorative status of the tooth including previous treatments, and the overall occlusion (SDCEP, 2025a).

With MIH, early identification of severity and prognosis are crucial to prevent more complex treatment in the future. This allows for early intervention and conservative management where possible, or in cases of poor prognosis FPMs, planned early loss of those teeth. Advise on early interceptive loss of a FPM while considering orthodontic implications has been published by the Royal College of Surgeons of England (RCS) (Noar et al., 2023). Globally, access to dental care and specifically specialist care is not always feasible due to location or finances. Therefore, general dentists might be solely responsible for care provision of MIH patients (Osborne et al., 2024). These differences highlight the need for a reliable tool to aid general dentists in primary care, in determining the prognosis of FPMs with MIH.

MOLAR INCISOR HYPOMINERALISATION

DEFINITION OF MIH

In the past, different terms were used to describe MIH lesions including 'cheese molars', 'idiopathic enamel hypomineralisation in the permanent first molars', and 'non-fluoride hypomineralisation in permanent first molars'; this led to research and global prevalence studies to be more challenging (Weerheijm et al., 2001). The EAPD recommended the use of a simplified definition where MIH would be diagnosed upon presence of a lesion on at least one FPM. Aside from possible involvement of the incisors, other teeth have shown similar hypomineralised opacities, such as primary

second molars and tips of permanent canines; their involvement is not indicative of MIH currently (Lygidakis et al., 2022).

The hypomineralised opacities in MIH are well demarcated and vary in size, position, and colour. They usually affect the occlusal / incisal or buccal surfaces of the tooth structure. Even within the same dentition, the teeth may be affected to varying degrees and the lesions may be completely absent on some of the FPMs or incisors. The colour of the lesion ranges from white or cream opacities to yellow or brown lesions; their surface area may be small, although those less than 1mm in diameter are negligible, or they may be large and present with PEB or atypical caries or restorations (Lygidakis et al., 2010).

PREVALENCE

The global prevalence of MIH has been reported as 12.9% (11.7-14.3%) with no significant difference between males and females. However, there were significant differences between super-regions, regions, and countries (Schwendicke et al., 2018, 2019). This global variation presentation is shown in Figure 1.1.

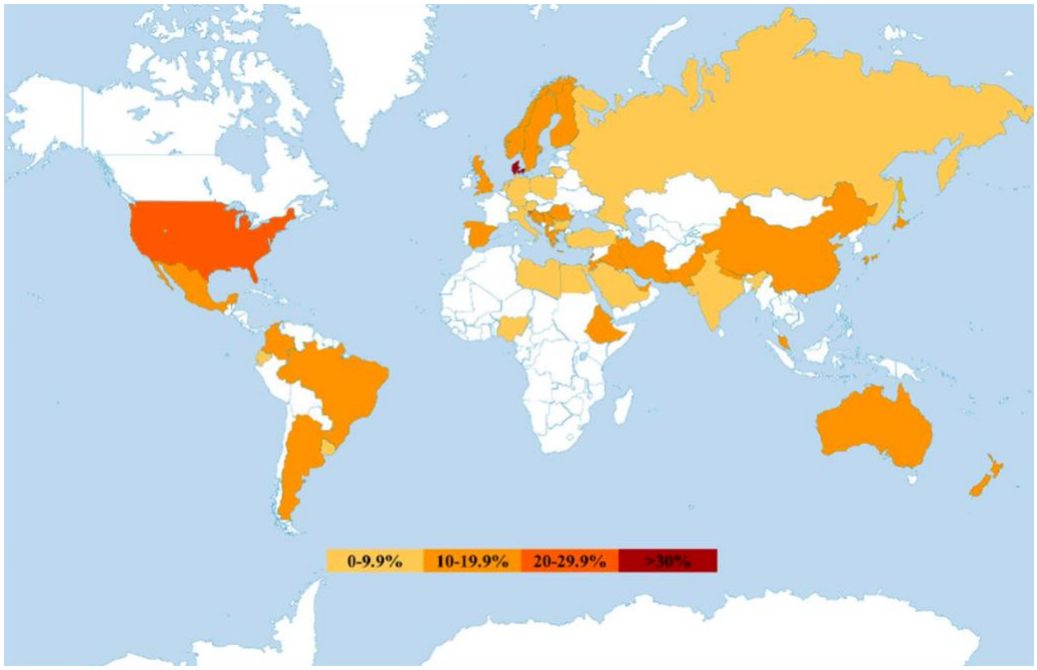


Figure 1.1: Global prevalence of MIH. Reproduced from Lygidakis et al. (2022), licensed under CC BY 4.0.

Since involvement of a FPM indicates if the patient has MIH, the prevalence of incisors being involved at the same time has been reported as 36.6% (Lopes *et al.*, 2021). The prevalence of having hypomineralised second primary molars (HSPM) at the same time as MIH has a variable representation in the literature, with a meta-analysis in 2021 reporting the prevalence as 3.6% while a systematic review in 2018 reported it as high as 19.94% (Garot et al., 2018; Lopes et al., 2021).

NORMAL DEVELOPMENT OF ENAMEL

AMELOGENESIS

Amelogenesis, which is the process of enamel formation, involves three main functional stages: secretory, transition, and maturation. Before enamel is secreted, ameloblasts go through a pre-secretory stage where they differentiate in preparation

for producing the enamel matrix. Next, during the secretory stage, these cells become more elongated and develop Tomes' processes apically as seen in Figure 1.2 (4); here enamel matrix proteins such as AMELX (amelogenin, X-linked) are mainly secreted by the ameloblasts along with calcium and phosphate ions, leading to the formation of hydroxyapatite crystals, AMELX acts as a base for matrix formation (Nanci, 2013; Gachova et al., 2022). AMELX makes up 90% of the enamel matrix proteins, with the remainder 10% formed by ameloblastin (AMBN) and enamelin (ENAM), which are also secreted in this stage. AMBN plays a role in ameloblast differentiation and proliferation as well as extracellular osteoclast differentiation. Ameloblasts also secrete proteinases such as matrix metalloproteinase-20 (MMP20, enamelysin) and kallikrein-related peptidase-4 (KLK4) (Smith et al., 2017). These proteins are secreted away from the dentine surface, thickening the enamel layer. Enamel crystals first form as ribbons which later with parallel crystalline ribbons form into rods, the Tomes' process continues to develop an apical projection, this in turn determines the rod and interrod enamel, as in Figure 1.2 (5) (Nanci, 2013). During the secretory stage, MMP20 regulates cellular interactions and degradation as well as cell movement, regulating the matrix structure (Smith et al., 2017). The transition stage follows, during which some ameloblasts undergo apoptosis and others shorten in preparation for the maturation stage. The maturation stage involves removal of the enamel organic material, KLK4 further degrades the remaining enamel matrix proteins allowing for further enamel thickness and controlled ion movement in and out of the enamel matrix which results in fully formed enamel, demonstrated in Figure 1.2 (6) (Nanci, 2013; Smith et al., 2017).

Enamel mineralisation generally occurs in two overlapping phases, initially when ameloblasts secrete the organic matrix layers at the enamel-dentine junction (EDJ) in the secretory stage, the matrix is quickly mineralised, but only partially. This means that the innermost part of the enamel is more mineralised than the rest. During the maturation stage, the secondary phase starts; the enamel continues to mature, resulting in a highly mineralised outer surface layer and well-mineralised inner layers. Mineralisation decreases as the enamel approaches the EDJ, but the innermost enamel layer becomes highly mineralised again (Nanci, 2013).

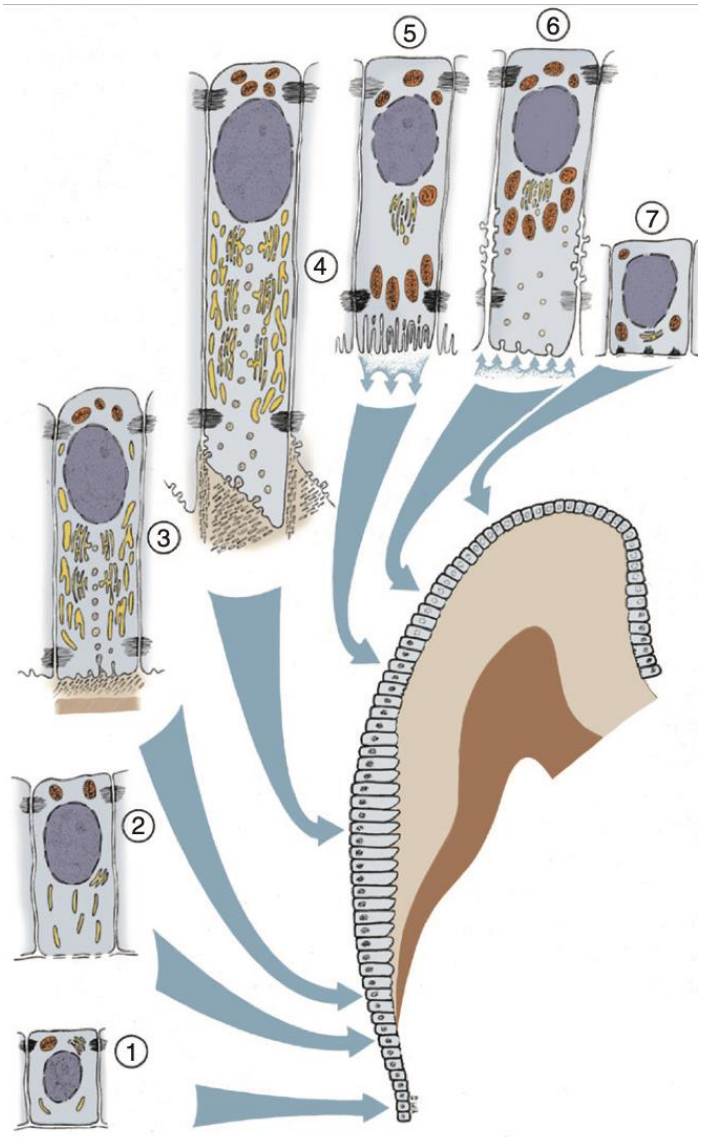


Figure 1.2: Amelogenesis' functional stages: (1) Morphogenetic stage. (2) Histodifferentiation stage. (3) Initial secretory stage without Tomes' process. (4) Secretory stage with Tomes' process. (5,6) Maturative stage. (7) Protective stage. Reproduced from Nanci et al. (2013). © Elsevier. Licensed under RightsLink License No. 6074191041454.

PATHOGENESIS OF MIH

Hypomineralisation of enamel occurs due to a disturbance in the transitional stage, maturation stage, or both stages during a specific time which leads to affecting the FPM and permanent incisors (Vieira and Kup, 2016). This disturbance might result in

incorrect deposition of proteins, and therefore alter maturation (Fagrell et al., 2013). A higher protein content in MIH affected teeth has been shown, including proteins from the oral fluid and blood, such as albumin. Presence of albumin in intact lesions implies that the disturbance was during mineralisation of the enamel (Mangum et al., 2010). With lesions that exhibit PEB, the protein absorption may have been at a later stage after eruption since oral-fluid proteins are evident (Mangum et al., 2010).

Healthy enamel is the most highly mineralised tissue with hydroxyapatite making up 96% of its composition, by weight; the rest being organic fluids (Denis et al., 2013). Microscopically, hypomineralised enamel has disorganised enamel prisms and a porous structure, which can be seen in Figure 1.3. This porous nature begins at the EDJ and continues towards the enamel surface, not necessarily to the outer layer of enamel. With less severe hypomineralised lesions, a thin outer layer of healthy enamel may be evident, whereas with more severely hypomineralised lesions, the porous hypomineralised enamel is on the outer layer. A light microscopic representation of hypomineralised and normal enamel within a FPM is seen in Figure 1.4, where the darker part represents hypomineralised enamel and the normal enamel appears lighter and more translucent; a thin outer layer of normal enamel is also evident. This porous nature might allow bacteria and other intraoral materials to reach the dentine through the enamel (Fagrell et al., 2013; Petrova et al., 2021).

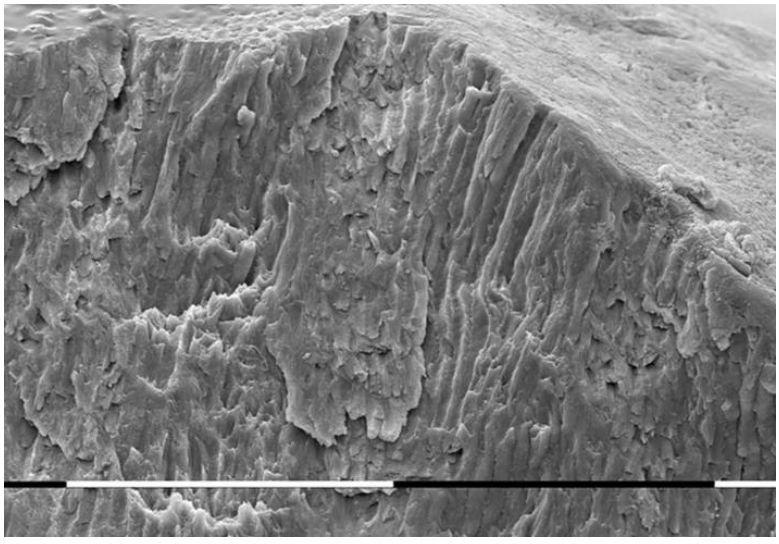


Figure 1.3: Disorganised prisms of hypomineralised enamel. Adapted from Petrova et al. (2021), licensed under CC BY 4.0.

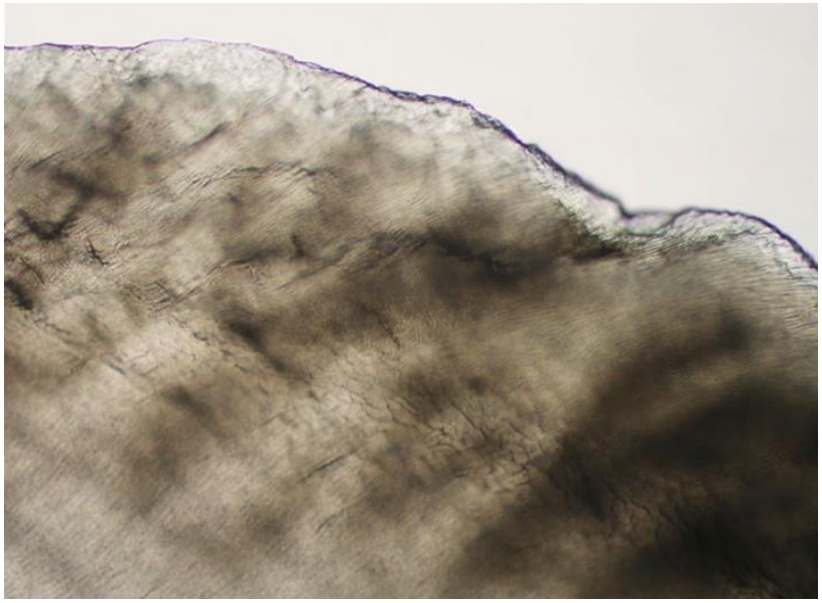


Figure 1.4: Light microscopic image of hypomineralised enamel where normal enamel appears lighter than the darker hypomineralised enamel. Adapted from Petrova et al. (2021), licensed under CC BY 4.0.

In one study where ten FPM sections were analysed, the enamel on the buccal side was shown to be mostly affected, mainly the mesio-buccal cusp followed by the disto-buccal cusp, those lesions have been shown to extend onto the occlusal surface suggesting a specific timing of insult for this occurrence (Fagrell et al., 2013). While in another study, it was unclear which areas of the enamel are more prone to hypomineralisation. They concluded that the mineral density, and hence hypomineralisation, may affect the entire circumference or may be localised to a specific surface or cusp and the pattern at which the lesion spreads varies between dentitions (Farah et al., 2010). This doesn't always follow a specific timeframe and might start during the maturation of primary second molars and last until the maturation of the permanent canines, since these teeth have shown to exhibit similar demarcations as MIH lesions in patients with MIH (Vieira and Kup, 2016).

AETIOLOGY OF MIH

The aetiology for MIH is believed to be multi-factorial with genetic and systemic factors acting synergistically leading to altered enamel formation (Lygidakis et al., 2022). The timing, duration, and strength of exposure would result in varying severities and presentations of MIH.

According to the systematic review by Lygidakis et al. (2022), there has been an increase in research looking at genetics and MIH. Considering that teeth other than FPMs and incisors have shown similar hypomineralised demarcations when MIH is present, this suggests a genetic component to the aetiology (Vieira and Kup, 2016). Variations in genes associated with amelogenesis, ENAM and AMELX for example, and immune response-related genes have been reported to be associated with increased susceptibility of developing MIH (Bussaneli et al., 2018).

There have been over 30 possible systemic factors associated with MIH in the literature which occur between the end of pregnancy (prenatal) up to the age of 4 years (perinatal and postnatal) (Alaluusua, 2010). A meta-analysis published in 2022 showed inconclusive evidence in the literature on prenatal aetiological factors since maternal illness was used as a generic term which can include anything from smoking and medication use during pregnancy to maternal fever or gestational diabetes, Table 1.1 summarises the perinatal and postnatal factors from this meta-analysis (Garot et al., 2022).

Table 1.1: Proposed aetiological factors of MIH

Perinatal	Postnatal
- Hypoxia at birth, or factors leading to hypoxia at birth - Caesarean section birth - Premature birth	- Childhood measles - Urinary tract infections - Bronchitis - Otitis media - Gastric disorders - Kidney diseases - Pneumonia - Asthma - Fever - Antibiotic use

These conditions or their symptoms might directly affect the formation of enamel and thus lead to MIH, or it might be management of the condition, such as the use of antibiotics; the actual cause isn't clear. Due to the multifactorial aetiological nature of MIH, it might be a combination of the above systemic, genetic, and epigenetic factors; where epigenetics would involve environmental influences (Garot et al., 2022). The clinical presentation of MIH would suggest it is not purely a genetic anomaly since generalisation and involvement of all FPMs or symmetry would be seen (Symons and Gage, 1987).

DIAGNOSIS

CLINICAL PICTURE

The EAPD diagnostic criteria for MIH are centred around the clinical picture and take into consideration hypersensitivity as well (Lygidakis et al., 2022). MIH may be

diagnosed as soon as one FPM erupts, although waiting to ensure it is in fact MIH and not a generalised defect may sometimes be indicated.

To diagnose MIH, at least one FPM should show enamel hypomineralisation and at the same time, permanent incisors may be affected. Similar lesions may be seen on the second primary molars, premolars, tips of the canines, and second permanent molar (SPM). The nature of the hypomineralised lesion is a well-demarcated opacity where the enamel translucency is altered, the colour ranges between white, cream or yellow to brown; these lesions may be soft and porous and vary in size and shape, the variable presentation may be seen in Figure 1.5 and Figure 1.6. The presence and severity of lesions are often asymmetrical, affecting teeth on one side more than the other; the underlying cause of this distribution is unclear (Biondi et al., 2019). These variations in colour, size, and shape are evident even within the same dentition.

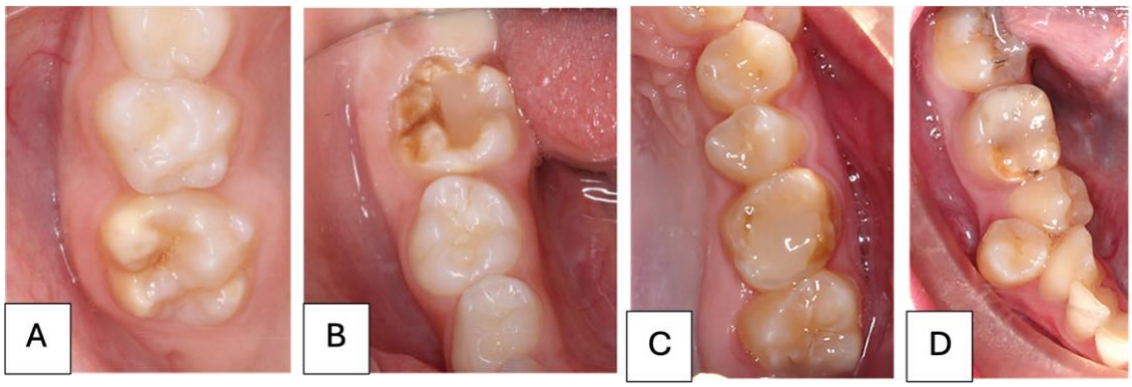


Figure 1.5: FPMs with variable MIH presentation. (A) and (B) Adapted from Afzal et al. (2024), licensed under CC BY. (C) and (D) Adapted from Vaiid et al. (2024), licensed under CC BY.

Figure 1.6: Incisors with variable MIH presentation. Adapted from Vaiid et al. (2024), licensed under CC BY.

The integrity of the enamel is important when diagnosing MIH which is mirrored in the severity. PEB may be present following tooth eruption due to masticatory forces and the porous nature of hypomineralised enamel, this in turn might expose dentine and precipitate caries and possible pulp involvement. Caries or restorations of atypical presentation may be seen where they extend to the smooth surfaces of the tooth. These should be classed as MIH lesions, especially where an opacity is seen at the margins of such restorations. As with extracted teeth, if the clinical records haven't noted the presence of MIH, the other FPMs must be examined for MIH opacities or atypical restorations (Lygidakis et al., 2010).

HSPM is not an indicative feature for MIH, although it may predict the development of MIH, which means that patients with HSPM may grow up to have a FPM erupting with MIH, but not all patients seen with HSPM would have a FPM affected by MIH nor all patients with MIH would have a HSPM. A systematic review in 2018 showed that there is an association, especially where there is mild HSPM without PEB, caries, atypical restorations, or atypical crown. Therefore, it is suggested to place an early preventative regimen with regular reviews to ensure reduced risk of hypersensitivity and PEB is experienced (Garot et al., 2018).

DIAGNOSTIC AIDS

Although MIH is diagnosed clinically, digital diagnostic tools including intraoral cameras may be used to identify MIH lesions. These tools offer enhanced visualisation by magnifying and illuminating the tooth surface, which facilitates clearer identification of subtle demarcated opacities, PEB, or atypical restorations that might otherwise be missed in clinical examinations. Intraoral photographs may be kept in the patient's records or be used to facilitate planning for management especially where a patient is to be referred to another specialist for a second opinion or orthodontic planning (Kühnisch et al., 2020).

Although radiographs may be routinely taken at the dentist for caries detection, they can't necessarily be used to detect the presence or absence of MIH; they may be used to understand the depth of PEB and proximity to the pulp and the alveolar bone. Radiographs are indicated where signs of pulpal involvement are apparent, if the patient requires an assessment prior to extraction of an MIH affected FPM, or if there are other clinical indications such as for assessment of dental caries or assessment of restorations. The type of radiograph is to be determined by the clinician based on the clinical indication, this may be intra-oral bitewings or periapical radiographs which are usually used for caries and periapical pathology assessment, or a dental panoramic tomograph (DPT) indicated for assessment of development and prior to extracting a FPM. While cone-beam computed tomography (CBCT) may be more detailed, the risks and benefits of radiation must be considered and their use is not routinely recommended (Rios and Santos-Pinto, 2024).

Transillumination may be used to help diagnose subtle MIH lesions or where the clinician is uncertain of the presence of a lesion, although it only aids in the detection of lesions on the incisors. When shining a light through the palatal or lingual aspect of the incisor, the hypomineralised lesion appears darker than normal enamel since the light scatters more in less mineralised or porous enamel. With molars, the scattering of the light is unreliable due to the anatomy of the tooth (Rios and Santos-Pinto, 2024).

ASSOCIATED SYMPTOMS

HYPERSENSITIVITY

MIH affected teeth may exhibit a level of hypersensitivity, this has a variable presentation between patients and sometimes even within the same dentition; it has been reported that around 1/3 of patients with MIH will experience hypersensitivity (Shields et al., 2024). Hypersensitivity is described as sharp, acute pain or discomfort from exposed dentin or a disturbance in the fluid-filled dentinal tubules in response to a stimulus, the stimulus may be tactile, thermal, osmotic, or chemical (Canadian Advisory Board on Dentin Hypersensitivity, 2003). Pain occurs in accordance with the hydrodynamic theory which explained that changes in temperature, osmotic, or physical changes within the dentinal tubules lead to fluid changes and movement resulting in stimulation of the baroreceptors leading to neural discharge (Bartold, 2006). MIH teeth are often affected due to their porous nature and reduced mineral quality as well as reduced enamel quantity in cases of PEB and exposed subsurface enamel or dentine, therefore there is easier access to the dentinal tubules which may present with altered properties of thermal isolation and conductivity. A study in Helsinki confirmed that the greater the severity of the MIH lesion, the more likely the patient would exhibit hypersensitivity. Those with PEB experienced more hypersensitivity than those with intact opacities and those which have defective enamel that has been restored or covered, the latter group still experienced sensitivity but to a lesser extent (Linner et al., 2021). This study also showed that younger patients did experience higher levels of hypersensitivity with their FPM after eruption, and as the age of the participants increased, the likelihood of experiencing hypersensitivity decreased. There are two theories that have been proposed, one of which is that over time physiological dentine formation and reactive dentine deposition occurs, since the dentine tubules are exposed. The regular use of topical fluoride in toothpaste, fluoride varnish applications, casein phosphopeptides-amorphous calcium phosphate (CPP-ACP) application, or desensitising agents would support this deposition and reduced tubular exposure. The other theory is that older children may have reduced awareness of tooth hypersensitivity or might have gotten used to the feeling. The size of the lesion had no correlation with hypersensitivity experience. MIH affected incisors did

experience less hypersensitivity than FPMs given that the FPMs are more prone to PEB and occlusal load.

DENTAL PAIN

Dental pain with MIH teeth may present as difficulty in maintaining good oral hygiene, difficulty when eating or drinking warm or cold foods or drinks, chronic pain, dental anxiety, or limited cooperation during dental treatment. Paediatric patients might find it more difficult to perceive dental pain due to boundaries with communication related to age or anxiety and inability to locate the pain. Children may experience pain as soon as the FPM erupts, and therefore that may be mistaken or confused with the pain of an erupting tooth (Bekes and Steffen, 2021).

DIFFERENTIAL DIAGNOSIS

DENTAL FLUOROSIS

Dental fluorosis commonly appears as white flecks on the dentition and may be apparent on the incisors, it may also have a pitted darker brown appearance. Fluorosis lesions occur due a prolonged period of high fluoride intake, which can range between direct ingestion of toothpaste, dietary fluoride supplements, or water, whether natural or fluoridated. This is usually associated with the permanent dentition which were developing at the time of high fluoride ingestion; that would be prolonged ingestion occurring between birth and age six with the first two years of life being most critical for the permanent teeth to be affected (The British Fluoridation Society, 2020). Severity of dental fluorosis is measured by the clinical image as per the Thylstrup-

Fejerskov (TF) index, where a score is given between 0-9. TF0 is a tooth with normal enamel translucency after prolonged air-drying, TF1 appears as narrow white lines, TF2 appears as more pronounced lines on smooth surfaces or scattered opacities <2mm on occlusal surfaces. TF5 would include enamel pitting <2mm and TF9 appears as change in the anatomical surface structure due to loss of enamel (Thylstrup and Fejerskov, 1978). Structurally, teeth affected by fluorosis are caries resistant, unlike MIH lesions which are caries prone (Weerheijm, 2004).

A systematic review by the University of York from 30 countries showed dental fluorosis to have a prevalence of 48% in fluoridated areas, whether naturally or artificially, and 15% in non-fluoridated areas. For aesthetically significant fluorosis, the prevalence was 10-12% in fluoridated areas and 12% in non-fluoridated areas. The prevalence and severity of dental fluorosis has been shown to increase as the water fluoride level increase (McDonagh et al., 2000). In the United Kingdom (UK), the prevalence for TF2 severity or more is 10% in fluoridated areas and 2% in non-fluoridated areas. The more aesthetically significant brown staining is usually with patients who have grown up in hot climatic areas with high levels of naturally occurring fluoride in the water and had malnutrition, therefore is uncommon in the UK (Pretty *et al.*, 2016). Two different representations of fluorosis may be found in Figure 1.7 and Figure 1.8.

Figure 1.7: Dental fluorosis. Contributed by Melina Brizuela, BDS. Reproduced from Rathee and Sapra (2025), licensed under CC BY-NC-ND 4.0.

Figure 1.8: Severe dental fluorosis. Reproduced with permission from Farid and Khan (2012). © BMJ Publishing Group Ltd. Licensed under RightsLink License No. 6072630164297.

AMELOGENESIS IMPERFECTA

Amelogenesis Imperfecta (AI) is a group of inherited conditions affecting the quantity and quality of enamel, therefore the structure and clinical appearance and may affect both the primary and permanent dentitions. Unlike the localised nature of MIH, AI has a generalised pattern affecting all or nearly all teeth. AI may be isolated or associated with other morphologic or biochemical changes in the body such as craniofacial anomalies (Aldred et al., 2003). Depending on the genetic mutation and phenotype associated; according to Witkop's classification, if the defects are in the enamel thickness they are known as hypoplastic, otherwise they are of defective quality presenting as hypomature or hypocalcified (Bloch-Zupan et al., 2023). Generally, AI is a rare dental condition, although its prevalence varies globally. In the United States of America (USA) it has an estimated prevalence between 1:14,000-1:16,000, with hypocalcified AI being the most common (National Organization for Rare Disorders, 2023). In Sweden, a prevalence of 13:10,000 has been noted, with hypoplastic AI as the most common type (Bäckman and Holm, 1986). It has been suggested that the global prevalence is <1:200, this may be lower than the actual prevalence due to inconsistent diagnostic measures (Gadhia et al., 2012).

AI may be classified according its phenotype, that being hypoplastic, hypocalcified, or hypomature, or it may be classified according to the mode of inheritance, that being autosomal dominant, autosomal recessive, x-linked, or sporadic (Reynolds et al., 2024). Hypoplastic AI is identified with reduced enamel thickness which may present as pits or grooves, this quality defect is on formation, therefore these features are apparent on radiographs prior to eruption and as soon as the tooth erupts. The reduced amount of enamel is seen in Figure 1.9 both clinically and radiographically. Hypocalcified and hypomature AI on the other hand have normal enamel thickness or quantity on eruption, they are classified with an altered quality of enamel. With hypomature AI, the enamel is of reduced hardness, it may appear chalky or opaque or even mottled and the enamel may chip easily, seen in Figure 1.10. With hypocalcified AI, the enamel may be yellow or brown in colour and it is softer and more

porous making it more vulnerable to PEB, as seen in Figure 1.11. Therefore, in the early mixed dentition, these lesions may be mistaken for MIH clinically and may be easily differentiated by conforming with their generalised pattern (Bloch-Zupan et al., 2023).

Figure 1.9: Hypoplastic AI. Adapted from Bloch-Zupan et al. (2023), licensed under CC BY.

Figure 1.10: Hypomature AI. Adapted from Bloch-Zupan et al. (2023), licensed under CC BY.

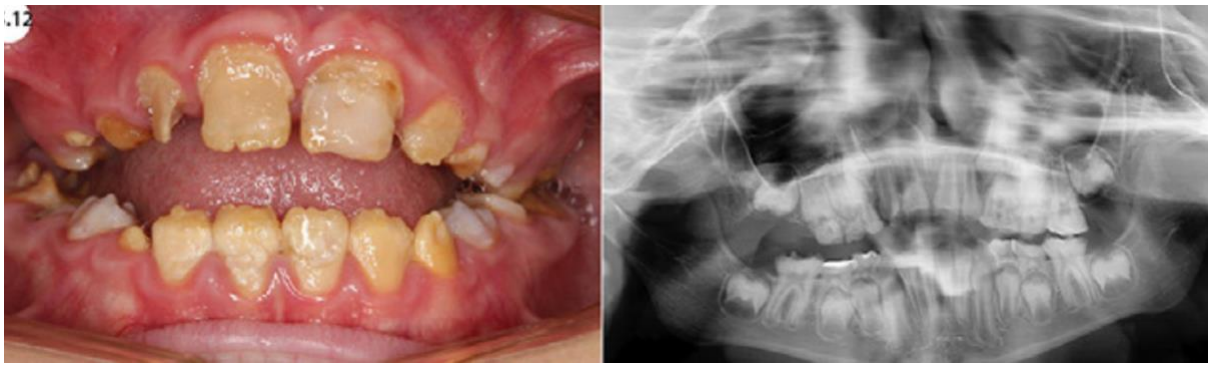


Figure 1.11: Hypocalcified AI. Adapted from Bloch-Zupan et al. (2023), licensed under CC BY.

Genetic testing may be offered for patients with AI where a study was undertaken to identify the correlation between certain genes and phenotypes. Isolated AI has been linked with genes like MMP20 and FAM83H (family with sequence similarity 83, member H) while FAM20A (family with sequence similarity 20, member A) for example was associated with syndromic forms (Bloch-Zupan et al., 2023). Therefore, a clinical examination, radiographic assessment, family pedigree analysis, and genetic testing if offered may confirm the diagnosis of AI.

ENAMEL HYPOPLASIA

MIH with PEB can be mistaken with enamel hypoplasia. Enamel hypoplasia is a quantitative defect where the enamel thickness is reduced, unlike hypomineralisation which is a qualitative defect with normal enamel thickness on eruption. Enamel hypoplasia may appear as pitted enamel, thinner enamel, or teeth that are smaller in size or are irregularly shaped. Enamel hypoplasia, like enamel hypomineralisation, may be localised or generalised. Localised enamel hypoplasia occurs due to trauma or infection to the predecessor primary tooth whereas generalised enamel hypoplasia may be due to environmental factors such as Vitamin D deficiency, systemic, or genetic factors. When generalised, the hypoplastic nature would follow a chronological

pattern within teeth developing at the time of insult, where applicable, as seen in Figure 1.12.

Figure 1.12: Chronological hypoplasia. Reproduced with permission from Patel et al. (2019), © Springer Nature. Licensed under RightsLink License No. 6072070119804.

To differentiate between enamel hypoplasia and MIH lesions with PEB one must examine the borders of the area with missing enamel. Hypoplastic lesions would have smooth and rounded borders, unlike the rough borders seen with MIH PEB. Where restorations already exist, the margins must be examined for signs of hypomineralisation. Also, hypoplastic enamel is hard and is of normal quality therefore bonding is not affected, unlike with hypomineralisation (Patel et al., 2019). Therefore, restorations might need to be replaced more often with hypomineralised lesions than with hypoplastic ones.

WHITE SPOT LESIONS

Early carious white lesions, also known as white spot lesions, are the initial visible sign of dental caries characterised by milky or chalky white opaque spots on the enamel surface; this is due to subsurface demineralisation caused by acids from bacteria. These lesions have an intact surface layer but reduced mineral content beneath, they are reversible with proper preventive care. They may be diagnosed using visual assessment, radiographs, fluorescence, and other advanced diagnostic methods

(Lopes et al., 2024). An example may be found in Figure 1.13. Management of white spot lesions focuses on non-invasive remineralisation strategies such as fluoride application, improved oral hygiene, and dietary advice to prevent progression to cavitation where it may require more invasive treatment (Lopes et al., 2024).

White spot early carious lesions are caused by external factors like bacteria and poor oral hygiene and may affect any tooth in the primary and permanent dentitions. They develop over time and are not present on eruption. Unlike MIH where it is a developmental defect of intrinsic factors present on eruption affecting the structure of enamel and MIH affects specific teeth in the dentition. Although both conditions present as white marks, they differ in cause and hence differ in management.

Figure 1.13: White spot lesions post-orthodontic treatment. Reproduced with permission from Sampson and Sampson (2020), British Dental Journal. © Springer Nature. Licensed under RightsLink License No. 6072620098079.

EARLY DIAGNOSIS OF MIH

General dentists and those working in primary care will encounter patients with MIH and early diagnosis in children is essential to reduce the long-term burden of treatment on the patient and parents or guardians, and treatment providers. Having a tailored

management plan means that the patient could either lose the affected FPM early or have a more definitive restoration at a younger age, reducing the need for repeat procedures. Along with the financial burden, the patient might have more frequent school absences and psychological stress, which may also affect the parents or guardians (Gambetta-Tessini et al., 2016).

RISKS OF MISDIAGNOSIS

Misdiagnosis of MIH may lead to provision of aggressive intervention early or over-treatment; under-treatment may also be evident, where a clinician doesn't have the full understanding of the treatment needs of the patient. When a clinician isn't confident and results in under-treatment or incorrect management provision, the patient's clinical journey is prolonged with frequent visits to dentist for possible failed restorations or symptoms that aren't managed appropriately. They may exhibit chronic discomfort and accelerated PEB which could have been avoided and therefore over-complicate future treatment (Al-Nerabieah et al., 2025).

PSYCHOLOGICAL IMPACT

MIH may be seen to cause dental fear and anxiety in children; in 2022, a systematic review was conducted to understand what psychological effects MIH may have on a child, one of their conclusions is that potential fear and anxiety were reported by the clinician or often the child's parents and therefore may not mirror the child's feelings. There as an impact though with the OHRQoL with MIH patients compared to those without MIH; especially when it comes to oral symptoms and functional limitations (Jälevik et al., 2022). OHRQoL would include the patient's perception on ability to

function, psychological status, social factors, and pain or discomfort (Bekes and Hirsch, 2013). The OHRQoL has been shown to improve in MIH patients after management when it came to hypersensitivity and function (Fütterer et al., 2020). Patients with MIH require treatment more often than those with healthy enamel, even into adulthood. FPMs with MIH have been shown to be treated 10 time more often than controls. Also, given that the teeth might not be easy to anaesthetise due to hypersensitivity, behaviour management is often required (Jälevik and Klingberg, 2012). Access to treatment might pose a time and financial burden on patients and their families; as a consequence, children might need to miss school more often for dental appointments, pain, or bullying (Almuallem and Busuttil-Naudi, 2018; Large et al., 2020).

When it comes to the aesthetic appearance of teeth affected by MIH, studies have shown that they will negatively affect a child's self-perception and social life (Silva et al., 2020). Children have self-reported receiving unkind remarks regarding their dental appearance (Rodd et al., 2011). Unkind remarks or bullying may result in short-term or long-term psychological distress or physical harm (Seehra et al., 2011), children have reported that they avoid smiling due to their dental appearance (Leal et al., 2017). Patients have been referred to secondary care for management of aesthetics that affect their social wellbeing and oral function. In a study by Large et al., which looked at patients with visible incisor opacities, 48% of the referrals from general dentists specified a social or functional impact while upon the first assessment in the hospital 86% of clinicians noted that those were of the patients' main concerns (Large et al., 2020).

SEVERITY

Many severity indices have been introduced including ones by the EAPD and American Academy of Pediatric Dentistry (AAPD), although their classification

systems seem very similar, they differ in clinical emphasis. The EAPD focuses on the visual characteristics of the enamel defect while the AAPD focuses more on the functional implications as well as the clinical picture. The EAPD advises to record the severity of MIH as mild or severe. Mild cases represent demarcated enamel opacities that have no signs of enamel PEB but may present with occasional sensitivity to an external stimulus such as air or water, but not to toothbrushing. In mild cases, there would be mild aesthetic concerns regarding the aesthetics of the anterior teeth. In severe MIH, there is clear enamel PEB, caries, or hypersensitivity which is spontaneous or persistent and therefore affects function such as when toothbrushing. The patient might have aesthetic concerns affecting their socio-psychological state (Lygidakis et al., 2010). On the other hand, the AAPD classified MIH severity as mild, moderate, or severe. Mild cases being those opacities in non-stress bearing areas in the absence of caries and sensitivity, moderate cases being those with atypical restorations, with caries or PEB that doesn't involve the cusps, the tooth may have mild sensitivity. In severe cases, there would be rapid PEB or widespread caries and the patient might complain of sensitivity or have aesthetic concerns (AAPD, 2024).

MANAGEMENT OPTIONS

When planning the management of teeth affected with MIH, there are several different considerations for anterior and posterior teeth, as well as at the patient level, at the oral level, and at tooth level (Lygidakis et al., 2022). For both anterior and posterior teeth, the patient's age, developmental stage, relevant medical history, cooperation, and access to dental care are some of the factors at the patient level. On an oral level, the patient's dental status in relation to decayed, missing, and filled teeth (DMFT) also influence treatment. Also, assessing symptoms, including hypersensitivity, both with the anterior and posterior teeth. Finally, the tooth and lesion itself are assessed for management, in relation to the size, location, the surfaces at which the defect is present, and more importantly presence or absence of PEB.

Considering anterior teeth, there might be a psychological factor as well since children might be bullied in school due to their dental appearance. The number and depth of the opacities as well as the position of the dentition where the clinician must consider potential for further growth would determine the type of treatment that may be offered (Lygidakis et al., 2022).

With the posterior teeth specifically, the presence or absence of symptoms would greatly influence the management plan. At an oral level with the posterior teeth, the number of teeth affected and the patient's occlusion which may dictate the need for orthodontic treatment as well as presence or absence of third permanent molars (TPM) and hypodontia of other teeth are important factors for treatment planning. Another consideration is that posterior teeth may already have atypical caries or large restorations in situ, these must be assessed individually for long-term prognosis, an assessment of recurrent caries and possible pulp involvement (Lygidakis et al., 2022).

According to the EAPD's Best Clinical Practice Guidance, a management summary for MIH affected FPMs has been developed as seen in Figure 1.14. This takes into consideration any signs or symptoms of PEB and its extent, DMFT, reversible or irreversible pulpitis or abscesses and cellulitis, sensitivity and the patient's dental age (Lygidakis et al., 2022). Where patients present with mild defects with mild sensitivity and a low DMFT index, in the absence of reversible or irreversible pulpitis and abscesses, regardless of their age, they may require fluoride therapy along with casein phosphopeptide-amorphous calcium fluoride phosphate (CPP-ACFP), and sealant placement. Although patients with MIH that have had fluoride varnish were still at an increased risk of caries and PEB (Bullio Fragelli et al., 2015), regular check-ups every 3-6 months and providing oral hygiene advise would allow early detection of caries and PEB, and possibly prevent more invasive treatments. The use of CPP-ACFP and fluoride varnish has been shown to remineralise enamel in MIH affected lesions, but those studies were considered to have moderate to high risk of bias as Somani et al. concluded in their systematic review (Somani et al., 2022); therefore, their use is

conditional. Placement of fissure sealants is generally recommended by Public Health England through their Delivering Better Oral Health (DBOH) toolkit for prevention and control of dental caries (Public Health England, 2021). Given that hypomineralised teeth are more prone to caries, those FPMs must have fissure sealants, and those sealants must be well-retained and topped up when needed during routine check-ups. Using a dental adhesive while placing fissure sealants on FPMs with mild MIH defects with intact enamel has been shown to increase the sealants full or partial retention over four years with no loss of sealants reported; full sealant retention was at 70.2%. Fissure sealants that were placed without an adhesive system were fully retained in 25.5% of the cases and 29.7% were fully lost at the four-year review (Lygidakis et al., 2009).

SIGNS/SYMPTOMS	Mild defect → Severe defect				
Post-eruptive breakdown/Caries					
No of breakdown surfaces					
Sensitivity					
DMFT					
Reversible Pulpitis	—	—	—	+	+
Irreversible Pulpitis	—	—	—	—	+
Abscess/Cellulitis	—	—	—	—	+
Dental Age (yrs)	6-16	6-9	7-16	7-16	8-10*
THERAPEUTIC APPROACH	**F/CPP-ACFP/ Sealants**	**Glass Ionomer**	**Composite Resin**	**Preformed metal crown**	**Extraction**

*preferable chronological period for spontaneous space closure.
— indicates absence and + indicates presence of the sign/symptom

Figure 1.14: Management of posterior teeth affected by MIH. Reproduced from Lygidakis et al. (2022), licensed under CC BY 4.0.

When teeth start to exhibit some PEB, caries, or sensitivity in the absence of symptoms such as reversible pulpitis, the patient's dental age would be considered. In younger patients between the age of 6-9 years where cooperation or moisture control for definitive restorations are not feasible, placement of glass ionomer cement (GIC) restorations is recommended as an interim measure to help with sensitivity and prevent further PEB. GIC might also be used where the teeth are of poor long-term prognosis and are awaiting timed extractions (Lygidakis et al., 2022). For older patients between the ages of 7-16 years, the EAPD recommends placement of composite restorations for defects that aren't considered neither mild nor severe, but somewhere in between.

When placing composite restorations, ensuring the tooth is isolated with rubber dam and the composite bonds to non-hypomineralised enamel is essential for success. Composite restorations have shown to have better success rates than GIC restorations within hypomineralised molars (Mejàre et al., 2005). Although removing all of the hypomineralised enamel may be very destructive, there is less risk of breakdown down at the margins if only the porous enamel were removed. Therefore, it is recommended to remove all hypomineralised enamel (Lygidakis et al., 2010); as shown in Figure 1.15.

Figure 1.15: Outline when removing all hypomineralised enamel. Adapted from Kopperud et al. (2017), licensed under CC BY 4.0.

Within the age group of 7-16 year olds, if there were more severe defects including PEB or caries affecting more surfaces or presence of reversible pulpitis, but the teeth are still restorable; the recommendation by the EAPD is to place a preformed metal crown (PMC) on that FPM (Lygidakis et al., 2022). A PMC would help preserve the remaining tooth structure in a FPM exhibiting PEB and help prevent further PEB, they can be placed on one visit and wouldn't require impressions and the extra cost of fabrication in a dental laboratory. Although orthodontic separators might be used prior to placement to make space, possibly on a separate appointment, the clinician may need to undergo an interproximal slice to place the PMC if one visit is required. PMCs also help resolve any hypersensitivity the patient might be experiencing and can buy a patient time until the FPM is due for timed extractions. Laboratory manufactured indirect restorations may be used but require clinically sound enamel to bond to, therefore extensive tooth preparation might be required prior to placement and thus a temporary restoration may be needed; this ads on to the cost and chair time for patients compared to PMC placement. An example of a fissure sealed FPM, composite restoration, and a ceramic restoration may be found in Figure 1.16.

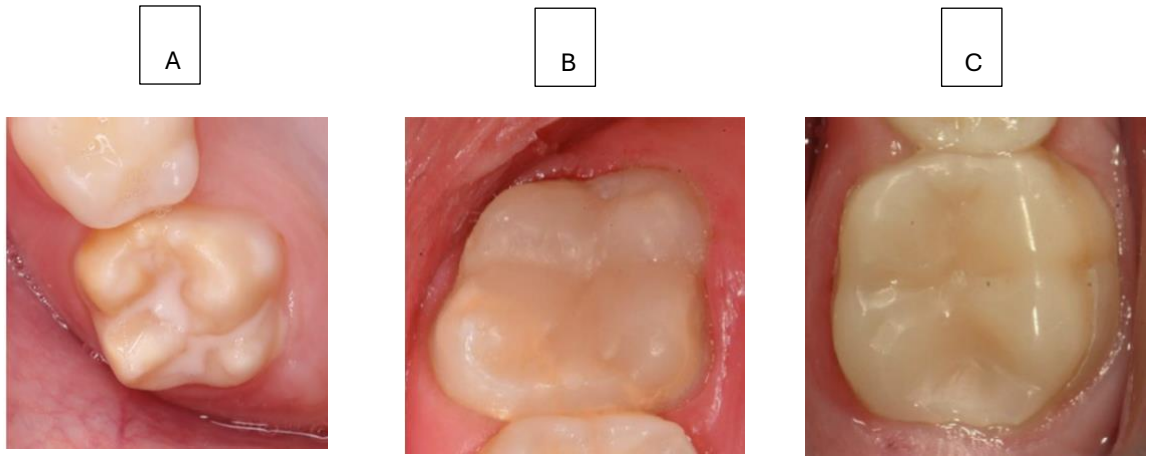


Figure 1.16: Different treatments for FPMs: (A) Adapted from Bekes et al. (2022), licensed under CC BY 4.0. (B) and (C) Reproduced from Linner et al. (2020), licensed under CC BY-NC-ND 4.0.

With the very severe lesions and where there are signs of reversible or irreversible pulpitis or abscesses and facial cellulitis, the tooth would need to be eventually extracted. Root canal treatment (RCT) at this stage may be considered if the tooth is restorable, considering the amount of tooth tissue that is to be removed or need for a

PMC; but there is limited evidence of long-term success of root canal treated FPMs affected by MIH. Therefore, the risks and benefits of keeping the tooth are considered keeping in mind the recommended chronological age for more predictable spontaneous space closure after extractions, which is between age 8-10 years (Lygidakis et al., 2022). RCT would require multiple longer appointments, which needs a cooperative patient. Also, the patient may have immature roots which further complicates the RCT, therefore the risks and benefits of RCT should be assessed (Masri et al., 2025).

RCS recommends that cases of FPM extractions should be referred to a centre where a multi-disciplinary treatment plan may be formulated between an orthodontist and paediatric dentist; if that is not feasible, RCS has developed a guideline to follow (Noar et al., 2023). An assessment of the patient's dental developmental age, an orthodontic assessment, assessment of hypodontia, presence or absence of a TPM, patient cooperation for complex treatment, and need for general anaesthesia for treatment might sway the management plan. Also, the parents/guardians or patients may not wish to undergo early extraction of a tooth that may be stabilised. Understanding the restorative and financial burden along with future need for extraction of poor-prognosis FPMs where the space has to be accepted is part of the discussion before consenting for extractions.

Part of the assessment is taking a DPT which is essential to facilitate assessment of crowding and the teeth that are developing. This also gives the clinician an idea of the position of the developing SPM, where mesial tipping and presence of a TPM had higher success rates of spontaneous space closure in the lower arch. If the SPM has already erupted, it won't migrate mesially. In the upper arch, usually the SPMs erupt into a good position regardless of their angulation at the time of the FPM extraction (Patel et al., 2017). Examples of residual space post-extraction of FPMs are shown in Figure 1.17. Several studies have reported good outcomes after extracting severely hypomineralised FPMs. A recent systematic review confirmed that good outcomes are expected in the maxilla after removal of an upper FPM irrespective of age, as long as the SPM has not yet erupted. In the mandible spontaneous space closure was not

always seen, even if the extractions were carried out at the optimal timing and start of mineralisation of the root of the SPM, Demirjian's stage E, with the presence of the TPM and mesial angulation of the developing SPM (Marchiori et al., 2016; Masri et al., 2025).

Where there is crowding in the upper arch or the patient has a class II incisor relationship which requires space for correction, it is advised to stabilise the FPM until the SPM erupts and future need for orthodontic treatment. Consideration of the presence or absence of TPM, although isn't always definitive at the age of 8 where it is recommended to plan such cases, is a good prediction of having ultimately two molars in that quadrant once the FPM is extracted. If the TPM is not visible on the DPT at this stage, the planning is more complex and is best to have an orthodontist explain the options to the patient and parent/guardian since there is a possibility of being left with one molar at that quadrant. Where the TPM is present, there has been evidence that removal of the interceptive extraction of a FPM would improve the position of the developing TPM due to an increase in space in that area (Ay et al., 2006).

When extracting any FPM, balancing extractions are not recommended to preserve the centreline. If extracting a lower FPM and the upper FPM would be unopposed for significant period of time or there is a clear occlusal need, then a compensating extraction of the upper FPM is recommended; otherwise, where the upper FPM requires extraction, compensating with the lower FPM is not required and each tooth would need to be treated on its own merit (Patel et al., 2017; Noar et al., 2023). There is a lack of research around mastication efficiency after removal of the FPM, OHRQoL, the patient and parents satisfaction post-extractions, and the preference of treatment modalities of dentists when extracting FPMs (Masri et al., 2025).

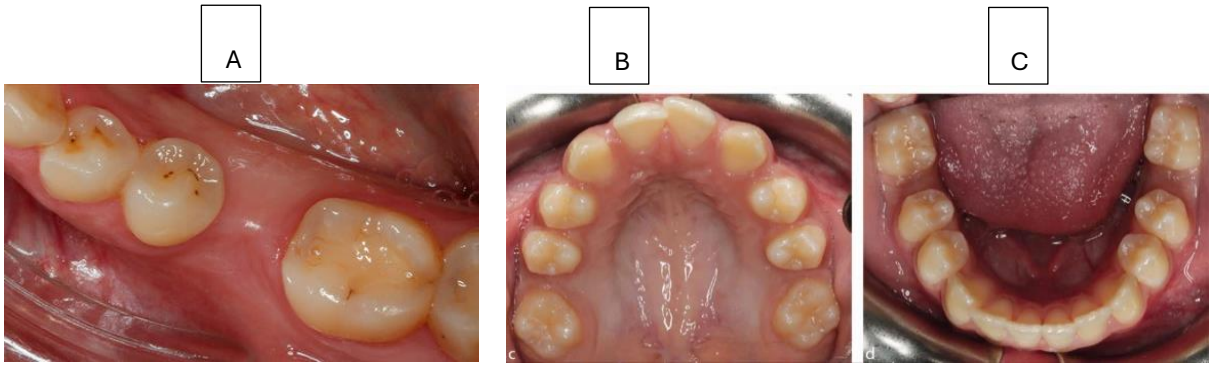


Figure 1.17: (A) Residual space after FPM extraction. Reproduced from Roig-Vanaclocha et al. (2021), licensed under CC BY. (B) and (C) Unfavourable positions and residual space after extraction of all FPMs. Reproduced from Lakhani et al. (2023), licensed under CC BY 4.0.

The EAPD Best Clinical Practice Guidance recommend treatment for anterior teeth affected by MIH, as seen in Figure 1.18. Treatments range between regular monitoring, regional tooth whitening, micro-abrasion, macro-abrasion, resin infiltration, composite restorations, or a combination of any. The least invasive treatments should be considered initially to ensure conservation of tooth tissue not to limit their options in adulthood. The severity of the lesion is initially assessed in accordance with the colour, location, any PEB or risk of PEB in the future. Then the patient factor is also tailored in with any aesthetic concerns to guide the management plan. External tooth whitening may be prescribed to camouflage the whiter opacities or mismatch in colour on the anterior dentition. This is carried out with custom-made trays and up to 6% hydrogen peroxide or with 10% or 16% carbamide peroxide (Lygidakis et al., 2022). The General Dental Council (GDC) only allows tooth whitening products containing or releasing between 0.1-6% hydrogen peroxide to be used in children or adolescents under the age of 18 years, wholly for the purpose of treating or preventing disease (General Dental Council, 2016). Therefore, their use may not be readily available. Micro-abrasion may be carried out under rubber dam isolation with an abrasive pumice mixed with 18% hydrochloric acid, rubbed onto the surface, with intermittent washing, after which the teeth should be dried, and fluoride is applied onto the surfaces to encourage remineralisation (Wong and Winter, 2002). 37% phosphoric acid with pumice followed by CPP-ACP may also be used (Bhandari et al., 2019). Micro-abrasion works well with superficial lines or patches where it removes 100-200 micrometres of surface enamel; this technique has been shown not to work as well for

multi-line or diffuse opacities (Wong and Winter, 2002). With resin-infiltration, 15-20% hydrochloric acid etchant, ethanol, triethylene glycol dimethacrylate (TEGDMA) monomer resin infiltration which may be used for white lesions on non-stress bearing areas since the effect on enamel microhardness is not fully understood and differs with manufacturer instructions. This should be carried out under rubber dam isolation and following the individual manufacturer's precise instructions. When lesions are not fully masked after non-invasive treatment or where PEB is evident, composite restorations with or without an opaquer may be used. Sometimes, MIH lesions require partial or full removal for improved aesthetics not to shine through a restoration, this would be considered macro-abrasion (Lygidakis et al., 2022). A combination of those treatments may be required for optimal results, this in turn requires the clinician to fully understand their mechanisms to ensure that they are carried out in a sequence that won't compromise results and risks the tooth integrity where it is avoidable. Examples of treatment to the anterior teeth may be found in Figure 1.19.

Severity	Clinical examination	Problems	Therapeutic approach
Severe ↑ Mild	Opacities + Loss of enamel structure	Risk of tooth fracture + Aesthetic concerns	Localised macro-abrasion/micro-abrasion + Resin infiltration + Composite restoration
	Opacities on the incisal edge	Aesthetic concerns ± Risk of tooth fracture	Localised macro-abrasion/micro-abrasion + Resin infiltration + Composite restoration
	Brown/yellow opacities	Aesthetic concerns	Localised macro-abrasion/micro-abrasion + Resin infiltration + Composite restoration
	White/creamy opacities	Aesthetic concerns	Regional whitening +/- Micro-abrasion +/- Resin infiltration OR don't do anything

Figure 1.18: Management of anterior teeth affected by MIH. Reproduced from Lygidakis et al. (2022), licensed under CC BY 4.0.

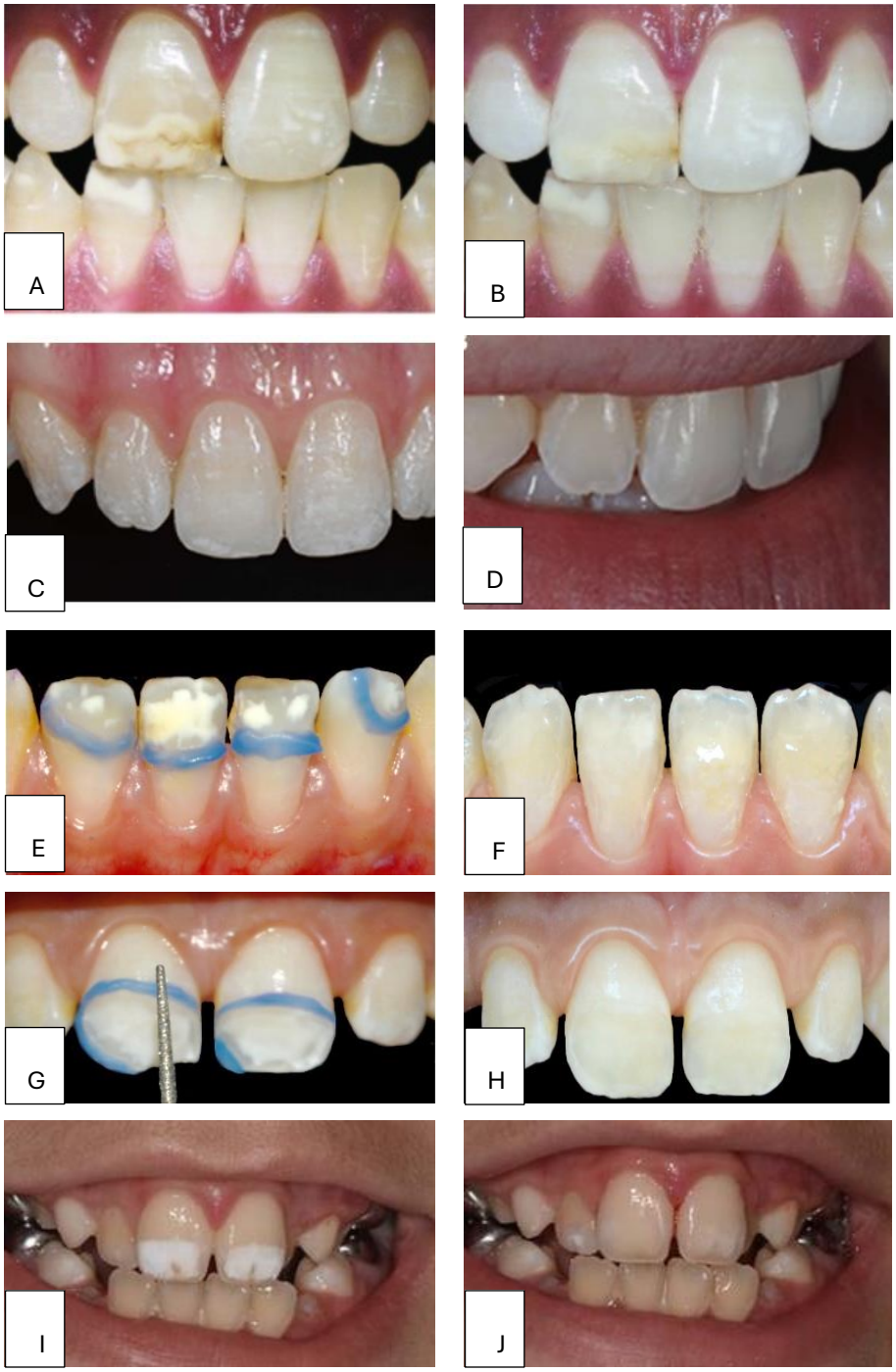


Figure 1.19: (A) Before tooth whitening and (B) after tooth whitening. Reproduced from Maroune et al. (2018), licensed under CC BY. (C) Before microabrasion and (D) after microabrasion. Reproduced from Pini et al. (2015), licensed under CC BY-NC 4.0. (E) Before resin infiltration and (F) after resin infiltration; (G) during macroabrasion and before composite restoration, and (H) after macroabrasion and composite restoration. Reproduced from Hajer and Ben Amor (2023), permission granted by author. (I) Before microabrasion and resin infiltration and (J) after microabrasion and resin infiltration. Reproduced from Hasmun et al. (2018), licensed under CC BY.

Hypomineralised teeth have been reported to be hypersensitive and difficult to anaesthetise. The enamel acts as a poor insulator for the pulp; leading to sensitivity to external thermal stimuli (Almuallem and Busuttil-Naudi, 2018). The porous nature would allow bacteria and other materials from the oral cavity to reach the dentine more easily (Fagrell et al., 2013). When anaesthetising the tooth, even if the amount of local anaesthetic is increased, the tooth might still be not fully anaesthetised since the chronic hypersensitivity leads to a hyper-reactive tooth. Some ways to overcome this with paediatric patients is through behaviour management, appropriate sedation, use of desensitising medicaments or fluoride varnish prior to the treatment appointment, or use pre-operative ibuprofen (Discepolo and Baker, 2011).

MODALITIES OF TREATMENT

Patients with MIH tend to require more dental treatment, up to 11 more times than controls, and therefore a good experience is required at every visit (Kotsanos et al., 2005). This can be achieved by avoiding pain at each part of the treatment, using the available tools for best possible pain control, and ensuring that the patient's behaviour and feedback are accounted for at each visit (Bekes and Steffen, 2021). A retrospective study in the UK where the management of MIH patients within a specialist centre was investigated, they concluded that of those requiring treatment, 42.6% had treatment under general anaesthesia and 20.8% had treatment with the aid of sedation, and 38.3% had treatment on the chair with behaviour management with or without local anaesthesia (Humphreys and Albadri, 2020).

Clinicians involved in treating children should be aware of different behaviour management strategies for successful treatment, this doesn't specifically apply to MIH patients. Examples include the tell-show-do technique where the patient is introduced to the procedure or steps through conversation followed by a demonstration outside the oral cavity and finally implementing the procedure. Enhancing control is another

technique where the patient is given the ability to pause treatment with a stop signal for example. Other techniques include behaviour shaping and positive reinforcement where small steps are taken to ensure the patient comprehends which behaviours we would want to reinforce by praise or physical reinforcer such as a sticker (Royal College of Surgeons England, 2002).

Another aspect to consider is that the examination must be painless to build patient confidence, therefore knowledge of risk of hypersensitivity and careful use of any thermal stimuli such as air from the dental unit, or through mechanical probing, to a lesser extent (Raposo et al., 2019). Due to hypersensitivity, teeth may be more difficult to anaesthetise, which will be discussed later in more detail, hence a clinician should assess if any adjuncts are needed from the initial encounter. These adjuncts include computer controlled local anaesthesia delivery (CCLAD) or an adjunct of premedication for treatment, or a form of sedation such as drug-induced or inhalation sedation. These must be considered prior to assessing if the patient requires a general anaesthesia, which in some cases may be optimal considering the type of treatment required (Bekes and Steffen, 2021).

Premedication is recommended where a reduction in chronic inflammation is required to allow local anaesthetic administration, therefore an analgesic with an anti-inflammatory effect is recommended. The clinician must refer to the local formulary prior to prescribing any medications. Post-treatment medication is not routinely recommended for MIH patients, unless the procedure itself was painful, such as with extractions of FPMs, a post-operative medication may be recommended (Bekes and Steffen, 2021).

Where a patient is anxious for dental treatment or where the clinician feels that the patient would benefit from a sedation adjunct, depending on the patient's medical history, age, and availability of services, conscious sedation is considered. That may be in the form of inhalation sedation with nitrous oxide and oxygen, this form of sedation offers an anxiolytic and sedative effect and may have also act as an analgesic

and muscle relaxant but isn't to be used as an anaesthetic (International Association of Paediatric Dentistry, 2024). Nitrous oxide is non-irritant, has a quick onset and recovery time, easily reversible, with low tissue solubility and minimum alveolar concentration (MAC) value, making it safe to use in the paediatric clinic. Medication induced sedation on the other hand may be with a short-acting benzodiazepine such as midazolam which has rapid onset and acts as an anxiolytic, sedative, anticonvulsant and muscle relaxant, and a hypnotic. Midazolam may be administered orally, intravenously via a cannula, or transmucosal as an intranasal drug for dental implications (Ashley et al., 2021). The clinician must follow the local guidelines for conscious sedation.

The final form of undergoing management is under general anaesthesia, this may be considered in cases of extreme anxiety, failed attempts at treatment on the chair with the aid of sedatives, where the patient is medically compromised where this mode of treatment is the only one available to be able to complete the treatment, or due to the complexity and extensiveness of treatment (Bekes and Steffen, 2021). It allows for comprehensive treatment to be carried out in a single visit, where factors like hypersensitivity and anxiety during treatment which may prolong the management on the chair are eliminated. Improvement of OHRQoL has been reported in children post general anaesthesia for management of MIH (Ridell et al., 2015).

TREATMENT CHALLENGES

INCREASED CARIES RISK

Dental caries is a progressive disease that leads to breakdown of dental hard tissue, due to cariogenic bacteria presence which lead to demineralisation. It is a multifactorial disease which involves the host or tooth structure, the microbial biofilm formed, the person's diet along with their salivary quality and quantity (Pitts et al., 2017). Molars in

general are the teeth most prone to dental caries due to their anatomical structure involving pits and fissures caries (Demirci et al., 2010). Developmental defects of enamel (DDE) in general as well have been shown to act as predisposing factors to dental caries (Seow et al., 2016). With MIH and caries, there has been a positive correlation in the literature (Paglia et al., 2023). Children with hypomineralised FPMs have been reported to be nearly 14 times more likely to develop dental caries in those molars compared with patients with non-hypomineralised molars (Arrow, 1998). Also, the more severe the MIH lesion, the more at risk the tooth is to dental caries and hypersensitivity as well (Afzal et al., 2024).

The porous nature of hypomineralised enamel would result in a more favourable surface for biofilm development. Also, the porous and soft nature means the enamel is more fragile, therefore leading to more rapid enamel breakdown under masticatory forces. PEB hence exposes the underlying dentine, which is more prone to the development of caries. Along with suboptimal oral hygiene practice due to hypersensitivity or a patient's socioeconomic status and caries experience in primary teeth, these factors lead to a higher risk of dental caries development (Weerheijm, 2004; Oreano et al., 2023).

DIFFICULTY IN ACHIEVING ANAESTHESIA

Achieving effective local anaesthesia with MIH affected teeth has been reported to be very challenging. Teeth exhibit increased sensitivity due to more porous enamel and possibly exposed dentine, especially in severely affected FPMs with PEB; therefore, they don't always respond to conventional anaesthesia and sometimes after multiple attempts to anaesthetise a tooth, the patient might still feel sensitivity. This may result in delaying treatment or losing the patient's confidence and cooperation in the future. Also, the porous nature and PEB would transfer the stimulus to the pulpal tissues quicker than in normal healthy enamel. This may be the case with other

hypomineralised teeth in the dentition that aren't being treated. Another aspect to consider is that teeth may exhibit chronic pulpal inflammation, leading to a lower pH in the surrounding tissues, therefore reducing the effectiveness of the anaesthetic drug that is administered (Bhalla et al., 2021). Therefore, different adjuncts to local anaesthesia may be necessary. Inhalation sedation or pre-emptive analgesia may help with the increased pain threshold, using different methods of administering local anaesthesia such as intra-ligamental, intraosseous, or palatal anaesthesia may be suitable, use of 4% articaine for infiltrations where feasible especially for pulpitis or inflamed FPMs, and always ensuring rubber dam isolation during restorative treatment to ensure patient comfort and cooperation for success (Almuallem and Busuttil-Naudi, 2018; Vicioni-Marques et al., 2022). More advanced delivery methods of anaesthesia such as The Wand, a CCLAD system, may ensure further comfort particularly for palatal and intra-ligamental sites. The Wand helps with pain perception as well as cooperation and anxiety in paediatric patients (Khehra et al., 2018). Although not always feasible and available in primary care clinics, these adjuncts to treatment ensure comfort and completion of treatment.

RESTORATION FAILURE

Patients with MIH have both an increased risk of caries and a greater need for dental treatment, and, in addition to that, a higher likelihood of restoration failure and the need for repeated restorations or sealants even after treatment. Fissure sealants tend to have a high failure rate in MIH FPMs. When conventional fissure sealant placement was compared to fissure sealants placed after treatment with a dental adhesive, 100% of sealants placed with adhesion were fully retained in 12 months and 70% in 48 months, while with those placed without an adhesive, only 79% were fully retained in 12 months and 26% in 48 months (Lygidakis et al., 2009). A study which looked at success and acceptability of restorations after an average of 5.2 years, GIC and resin-modified glass ionomer cement (RMGIC) restorations had around 49% success while composite restorations had around 85% success, amalgam was also assessed,

although it is no longer recommended (Mejàre et al., 2005; Lygidakis et al., 2010). Although placement of PMC and indirect restorations has been recommended and it has been suggested they have high success rates, considering their placement on carious molars, not many studies have been published on their long-term success rates when placed on MIH FPMs (Lygidakis et al., 2022). A retrospective study carried out in South Korea which looked at 115 PMCs placed on FPMs in paediatric patients showed an overall 5-year survival rate of 82.8%, 50 of those FPMs had a PMC placed due to MIH, their survival rate was 86% (Oh et al., 2020). With all of the PMCs assessed, more than half (55.6%) had failed due to being defective and the rest either de-bonded (22.2%), developed periapical pathology (16.7%), or perforated due to wear (5.6%). Defective PMCs included those where there were open margins and the crown wasn't fully seated, an overall poor fit, or lodged crowns. Where a tooth requires RCT, there isn't enough evidence on success of root canal treated FPMs affected by MIH (Somani et al., 2022). A systematic review which looked at compromised FPMs, expressing that most compromised FPMs are due to caries or MIH, explained that the success rate was high for coronal pulpotomies (90.5% with mean follow-up at 28.4 months) and for partial pulpotomies (91.3% with mean follow-up at 24.4 months (Taylor et al., 2020). The systematic review also noted that there is limited evidence for success of pulpectomies and success of regenerative techniques for immature roots.

EXTRACTIONS OF POOR PROGNOSIS FPM

Spontaneous space closure post-extraction of a hypomineralised FPMs has been studied to ensure the best timing for extractions where a patient can avoid need for orthodontic space closure in the future. In a retrospective study after an average of 4.8 year follow up, the spontaneous space closure was assessed clinically, and the exact timing of extractions was found not to be overly critical around the ideal timing of 8-10 years. Extraction of upper FPMs usually resulted in favourable results regardless of extraction timing. In the lower arch, even when at the optimal SPM root development

stage, there was incomplete space closure between the SPM and second premolar, rotations, angulation of the SPM or premolar, or distal drifting of the SPM, or a combination of two or more (Teo et al., 2013).

Where HSPMs require extractions, it is important to assess the need for treatment and if stabilisation or restorations are appropriate since there are orthodontic implications associated and future need for orthodontic treatment (Pedersen et al., 1978).

PROGNOSIS

In dentistry, prognosis refers to the predicted clinical outcome or long-term stability of the tooth within the patient's oral cavity, it includes the status of the tooth and patient factors, therefore it differs between each tooth in each patient (Samet and Jotkowitz, 2009; Eachempati et al., 2024). First are the tooth factors determining prognosis include an assessment of the restorative, periodontal, and endodontic outcome of the tooth. Second are the patient related factors which include the environmental, financial, and behavioural considerations which may limit access and management options.

When assessing the restorability of a tooth affected with MIH, the quantity of remaining sound coronal tooth structure must be assessed, therefore hypomineralised enamel is excluded due to its compromised structure (Samet and Jotkowitz, 2009). The Scottish Dental Clinical Effectiveness Programme (SDCEP) described the specific characteristics which determine poor prognosis hypomineralised permanent molars (SDCEP, 2025b). Within this guideline, the visual aspects such as colour and location were included. The colour of the hypomineralised lesion would determine how severe the lesion is and potential for PEB; where white and cream lesions are the least severe, followed by the yellow lesions being of moderate severity, and brown lesions

being the most severe and more likely to breakdown. Lesion location also plays an important role in prognosis, those that are on smooth surfaces are the least severe, then come lesions on the occlusal surfaces or incisal edges being moderately severe, and finally those with cuspal involvement being the most severe. In addition, the presence of atypical restorations would mean the molar is of poor prognosis. Other factors that were included were symptoms including hypersensitivity from the tooth, this includes hypersensitivity to changes in temperature or while tooth brushing.

The restorative factors to assess when determining the prognosis of a tooth include presence of dental caries and the extent and depth of the caries, this determines the amount of healthy tooth tissue for a restoration to bond to (Eachempati et al., 2024). Where a tooth presents with atypical caries as well as MIH, the caries may be considered as a consequence of MIH (Gevert et al., 2024). The tooth assessment requires the aid of radiographs and caries risk assessment as well. Larger lesions and those with close proximity to the gingival margin may have a poorer long-term prognosis when restored. This is considering their long-term stability and bonding to healthy tooth tissue and ability to achieve good isolation. Another factor to consider is the remaining circumferential dentine's height and width, a restoration would require 2-3mm of healthy dentine for support and stability of the restoration, this is turn also ensures there is enough healthy tooth tissue to bond to. The clinician should ensure that the tooth is able to withstand a restoration. A ferrule height of at least 2 mm continuously around the crown is required where teeth are very compromised to ensure there is enough structure to withstand occlusal forces and prevent tooth fracture. One must also keep in mind the crown-to-root ratio when planning for restorations, especially where teeth are to be used as abutments for a prosthesis or if root resorption is evident. A comprehensive visual examination might diagnose a crack or fracture in the tooth, this in turn reduces the long-term prognosis of the tooth. Further imaging may be required such as CBCT where there is difficulty in determining root fractures on intraoral plain radiographs and visually (Eachempati et al., 2024).

The SDCEP has also developed a guidance on Prevention and Management of Dental Caries in Children. When looking at FPMs, the factors to take into consideration with

poor prognosis include caries, restorations, symptoms, and hypomineralisation which was discussed above. Assessing the extent of dental caries whether it is limited to the occlusal surface or if it involves the proximal surfaces would help indicate poor prognosis. Where a tooth is cavitated or there is evidence of toot tissue loss, the question would be whether the tooth is restorable with an adhesive restoration if an indirect restoration is not indicated. Where a tooth has been previously restored, the caries pattern and caries risk are analysed along with assessment of the margins and extent of the restoration, considering if recurrent caries is present. Finally, if the tooth is showing signs of infection or pulpal involvement, it would be deemed poor prognosis due to depth of the lesion and future treatment burden as well. Other general factors to consider as described by SDCEP when restoring permanent molars are the patient's dental age and whether the SPM has erupted, to help determine if interceptive extractions are indicated. Assessment of the patient's occlusion and current or future orthodontic needs are also important. The patient's cooperation is considered, which may be mirrored by their age, especially if any orthodontic or surgical treatment is required; this would lead the clinician in deciding which modalities of treatment are appropriate. Also, the patient and parents or guardians' views on short-term and long-term management, where management may be required into adulthood. While assessing FPMs, SDCEP recommends at least taking a DPT radiograph to determine location of the dentition, including the SPMs and TPMs. The guidelines also recommend any additional intraoral radiographs, where needed, especially in cases of dental caries and close proximity to the pulp (SDCEP, 2025b).

MIH CHARACTERISTICS AFFECTING THE PROGNOSIS

LESION COLOUR

It has been well established that yellow and brown lesions are more prone to PEB than white or creamy lesions. In a study conducted in Brazil which assessed the same patients with MIH at baseline and after 18 months follow up, the darker brown lesions

increased in MIH severity by 28.3% while yellow lesions increased in 15.2%, and white lesions by only 2.6% (Costa Silva et al., 2011). This is because the colour of the lesion reflects the depth of the lesion, porosity, and mineral density values. Yellow-brown lesions extend to the full enamel thickness and are more porous and less mineralised (Farah et al., 2010), hence are more prone to PEB, sensitivity, caries, restoration failure, and even may require more complex dental treatment. White or creamy lesions on the other hand seem to be more stable with a lower risk of PEB. A study which was conducted on second primary molars showed that those that exhibit hypomineralised yellow or brown opacities have a 20-22% reduction in mineral density than non-hypomineralised molars or those with white opacities making them more prone to caries and hypersensitivity (Elfrink et al., 2013). With anterior teeth, the lesion colour may be the major factor that would indicate need for treatment. Different management strategies are required for each colour and the EAPD guidelines reflect that, as previously discussed.

LESION LOCATION AND SIZE

When assessing a MIH lesion, the surface area at which is covers would help determine the long-term prognosis of the tooth. If a lesion is covering a stress-bearing area such as the cusps, there is an increased risk of enamel PEB in the future due to increased masticatory forces, hence become of poorer long-term prognosis. This is more commonly seen in FPMs than in incisors (Bullio Fragelli et al., 2015). Mesio-buccal cusps have been reported as being most severely affected in the literature (Fagrell et al., 2013). The enamel in the transitional zone between MIH affected enamel and healthy enamel has an altered prism sheath, which reduces its mechanical properties and may fracture more easily (Chan et al., 2010). Those on occlusal surfaces or incisal edges may also exhibit some PEB but not as severely as those involving the cusps; similarly, lesions on smooth surfaces where there is less occlusal load would have a better long-term-prognosis. It is known that the highest magnitude of forces is experienced by molars, specifically the FPMs, and the forces

decrease with the teeth more anteriorly and more posteriorly to the FPM; that is due to the highest masticatory muscle forces being applied in this region (Spencer, 1998).

PEB

Where a tooth already exhibits PEB, careful assessment of location and potential for further PEB is considered. Some teeth erupt appearing both hypoplastic and hypomineralised or PEB occurs as soon as they come into the oral cavity due to masticatory forces. Therefore, teeth that have been in the oral cavity for longer might exhibit more PEB or appear to be more severe (Leppäniemi et al., 2001). To distinguish between hypoplasia and PEB, the borders of the breakdown or enamel loss is assessed. MIH PEB has an irregular pattern with borders that ragged, not smooth, and poorly defined unlike the hypoplastic smooth and well-defined borders; and as the name suggests, PEB occurs post-eruption while hypoplasia is pre-eruption due to a quantitative defect (AAPD, 2024). Where an MIH tooth doesn't show evidence of MIH, an assessment of potential PEB is considered since even with routine check-ups and prevention, MIH FPMs still do undergo PEB (Bullio Fragelli et al., 2015).

ATYPICAL CARIES AND ATYPICAL RESTORATIONS

Teeth with MIH are 4.8 times more at risk of developing dental caries than teeth without MIH (Americano et al., 2017), especially where there is PEB into dentine (Lygidakis et al., 2010). Where the patient presents with gross caries in one FPM and no signs of MIH on the incisors, MIH might be undiagnosed since the carious lesion and breakdown may eliminate any sign of hypomineralisation. Where the caries is not that extensive, caries and MIH may co-exist and the hypomineralised enamel would favour

rapid caries progression, possibly leading to pulpal involvement or PEB. Since hypersensitivity is a common symptom seen with MIH, patients might not adhere to good oral hygiene practices and therefore further exacerbate their caries risk. A study conducted in Valencia in Spain shows that caries is related to the severity of the MIH lesion where those with severe MIH had higher caries prevalence (60.7%) than those with mild MIH (43.1%) (Negre-Barber et al., 2018).

When MIH teeth are restored, these restorations tend to be of poorer long-term success and therefore patients might need further management which adds to the burden and cost of treatment as described by the International Association of Paediatric Dentistry (IAPD) (2020). The pattern of the dental caries or restorations is often seen as atypical, where the cusps and free surfaces are involved. This helps to determine if a tooth was restored due to MIH and the extent of the lesion, if the documented notes are not available. Usually, MIH opacities will be seen around the carious lesion or restoration as well (Elfrink et al., 2024). When assessing a restoration on an MIH affected tooth, there is a risk of further PEB around the enamel margins of the restoration, which may result in gaps and recurrent caries or restoration failure (Chan et al., 2010).

MIH has a variable presentation on eruption and with time may exhibit PEB and develop caries, some of which may be restored, or a tooth may be extracted due to MIH. This may lead to difficulty in determining the root cause and proper diagnosis. When treatment planning, considering different patient related and tooth related factors may be overwhelming, and a clinician may seek support if they don’t encounter MIH patients often.

CONFIDENCE OF GENERAL DENTISTS

Due to the factors described in the section above, dentists lack confidence in diagnosing and assessing the prognosis of FPMs affected by MIH. In the UK, 48.4% of general dentists were slightly confident or not confident at all when diagnosing MIH as opposed to being confident, very confident, or extremely confident (Kalkani et al., 2016).

DENTIST'S KNOWLEDGE OF MANAGING MIH WORLDWIDE

Despite the increasing global awareness and research on MIH and updated clinical guidelines to diagnose MIH, general dentists still face difficulties to proper diagnosis of MIH lesions. General dentists find it challenging when caries is present or when FPMs are solely affected without any hypomineralisation on the incisors (Humphreys et al., 2021). In the same study, some difficulty to diagnose MIH was noted when HSPM is evident. Also, general dentists found it difficult to distinguish between hypomineralisation and hypoplasia according to Humphreys et al. (2021). The name MIH may mislead some general dentists that both FPMs and incisors should be affected, which is not the actual definition of MIH. There have been different indices for the severity and management of MIH, this lack of universal uniformity would complicate both research and clinical interpretation and therefore management across different countries (Silva et al., 2016). A study in Australia showed that limited access to specialist consultations and the nature of busy clinics may further limit the opportunity for a thorough assessment (Gambetta-Tessini et al., 2016).

A comparison of confidence of general dentist's worldwide when it comes to diagnosis, treatment planning and management, referring to a specialist, and importance of further teaching and education is found in Table 1.2.

When it came to referring to paediatric specialists for management of MIH, UK general dentists preferred to manage patients in their clinic since referring to a specialist is a lengthy process, and the patient may develop further complications or pain. Therefore, they would refer as a last resort (Humphreys et al., 2022). Access to specialists in Australia and Chile may be challenging due to shortages in specialists in certain rural areas; therefore, similarly to the UK, general dentists try to manage MIH locally (Gambetta-Tessini et al., 2016).

Table 1.2: General Dentist's and MIH views

Country	%	Source
Confident with diagnosing MIH		
Indonesia	38.5%	(Dian et al., 2022)
Kuwait	27.8%	(Alanzi et al., 2018)
Malaysia	54.6%	(Hussein et al., 2014)
Portugal	53.1%	(Delgado et al., 2022)
UK	71.93%	(Humphreys et al., 2021a)
Confident with treatment planning and management		
Australia	83%	(Gambetta-Tessini et al., 2016)
Chile	62.1%	(Gambetta-Tessini et al., 2016)
Indonesia	36.8%	(Dian et al., 2022)
Malaysia	74.2%	(Hussein et al., 2014)
Referring to a specialist centre		
Australia	78.8%*	Gambetta-Tessini et al., 2016)
Chile	40.1%*	Gambetta-Tessini et al., 2016)
Malaysia	57.1%*	(Hussein et al., 2014)
UK	41.4% would refer mild MIH, mostly for aesthetic treatment or opinion	(Humphreys et al., 2021b)

	32.8% would refer severe MIH, mostly for restoration, extraction, or opinion	
Further training or education on MIH required		
Indonesia	96.7% for MIH diagnosis 93.4% for MIH aetiology 97.5% for MIH treatment (average 95.9%)	(Dian et al., 2022)
Kuwait	18.3% for MIH diagnosis 9.6% for MIH aetiology 28.7% for MIH treatment 33.9% for all aspects	(Alanzi et al., 2018)
UK	94.8%	(Humphreys et al., 2021b)
* No specific scenario was reported, therefore in general any FPM affected by MIH		

TRAINING AND EDUCATIONAL NEEDS FOR GENERAL DENTISTS

The consistent reported lack of confidence among general dentists when diagnosing and managing MIH highlights the importance of targeted education and continuing professional development (CPD). This may be in the form of workshops or tools which support decision making to increase the confidence of general dentists. Ghanim et al. developed a training manual to help guide practitioners into diagnosing and grading MIH lesions in practice which may be used for clinical field studies, prior to that they had developed a guide for epidemiological studies as well (Ghanim et al., 2015, 2017). Several studies have used these manuals to calibrate their examiners for assessment of MIH. In Fujairah, United Arab Emirates (UAE), they used the training manual developed in 2017 by Ghanim et al. to calibrate their examiner for the purpose of analysing the prevalence and severity of MIH in that region (Brejawi et al., 2023). Another study used the 2015 guidance by Ghanim et al. for assessing MIH to calibrate their examiner to assess dental anxiety in paediatric patients with MIH and caries, the reported inter-examiner Cohen Kappa value between the expert researcher and the

trained examiner was 0.85 for clinical presentation and 0.81 for defect extent (Rodríguez et al., 2024). An international multi-centre study, which is currently being conducted, has used the training manual to calibrate 22 senior paediatric dentists in 15 countries; their aim is to understand the association of MIH with other developmental anomalies. The training involved online lectures based on the 2017 Ghanim et al. training manual followed by two exercises that were two weeks apart and required a Cohen Kappa coefficient between 0.61-1.00 from the examiners to be recruited (Rodd et al., 2023).

To ensure the future generations of general dentists don't face the same challenges, ensuring early exposure to MIH in the undergraduate curriculum is important. A Swiss national survey with final-year students showed that 99% were aware of MIH but only 12% were confident to diagnose it clinically (Hamza et al., 2021). Similarly, in Egypt around 88% of students were not able to distinguish MIH from other enamel defects (Yehia et al., 2022). In the UK, undergraduate dental schools have incorporated teaching their students about MIH and assessing them within the paediatric curricula, although multi-disciplinary care, teaching on certain aesthetic treatments such as resin infiltration, and the OHRQoL related to MIH were not always included (Humphreys et al., 2024). Although MIH is a lifelong condition affecting the adult teeth, undergraduate students may link it with paediatric patients if it were only taught within the paediatric curricula. Therefore, as suggested in the study by Humphreys et al., it must be included in all teaching, including restorative and orthodontic, to ensure clinicians understand that adults may present with MIH and be able to provide appropriate management.

ACCESS TO DENTAL CARE

Various dental treatment options might not be readily available for all patients, therefore availability of services, location, waiting times, and cost should be accounted

for when addressing paediatric patients. Initial treatment with a paediatric dentist may be free of charge and readily available in some countries such as the UK, the future need for treatment may not be covered. The layout of dental treatment in the UK under the National Health Service (NHS) starts at the general dental practice. Therefore, the treatment that may be provided varies; where a paediatric patient for example needs to be referred, that would be to a specialist or hospital-based paediatric service for those under 16 years of age (NHS England, 2023). Depending on the geographic location within the UK, waiting lists for referrals and treatment differ and may extend to several months, specifically in the case of treatment under sedation or general anaesthesia, where available (Marshman et al., 2023).

CONCLUSION

MIH is a developmental enamel condition of systemic origin, with a multifactorial aetiology involving genetic, systemic, and environmental factors and influences. The affected enamel is porous and protein-rich, resulting in increased risk of PEB, caries, hypersensitivity, and restoration failure. These clinical features pose significant challenges in both diagnosis and long-term management.

Successful management of MIH requires a thorough assessment at the patient, oral, and tooth levels, taking into account factors such as age, symptoms, dental development, and occlusal considerations. Treatment must be tailored accordingly, ranging from preventive measures and minimally invasive restorations to PMCs and extractions where appropriate. With anterior teeth, aesthetic concerns and psychosocial impact are also key considerations.

The prognosis of MIH-affected teeth depends on the lesion’s colour, size, location, and presence of PEB. Lesions on stress-bearing surfaces, particularly yellow-brown

ones involving cusps, tend to have poorer long-term outcomes or prognosis. Atypical caries patterns and restorations may also indicate lesion severity, particularly when clinical notes are limited, and hence may have poorer long-term prognosis as well.

General dentists may lack confidence when diagnosing and managing MIH, especially in complex cases. This highlights the need for further education, clearer diagnostic tools, and aid in determining prognosis and management in primary care since specialist services may not always be accessible.

In summary, MIH is a challenging condition requiring a good understanding of the aetiology, clinical, presentation, long-term prognosis, and management options that are suitable keeping in mind patient and parent or guardian wishes and availability of services. These are key to improving patient outcomes and guiding treatment planning.

OVERALL PROJECT AIM

The overall aim of this project is to develop, (or refine) a clinical toolkit to assist general dentists in primary care in determining the prognosis of FPMs affected by MIH. The goal is to improve identification of prognosis to aid general dentists in managing patients locally or to facilitate referrals to specialists, where required.

PROJECT OBJECTIVE

- Part I: Conduct a scoping review of the available tools and guidelines that may assist clinicians in determining the prognosis of FPMs affected by MIH.

- Part II: Carry out semi-structured one-to-one online interviews with general dentists to explore their views on assessing the long-term prognosis of MIH. This includes what tools or guidelines they currently use, if any, and what the limitations and strengths of those aids. Also, to investigate what general dentists would prefer to be included in a prognostic tool.

- Part III: Develop a prognostic toolkit (or refine an existing one), for assessing FPMs with MIH, with the aid of the information and data analyses carried out in Part I (scoping review) and Part II (interviews).

- Part IV: Pilot the developed prognostic toolkit through semi-structured one-to-one online interviews with general dentists to assess the toolkits usability, relevance, reproducibility, and clarity and identify any necessary adjustments.

CHAPTER 2 : AN MIH PROGNOSIS GUIDE TO BE USED IN THE PRIMARY CARE SETTING: SCOPING REVIEW

INTRODUCTION

Effective management of patients with hypomineralised FPMs requires a good understanding of the long-term prognosis of affected teeth. MIH presents significant clinical challenges due to its risk of PEB, patient daily discomfort and that during treatment, and possible need for more comprehensive treatment. Multiple guidelines have been developed to aid in diagnosis of MIH, diagnosis of its severity, and on provision of management, although there is a lack of guidance on the long-term picture of those teeth affected by MIH.

AIM

This scoping review aimed to identify and evaluate the prognostic tools and classification systems specific to FPMs affected by MIH. Tools identified have been highlighted for their applicability in a primary care dental setting for general dentists.

METHODOLOGY

REVIEW QUESTION

What prognostic tools are currently available for assessing MIH-affected teeth in children that may be applicable for primary care and general dentists?

PROTOCOL AND REGISTRATION

The methodology followed the Joanna Briggs Institute (JBI) guidelines for scoping reviews (Peters et al., 2020). This project was registered with University College London's Ethics Committee (Registration No. 27527/001) and the Data Protection Office (DPO) (Ref: Z6364106/2024/03/97).

KEYWORDS

"Chalky teeth," "dental anomalies," "first permanent molars," ''FPM'', "molar incisor hypomineralisation," ''molar incisor hypomineralization'', ''prognosis'', "severity'', ''MIH'.

ELIGIBILITY CRITERIA

Defined using the participants, concept, context (PCC) framework:

Participants: Children under 18 with MIH, as defined by Weerheijm et al. (2001).

Concept: Tools or indices used to predict prognosis in MIH-affected molars.

Context: Application within primary care dental settings.

INCLUSION CRITERIA

- Peer-reviewed journal articles
- All languages (translations provided)

EXCLUSION CRITERIA

- Grey literature (e.g., dissertations, unpublished reports)

SEARCH STRATEGY

Databases searched included Embase, MEDLINE, and PubMed using the terms:

1. (Molar incisor OR molar-incisor) AND (hypomineralisation OR hypomineralization)
2. Prognos*
3. 1 AND 2

SOURCE OF EVIDENCE SELECTION

This scoping review included a range of publications including but not limited to randomised control trials, non-randomised control trials, before-and-after studies, case reports and case series, and cohort studies. Also, where applicable, systematic reviews and meta-analysis have been included.

After the search was conducted on the abovementioned search engines, the relevant publications' reference lists were screened for additional publications. Five more results were identified and included in this scoping review. The results of the search were uploaded into Zotero (Corporation for Digital Scholarship, 2025) and the full text was analysed by the Investigator Mees Alkandari (MA) in reference to the inclusion criteria. Any literature that was excluded was recorded and any disagreements between the authors on the selection process was resolved through discussion between the Investigator (MA) and the Chief Investigators Susan Parekh and Paul Ashley (SP and PA). Any relevant missing data within individual literature was requested from the authors. The scoping review was conducted between September 2024 and May 2025.

DATA EXTRACTION

From the valid publications, data extraction was performed by two of the authors using a pre-determined data extraction form which included the participants, concept, context, and the key findings. The Data Extraction Form is seen in Appendix 1, it was formulated following JBI Data Extraction (JBI, 2024). This form was piloted to extract data from the first three results and was reviewed by one Chief Investigator (SP) and Investigator (MA), modifications were applied, and the rest of the included results were analysed. Disagreements between the authors during the data extraction process were resolved through discussion or through an additional reviewer, Chief Investigator (PA).

PRESENTATION OF THE RESULTS:

SEARCH RESULTS

The search was completed on 14/09/2024. Reference lists of identified articles were screened. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guidelines were followed (see Figure 2.1) (Page et al., 2021).

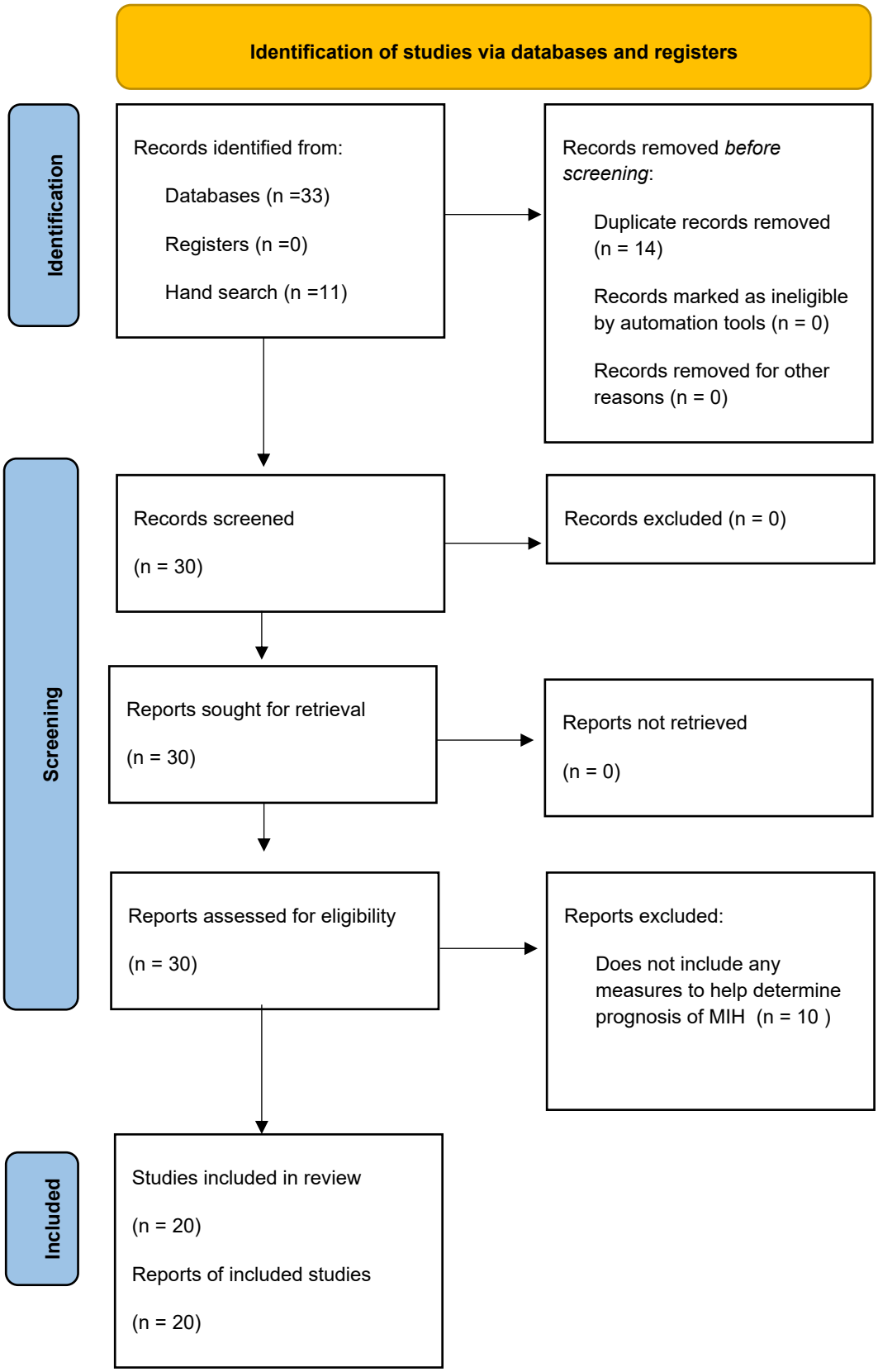


Figure 2.1: PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only. Adapted from Page et al. (2021), licensed under CC BY 4.0.

Within the 20 studies included, only one focused on the prognosis of MIH FPMs, as part of the clinical guideline for management of dental caries in children (SDCEP, 2025b). The rest of the studies either focused on severity of the MIH lesions or management. After discussions between the authors, it was agreed to include the studies classifying severity of lesions or characteristics of lesions that may define the prognosis. The review identified that the EAPD criteria remain the most widely used standard for MIH definition and classification. However, there are other indices and classifications used which further complicate prevalence studies and systematic reviews or meta-analysis (Lygidakis et al., 2022). Of the studies included, there was a mixture of clinical guidelines, systematic and literature reviews, retrospective service evaluations and record analysis as well as new conceptual frameworks and a validation study. Publications that were excluded were mainly focused on management of MIH and not what the prognosis was, nor did they discuss the characteristics of lesions that would define their prognosis. This was the case for eight studies, three of which only focused on extraction patterns and timing and two focused on modalities of treatment and materials. The rest of the excluded publications focused on the bigger picture of MIH. Table 2.1 summarises the data extraction with the key findings.

Table 2.1: Summary of the key findings from the Data Extraction.

No	Title	Author(s), Year	Study Type	Key Findings Related to Prognosis
1	A Qualitative Analysis of Treatment Patterns for Mild and Severe Molar Hypomineralization in Permanent Teeth: A Systematic Review	(Ritto et al., 2023)	Systematic Review	○ Restored yellow-brown defects have the poorest prognosis regardless of the restorative material used to restore them. ○ Higher risk of restoration failure in molars due to low bond strength. ○ Higher risk of restoration failure where MIH is present in high stress-bearing areas and if it includes cusps or incisal edges.
2	Molar Incisor Hypomineralisation (MIH): A Review	(Bora et al., 2022)	Literature Review	○ MIH prognosis depends on severity and symptoms. ○ Mild defects are limited to opacities without PEB. ○ Severe defects involve PEB or sensitivity. ○ Severe defects are more complex to manage.
3	Management of compromised first permanent molars in a cohort of UK paediatric patients	(AlKhalaf et al., 2022)	Qualitative Service Evaluation	○ There is no guidance on predicting the prognosis of compromised FPMs. ○ FPMs exhibiting PEB would usually be extracted.

	referred to hospital-based services			
4	Prevention and Management of Dental Caries in Children	(SDCEP, 2025b)	Clinical guideline	○ Assessment of poor prognosis hypomineralised FPMs includes assessment of the colour and location of the lesion which helps understand its severity and likelihood of breakdown. ○ White/ cream lesions being the least prone to breakdown followed by yellow and the most severe and likely to breakdown are the brown lesions. ○ Those located on smooth surfaces are the least severe, followed by those on the occlusal surfaces and the most severe are those involving a cusp. ○ Teeth with atypical restorations are considered of poor long-term prognosis. ○ Symptoms to consider when assessing prognosis of the tooth are sensitivity to toothbrushing and temperature.
5	Adherence to RCS recommendations for extraction of first permanent molars in a teaching hospital: To	(Lee et al., 2021)	Retrospective Analysis	○ A limitation of the study was that the determination of prognosis of MIH is subjective and not standardised. ○ Prognosis of FPMs often based on hypomineralisation and caries presence.

	compensate or not to compensate?			
6	Breakdown of demarcated opacities related to molar-incisor hypomineralization: a longitudinal study	(Neves et al., 2019)	Prospective Study	○ 41.8% of yellow-brown opacities resulted in enamel breakdown in 12 months. ○ 27.5% of yellow-brown opacities resulted in dentine breakdown, atypical restorations, or extraction in 12 months. ○ 16.3% of white/creamy opacities resulted in enamel breakdown in 12 months. ○ 46.9% of teeth with PEB resulted in further breakdown involving dentine or required atypical restorations or extraction in 12 months. ○ Prognosis is worse in surfaces with breakdown regardless of masticatory exposure.
7	Longitudinal Evaluation of the Structural Integrity of Teeth Affected by Molar Incisor Hypomineralisation	(Bullio Fragelli et al., 2015)	Prospective cohort study	○ Mild lesions (those without PEB) are less at risk of PEB, 99% of affected incisors and 93% of affected molars remained intact after 12 months. ○ Severe lesions (those with PEB or atypical caries) showed higher levels of PEB and deterioration. ○ Molars were more likely to be affected by MIH and had more severe lesions.

8	National clinical guidelines for the extraction of first permanent molars in children	(Cobourne et al., 2014)	Clinical guideline	○ MIH molars with PEB may require extractions due to poor long-term prognosis, this can be evaluated by the extent of PEB, prediction of further PEB, and presence of a caries. ○ Intra-coronal restorations should be assessed as they usually have poor prognosis.
9	Nonfluoride hypomineralizations in the permanent first molars and their impact on the treatment need	(Leppänie mi et al., 2001)	Cross-sectional observatio nal study	○ Three categories have been suggested for severity of MIH as: 1. extracted due to MIH or those with atypical restorations; these were severe lesions. 2. lesions exhibiting PEB; these were moderate severity lesions. 3. enamel is intact but demarcated opacities are evident; these were of mild severity. ○ The size of the lesion was also considered as small, around 2mm, medium, around 2-4mm, and large, greater than 4mm; those under 2mm were excluded for accuracy and consistency when diagnosing.
10	Clinical studies on molar-incisor-hypomineralisation part 2: development of a severity index	(Chawla et al., 2008)	Retrospect ive Record Analysis	○ Developed a Hypomineralisation Severity Index to aid prognosis and referral decisions. ○ The higher the severity, the more intervention that is needed long-term.

				○ Where the tooth is compromised by bacterial penetration, it has poorer long-term prognosis. ○ The other severity index available is the World Dental Federation (FDI) Index for developmental defects in enamel. Two additional measures may be added to the index: the presence or absence of PEB and presence or absence of atypical restorations. ○ The opacities may also be broken down into colour, where white opacities are the least severe, then yellow, and finally yellow-brown being the most severe. ○ This index that has been developed is to guide primary care dentists to refer the higher indices to a specialist for input from a multidisciplinary team with an orthodontist.
11	A Modified DDE Index for Use in Epidemiological Studies of Enamel Defects	(Clarkson and O'Mullane, 1989)	Methodological observational study	○ Presented a modification of the FDI DDE index; where they grouped the opacities as demarcated, diffuse, or hypoplasia. The modified version also allows specifying which surface the lesion is, the extent of the defect, and the number of surfaces affected on that tooth.
12	First permanent molars with molar incisor hypomineralisation	(Fitzpatrick and O'Connell, 2007)	Clinical Overview	○ Severity: ○ Mild = white/ creamy demarcated opacities without PEB. ○ Moderate = yellow/ brown demarcated opacities without PEB.

				○ Severe = PEB of enamel present. ○ Due to the porosity of the enamel, it is subject to PEB in areas under occlusal load.
13	Management of Molar Incisor Hypomineralisation (MIH): A 1-Year Retrospective Study in a Specialist Secondary Care Centre in the UK	(Humphreys and Albadri, 2020)	Retrospective Service Evaluation	○ There is no clear guidance to determine the prognosis of molars with MIH. ○ Primary care dentists lack diagnosing MIH correctly. ○ The EAPD guidelines on severity from 2010 were followed.
14	The Würzburg MIH Concept: the MIH treatment need index (MIH TNI): A new index to assess and plan treatment in patients with molar incisor hypomineralisation (MIH)	(Steffen et al., 2017)	Conceptual Framework	○ Developed the Molar Incisor Hypomineralisation treatment need index (MIH-TNI) which allows grading of treatment need based on hypersensitivity and extent of enamel loss. ○ Their tool supports prognosis-based decision-making.

15	Distribution and severity of molar hypomineralisation: trial of a new severity index	(Oliver et al., 2014)	Clinical Evaluation	○ Developed the MIH Severity Index (MIHSI). ○ Severity scores correlated with treatment type: higher scores led to increased restorative burden and extractions. ○ Prognosis linked to colour and defect location.
16	Best clinical practice guidance for clinicians dealing with children presenting with molar-incisor-hypomineralisation (MIH): an updated European Academy of Paediatric Dentistry policy document	(Lygidakis et al., 2022)	Clinical guideline	○ Severity of MIH is either mild or severe. ○ Mild is when there is no PEB and if hypersensitivity is present, it is only occasional to an external stimulus and there is no aesthetic concern. ○ Severe includes PEB, caries, persistent or spontaneous hypersensitivity, or strong aesthetic concerns affecting the patient's socio-psychological state.
17	Diagnosis and treatment of molar incisor hypomineralization	Mathu-Muju and Wright, 2006 (cited in Wright, 2015)	Clinical review article	○ Developed a chart to help define the severity of MIH as mild, moderate, or severe according to appearance and structural integrity with aesthetics and hypersensitivity being considered. ○ Mild severity is where the opacities are white or creamy and the enamel is intact with no PEB and normal sensitivity.

				○ Moderate severity is where there is no PEB on eruption but may develop over time without cusp involvement and only one or two surfaces are involved, parents may express aesthetic concerns but normal sensitivity. ○ Severe is where there is PEB on eruption and it is rapid, would involve widespread caries, and there is a history of sensitivity and aesthetic concern.
18	Reliability and validity of a new classification of MIH based on severity	(Cabral et al., 2020)	Validation study	○ Developed a scoring system for MIH based on different factors. ○ It was concluded that darker and yellow/ brown opacities have poorer long-term prognosis than white/ creamy opacities.
19	Prevalence and Severity of Molar Incisor Hypomineralization in a Region of Germany – A Brief Communication	(Preusser et al., 2007)	Cross-sectional epidemiological study	○ Described one of the earliest indices which Wetzel and Reckel developed, it categorised MIH into three degrees based on appearance and structural integrity. ○ Degree 1 is where there is no PEB. ○ Degree 2 is where there are yellow-brown hypomineralisation with slight PEB. ○ Degree 3 has extensive PEB.

20	Best Practices: Molar-Incisor Hypomineralization	{Citation}	Clinical guideline	○ Mild severity is where opacities are in non-stress bearing areas with no caries nor hypersensitivity. ○ Moderate severity is where there is no initial PEB, there might be atypical restorations, caries or PEB that doesn't involve the cusps, and possible mild hypersensitivity. ○ Severe is where there is rapid PEB, widespread caries, hypersensitivity, and aesthetic concern.

DISCUSSION

PROGNOSIS OF MIH

In the SDCEP guidelines on management of caries in children, there is a detailed section dedicated to management of permanent molars, this section covers FPMs that are carious as well as those affected by hypomineralisation and MIH specifically, this guideline was updated in 2025 and is available online (SDCEP, 2025b). The guidance highlights that the enamel quality in MIH is qualitatively poor and of high porosity, this results in abnormal etching and resin penetration and bonding. Therefore, this usually results in unpredictable restorative and bonding outcomes and possible restoration failure. A patient might require further restorative treatment, or in some cases, need for extraction after multiple attempts to restore.

SDCEP recommends assessing each FPMs independently for its prognosis since teeth in the same dentition may be affected by MIH to different degrees. The factors that should be considered are the colour, location, previous caries or PEB experience, and any symptoms associated with the lesions. Regarding colour, darker lesions are more prone to breakdown; regarding location, those involving cusps or occlusal surfaces are more prone to breakdown due to weak hypomineralised enamel being under high occlusal load. Patients who present with previously treated MIH molars would have atypical restorations or may have had an extraction due to MIH or may present with atypical caries requiring further investigation and management. Finally, assessment of symptoms including sensitivity and pulpal involvement are taken into account; sensitivity to toothbrushing or temperature would be recorded and would aid the management plan (SDCEP, 2025b).

SEVERITY SCORING SYSTEMS

EARLY ENAMEL DEFECT CLASSIFICATIONS

Early indices, such as those by Wetzel and Reckel, focused primarily on the degree of enamel discolouration and loss (1991, 2004, as cited in (Preusser et al., 2007)). Wetzel and Reckel categorised MIH-affected enamel into three degrees of severity based on the extent and location of opacities and enamel breakdown. Degree 1 would include an isolated white-creamy to yellow-brown discolouration which is found on the upper part of the crown and the occlusal surface without PEB, degree 2 includes yellow-brown enamel hypomineralisation of the cusps with slight PEB, while degree 3 deficiencies are yellow-brown with extensive loss of enamel which has led to a change in the crown morphology. Hypersensitivity, restorations, and extractions at that time were not taken into consideration.

The FDI introduced the DDE Index in 1977 to standardise enamel defect assessments. The index categorised defects as opacities, hypoplasia, or discolouration, and distinguished between single or multiple defects and finally their location, based on whether they covered the lingual or buccal surfaces (Clarkson and O'Mullane, 1989). The DDE Index was modified by Clarkson and O'Mullane to facilitate its use for general purpose epidemiological studies and for screening surveys, as in Figure 2.2. With this modified version, scores were given to different characteristics. The type of defect was subdivided into demarcated or diffuse where present; the demarcated opacities were either scored 1 if white or cream or 2 if yellow or brown. The diffuse opacities were scored between 3-5 depending on their nature and if loss of enamel was evident, they were scored a 6. Different hypoplastic lesions were also scored in accordance with their presentation as pits or missing enamel, 7 and 8 respectively. If other defects were seen that aren't in the index, they had their separate score of 9. Lastly, the extent of the lesion was identified as <1/3, between 1/3 to 2/3, and 2/3 or more of the surface area being involved. For screenings, defects were summarised under broader categories as seen in Figure 2.3.

MODIFIED DDE INDEX FOR USE IN GENERAL PURPOSE EPIDEMIOLOGICAL STUDIES

	Code
Normal	0
Demarcated opacities:	
white/cream	1
yellow/brown	2
Diffuse opacities:	
Diffuse - Lines	3
Diffuse - Patchy	4
Diffuse - Confluent	5
Confluent/patchy + staining + loss of enamel	6
Hypoplasia:	
Pits	7
Missing Enamel	8
Any other defects	9
Extent of Defect	
Normal	0
<1/3	1
at least 1/3 < 2/3	2
at least 2/3	3

Figure 2.2: Modified DDE Index. Reproduced with permission from Clarkson and O'Mullane (1989). © SAGE Publications. Licensed under RightsLink License No. 6072100502141.

MODIFIED DDE INDEX FOR USE IN SCREENING SURVEYS

	Code
Normal	0
Demarcated opacity	1
Diffuse opacity	2
Hypoplasia	3
Other defects	4

Figure 2.3: Modified DDE Index for screening surveys. Reproduced with permission from Clarkson and O'Mullane (1989). © SAGE Publications. Licensed under RightsLink License No. 6072100502141.

Another system which existed prior to the EAPD criteria was by Alaluusua et al., where they initially developed a classification system for developmental defects in children who were breastfed (Alaluusua et al., 1996). Hypoplastic defects or those due to fluorosis or disturbances to general health were excluded. Teeth are divided into two units; the occlusal surface and cusps were one, and the proximal surfaces were the other unit. If only colour change was evident, that being white, yellow, or brown, the defect was classified as mild. Those defects with loss of enamel were classified as moderate and if both enamel and dentin loss is evident, the defect is classified as severe. The size of the defect was also noted; if the diameter was around 2 mm the defect was classified as small, moderate sized defects were those around 3.5 mm and large defects were those 4.5 mm and above. Some of the same authors revisited this classification in 2001 (Leppäniemi et al., 2001). The FPMs were divided into three sections in this classification: an occlusal, a buccal, and a lingual section. Three categories were formulated; the first category included teeth that have been extracted due to hypomineralisation, determined by investigation of the clinical records; it also included teeth with atypical restorations of unusual shape, location, or with opacities adjacent to the fillings. The second category was reserved for lesions with breakdown of enamel, that might present as rough. The third category covered lesions of white or opaque, yellow, or brown colour changes where the enamel was intact and smooth. The sizing of the lesions was also revised; small lesions are of 2 mm, medium lesions are between 2-4 mm, and large lesions are greater than 4 mm; lesions smaller than 2 mm were excluded along with lesions due to fluorosis or hereditary dental hard tissue defects. The most severe defect determined the patient's category.

EAPD BASED AND SIMPLIFIED CLASSIFICATIONS

Mathu-Muju and Wright classified the severity of MIH into three categories: mild, moderate, and severe, as seen in Figure 2.4 (2006, cited in Wright, 2015). The mild classification included teeth with demarcated opacities evident in non-stress-bearing areas of the FPM. Those opacities would be isolated with no caries association nor

sensitivity and aesthetics would not be of concern. With moderate lesions, the occlusal or incisal third of the tooth wouldn't exhibit PEB; but there might be an intact atypical restoration, PEB, or caries may be present which is limited to one or two surfaces sparing the cusps. Within moderate lesions, the teeth are usually of normal sensitivity, but parents might express aesthetic concern. A severe lesion therefore would include PEB, which might develop as soon as the tooth erupts. Caries might be seen, the patient might complain of sensitivity, and the parents would usually be concerned with aesthetics.

	Mild	Moderate	Severe
Crown appearance	Demarcated opacities in non-stress-bearing area of molar	Intact atypical restoration present	Posteruptive enamel breakdown present
Enamel loss	Isolated opacities	Occlusal/incisal third of teeth without initial posteruptive enamel breakdown	Posteruptive enamel breakdown on erupting tooth that can be rapid
Caries	No caries associated with affected enamel	Posteruptive enamel breakdown/caries limited to one or two surfaces without cuspal involvement	Often develop widespread caries associated with affected enamel
Sensitivity	Normal dental sensitivity	Usually normal dental sensitivity	Usually history of dental sensitivity
Esthetics	Usually not an issue	Parents often express concern	Parents typically concerned

Figure 2.4: Mathu-Muju and Wright classification of MIH Severity. Reproduced with permission from Wright, 2006. © Licensed under RightsLink License No. 6072110030257.

An EAPD Policy Document published in 2010 recommended scoring the severity of MIH lesions simply as mild or severe (Lygidakis et al., 2010) and an updated EAPD guideline was published in 2022 with the same severity classification (Lygidakis et al., 2022). Mild being demarcated enamel opacities without signs of PEB, there might be occasional sensitivity to an external stimulus, such as when eating, drinking, or to air but not while toothbrushing. The severe category would therefore include lesions of disintegrated enamel; with PEB, caries, or hypersensitivity which is persistent or

spontaneous affecting function. If there is aesthetic concern which is affecting the socio-psychological state of the patient, then it would fall under the severe category (Lygidakis et al., 2010). The reason for combining moderate and severe lesions is that moderate lesions were usually those with PEB that has been restored and therefore mimic lesions with PEB that hasn't been restored yet. A similar classification was described by Bullio Fragerlli et al. but aesthetics, hypersensitivity, and caries were not taken into consideration; they only focused on mild MIH being exclusive to opacities while severe includes MIH with PEB or atypical restorations (Bullio Fragelli et al., 2015).

The AAPD classified the severity of MIH into mild, moderate, and severe. Where there are demarcated or isolated opacities affecting non-stress bearing areas with absence of caries and hypersensitivity, the lesion is considered mild. Where there are demarcated opacities but there was no PEB on eruption but at a later stage which doesn't involve the cups, limited caries not involving the cusps, atypical restorations and absence or mild hypersensitivity, a lesion is considered moderate. Severe lesions are those that exhibit rapid PEB, widespread caries, hypersensitivity, or are of aesthetic concern (AAPD, 2024).

QUANTITATIVE SCALES

The MIHSI is another index which is also based on the EAPD criteria to define MIH, this index aims to help guide management (Oliver et al., 2014). The clinical examination was of clean wet teeth and only the FPMs and the permanent incisors (PI) were examined. The MIHSI is shown in Figure 2.5. Any tooth that has not erupted is scored a 0 and 1 if erupted. Depending on the colour of the defect the tooth receives a specific score; if the defect was white or cream coloured it would receive a score of 1, yellow is scored 2, and brown is scored 3. The location of the defect also influences its score, if it were on a smooth surface that was scored as a 1, those on occlusal

surfaces of FPMs or incisal tips of incisors were scored 2, and those involving the cusps were scored a 3. Restorations and the type of restoration are also considered; if there is one restoration then it is given a score of 1 and if there are two or more restorations then it scores 2. If the restoration was atypical then this is an additional score of 1. If there are signs of PEB of the enamel, then the tooth is given a score of 1. Sensitivity has been split into two categories and is self-reported, sensitivity to temperature, which has a score of 1 and sensitivity to toothbrushing has a separate score of 1 as well. The scores are then added together from the MHSI and therefore each tooth has its own score, or they may be added together for an overall picture of the dentition. A tooth scoring 3-6 is considered as having mild MIH, 7-9 is moderate, and 10-13 is severe MIH. If a patient has an overall score of 5-12 the dentition has mild MIH, 21-36 is moderate, and 37-52 is severe; this severe dentition score is usually seen where all four FPMs are affected.

Characteristics of molar hypomineralisation defects	Severity of Characteristic	Weighting assigned
Eruption status	Unerupted	0
	Erupted	1
Colour of most severe defect	None	0
	White/cream	1
	Yellow	2
	Brown	3
Location of most severe defect	None	0
	Smooth surface	1
	Occlusal surface (FPMs)	2
	Incisal edge (PIs)	2
	Cuspal involvement (FPMs)	3
Restorations placed/ replaced (prior to study entry)	None	0
	One	1
	Two or more	2
Atypical restorations (prior to study entry)	None	0
	Present	1
Post eruptive enamel breakdown (PEB)	None	0
	Present	1
Sensitive to temperature (child report)	None	0
	Sensitive	1
Sensitive to tooth brushing (child report)	None	0
	Sensitive	1

Figure 2.5: MIH Severity Index. Reproduced from Oliver et al. (2014). © John Wiley and Sons. Reproduced with permission under RightsLink License No. 6072120093532.

In 2020 the MIH severity scoring system (MIH-SSS) was introduced by Cabral et al. (Cabral et al., 2020) which both allows diagnosis of MIH and classification of the severity, seen in Figure 2.6. There are 10 codes in the scoring system, each FPM and incisor are examined under artificial light after toothbrushing to remove any debris, but the teeth shouldn't be dried; if excess saliva is evident then it is wiped with gauze or a cotton roll. A mirror and an explorer are used to examine the teeth. Only demarcated opacities greater than 1 mm in diameter were recorded and if two defects are evident on the same tooth, the most severe defect is recorded. The severity follows the coding system; Code 0 indicates no enamel opacity; code 1 indicates white or cream enamel opacity without PEB; code 2 is for yellow or brown opacity without PEB; code 3 is where enamel PEB is present with a white or creamy opacity and where PEB is present within a yellow or brown opacity it would fall under code 4; code 5 is where PEB is into dentine, but is hard on probing; code 6 is where PEB exposes dentin and the dentine is soft on probing; code 7 is where atypical restorations are present but there are no marginal defects evident, where code 8 is for those atypical restorations with marginal defects; code 9 is the highest score and it indicates that the tooth was extracted due to MIH; this may be concluded if another FPM or incisor shows signs of MIH. Code 10 is reserved for un-erupted teeth or those that cannot be examined.

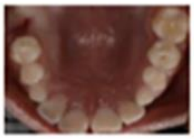
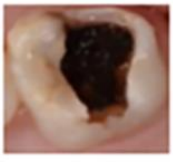
Code	Description	Code	Description
0	 Normal enamel translucency	6	 Post-eruptive breakdown with exposed dentin defect. The dentin is soft.
1	 White/creamy opacity White/creamy demarcated opacity involving an alteration of enamel translucency.	7	 Atypical restoration without marginal defect Size and location of the restoration are atypical. Opacity may be detected at the border of the restoration.
2	 Yellow/brown opacity Yellow/brown demarcated opacity involving an alteration of enamel translucency.	8	 Atypical restoration with marginal defect Size and location of the restoration are atypical. Opacity may be detected at the border of the restoration. Secondary caries or faulty restoration margins.
3	 Post-eruptive breakdown restricted to enamel Defect indicates loss of enamel structure after tooth eruption. Defect is associated with white/creamy opacity.	9	 Extraction due to MIH. Diagnosis based on the absence of a first permanent molar, and on the presence of demarcated opacities with or without post-eruptive breakdown in other first molars or incisors.
4	 Post-eruptive breakdown restricted to enamel Defect indicates loss of enamel structure after tooth eruption. Defect is associated with yellow/brown opacity.	10	Unerupted/Cannot be examined
5	 Post-eruptive breakdown with exposed dentin Defect with exposure of dentin. The dentin is hard.		

Figure 2.6: MIH-SSS. Reproduced with permission from Cabral et al. (2020). © Springer Nature. Licensed under RightsLink License No. 6072610627848.

TREATMENT BASED CLASSIFICATION

In 2017, the Würzburg MIH-TNI was introduced as an easy-to-use index for screening and monitoring MIH (Steffen et al., 2017). The first step would be to identify if the patient has MIH according to the EAPD definition, and any of the following features lead to further grading and classification with the MIH-TNI. Both primary and permanent teeth are examined for any clearly defined opacities of the occlusal or buccal surfaces, defects with varying shapes, sizes, and patterns, any white, cream, yellow-brown colour deviations, any defects with variable sizes excluding those less than 1 mm, teeth with hypersensitivity, teeth with atypical restorations, teeth that are missing for suspected MIH, or a combination of the above. The index is then used after drying the teeth and dividing each arch into three sextants. It is based on four indices focused on hypersensitivity and PEB. The upper right most distal tooth to and including the first premolar, upper anterior teeth from canine to canine and upper left most distal tooth to and including the first premolar. Similarly, the lower arch is divided into three sextants. All primary and permanent teeth in the oral cavity on examination are taken into consideration and the worst score for that sextant is recorded. The MIH-TNI is intended to be used for epidemiological studies or for a tailored risk assessment for each tooth with MIH. As seen in Figure 2.7, if the sextant has no clinical signs of MIH, the sextant is scored as index 0. If there is MIH but no hypersensitivity nor a defect, index 1 is scored. If a defect is present but the patient still has no hypersensitivity, that would fall under index 2 which is further subdivided into three parts; 2a is where the defect extends <1/3 of a tooth, 2b is where the defect is between 1/3 and 2/3 of a tooth, and 2c is where the defect extends >2/3 of a tooth and/or is close to the pulp, or has an atypical restoration or a tooth there was previously extracted. If there is hypersensitivity without a defect, an index 3 is given. If there is hypersensitivity and a defect, then an index 4 is scored. This is further subdivided into three parts, as with index 2; as 4a where the defect extends <1/3 of a tooth, 4b where the defect is between 1/3 and 2/3, and 4c where the defect extends more than 2/3, is close to pulp, has an atypical restoration, or a tooth in that sextant has been extracted due to MIH. Each sextant is given the highest score within it.

Index	Definition
Index 0	No MIH, clinically free of MIH
Index 1	MIH without hypersensitivity, without defect
Index 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
Index 3	MIH with hypersensitivity, without defect
Index 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

Figure 2.7: MIH-TNI. Reproduced with permission from Steffen et al. (2017). © Springer Nature. Licensed under RightsLink License No. 6072611076878.

CONCLUSION

This scoping review identified a wide variety of classifications systems and tools used to assess the severity of MIH affected FPMs in children, but only one guideline, developed by SDCEP, focused on poor prognosis FPMs with MIH. Prognosis of MIH is currently determined by the colour, lesion location, presence of PEB, hypersensitivity, and previous restorations. Although these indicators are essential to guide a clinician, focusing only on the poor prognosis as the SDCEP guideline has done, leaves a vague and variable interpretation of good prognosis and moderate prognosis lesions; those that can be maintained long-term despite their MIH characteristics.

While the EAPD seems to be the most widely accepted tool for severity, others like the MIHSI, MIH-TNI, and MIH-SSS are all credible sources to aid in clinical guidance and management. These tools focus on grading the lesion and helping guide the clinician in management rather than predicting the long-term outcome; hence scoring severity. The MIHSI and MIH-TNI require assessing and grading certain characteristics on the tooth, although this method is reproducible and specific, it may be prolonged and difficult to remember during clinic. The MIH-SSS does provide images that explain certain characteristics for different scorings, but having one image may confuse the clinician as that may be the only presentation for a certain score.

The scoping review confirmed that there is a gap in the literature for a validated, user-friendly prognostic tool that may be used in primary care by non-specialised general dentists. A development of such a tool would ensure consistent prognosis evaluation, improved management in the primary care setting, and would support referrals to specialist care for management or orthodontic input, where needed.

CHAPTER 3 : ASSESSING NON-SPECIALISED DENTIST'S VIEWS ON PROGNOSIS OF MIH FPMS AND AVAILABLE PROGNOSTIC TOOLS WITH QUALITATIVE INTERVIEWS

INTRODUCTION

The scoping review identified a lack of prognostic tools or guidelines specifically for MIH affected FPMs. The next step was to gather more information to develop a toolkit. Clinicians that often treat children with MIH were approached to understand their views on MIH and guidelines that may assist in provision of a prognostic toolkit. This chapter presents a qualitative approach through semi-structured one-to-one interviews followed by analysis of the collected data.

AIMS AND METHODS

AIM

The aim of this part of the project was to explore non-specialist dentists' perspectives on the prognosis of MIH and if they are aware of any prognostic tools for affected FPMs that they are using. Through one-to-one semi-structured interviews, the interviewer explored what features would the dentists find valuable in a prognostic tool. The interviews in this part of the project will assist in formulating a new tool or refining an existing one if any of the participants disclosed using one, to be used in the primary care setting.

METHODS

ETHICAL APPROVAL

Ethical approval was required to conduct the interviews therefore was obtained from University College London's (UCL) Life and Medical Sciences (LMS) Research Ethics Committee on 12/09/2024 (project ID 27527/001). The study was also registered with the UCL's DPO (reference number Z6364106/2024/03/97 health research).

STUDY DESIGN

Semi-structured one-to-one scheduled interviews were carried out for participants who fit the inclusion criteria between March-April 2025 on Microsoft Teams (Microsoft Corporation, 2025). The interviews included a set of questions to guide the discussion and involved ten clinical images with different MIH prognoses. The interviews were automatically transcribed as part of the agreement and pre-obtained consent, and the transcripts were analysed through Microsoft Excel (Microsoft Corporation, 2025). The transcripts are stored anonymously and securely; a soft copy is kept securely in the UCL N-Drive.

QUALITATIVE RESEARCH

To ensure a descriptive approach, qualitative research was chosen where the research would focus on enquiries and questions like 'how' and 'why' instead of a quantitative approach to research where one would investigate an explanation or a cause and effect that can be measured (McGill University, 2001). Participants are from

a purposive sample and not necessarily one that covers the whole population since the aim is to explore the views on a certain question or phenomenon. Qualitative research is evaluative and generative (Lumsden, 2023); where we can evaluate what already exists, in this case existing prognostic tools for FPMs with MIH and how the research participants express the strengths and limitations of those tools, and therefore we are able to generate a new strategy to fit in the criteria we have already evaluated.

Different methods and techniques are available to conduct qualitative research; one of which is semi-structured interviews. Interviews may be structured, unstructured, or semi-structured interviews. In structured interviews, there is a structured survey or questionnaire, and all participants would undergo the same sequence of questions during the interview with the interviewer being neutral throughout. This type of interview is ideal for larger groups, and the results are close to being quantitative. Unstructured interviews are much more flexible and as their name suggests, they aren't structured. The interviewer here allows the interviewee to express their views on a subject but throughout the process of interviews they would develop recurring themes and may change the focus of the research along the way. Semi-structured interviews on the other hand would fall in between; the interviewer would have certain questions and topics they are aiming to explore, all of which are open-ended. There is some structure throughout each interview allowing the interviewer to compare and analyse themes between multiple interviews that are conducted. Interviews in the form of focus groups are guided by a moderator where the information being discussed and explored is as important as the interaction between the participants in the focus group. There are other methods which are visual and creative and may be art-based as well (Lumsden, 2023).

An analysis of naturally occurring data to understand social behaviour or a phenomenon in its natural setting is a way of undergoing qualitative research. This would cover the subconscious part of participant behaviour and interactions. The focus of the research may also be centred around a participant or their ethnography as well. This in turn investigates the cultural and community aspects of life and how that

influences different experiences. The researcher may generate the data needed and with interviews or focus groups they may reconstruct ore re-process that data. Qualitative methods may be combined to tailor the research for the required purpose and combining qualitative and quantitative research may also be undertaken (Lumsden, 2023).

In the second part of this project, interviews were conducted to explore if any tools or guidelines are used but have been missed by the scoping review and to gain a deeper understanding of the clinical characteristics and signs that facilitate a dentist's decision when assessing a MIH affected FPMs long-term-prognosis. A descriptive approach was required since the aim isn't to measure an outcome, but rather to investigate a clinician's perception. Similarly, in the fourth part of the project, feedback from general dentists was required for usability and practicality of the developed prognostic toolkit, a qualitative approach was needed for feedback and toolkit adjustment.

QUALITATIVE RESEARCH TRAINING

The main researcher (MA) underwent an online Foundations of Qualitative Research Online Course with The Social Research Association in October 2023 (Lumsden, 2023). This clarified the principles and paradigms of qualitative research, the methods and techniques of qualitative research, designing a qualitative study, research instruments including ethical considerations, evaluating qualitative research, and designing qualitative data analysis with a chance to design a qualitative study in small groups online. In turn, semi-structured interviews were undertaken, and thematic analyses was used to analyse the data obtained from those interviews.

PARTICIPANT RECRUITMENT

INCLUSION CRITERIA

- Qualified dentists
- Involved in the management of paediatric patients
- English speaking

EXCLUSION CRITERIA

- Specialists or Consultants in Paediatric Dentistry

The participants approached to join the research and undergo the one-to-one interviews are not intended to represent the whole population, rather were selected as dentists who have not yet qualified as specialists but already manage paediatric patients. Therefore, they represented a sample of general dentists for which the intended prognostic toolkit which was developed at the end of this project would serve.

Recruitment of potential participants included full-time Doctorate of Dentistry (DDent) Paediatric Dentistry Program at UCL and part-time Master of Science (MSc) Paediatric Dentistry students at UCL, participants were approached directly through their university email or through the MSc shared online UCL Moodle platform. All participants were provided with the Participant Information Sheet (Appendix 2) and a brief overview of the project, they were then asked to email MA via their university email if they wish to participate and to be provided with consent forms (Appendix 3). Participants were given the chance to ask the student researcher MA any questions prior to signing the consent and the participation was confirmed on the day of the

interviews as well. They were also provided with a draft of the interview questions prior to their interview to ensure they familiarised themselves with the topic. These forms clarified the reason for conducting the research and the project's purpose, their role in participating if they wish to participate, why they have been approached to participate, disadvantages, risks, and benefits of participating in the project, information on the interviews, recording of the interview and transcription, data storage and confidentiality, as well as further contact information of the project supervisors and UCL Research Ethics Committee. Participants were required to sign the consent form and return it to MA before setting a date and time for the interviews. The timings provided were flexible to work around different time-zones and working hours as the participants were internationally recruited.

INTERVIEW QUESTIONS

The interview questions were formulated by MA with the aid of the supervisors SP and PA (Appendix 4). The interviews were piloted with the DDent program students from the UCL program working at the Eastman Dental Institute (EDI). The initial draft was changed after the pilots and again after the first interview since the layout required adjustments, but the overall picture remained the same. The first changes included presenting the questions in a slideshow presentation format to be able to focus on each individual question. The wording of the questions was also changed from ''prognosis'' to ''long-term prognosis'' throughout the document for clarity. After the first interview, in the section where participants were asked about the long-term prognosis of certain images, the options were placed on each slideshow as bullet points and the addition of ''and why'' was incorporated for clarity and to ensure that the participants explained their reasoning.

The questions mirrored the aims of the project and covered the main concepts to explore participant's understanding of prognosis of FPMs with MIH and what tools they

use to aid their conclusion. The questions also explored participant confidence in determining the prognosis and if they regularly liaise with colleagues to discuss their findings. The interview questions were open ended, and MA ensured throughout the process of interviews that the main concepts were thoroughly discussed by guiding the discussions.

Within the interview questions, participants were asked to describe the prognosis of 10 images of FPMs with MIH. The interview participants were asked to describe the prognosis of the FPM as good, moderate, or of poor long-term prognosis, and if they were of poor long-term prognosis, they would further elaborate on whether they are able to stabilise the molar. They were also asked to further explain the reason behind their decision when determining the prognosis, as what factors and characteristics in the images have helped them reach a decision. It was emphasised that only the visual aspect is taken into account, without considering symptoms such as pain nor sensitivity, modalities of treatment such as if restorations were to be conducted under local anaesthesia only or with the aid of a sedative or under general anaesthesia, the patient's age and dental development, nor patient cooperation for treatment. This decision was reached after discussion between the authors since these factors may alter the management of the tooth and may differ from one appointment to the other. It was decided that the project would aim to focus solely on the tooth's clinical structure to give the clinician the freedom of building up the other factors and tailoring the management plan for that individual.

DATA COLLECTION

The interviews were undertaken by MA; initially, MA introduced themselves and gave a brief overview of the project and confirmed that the consent for participation was signed and that the participant is still happy to proceed with the project and transcription. The interview questions were screen shared during the interview and the

participants were prompted to answer and MA allowed participants to elaborate throughout the interview via open-ended questions. Participants were given a chance to ask any further questions or add any comments at the end of the interview while still transcribing and after closing the transcriptions and thanking them as well which was left off record.

DATA ANALYSIS

Systemic thematic analysis for qualitative research and semi-structured interviews was undertaken. Here, themes are identified from the text or transcripts available and were developed as the project and interviews progressed, adjusting the interview questions along the way (Lumsden, 2023). This method is inductive, unlike deductive methods which are used in quantitative surveys and to test hypotheses. As described by Naeem et al., there are six steps to Braun and Clarke's approach for thematic analysis (Naeem et al., 2023). The first is to create a transcript and familiarise oneself with the data, in this case MA transferred the transcripts from the interviews to Microsoft Excel and each response was assigned a single or multiple rows depending on the length of the sentence and ideas in the sentence (Microsoft Corporation, 2024). The second step is to identify keywords from the transcripts; here, MA highlighted keywords which were grouped into different codes, these codes were inserted in a separate column. The following step is to develop themes. In this step, MA grouped different codes into overall themes, these themes were colour coded to aid the final step. The final step is to develop a conceptual model to tie in the ideas together.

RESULTS

A total of five participants were recruited for online interviews with interview lengths ranging between 20-41 minutes. One interview required re-scheduling 48 hours prior to the scheduled time due to a change in the participant's clinical activity; apart from that, there were no other issues with scheduling nor connectivity. All of those recruited completed the interviews. There was a variety of participants working within the NHS and internationally, being both private and government based, as well as in the primary care setting, community dental practice, and teaching hospital setting.

All participants were asked the same questions and themes were developed along the way. MA analysed the transcripts of the first two interviews to identify the recurring themes and ensure that the interviews were running smoothly; some of the questions were rephrased for clarity after the first interview as well. Due to immediate analysis, MA was able to conclude that the number of participants was sufficient due to the absence of new concepts and themes in the last two interviews indicating saturation of themes and results.

THEME DEVELOPMENT

The transcripts were analysed as described in the methods section above, a total of five themes were developed, as seen in Table 3.1. A snapshot of the transcripts and the themes and subtheme analysis may be found in Appendix 5 and 6, respectively. These are discussed below.

Table 3.1: Developed themes and sub-themes

Theme 1: Participant Demographics		
Sub-theme 1.1	Participant demographics	Year of qualification
		Job title and nature of clinic they work in
Sub-theme 1.2	MIH prevalence	Number of MIH patients seen per month
Sub-theme 1.3	Availability of services	Availability of free dental care for paediatric patients
		Availability of orthodontic care
Theme 2: Clinician confidence and experience		
Sub-theme 2.1	Confidence in determining prognosis	
Sub-theme 2.2	Liaising with a colleague	For prognosis
		For orthodontic input
		For endodontic input
Sub-theme 2.3	Participant knowledge and experience	
Theme 3: Use of existing tools and guidelines		
Sub-theme 3.1	Available tools and guidelines	Nature of guidelines
		Limitations of guidelines
		Management options with guidelines
Sub-theme 3.2	Prognosis and treatment challenges	
Theme 4: Guideline development		
Sub-theme 4.1	Visual factor	Pictures
		Easy to follow
Sub-theme 4.2	Tooth factors	Lesion colour
		PEB risk

		Restoration prognosis
		Severity and prognosis
Sub-theme 4.3	Management factors	Treatment options
		When and how to monitor
		Age and cooperation
		Symptoms
Theme 5: Assessment of prognosis		
Sub-theme 5.1	Assessment of enamel	Integrity of remaining tooth structure and PEB
		Colour of lesion
		Caries presence
		Bonding to enamel and dentine challenges
Sub-theme 5.2	Assessment of restoration	Restoration presence and integrity
		Size of restoration
Sub-theme 5.3	Patient factors	Patient age and development including SPM development
		Symptoms
Sub-theme 5.4	Need for further assessment and management	Inability to determine prognosis visually and need for radiographic assessment
		Possible future need for treatment

From these themes, a conceptual model was developed, as seen in Figure 3.1. Participant confidence stems from the available resources and knowledge that they have gained over the years since being qualified. Being up to date with the current practices is important. To develop a new toolkit, the available guidelines should be understood as well. Alongside that, what limitations do clinicians feel the current guidelines have should be taken into consideration. Finally, to determine prognosis

the clinician should be confident with good knowledge of what guidelines are available and be able to implement those and assess the patient's condition.

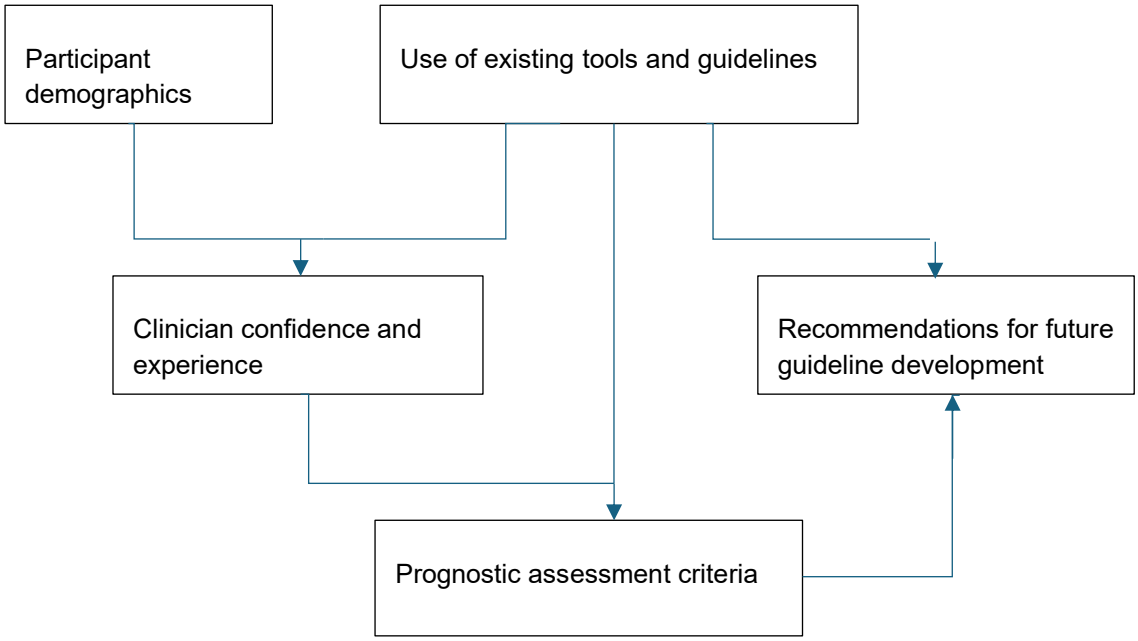


Figure 3.1: Conceptual model.

THEME 1: PARTICIPANT DEMOGRAPHICS

SUB-THEME 1.1: PARTICIPANT DEMOGRAPHICS

Participants were asked if they are involved in the management of paediatric patients often or if they do work solely in a clinic for paediatric patients. This was followed with enquiring about the year of qualification to further understand their overall experience which may be mirrored in their confidence.

Responses show a range of clinical experience as general dentists working in a primary care setting, a community dentist, and hospitals in three different countries with a range of years of experience as mirrored in their year of qualification, as shown in Table 3.2.

Table 3.2: Demographics of participants

	Place of work	Country	Job role	Year of qualification
Participant 1	Community dental practice	UK	Senior dental officer	1999
Participant 2	Paediatric general dental practice	Canada	General dentist	2009
Participant 3	Dental hospital	New Zealand	General dentist	2014
Participant 4	Dental hospital	UK	Post-graduate full time student	2021
Participant 5	Dental hospital	UK	Post-graduate full time student	2020

A variable age of patients was seen between those practicing in the UK and elsewhere; for example, the participant working in general practice in Canada treats paediatric patients up to the age of 18 years old.

‘’ [Patients age range] Zero to 18. We usually graduate them at 18, and there are some like higher needs adults’’ (Participant 2).

Similarly, in New Zealand in the hospital setting, paediatric patients were seen up to the age of 18 years old.

‘’ I work at (x) Hospital in New Zealand. And so, for the public health system here. And I am a general dentist, but our paediatric specialist retired, and we haven't been able to replace him; so, I do a lot of paediatric work. Probably 75% of my case load is paediatrics and the other 25% would be special needs adults or you know … [on age of patients] anything from zero to 18’’ (Participant 3).

SUB-THEME 1.2: MIH PREVALENCE

Although the sample isn’t large enough to assess the number of MIH cases seen per month nor was method precise for recording such data, the question was asked to ensure that the participants are regularly exposed to patients with MIH.

‘’Sometimes you'll see three to four a month and then a couple of months you'll not see any. So, on average, 20-22 per month’’ (Participant 1).

‘’Every day that I work, I see at least one person, and I work about 20 days a month; I probably see 20-25 a month. When I practiced in general practice, I rarely saw it, but in this practice, I see it every single day’’ (Participant 2).

‘’[On prevalence of MIH] Daily, like probably more than one a day on average’’ (Participant 3).

‘’I'd say once a week … around 4 patients a month’’ (Participant 4).

SUB-THEME 1.3: AVAILIBILITY OF SERVICES

Another area that was explored was the availability of services, this wasn’t anticipated when the questions were set, but it became relevant as more diversity was seen within the responses.

Responses from participants declared that different management options may be used in different countries due to the availability of services for children and adults:

‘*’We tend to extract more teeth, and I think you would in the UK because it ends up being a cheaper and more pain free’’* (Participant 3).

‘’You would refer; it would be a private clinic. Everything’s private here. Paediatric dentists do work in the hospital, but most access to them would be in a private clinic’’ (Participant 2).

‘’It's children's dentistry that is free until 18 and after 18, they're kind of on their own unless we can justify specialist dentistry for them, but there's not much availability there’’ (Participant 3).

‘’*Unfortunately, orthodontics is not free here, for some people that's not an option… there's monetary factors here that aren't much of a factor in the UK’’* (Participant 3).

THEME 2: CLINICIAN CONFIDENCE AND EXPERIENCE

SUB-THEME 2.1: CONFIDENCE IN DETERMINING PROGNOSIS

Most participants expressed their confidence did increase with time when asked how confident they felt when determining the prognosis of MIH affected FPMs. They were also asked if they do liaise with any of their colleagues when determining the prognosis and how often, is it for all cases or one out of ten for example. If they do liaise with a colleague, does the colleague have more years of experience, a specialist degree, or do they require a supervisor to confirm certain complex cases with.

Responses on confidence:

‘’I would say I am moderately confident’’ (Participant 3).

‘’Maybe 75% confident’’ (Participant 2).

‘*’I am not confident to differentiate between moderate and the poor prognosis. If I can stabilise it or not’’* (Participant 5)

‘’I will explain everything to the parent, but I have no idea the absolute prognosis’’ (Participant 2).

‘’I'm doing my masters in specialising in paediatric dentistry ... and prior to that I wasn't very confident, but since … I feel fairly confident’’ (Participant 1).

‘’Yeah, the more I get exposed to like cases, the more I feel confident’’ (Participant 4).

‘’I think this is great because I went from not seeing MIH to now seeing a lot. We just see more of it now or is just the practice and the demographics” (Participant 2).

‘’[On confidence] It comes with experience, and it also comes from my colleagues; I worked with a paediatric specialist for a long time” (Participant 3).

SUB-THEME 2.2: LIAISING WITH A COLLEAGUE

Participants expressed they not only liaised with other colleagues within the practice for advice on management of MIH lesions, but also with orthodontists and endodontists. This in turn shows that a multi-disciplinary approach is sometimes required for management of MIH affected FPMs.

Responses on liaising with a colleague:

*‘’One out of every 10 cases, maybe once ... [liaising with] my colleague, she is also a senior dental officer and she has a masters [degree] in special care, and she's got 10 years’ experience” (*Participant 1).

‘’Maybe like two years ago, maybe I did, but I kind of have a better idea now that I have seen it a lot more. I certainly haven't seen it all but more than when I came from general [practice]” (Participant 2).

‘’I'd say two out of four times” (Participant 4).

Responses on liaising with other specialties as part of multi-disciplinary care provision:

*‘’Consulting with orthodontics, if all other four need extractions as well” (*Participant 2).

‘’I tend to go to an orthodontist with pretty much every case, not the really mild ones, but the moderate ones I tend to go to an orthodontist at least” (Participant 3).

‘’We do send for endodontic consultations before extractions as well” (Participant 2).

SUB-THEME 2.3: PARTICIPANT KNOWLEDGE AND EXPERIENCE

The experience of the participants varied which was mirrored in the year of qualification and place of work. Where a more recently qualified dentist hadn’t come across MIH before working in a hospital setting in the UK, all participants felt they had more knowledge and experience with time and exposure to MIH patients.

‘’Actually, as an undergrad, I wasn't exposed to MIH. So, it is my first time to be exposed to MIH” (Participant 5).

One participant who was working in a hospital setting in New Zealand felt that they had become more experienced in management of FPMs where a patient might have other orthodontic needs.

‘’ *[On orthodontic planning] I do my best ... but I am not a specialist … I even supply some limited orthodontics for when they really need it… A big part of my job is*

recognising the right age for taking OPGs (orthopantomograms) and recognising when the 7s are in the right spot developmentally to kind of pull out the 6s'' (Participant 3).

THEME 3: USE OF EXISTING TOOLS AND GUIDELINES

SUB-THEME 3.1: AVAILABLE TOOLS AND GUIDELINES

Participants were asked if they are aware of any prognostic tools, or if they use any, that aid in determining the prognosis of MIH affected FPMs. Since none of the participants know of any tools, MA gave them a chance to elaborate on what aids they use to help determine the prognosis, of which were the EAPD and AAPD guidelines as well as the MIH-TNI. The strengths and limitations of those tools was explored.

A response on the reason for using the EAPD guideline:

‘*’EAPD is kind of recognised as the universal standard, more or less”* (Participant 3).

Some responses on the limitations of the available guidelines and tools:

‘*They're not easy [to follow]; so, for example, if you're in clinic and you want to just quickly go through something, you won't be able to do that’’* (Participant 4).

‘’I dislike sometimes the intricacies and complexities of it” (Participant 3).

‘’Grading that is clinician dependent. It’s not a strict grading structure like how you have probing depths, that is strict’’ (Participant 1).

‘’ [On AAPD and MIH-TNI] I feel they're both a bit subjective, it's like what I think I'm seeing, and I don't think I'm saying that one is the exact same as the other day-to-day if that’’ (Participant 2).

‘*’Because it [the guideline] depends on how cooperative the patients are. And usually when they are very young, the treatment planning revolves mainly around cooperation and age’’* (Participant 1).

‘’I find it difficult because I like to give information, I want it to be evidence based. I find it challenging to back that up with evidence based, because now at present you are using your own assessment where they are put in categories of mild, moderate, and severe’’ (Participant 1).

SUB-THEME 3.2: PROGNOSIS AND TREATMENT CHALLENGES

Most participants expressed they find moderate lesions the most challenging; here other challenges were also explored including those faced with management which stems from determining the prognosis first.

These responses declare the challenges with determining moderate prognosis:

‘’ I am not confident to differentiate between moderate and the poor prognosis. If I can stabilise it or not’’ (Participant 5).

‘’ Moderate [prognosis] is a very grey area’’ (Participant 1).

Responses on challenges with parent and patient expectations:

‘’I don’t think I'm very good at clearly explaining the prognosis to parents, more often than not, you'll find 2 or 3 molars affected. And they are asking why it can't be restored’’ (Participant 1).

‘’*The conversation I have is that dentists find this difficult to diagnose and treat properly. And how can you expect, you know, a parent to understand all that you, on a consultation appointment’’* (Participant 3).

Responses on challenges with management:

‘’I think for me the biggest concern would be the restoration’’ (Participant 1).

‘’I probably got a bit too extraction heavy over my years in practice, because it tends to be a better long-term outcome’’ (Participant 3).

‘’*I wonder if there's some kids where I could've restored the tooth, and it would have been fine; but you need a crystal ball to really determine that for some of the moderate MIH restorations’’* (Participant 3).

‘’Some are tricky to anaesthetise at times, so I started using nitrous oxide, which seems to help’’ (Participant 2).

THEME 4: GUIDELINE DEVELOPMENT

Since participants were not aware of any toolkits for determining the long-term prognosis of FPMs with MIH, they were given a chance to express what features they feel would be of importance.

SUB-THEME 4.1: VISUAL FACTOR

Participants agreed that having a visual aid in the guideline would help ensure it is easy to follow and easy to remember.

SUB-THEME 4.2: TOOTH FACTORS

''An idea of how long these restorations last, what to look out for breakdown, list of criteria you need to look for to ensure that a restoration maintains its integrity or it's losing its integrity, like to watch out for this colour on the margins'' (Participant 1).

''I'm thinking the number of surfaces affected, which is already I think it's already there, if it can be stabilised'' (Participant 4).

''I think it is better to include the colour of the MIH'' (Participant 5).

SUB-THEME 4.3: MANAGEMENT FACTORS

‘’A bit more finite advice or guidelines looking at the integrity of a restored tooth that has hypomineralisation and how to monitor with the frequency and need for radiographs’’ (Participant 1).

‘’If the patient's having symptoms, how would that affect how we manage the case’’ (Participant 4).

‘’I think what I would like would be, not tell you how to how to assess a treatment plan, but to give you a structure’’ (Participant 1).

THEME 5: ASSESSMENT OF PROGNOSIS

When faced with a FPM affected by MIH, what factors are taken into consideration to determine the tooth’s long-term prognosis.

SUB-THEME 5.1: ASSESSMENT OF ENAMEL

Responses on the enamel integrity:

‘’What I look for when it comes to stabilising a tooth is the available tooth structure, and the integrity of the tooth structure, extensive PEB, loss of cusps, loss of a vast area of the tooth that is compromised’’ (Participant 1).

‘’ [Good prognosis] because the post eruptive breakdown, it is only limited to one area of the tooth’’ (Participant 5).

‘’ [On being poor and not moderate prognosis] because there is not enough occlusal from the tooth; so, it is almost broken down’’ (Participant 5).

‘’That looks pretty hopeless … I'd almost always try and stabilise it with a PMC, so I'd give it a go telling the parents that the prognosis is very poor here’’ (Participant 3).

SUB-THEME 5.2: ASSESSMENT OF RESTORATION

Responses on restoration integrity:

‘’I would make sure that I check the margins of the restoration’’ (Participant 1).

‘’The cusp most of it Is intact and only the occlusal, there is a large restoration, so I am going with moderate not poor prognosis’’ (Participant 5).

‘’If we plan to restore it, well it'd be difficult because there is nothing to bond to’’ (Participant 4).

SUB-THEME 5.3: PATIENT FACTORS

Participants felt that the patient's age and cooperation were important factors when determining the long-term prognosis of a FPM.

‘’*Because it depends on how cooperative the patients are. And usually when they are very young, the treatment planning revolves mainly around cooperation and age”* (Participant 1).

SUB-THEME 5.4: NEED FOR FURTHER ASSESSMENT AND MANAGEMENT

Participants felt that visual assessment for prognosis is not sufficient and other aids including symptoms must be taken into consideration:

‘’ [On stabilising a poor prognosis tooth] it depends on the symptoms” (Participant 3).

‘’Depending on the symptoms the patient has. If the patient has, like, really severe symptoms, I'd say it's not [stabilisable]” (Participant 4).

‘’Cannot just eyeball it [to determine prognosis]” (Participant 1).

‘’You don't know the integrity of the underlying dentine and enamel” (Participant 1).

‘’I don't know what the prognosis is from these photos. Like when I see this, a patient is attached to it’’ (Participant 2).

‘’I think it is difficult because I wouldn't just go on appearance of the tooth. Going to the child’s pain, x-rays, and things’’ (Participant 3).

‘’Eventually it would need treatment … and in the future maybe an onlay’’ (Participant 2).

DISCUSSION

Following the thematic analysis of the interview transcripts, several key themes and subthemes were identified through Microsoft Excel (Microsoft Corporation, 2024); it was made apparent that there are currently no tools or guidelines that may be used solely to determine the long-term prognosis of MIH affected FPMs.

THEME 1: PARTICIPANT DEMOGRAPHICS

The first theme summarised the demographics of the participants. All participants, as the inclusion criteria specified, are qualified general dentists involved in the management of paediatric patients, and none hold a formal specialist qualification. The years of experience varied widely, with a participant qualifying in 1999 and another as recent as 2021. Three of the participants practice in the UK, two within the paediatric department of a dental teaching hospital and one in a community practice. Community dental services in the UK generally provide specialised dental services for

children who are very anxious, have physical or learning disabilities, complex medical conditions for which the general dentist is unable to provide the best management, and those in specific social vulnerabilities, as well as adults with complex medical needs or with physical or learning disabilities (NHS, 2023). Within the international participants, one participant treats patients in a dental hospital in New Zealand within the public health system. Most of their patients are paediatric patients, along with management of adults with special needs. The final participant in the group works as a general dentist in a private paediatric practice in Canada where the age of paediatric patients is up to 18 years, unlike in the UK and New Zealand where the age range is up to 16 years.

Distinct differences in the care provision of different healthcare systems were noted. For example, unlike the UK where all dental treatment for children is free under the NHS at general dentists, community dentists, and dental hospitals, in Canada most paediatric patients are seen privately since a small number are eligible for free dental treatment within hospitals. In Canada and New Zealand, unlike in the UK, orthodontic treatment is self-funded. A global survey showed that there are vast differences with some countries having well-developed oral health policies and others lacking any. Some countries have adopted the Universal Health Coverage (UHC) in line with the World Health Organisation (WHO), where all individuals would have access to the full range of health services they need, independent of time and place, without financial hardships. Even then only 48% of countries who participated in the survey did include dental health (Gaffar et al., 2024; WHO, 2025). These differences in access to certain dental services does change the overall picture of management and hence the importance of determining the long-term prognosis of a FPM at a younger age.

Participants who have been qualified more recently have expressed they see 2-4 MIH patients per month. This is mirrored in the number of days those participants work and the nature of the clinics that run on those days. Those with more dental experience have expressed that they see 20-25 MIH patients on average per month, these clinicians also do work full time with more patients attending those clinics; this shows increased exposure to MIH patients over time. participants were asked about the

number of MIH cases they see per month to ensure they are regularly exposed to MIH and therefore their input in the interview would be relevant and valuable in the development of such toolkit.

THEME 2: CLINICIAN CONFIDENCE AND EXPERIENCE

While none of the participants expressed complete confidence, all participants did express that their confidence increased with clinical experience when determining the prognosis of those FPMs. This may be compared with the findings discussed in Chapter 1 where general dentists aren't 100% confident when diagnosing MIH neither in the UK nor internationally, where reported confidence levels was between 48.4% - 52.5% (Dian et al., 2022; Kalkani et al., 2016). It is therefore plausible that if there is a lack of confidence with diagnosing MIH, there would be lack of confidence in determining the prognosis of a tooth with MIH.

Participants highlighted that determining moderate prognosis is usually the most challenging, where it isn't obvious that the tooth is of good prognosis, and the clinician is therefore uncertain on the long-term restorability. Participants expressed that their confidence increased with time and that during their initial encounters with MIH patients, they were able to discuss the cases with a more experienced colleague, that being one with a specialist interest, specialist degree, or a consultant in paediatric dentistry. This allowed clinicians to understand the decisions regarding management better with time and experience. Most participants find themselves liaising with a colleague less often than when they initially started treating paediatric patients. Therefore, exposure to more MIH cases would build on experience and confidence.

THEME 3: USE OF EXISTING TOOLS AND GUIDELINES

The interviews showed that participants were not aware of any available tools or guidelines solely for determining the prognosis of MIH affected FPMs, which is in line with the results of the scoping review completed in Chapter 2. Participants did express they use the available guidelines, such as the EAPD and AAPD which generally cover the diagnosis and severity of MIH lesions, to conclude the prognosis and hence management of the tooth. Participants though found that the guidelines are hard to follow and not suitable as a quick reference. To overcome confusion with the presence of multiple guidelines, one participant explained that their department developed a modified version of the EAPD which is tailored to their hospital and the care they provide.

The interviews showed a shared need for a prognostic tool which is concise and simple to follow on clinic, and which can be shown to parents as a reference. One of the participants uses the MIH-TNI at the initial appointment to discuss their findings with the parents or guardians. Some of the participants feel that assessing prognosis is subjective and may yield different results between clinicians or even within the same clinician on a different day.

Although guidance on management of MIH FPMs is available, participants still felt that it isn't clear what materials or methods should be chosen. That goes back to confidence when determining what the prognosis is in the first place and what restorations would be optimal for each patient. There is confusion on when to use PMCs and even when it is recommended, some participants felt it is and to opt for a restoration with composite or GIC. Also, what can be provide for younger patients is sometimes challenging due to cooperation and knowing that they would start their restorative cycle early. Despite the guidance from the EAPD recommending restoring hypomineralised teeth under rubber dam isolation and composite, one participant expressed they find it difficult to place a rubber dam clamp on those teeth therefore they would often use other materials rather than composite. Due to the

hypomineralised nature, three of the participants would choose GIC over composite when restoring those molars. When it comes to extractions, participants are aware of the Royal College of Surgeons (RCS) guidance. One participant explained that over the years they have been extracting FPMs more often due to limited access to orthodontic facilities. Therefore, orthodontic needs are taken into consideration when planning patients with MIH in the paediatric clinic.

THEME 4: ASSESSMENT PRIOR TO TREATMENT PLANNING

Radiographic assessment prior to treatment planning was discussed by several participants, they felt that having a visual representation of the depth of the cavity and the hypomineralised enamel is essential. This highlighted that some participants don't fully understand how hypomineralisation effects the enamel. Hypomineralisation is usually non-diagnosable on two-dimensional radiographs, especially with mild and moderate cases. In cases where there is PEB, a clinician can detect the breakdown extent on a radiograph, but not the hypomineralisation surrounding it (Henriksen et al., 2023).

Patient's age and cooperation were also important factors when assessing a tooth. Two participants expressed that these factors dictate what management options may be offered. Cooperation of a patient isn't always determined by their actual age, rather different factors such as their cognitive development, maturity, personality and past dental or medical experiences. Their development may be influenced by their medical condition and their parent's views as well (Juárez-López et al., 2022). Different behaviour management strategies may be helpful in these instances, but at the end of the day the management plan must be tailored to the patient themselves, accessibility to treatment, and what the clinician is able to offer.

When treating a paediatric patient, their parents/guardians are also involved in their care, and their expectations must be considered. Where a systematic review showed that parents value professionalism, provision of guidance, and referring them to supporting materials and resources are of importance (Dalsochio et al., 2025). These discussions are also beneficial to the clinician themselves since a paediatric patient's oral health, dental condition, and attendance are dependent on the parents/guardians' knowledge and attitude towards dental health and treatment; therefore, parents/guardians must be well-informed. One participant expressed how challenging they found it to explain MIH and its complexity of management to the parents/guardians.

Most participants were aware that compromised FPMs sometimes require referrals to an orthodontist, as advised by the RCS guidelines (Noar et al., 2023). These guidelines have been developed to aid general dentists in understanding what cases need to be referred to an orthodontist or a multi-disciplinary team with an orthodontist and paediatric dentist. Where it isn't feasible to refer, the guidelines support a clinician in management in terms of interceptive extractions of FPMs.

THEME 5: GUIDELINE DEVELOPMENT

Some participants expressed what they would like in an overall concise guideline on MIH; that would include severity and prognosis, although severity is already in multiple guidelines such as the EAPD and AAPD (Lygidakis et al., 2022; AAPD, 2024). Similarly, management exists is in those guidelines, but one participant expressed they wanted a more structured approach to management options which would take age into consideration, while another participant was unaware of the available guidelines on management of teeth with MIH. Most participants felt that having a visual aid such as a chart or images of teeth included in the guidelines to be useful as a quick representative reference during patient assessment. This would give the clinician a

visual representation when determining the prognosis and a resource to share with parents or guardians when discussing prognosis.

Upon discussing what tooth factors should be included in a guideline on prognosis, participants felt that the colour of the lesion was an important factor. Also, the crown's integrity and presence of PEB and how those influence the long-term prognosis. Where PEB already exists, participants wanted a more defined approach to assess the longevity of the tooth and predict further PEB in the future. Similarly, in the presence of a restoration, how would one predict what the future of that restoration would be and if it would alter the prognosis. One participant included that when assessing the long-term stability of PEB and restorations, would the clinician need to monitor patient presenting with those factors more often. These findings support the need for a concise, visual, and user-friendly toolkit.

THEME 6: ASSESSMENT OF PROGNOSIS

The interviews allowed for a detailed assessment of what clinicians felt is essential when determining the long-term prognosis of a FPM with MIH. One of the most important factors was consideration of the integrity of the healthy tooth structure and if any PEB was evident. An assessment of the surface(s) where the lesion is seen and if any cusp or fissure involvement are evident. Where cusps are involved, some participants considered what the outcome of those cusps would be in a few years and longer term to predict if PEB, or further PEB, would occur. Participants showed a good understanding of where the margins of the hypomineralised lesion end, but most didn't express that the whole lesion would determine the prognosis, where PEB was present, most focused on the PEB itself and the cusps and didn't consider the rest of the lesion of high importance to determine prognosis. For example, where only a cusp showed PEB and the whole occlusal surface was affected by a yellow lesion, some participants felt that the PEB may be resorted therefore the tooth is of good or moderate long-term

prognosis. While other participants included assessing the margins, they felt that most can be restored even with a PMC therefore would be of moderate prognosis. Although in the EAPD guidelines, it is recommended to remove all hypomineralised enamel for the best long-term restorative outcome (Lygidakis et al., 2022).

Where restorations are already in situ, participants focused on the margins of the restorations and if any hypomineralisation is surrounding the restoration. Some participants questioned the size and surface area covered by the restorations and felt that changed its prognosis while one participant questioned the depth of the restoration in the image provided. When considering restorability, bonding to healthy enamel is also considered. This would determine the surface area of the restoration and the number of surfaces it would cover and therefore determine the restorations prognosis when the hypomineralised enamel is removed, as per recommendation of the EAPD guidelines (Lygidakis et al., 2022).

When assessing the colour of the lesion, participants expressed that lighter lesions are of better long-term prognosis than darker ones, as made clear in the literature, darker lesions are of higher severity as well (Costa Silva et al., 2011). The colour of the hypomineralised lesion whether it was lighter as white or creamy or if it was darker as yellow or brown. This was in accordance with the severity scores previously mentioned, the EAPD and AAPD (Lygidakis et al., 2022; AAPD, 2024).

When assessing the colour of the lesion, participants were able to distinguish between MIH and dental caries. Although they did express that further investigation is required to assess the darker fissures and buccal caries which were present on some of the photographs shown during the interviews. It is important to distinguish between MIH and caries but also to understand that MIH increases the risk of caries development and sometimes where gross caries is present, it masks the MIH lesion; these two problems can co-exist (Almuallem and Busuttil-Naudi, 2018).

As discussed earlier with assessment prior to planning, most participants felt that they cannot determine the prognosis visually and would need radiographs to assess the depth of the hypomineralisation or restorations and their proximity to the pulp; this is valid in terms of PEB which can be visualised on a radiograph (Henriksen et al., 2023).

As per the SDCEP guidelines highlighted in the scoping review, symptoms such as hypersensitivity and pain are considered when managing poor prognosis FPMs with MIH; therefore, some participants felt that a pain history is required which also involves asking about hypersensitivity. Some expressed that a precise prognosis wouldn't be reached unless symptoms are included while others felt that that would be the tipping point in some situations between being able to stabilise poor prognosis FPMs and not being able to stabilise them. This has previously been discussed in the RCS guidelines, where it highlights that in the presence of symptoms or presence of swelling or infection, the clinician must assess on their own terms time of intervention (Noar et al., 2023).

When stabilising teeth of poor prognosis, some of the participants took into consideration long-term planning such as providing a lab-made crown in the future or extractions at the optimal age of 8-10 years, as recommended by the RCS guidelines (Noar et al., 2023). One participant expressed they would always try and stabilise the tooth since the accessibility of orthodontic services in their country is limited.

General dentists who regularly see paediatric patients are not very confident when determining the prognosis of MIH affected FPMs, let alone dentists who rarely see patients with MIH. All participants were very enthusiastic on the hopes of having a new toolkit developed would aid proper assessment and therefore management of patients and aid referrals where appropriate.

CONCLUSION

Through the thematic analysis of semi-structured interviews with general dentists involved in the management of paediatric patients, it became evident that there is currently no dedicated prognostic toolkit or guideline for MIH affected FPMs for clinical use. While existing guidelines, such as those from the EAPD and AAPD, provide a framework for diagnosis and general management, they lack the specificity and clarity needed for determining long-term prognosis. Furthermore, participants expressed challenges in applying these guidelines consistently due to their complexity and subjectivity, especially when managing moderate MIH lesions.

The interviews revealed that clinician's confidence in assessing prognosis increases with experience and exposure to MIH cases; however, even experienced practitioners reported uncertainty, particularly in distinguishing between moderate and poor prognoses. Key factors considered in prognosis included enamel integrity, extent of PEB, lesion colour, presence and condition of restorations, and the need for radiographic and symptomatic assessment. The importance of an interdisciplinary approach especially with orthodontics has been highlighted.

Most participants expressed the need for a simple yet effective, user-friendly prognostic toolkit that includes visual aids and clear clinical criteria to support consistent treatment planning and communication with patients and parents or guardians. The findings from this chapter highlight the need for an MIH prognostic toolkit for FPMs to aid general dentists.

CHAPTER 4 : DEVELOPMENT OF A PROGNOSTIC TOOLKIT

INTRODUCTION

This chapter highlights the development of the toolkit, which is the main aim of this project. Following from the previous chapters, the scoping review's results included a variety of lesion severity indices and guidelines on management rather than the prognosis of FPMs with MIH, with only one guideline which focused only on poor prognosis FPMs. The interviews did confirm there is lack of confidence when determining the prognosis. Both the scoping review and the qualitative interviews confirmed the need of a toolkit to determine the prognosis of FPMs with MIH.

AIM

To develop an easy-to-use prognostic toolkit for general dentists to assess the long-term prognosis of FPMs affected by MIH, based on the results obtained from the scoping review in Part I and the thematic analysis of the one-to-one interviews conducted in Part II of the project (Chapter 2 and Chapter 3, respectively). This in turn would aid general dentists when planning for management in the primary care setting and hence aid in referrals, where appropriate.

The toolkit does not aim to give a definitive prognostic value to each tooth, but rather a relative prognostic value, which helps the clinician differentiate between good and poor prognosis, and those in between (Samet and Jotkowitz, 2009).

METHODOLOGY

The development of the toolkit followed a multi-phase process; the first step includes analysing the gathered data from the scoping review and the qualitative interviews to identify the main characteristics of an MIH lesion that determine its long-term prognosis. The next step involves identifying which characteristics deem the lesion of good or poor prognosis, and which characteristics lay in between. Since these characteristics would co-exist, which combinations would deem the tooth of poorer prognosis as well. This step would require quantifying the characteristics to enable justified conclusions. To ensure better visualisation and easier flow of the information for clinical use, the scale was developed into a flowchart. The final step is to develop the toolkit itself, with a visual aid to assist clinicians in their daily practice in primary care.

ANALYSIS OF THE DATA FROM PART I AND II:

The scoping review and the qualitative interview analysis have set a good foundation for the development of this toolkit.

The comprehensive scoping review conducted didn't identify any existing prognostic tools and guidelines for MIH affected FPMs apart from the poor prognosis FPMs affected by MIH guideline by SDCEP. The remainder of the results must not be disregarded since some of those results included indices and guidelines on determining severity of MIH lesions. These indices were mostly developed for use in research and specialist settings rather than being a quick guide for general dentists in the primary care setting. To determine the severity of an MIH lesion, certain characteristics must be taken into account, some of which overlapped with those discussed in the SDCEP guideline (SDCEP, 2025b).

The semi-structured interviews with general dentists clarified what characteristics were deemed important when assessing a lesion's long-term prognosis. there was an overall lack of confidence with uncertainty towards the available tools and guidelines. Participants found it difficult to see the tooth individually and always took into account how the patient's symptoms or cooperation would guide their management; they found it difficult to have a baseline idea of the long-term prognosis of the tooth in the absence of patient factors. This highlighted the need for a simple toolkit to help clinicians when providing management to ensure the best available options are provided considering the long-term prognosis of the tooth. Many participants expressed the need for a simple, visual, and clinically relevant toolkit to aid them in tailoring the treatment for the patient.

Therefore, it was identified that the toolkit needs to include:

- The prognosis determining characteristics that have been identified in both parts I and II.
- A visual aspect which is easy to follow in the primary care setting.
- Consistent and reproducible results.

DEVELOPMENT OF A PROGNOSTIC SCALE

Within the scoping review, different severity indices were identified, one of which was the Oliver et al.'s MIHSI (2014). This was used as the core structure for the development of the toolkit. To enable identification of which lesion characteristics influence the overall prognosis of the tooth, the characteristics were quantified with the MIHSI. This quantification enabled the placement of the different scenarios onto a scale depending on their severities. This scale categorises affected FPMs into three prognostic groups—good, moderate, or poor—based on:

- Enamel loss in the form of PEB, atypical caries, or atypical restorations.
- Colour of the lesion (e.g., white, yellow, brown),
- Location of the defect on the tooth surface
- Extent (number of surfaces involved)

DEVELOPMENT OF A PROGNOSTIC FLOWCHART

To ensure the toolkit guides the clinician during an intra-oral assessment to be able to reach a conclusion on the prognosis instantly, a flowchart seemed to be more appropriate than a scale. Therefore, during assessment, the clinician would answer questions on certain features they see on the tooth that would guide them to the conclusion of the tooth's prognosis. This flowchart aims for consistent prognosis evaluation across clinicians and supports a quicker chairside decision to be made.

TOOLKIT DEVELOPMENT:

The final toolkit was developed as a document which includes the flowchart as the main component, encouraging a quick and consistent assessments within the clinic. The rest of the toolkit includes further explanation on when and how to use the toolkit. It also refers the reader to additional guidelines which would aid in the next step after identification of the prognosis, those on management and interceptive extractions.

RESULTS

Since the scoping review didn't identify any prognostic tools exist apart from the SDCEP guidance for poor prognosis FPMs affected by MIH and none of the participants were aware of any tools, it was concluded that none exist at the moment (SDCEP, 2025b).

The semi-structured interviews did highlight what aspects clinicians felt are of importance when assessing the prognosis of FPMs with MIH, in agreement to what the SDCEP guidance suggested for permanent molars, these factors were considered for the development of the toolkit (SDCEP, 2025b). This includes the presence or absence of any PEB, atypical caries, or atypical restorations suggesting that there was enamel loss as described previously in the EAPD guidelines, where atypical restorations or atypical caries are present, it is indicative of an MIH lesion, therefore they have been scored similarly to PEB where MIH is present in the dentition (Lygidakis et al., 2010). The colour of the lesion, the surface area on which the lesion exists, and the number of surfaces in which MIH lesions are evident were all taken into consideration. These characteristics have also been repeatedly assessed in different severity indices such as the MIHSI and within the EAPD guidance to determine severity of MIH (Lygidakis et al., 2010). Hence, it was sensible to score them as seen in Table 4.1 as to what was done in the MIHSI (Oliver et al., 2014). But since we are looking at the visual clinical aspect only, hypersensitivity was not included as part of the long-term structural prognosis.

Table 4.1: Scoring characteristics of MIH according to Oliver et al., 2014

Colour	White	1
	Yellow	2
	Brown	3
Location	Smooth surfaces	1
	Occlusal surfaces	2
	Cusp involvement	3
Loss of enamel	PEB or atypical caries or restorations	3

Assigning scores to the colour or presence of loss of enamel, location, and number of surfaces affected and combining those characteristics as we might see clinically enabled us to have a combined score to aid determining the prognosis. Table 4.2 summarises each colour of lesion or loss of enamel in combination with the surface or surfaces it affects. For example, a brown lesion affecting a smooth surface was given a score of 3 for colour and 1 for location with a combined score of 4. While a brown lesion affecting the smooth and occlusal surfaces was given a score of 3 for colour and two scores for location, 1 and 2, with a combined score of 6, since it is covering two surfaces. The scores that were assigned to each characteristic are from the MIHSI (Oliver et al., 2014).

After each combination was given a combined score, the cutoff point for different prognoses were decided amongst MA, SP, and PA in relation to which scores are more likely to undergo PEB and loss of enamel. A combined score of 2 was decided to be of good long-term prognosis, those with a combined score of 3, 4, or 5 were decided to be of moderate long-term prognosis, and those with a combined score of 6 or more were deemed of poor long-term prognosis. Although, the combination of scores with white lesions did lead to scores 5 and higher, it was agreed not to consider them as poor prognosis since white lesions are not at high risk of PEB, as discussed earlier in Chapter 1. Also, based on thorough expert discussion, yellow lesions without

cusp involvement, regardless of the number of surfaces, were excluded from the poor long-term prognosis category. These exclusions are highlighted in yellow in Table 4.2.

Table 4.2: Combining the scores of MIH characteristics based on Table 4.1 and Oliver et al.'s index (2014).

Appearance score		Smooth Score	Occlusal Score	Cusp Score	Total score
White	1	1			2
	1		2		3
	1			3	4
	1	1	2		4
	1	1		3	5
	1		2	3	6
	1	1	2	3	7
Yellow	2	1			3
	2		2		4
	2			3	5
	2	1	2		5
	2	1		3	6
	2		2	3	7
	2	1	2	3	8
Brown	3	1			4
	3		2		5
	3			3	6
	3	1	2		6
	3	1		3	7
	3		2	3	8
	3	1	2	3	9
PEB	3	1			4
	3		2		5
	3			3	6
	3	1	2		6
	3	1		3	7
	3		2	3	8
	3	1	2	3	9
Colour coding reference:					
Good long-term prognosis		Moderate long-term prognosis	Poor long-term prognosis	Excluded from poor to moderate	

DISCUSSION

The MIH prognostic toolkit is a clinical decision-making toolkit designed to guide general dentists in assessing the long-term prognosis of teeth affected by MIH.

The document first explains prognosis and what factors contribute to prognosis; it categorised long-term prognosis into good, moderate, and poor; and based this on a range of clinical factors to aid long-term planning.

A good prognosis is assigned when the tooth is stable, with lesions that do not require long-term restorations or extraction due to MIH-related defects. A moderate prognosis applies to teeth where long-term restoration is possible; however, if orthodontic extractions are planned in the quadrant, these moderate prognosis FPMs may be considered for extraction. A poor prognosis indicates that the lesion is non-restorable or pulpally involved and therefore planned tooth loss is recommended. In such cases, the tooth may be temporarily stabilised to fit within an orthodontic treatment plan for timed extractions. The assessment of prognosis is then described within the toolkit in accordance with the SDCEP guidelines (SDCEP, 2025b).

From a restorative perspective, prognosis depends heavily on the quantity and quality of remaining healthy tooth structure, as successful long-term restorations rely on bonding to sound enamel. Therefore, an assessment of the remaining tooth structure post-removal of all caries, restorations, and hypomineralised enamel would suggest how restorable a tooth is (Lygidakis et al., 2022). Another factor to consider when restoring the tooth is any symptoms a patient has including hypomineralisation. This may greatly alter the management options where a tooth might not be stabilisable due to pulpal involvement and swellings.

Additional indicators of compromised prognosis include the presence of atypical caries, prior extensive restorations, and involvement of multiple surfaces or cusps. Existing restorations should also be critically evaluated—restoration margins should be assessed for placement within hypomineralised enamel or evidence of recurrent caries, both of which may compromise long-term outcomes.

The toolkit includes a flowchart (Figure 4.1) which aids in guiding the dental practitioner through assessing a MIH affected FPMs where MIH presents. The flowchart begins with determining the presence of PEB or associated atypical caries or restorations. If none are present, the clinician proceeds based on the lesion's colour—white/creamy, yellow, or brown—and whether it affects smooth surfaces, occlusal areas, or cusps. White or creamy lesions limited to smooth surfaces suggest a good prognosis, while involvement of occlusal surfaces or cusps indicates a moderate prognosis. Yellow lesions without cusp involvement are also considered moderate, but if the cusp is affected, the prognosis worsens resulting in poor long-term prognosis. Brown lesions affecting one surface may be moderate or poor depending on cusp involvement, whereas multi-surface brown lesions are classified as poor prognosis. If PEB or atypical caries or restorations are present, prognosis depends on the extent and location: one-surface involvement without cusp compromise would still be moderate, but cusp involvement or multiple affected surfaces leads to a poor prognosis.

The more severe characteristics are prioritised over less severe ones when determining prognosis. For example, PEB, atypical caries or restorations, and brown discolouration take precedence over yellow and white lesions, and yellow lesions are prioritised over white patches. Additionally, restorability depends on the remaining surface area of healthy enamel after all hypomineralised enamel, caries, and defective restorations have been removed. This structured approach helps clinicians tailor management strategies to the severity and long-term stability of each MIH FPM.

The flowchart was piloted in a monthly Journal Club meeting at EDI with clinicians with a range of clinical background and experience, all of which routinely see paediatric patients with MIH. This ensured that the flowchart is precise, and the information provided is sufficient. The flowchart was adjusted after taking on board the comments that were presented, mainly on the visual flow of the flowchart.

The toolkit recommends what guidelines to follow for management including the EAPD and RCS guidelines at the end (Lygidakis et al., 2022; Noar et al., 2023). Here, the management of different lesions are explained with evidence on materials that can be used in the short and long-term; also, recommendations on timed extractions and orthodontic assessment prior to extractions if an orthodontics referral is not feasible.

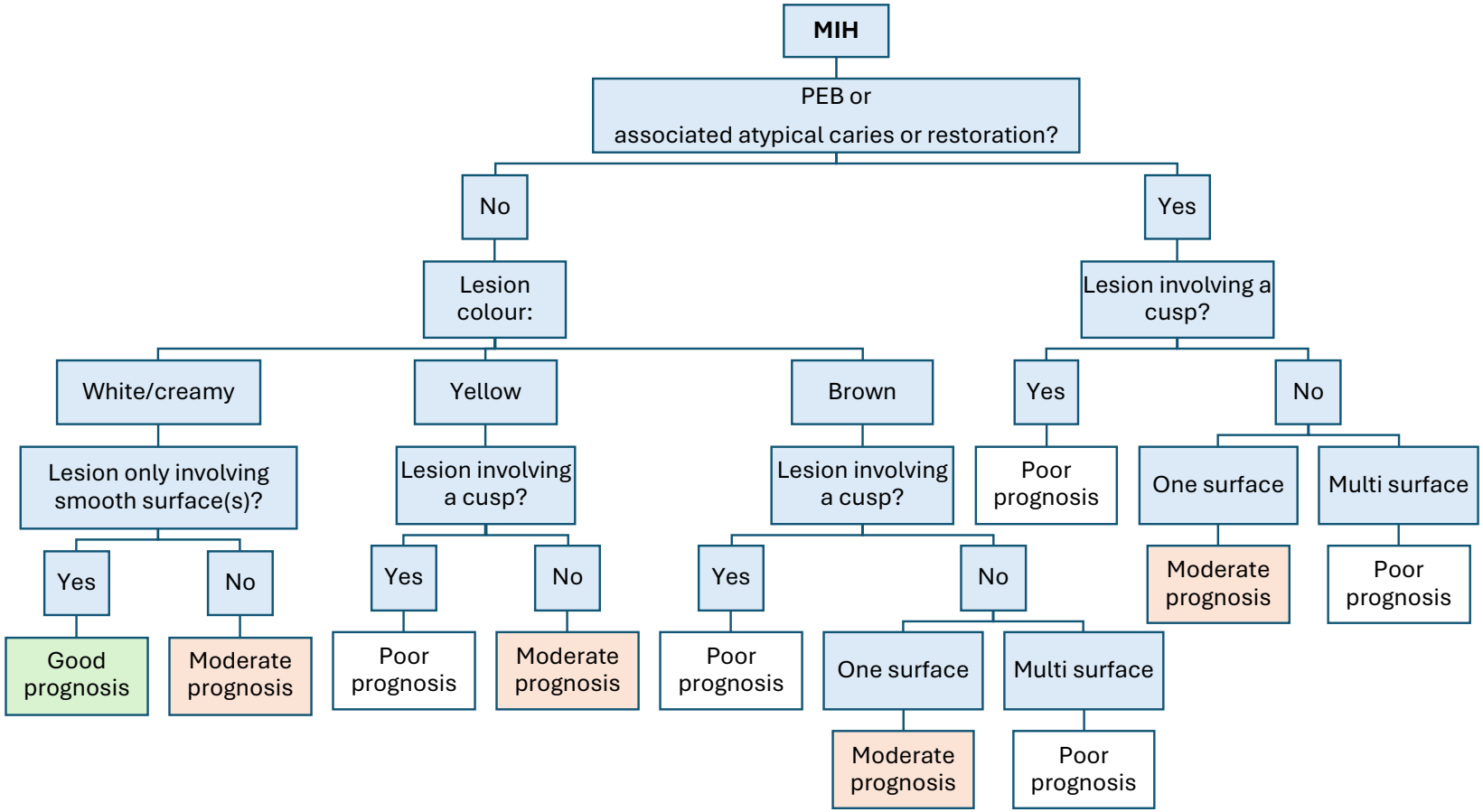


Figure 4.1: Developed flowchart to aid determining prognosis of MIH FPMs.

CONCLUSION

This chapter outlined the development of the prognostic toolkit to aid general dentists in assessing the long-term prognosis of FPMs with MIH. This was based on the evidence from the scoping review and the analysis of the semi-structured interviews that were conducted. The interviews confirmed a need for a simple, visual aid that could be used daily in a busy clinic. The inclusion of lesion colour, location, number of surfaces involved, and most importantly the presence or absence of PEB or enamel loss were included. These features were transferred into a scale with different weighting and therefore facilitated the formation of a flowchart for a structured and more user-friendly visual flow. The toolkit ensures the clinician is made aware of the guidelines available for management since its aim is to aid in determining the prognosis only and is not to replace the clinical judgment of the practitioner. This toolkit addressed the current gap in clinical practice by providing an organised, structured, and easy to follow method to diagnose prognosis, which previously didn't exist.

CHAPTER 5 : PILOTING THE MIH PROGNOSTIC TOOLKIT WITH QUALITATIVE INTERVIEWS

AIM

To pilot a newly developed prognostic toolkit for FPMs affected by MIH through one-to-one semi-structured interviews with general dentists who regularly manage paediatric patients presenting with MIH, in order to evaluate its usability, clarity, and clinical relevance, and to refine the toolkit based on their feedback.

METHODS

Qualitative interviews in the form of one-to-one semi-structured interviews with dentists to evaluate a newly developed prognostic toolkit have been conducted via Microsoft Teams (Microsoft Corporation, 2025). The interviews have been transcribed and analysed through Microsoft Excel (Microsoft Corporation, 2024).

ETHICAL APPROVAL

Ethical approval has been obtained from UCL's LMS Research Ethics Committee on 12/09/2024 (project ID 27527/001) and the study has been registered with UCL's Data Protection Office (reference number Z6364106/2024/03/97 health research).

PARTICIPANT RECRUITMENT

Recruitment was conducted via the Moodle platform used by MSc Paediatric Dentistry students at UCL. Those who were interested have been invited to contact the researcher MA to express interest and a Participant Information Sheet and Consent Form were provided to all interested individuals; the consent form was signed prior to the interview.

INCLUSION CRITERIA:

- Qualified dentists
- Involved in the management of paediatric patients
- Familiar with MIH
- English speaking

EXCLUSION CRITERIA:

- Specialist dentists (e.g., paediatric specialists, orthodontists, or restorative consultants)

SEMI-STRUCTURED INTERVIEWS

Written informed consent was obtained prior to participation; a copy of the toolkit was not distributed prior to the interview to prevent circulation prior to finalising the toolkit and completion of the project. Interviews were conducted by MA remotely using Microsoft Teams (Microsoft Corporation, 2025) and were auto transcribed through the program. Transcripts were saved anonymously securely and a soft copy kept secure on the UCL N-Drive.

The transcripts were analysed by MA using Microsoft Excel (Microsoft Corporation, 2024) and a thematic analysis approach was used to identify common themes, participant perceptions, and suggestions for improvement. Based on this feedback, adjustments were made to the toolkit to improve its clinical usability, clarity, and relevance for general dentists. As the interviews were conducted, MA analysed the transcripts, and once participant saturation was reached with no new themes emerging and no new feedback given, MA decided to conclude the interviews with a total of four interviews. A range of dentists from the UK and internationally were interviewed, both working for a government job and private, in primary care dental clinics and hospital based, therefore a variety of points of view were included. Interview lengths ranged between 15-27 minutes.

DATA COLLECTION

Interviews were conducted online by MA and at the start of each interview there was a brief overview of the project and how the toolkit was developed. The interview questions may be found in Appendix 7.

Participants were asked to confirm consent for transcription prior to starting the transcription and the toolkit was shared on the screen by MA. The same overall outline was carried out by MA where at the start MA read through the toolkit and explained the importance of each part of the toolkit. The flowchart was left on the screen at the end of the document overview to give the participants to analyse it further, if needed. After that, the participants were asked if they had any comments or questions on each part of the toolkit and the overall outline of the document. These were answered by MA and then MA asked about three main themes, if not already covered by the discussion; these were on how precise and reliable the information is, if results would be reproducible in different scenarios and with different clinicians, and the overall outline of the document. At the end of the interviews, participants were asked if they had any other comments or feedback before thanking them and ending the transcription and interview.

DATA ANALYSIS

Systematic thematic analysis for qualitative research and semi-structured interviews was also undertaken for this part of the project. The same structure as the one described in Chapter 3 was followed.

RESULTS

A total of four interviews were conducted with dentists who fit the inclusion criteria. All participants had the same flow during the interviews and were given a chance to give feedback therefore each interview had a slightly different focus and discussion, depending on the participants views. Different themes were developed throughout the analysis while the interviews were still being conducted and therefor once saturation of participants was reached, the interview recruitment was concluded.

Three themes have been developed after analysing the transcripts as seen in Table 5.1; assessment and management, use of the toolkit, and format of the document. The conceptual model may be found in Figure 5.1, which clarifies which aspects of the toolkit work well and which ones need to be adjusted. This includes the clarity of prognosis categories, the flowchart as a visual aid, referring the reader for more information on management, and addition of a disclaimer that this document is to guide clinicians only. This is in line with the overall aim of the project which would be to support general dentists to determine the prognosis of an MIH FPM before management.

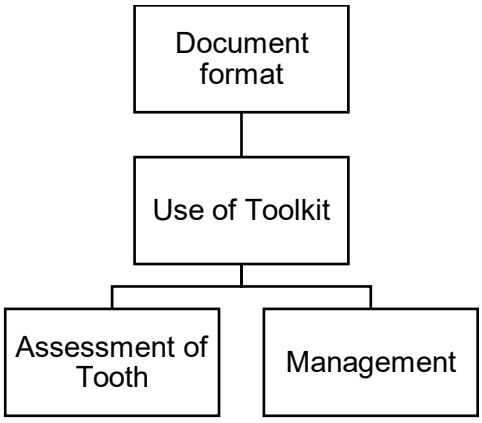


Figure 5.1: Conceptual model for toolkit pilot interviews.

Table 5.1: Themes and Sub-themes from Part Four

Theme 1: Assessment and management		
Sub-theme 1.1	Assessment of tooth and patient	Early stages of PEB and early caries
		Symptoms associated with MIH
Sub-theme 1.2	Management	Available guidelines
Sub-theme 1.3	Confidence when determining the prognosis	
Theme 2: Use of the toolkit		
Sub-theme 2.1	Concise toolkit	Relevant information
		Good to share with the patient and parents or guardians
Sub-theme 2.2	Reproducible results	
Sub-theme 2.3	Ease of use	Use in primary care by general dentists
		Use in private clinics
Sub-theme 2.4	Limitations	Disclaimer that this is only a guide
Theme 3: Format of the document		
Sub-theme 3.1	Visual aid	Flowchart
Sub-theme 3.2	Document outline	Spelling
		Terminology
		Flow of the document

THEME 1: ASSESSMENT AND MANAGEMENT

SUB-THEME 1.1: ASSESSMENT OF TOOTH AND PATIENT

During assessment of the tooth, a participant wanted to ensure that the characteristics of MIH are explained in precision in the toolkit to prevent any confusion. For example, they found that the surface hardness must explained in the toolkit:

‘*’’With white creamy and the yellow lesions, when you talk about surface hardness; you know the beginnings of chalkiness’’* (Participant 1).

SUB-THEME 1.2: MANAGEMENT

All participants felt that providing a guide on how to manage MIH affected FPMs is useful, where we had referred the reader to the EAPD and RCS guidelines.

‘’It’s worth including the RCS somewhere in there because I think it does talk about pain, to prioritise’’ (Participant 3).

One participant suggested adding a hyperlink to the guidelines, for easy access:

‘’*If you have like a link to the RCS toolkit on management of poor first permanent molars, I think that will make it more helpful because then I'm just thinking me as a general dentist. If say I could just go on the link’’* (Participant 2).

One participant also expressed that having a disclaimer that this is a guide only would encourage clinicians to tailor their approach when managing FPMs with MIH:

‘’*I feel like you can also put just a sentence there for disclaimer. Just saying that disclaimer, this is not definitive. This is a guide for you to visually understand what is poor, moderate, mild”* (Participant 2).

SUB-THEME 1.3: CONFIDENCE WHEN DETERMINING THE PROGNOSIS

One participant expressed that having a toolkit to follow would increase the confidence of the clinician when assessing the prognosis:

‘*’Having the confidence to make those decisions; this helps you have that confidence to make that [decision] and it also supports the decisions you've made”* (Participant 1).

THEME 2: USE OF THE TOOLKIT

SUB-THEME 2.1: CONCISE TOOLKIT

It was important to ensure that the toolkit is concise and had the right information to help guide clinicians to determine the prognosis of a FPM prior to planning its management.

‘’You kept it simple, and you didn't use big terminology … You didn't get too in depth with anything. Exactly what questions we would run through our mind … it's straightforward’’ (Participant 1).

‘’You can't misunderstand anything you've said that everything is very definitive’’ (Participant 1).

‘’Having as few categories while still covering everything you need is probably the easiest way’’ (Participant 3).

‘’I quite like this. How this is laid out. There's nothing like this out there to guide us’’ (Participant 4).

One participant asked if they could have the document sent to implement the toolkit now since they feel it’ll aid their assessment. Some participants expressed that the toolkit and especially the flowchart would be useful for general dentists as well as those working in private clinics.

‘’*Especially in general practise. I work for the community. we get a lot of referrals from general practitioners’’* (Participant 1).

‘’It's still helpful in private … you got to really consider … restorability for an MIH tooth’’ (Participant 4).

While two participants expressed that the flowchart would be very useful when explaining prognosis to patients and their parents or guardians.

‘*’It's very helpful because then you have something to tell the families”* (Participant 2).

‘’*What I really like about this flow chart is you could easily show a parent, it's yellow, it's brown, it's two surfaces and then it's red. I quite like that because you're often showing a picture and they just have to believe what you're saying about, like the prognosis of the tooth”* (Participant 4).

SUB-THEME 2.2: REPRODUCIBLE RESULTS

The toolkit and flowchart were designed in a way that they can be easily reproducible in different clinics with different clinicians assessing the same tooth, this question was asked, and all participants agreed.

‘’Absolutely; if I had to ask my colleague to follow this, we would come up with similar prognosis” (Participant 1).

‘’*Yes”* (Participant 4).

SUB-THEME 2.3: EASE OF USE

Participants agreed that the toolkit is easy to use and may be used daily on clinic with MIH patients.

''It needs to be simple enough to use on an everyday basis because you are busy'' (Participant 1).

''If I was on clinic and then I had like an MIH patient, which I did today … I restored a cusp which was broken down; lesion involving a cusp. So that would be poor prognosis'' (Participant 2).

SUB-THEME 2.4: LIMITATIONS

One participant pointed out that defining MIH at the start of the document would prevent confusion, since many general dentists easily confuse MIH with fluorosis or dental caries.

''I think having a really good definition of it [MIH] .... if you're aiming it for the general dentist, I think it has to be like really clear what you're talking'' (Participant 3).

THEME 3: FORMAT OF THE DOCUMENT

SUB-THEME 3.1: VISUAL AID

To ensure the toolkit is easy to use and understand, a visual flowchart was added. All participants found that to be very useful for daily use.

‘’Your type of flow chart, it's very concise’’ (Participant 1).

‘’*The flow chart is very good because otherwise, if you're ploughing through all the definitions’’* (Participant 1).

‘’The different the colour coding to make it easier for the eye’’ (Participant 2).

‘’It's useful to have things visual and to have steps to go through’’ (Participant 3).

One participant expressed that adding images of teeth to the toolkit would make it easier to compare the prognosis to:

‘’I think if it has things like photos and you know things to compare it to’’ (Participant 3).

SUB-THEME 3.2: DOCUMENT OUTLINE

The overall outline of the document would need to be simple and easy to follow to facilitate its use, especially in primary care where general dentists may not be exposed to MIH as often specialist dentists.

''I can easily sit with this and then work through'' (Participant 1).

''It's very self-explanatory'' (Participant 1).

DISCUSSION

Overall, there was good acceptance of the toolkit that was developed. All participants expressed that the toolkit and the flowchart specifically would aid their prognosis evaluation and hence help with tailoring the management plan for each patient.

THEME 1: ASSESSMENT AND MANAGEMENT

The participants agreed with the characteristics of MIH that were assessed to determine the prognosis, and they felt that it was explained in the toolkit clearly why these characteristics are used, by following the SDCEP guidelines (SDCEP,

2025b). The participants felt that this statement would give the clinician that is using the toolkit more confidence in determining the prognosis.

Although symptoms are not part of the toolkit and it is an additional aspect that the clinician must assess themselves when treatment planning, one participant did point out the importance of clarifying that within the text in the toolkit. This has already been emphasised in the toolkit, and the readers were referred to the EAPD and RCS guidelines on MIH and poor prognosis FPMs, respectively. These documents emphasise the importance of a good assessment prior to concluding what management is required. Factors that would tailor a treatment plan are explained within these documents, such as symptoms, patient cooperation, and modalities of treatment amongst other factors (Lygidakis et al., 2022; Noar et al., 2023).

THEME 2: USE OF THE TOOLKIT

Participants found that the information included in the toolkit was concise, especially that prognosis was explained in detail. Overall, all the information that a clinician would need to determine the prognosis is clearly included. The clarity in the document also reflects in its ease of use and hence reproducibility. Within a busy dental clinic where paediatric patients are seen, a quick guide which a clinician can refer to aid diagnosis and therefore management is essential. The participants confidently confirmed that the document may be used by a general dentist in both primary care clinics and private practices. This doesn't mean it is limited to general dentists; the document can be used as a reference for specialists as well. The document is also easy-to-follow; therefore, it may be used to explain the prognosis to parents or guardians. One participant expressed that when

different FPMs have different prognoses, it is helpful to have a document which can reassure parents or guardians on the reason behind that diagnosis.

On reproducibility, all participants were asked if they felt that if they saw a patient with MIH and followed this toolkit, would they have the same prognosis as another general dentist in another practice who sees this patient as well, and all participants agreed that they would certainly do. Although one participant expressed that in dentistry a lot of management is subjective, but when diagnosing the prognosis and following this flowchart, the two clinicians would have a similar answer. Reproducible results were one of the aims when developing the toolkit, this is because reproducibility is fundamental to deliver the appropriate management, if the results weren't reproducible, management may result in under- or over-treatment (Bader and Shugars, 1995).

One limitation that was pointed out was that clinicians might use this document as the only source for their diagnosis leading to planning the management. An additional disclaimer was added to the toolkit after one of the interviewees expressed that clarifying that this is a guide only to aid in diagnosis of the prognosis. This disclaimer ensures that the clinician using this toolkit would take into consideration all other patient-related factors that may alter the management plan.

THEME 3: FORMAT OF THE DOCUMENT

All participants felt that the flowchart was a very important aspect of the toolkit, this visual aid would encourage clinicians to use the toolkit. Having a visual reference may resonate in one's mind and allows for a quick overview during assessment. Participants expressed that it was easy to follow and doesn't include a lot of text; therefore, if a clinician would like more information, they can refer to the whole document. Having quick 'yes' or 'no' outcomes to different characteristics seen with an MIH FPM facilitated the ease of use.

Although the document was deemed precise, one participant felt that adding the definition of MIH at the beginning would prevent confusion. General dentists may mistake MIH for caries or fluorosis, and therefore by clearly stating what MIH is would ensure correct diagnosis. Misdiagnoses has been reported previously in the UK where 3.95% of general dentists included in the study correctly diagnosed mild MIH affecting molars only and 65.79% correctly diagnosed MIH when both molars and incisors were involved (Humphreys et al., 2021a). Therefore, it was decided to add the definition of MIH to the toolkit, the definition used is the one suggested by the EAPD (Lygidakis et al., 2022).

CONCLUSION

Piloting the prognostic toolkit for MIH through interviews with general dentists has been a valuable step in understanding how the toolkit might be used in practice daily. The feedback from participants helped to highlight what worked well;

specifically, the simplicity of the toolkit, the clarity of the flowchart, and how easy it is to follow, even in a busy clinical setting as well as being able to share with the parents or guardians. The results of the interview concluded that the toolkit is precise and would be reproducible, which were some of the aims when it was being developed.

A few helpful suggestions were raised, like adding a clear definition of MIH, linking to existing guidelines, and including a short disclaimer to remind users it’s a guide rather than a strict protocol. These have all been taken on board and added to the final version of the toolkit, which may be found below in Figure 5.2.

Overall, this part of the project has shown that the toolkit has real potential to support general dentists in making consistent and confident decisions when assessing the prognosis of FPMs affected by MIH.

Figure 5.2: Final version of developed toolkit

MIH PROGNOSTIC TOOLKIT

This toolkit is designed to assist dental practitioners in evaluating the long-term prognosis of Molar-Incisor Hypomineralisation (MIH) affected molar. It categorises prognosis into three levels (Good, Moderate, and Poor) to support clinical decision-making and treatment planning.

Definition of MIH

MIH is defined as a qualitative enamel defect where at least one First Permanent Molar (FPM) is affected, permanent incisors may also be affected. The defect is well demarcated and varies between white or a creamy opacity to yellow brown, which may be associated with Post-Eruptive Breakdown (PEB) or atypical caries or atypical restorations of variable size, those less than 1 mm in diameter are negligible (Lygidakis *et al.*, 2022).

Prognosis Categories

Good – tooth is stable and does not require long-term restorations or extractions regarding the MIH lesion.

Moderate – MIH lesion may be restored long-term but if orthodontic extractions are indicated in that quadrant, this tooth should be considered for loss.

Poor – MIH lesion is non-restorable or may be pulpally involved, with a poor long-term prognosis. The tooth may be stabilized for extractions as part of an orthodontic plan.

1

Examples of good, moderate, and poor prognosis FPM:

Figure 1: Good long-term prognosis. Adapted from Sidaly et al. (2017), licensed under CC BY 4.0.

Figure 2: Moderate long-term prognosis. Adapted from Afzal et al. (2024), licensed under CC BY.

Figure 3: Poor long-term prognosis. Adapted from Afzal et al. (2024), licensed under CC BY.

Clinical Considerations for Assessing Prognosis

When determining whether a FPM affected by MIH has a good, moderate, or poor long-term prognosis, several clinical and patient-centred factors must be considered. The Scottish Dental Clinical Effectiveness Programme (SDCEP, 2025) advises that the severity of hypomineralised lesions is influenced by both colour and location. White or creamy lesions tend to be the least severe, followed by yellow lesions of moderate severity, while brown lesions are the most severe and most prone to breakdown. Similarly, the lesion's location affects prognosis: smooth surface lesions are less concerning, those on occlusal surfaces or incisal edges are moderately concerning, and lesions involving cusps carry the highest risk due to masticatory forces and therefore have the highest potential of PEB.

From a restorative perspective, prognosis depends on the amount and quality of remaining healthy tooth structure, as the final restoration needs to be bonded to healthy enamel. Teeth with deep caries or extensive hypomineralisation require careful evaluation. Teeth with atypical caries or restorations, especially where cusps or multiple surfaces are involved, would indicate a history of significant structural compromise and contribute to a poorer prognosis. When assessing restorations, margins should be examined to determine if they are within hypomineralised defects or recurrent caries.

Decision Support Flowchart

The following flowchart (figure 1) is a clinical decision-making tool designed to guide dental practitioners in assessing the long-term prognosis of FPMs affected by MIH.

To use the flowchart, the first step is to determine the presence of any PEB or associated atypical caries or restorations. If none are present, the next step is based on the lesion's colour—white/creamy, yellow, or brown—and whether it affects smooth surfaces, occlusal areas, or cusps. With brown and yellow lesions or those associated with PEB or atypical caries or restorations, the number of surfaces that are affected is taken into account.

- Good prognosis
  - White or creamy lesions limited to smooth surfaces
- Moderate prognosis
  - White or creamy lesions involving occlusal surfaces or cusps
  - Yellow lesions affecting one surface, without cusp involvement
  - Brown lesions affecting one surface, without cusp involvement
  - PEB, atypical caries, or atypical restoration affecting one surface, without cusp involvement
- Poor prognosis
  - Yellow lesions affecting a cusp or multi-surface
  - Brown lesions affecting a cusp or multi-surface
  - PEB, atypical caries, or atypical restoration affecting a cusp or multi-surface

The more severe characteristics are prioritised over less severe ones when determining prognosis. I.e.:

  - PEB, atypical caries/restorations, and brown discolouration take precedence over yellow and white lesions.
  - Yellow lesions take precedence over white patches.

This structured approach helps clinicians tailor management strategies to the severity and long-term stability of each MIH molar.

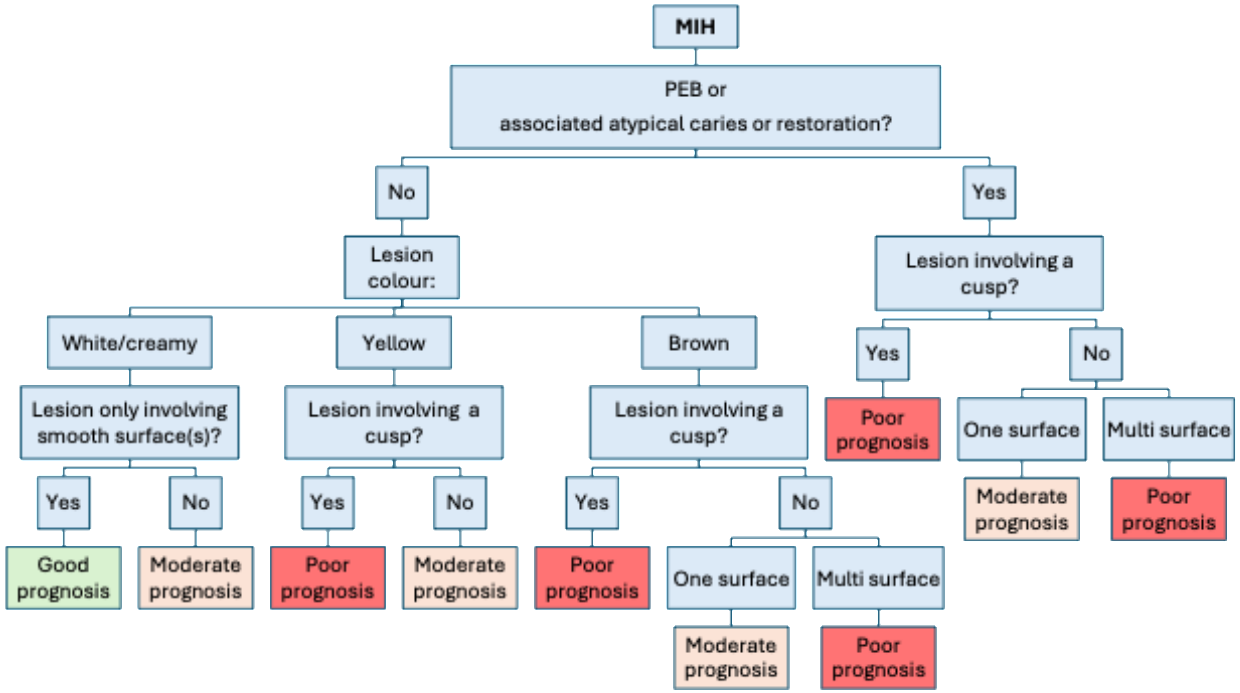


Figure 1: Flowchart for determining MIH prognosis.

5

General principles after determining prognosis:

After determining the long-term prognosis, tooth restorability would depend on the remaining surface area of healthy enamel after all hypomineralised enamel, caries, and defective restorations have been removed; therefore a clinician must reach the decision themselves; the EAPD guidelines may help a clinician with formulating a management plan (Lygidakis *et al.*, 2022).

The Royal College of Surgeons of England (RCSE) have developed a guideline on management of compromised FPM where interceptive extractions are recommended for FPM with poor long-term prognosis. Therefore, an assessment of occlusion and/or liaison with an orthodontist may be necessary; where symptoms are present and/or stabilisaiton is not possible, immediate extractions may be recommended (Noar *et al.*, 2023).

This toolkit is to be used as a guide and is not a strict protocol, a clinician must assess the overall patient and their dental needs and therefore tailor the management plan to the patient.

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CHAPTER 6 : CONCLUSION

SUMMARY OF RESULTS

The previous chapters highlighted the development of an MIH prognostic toolkit for FPMs to be used in the primary care setting by general dentists, the scoping review conducted in Chapter 2 highlighted the absence of a published toolkit in the literature with a similar purpose. Also, the qualitative interviews in Chapter 3 confirmed the need for a toolkit in primary care.

Multiple severity indices and tools have been developed in the past to aid a clinician in determining how severe a lesion is, and hance plan management from those findings. One of those indices, the MIHSI, by Oliver et al. scored the different characteristics of MIH that would influence the lesion's severity (Oliver et al., 2014). As previously mentioned, only SDCEP has included a criterion of diagnosing poor prognosis FPMs with MIH in their guidance (SDCEP, 2025b). This guideline also highlighted what lesion characteristics influence prognosis.

The qualitative interviews with general dentists highlighted the importance of the development of a toolkit that is simple to use in primary care with patients presenting with MIH to predict the longevity of the tooth. Also, these interviews confirmed that clinicians are aware of what characteristics would predict the prognosis of an MIH affected tooth, but they weren't confident in determining what these characteristics meant in the long-term.

Therefore, the toolkit was developed based on the scoping review findings and the qualitative interview analysis. The characteristics that have been acquired from the scoping review and the scoring system developed by Oliver et al. were used. For the development. These were the presence or absence of PEB, atypical

restorations, or atypical caries, and the colour of the MIH lesion, the location of the MH lesion, and the number of surfaces the lesion covers. Although both sources also accounted for symptoms such as hypersensitivity, this was excluded when developing the toolkit since the aim of the toolkit is to predict the long-term prognosis of the tooth, regardless of the patient factors, which would be dictated by individual clinicians to be able to provide management. The toolkit was designed to help clinicians determine if the tooth is of good, moderate, or poor long-term prognosis. To ensure the toolkit is user friendly in a busy primary care clinic, a flowchart has been included to guide the clinician through the process.

The toolkit was piloted with another set of qualitative interviews with general dentists. Minor adjustments were made including the inclusion of the definition of MIH to ensure readers have the correct diagnosis prior to using the toolkit. The interviewees showed interest in implementing the toolkit when it was shown to them during the interviews.

LIMITATIONS AND RECOMMEDNATIONS OF THE STUDY

AN MIH PROGNOSIS GUIDE TO BE USED IN THE PRIMARY CARE SETTING: A SCOPING REVIEW

LIMITATIONS

The inclusion of only peer-reviewed published literature and exclusion of grey literature may have introduced publication bias; this may have led to not

recognising insights from preliminary research. Another limitation within the scoping review is the focus on the severity classifications identified, diagnostic criteria, and management guidance for MIH, with only one guideline, the SDCEP, specifically addressing prognosis (SDCEP, 2025b). Therefore, the scoping review was limited to one source and therefore it wasn't feasible to compare the validity and reliability to another tool. Even when considering the identified severity indices, the differences in the aims between studies, and methodologies resulted in difficulties in precise comparison.

RECOMMENDATIONS

The findings of this scoping review highlighted a clear gap in the literature, there is absence of prognostic guidance developed specifically for MIH affected dentition, let alone FPMs affected by MIH. Although various indices and guidance is available to determine severity, none included a guide to determine the longevity and long-term outcome of those teeth. However, these guidelines and indices vary and call for an internationally recommended index or guideline for clinical use, and a separate one tailored for epidemiological studies. This in turn would ensure greater consistency in diagnosis, classification, and hence management as well as ability to conduct international large-scale research by being able to compare data. This highlights the need for primary research on development of prognostic tools or guidelines and piloting and validating them giving clinicians more precise recommendations for evidence-based management. Future research would need to assess the use of those tools amongst different clinicians and in different centres to ensure reproducible and concise results and provision of dental care.

Further research is needed to understand the perspective of clinicians, both general dentists and specialists, regarding the characteristics that determine the prognosis of MIH. While SDCEP does outline the criteria for poor prognosis molars with MIH, more detail is required to include the molars of better prognosis and what characteristics would be the pivotal point between different prognoses (SDCEP, 2025b). Furthermore, it is essential that other national guidelines bodies such as the EAPD and AAPD address the prognosis of FPMs affected by MIH as well to support clinicians in other countries.

ASSESSING NON-SPECIALISED DENTIST'S VIEWS ON PROGNOSIS OF MIH FPMS AND AVAILABLE PROGNOSTIC TOOLS WITH QUALITATIVE INTERVIEWS

LIMITATIONS

This part of the study included a small sample size, and the inclusion criteria specified general dentists. The small sample size wouldn't mirror general dentist's views. Also, despite having international recruits and a variety of clinicians working in different clinical settings, the views do not reflect the views of paediatric dentists who may have a better understanding of the clinical picture. Due to differences in healthcare systems in the included countries, the structure of referrals, availability of services, and funding would influence the clinicians' views, hence it cannot be generalised as only one recruit was interviewed in each country.

RECOMMENDATIONS

The qualitative interviews conducted with general dentists working in various centres showed a clear need for a structured tool to aid clinicians, specifically general dentists in primary care, in determining the prognosis of FPMs affected by MIH. Within the interviews, it was made apparent that general dentists were not entirely certain about management, despite the available guidelines, amplifying the need for simplified toolkit for general use. This lack of confidence would require future educational interventions and clinical training on MIH management and prognosis, in turn ensuring correct management and reducing unnecessary referrals.

Although the interviews were aimed at non-specialised general dentists, in the future, other clinicians may be recruited such as paediatric specialists, restorative specialists, and orthodontists, to allow for a better understanding of the restorative and orthodontic implications that the prognosis and hence management would influence or complicate.

DEVELOPMENT OF THE PROGNOSTIC TOOLKIT

LIMITATIONS

This toolkit has been developed after analysis of the available literature and clinician experience through qualitative interviews. The scoping review mainly covered severity indices, and the interviews included a small number of general

dentists, therefore full clinical variations may not have been fully captured. In addition, the toolkit aims to be a supportive tool, and not a substitute of clinical judgement as previously explained. Therefore, variability in use and interpretation may occur.

RECOMMENDATIONS

The toolkit aims to be concise, simple, and well-structured to guide the general dentist to assess the long-term prognosis of FPMs affected by MIH. It is recommended that the toolkit is trialled in clinic with general dentists and paediatric specialists to ensure reproducibility and precision. After which, it is recommended that it is integrated into the routine dental assessment of MIH prior to formulating a management plan or referring a patient to a specialist centre. It may also be recommended that this toolkit is adopted into the undergraduate and postgraduate dental education and through CPD teaching. Also, the flowchart may be developed into a chair-side printout or as an interactive app improving accessibility and use.

It is recommended that national and international guidelines consider including similar structured prognostic guidance into their MIH guidelines to support clinicians in management decision making which would ensure uniformity.

PILOTING THE MIH PROGNOSTIC TOOLKIT WITH QUALITATIVE INTERVIEWS

LIMITATIONS

One limitation of this part is the small sample size recruited for the interviews, piloting the toolkit on a larger scale may allow for additional adjustments ensuring further clarity. Another limitation is that the toolkit was piloted through an online interview, without the chance to test it clinically nor with photographs that may have been shared during the interview; this would have allowed for a more tailored response from clinicians on ease of use and credibility.

RECOMMENDATIONS

Upon piloting the developed toolkit with general dentists, it was confirmed that the toolkit has good potential in guiding the prognostic assessment in primary care, with the minor adjustments being considered. In the future, it is recommended that the toolkit is tested in clinic with various clinicians and patients to confirm its ease of use, precision, and reproducibility. Using the toolkit in real time in clinic would also allow for assessment of its need and influence on decision making and referrals.

OVERALL CONCLUSION

In summary, the development of the MIH prognostic toolkit was formulated through a review of the existing literature and qualitative interviews from general dentists. The toolkit that has been developed aims to provide concise and accessible help and guidance. The piloting phase confirmed the toolkit's relevance and ease of use, with positive feedback from general dentists with minor adjustments. Overall, the toolkit is a potentially useful resource that would support general dentists in making informed decisions regarding the prognosis of MIH affected teeth in primary care.

OVERALL RECOMMENDATION FOR FUTURE RESEARCH

The final recommendations are to pilot the toolkit in clinical practice, validate its use between multiple clinicians and centres, integrate it into the dental education, and consider inclusion in national or international guidelines for consistent care provision.

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APPENDICES:

APPENDIX 1: DATA EXTRACTION FORM FOR THE SCOPING REVIEW

Result ---	
Title	
Author	
Year of publication	
Publication	
Location data was collected in	
Aims or purpose	
Methodology	
Population and sample size	
Outcome measure	
Key findings	
Discussion	
Conclusion	

APPENDIX 2: PARTICIPANT INFORMATION SHEET FOR CONDUCTING INTERVIEWS

London's Global University

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Participant Information Sheet for Qualified Dentists

UCL Research Ethics Committee Approval ID Number: 27527/001

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title: An MIH Prognosis Guide to be Used in the Primary Care Setting

Department: Faculty of Medical Sciences, UCL Eastman Dental Institute

Name and Contact Details of the Researcher(s): Mees Alkandari, mees.alkandari.22@ucl.ac.uk, Paul Ashley, p.ashley@ucl.ac.uk, Susan Parekh, s.parekh@ucl.ac.uk.

Name and Contact Details of the Principal Researcher: Mees Alkandari, mees.alkandari.22@ucl.ac.uk.

You are being invited to take part in a research project for the DDent Paediatric Dentistry program at UCL. Please read the following information and take time to understand the reason for the research and what participating in the research would involve. If you have any questions, if any information is unclear, or if you require more information, please feel free to ask for clarification and feel free to discuss the information with others. Thank you for reading this.

1. **What is the project's purpose?**
   The project aims to develop a tool that aids in determining the prognosis of teeth affected by Molar Incisor Hypomineralisation (MIH) that may be used in the primary care setting for paediatric patients. The project would involve three parts, the first being a scoping review of any available tools and the second part would involve online scheduled interviews with general dental practitioners to discuss what prognostic tools they use, if any, and what limitations they have with such tools or what they view as useful in a prognostic tool for MIH. The third part is to develop or refine an MIH prognostic tool.

2. **Why have I been chosen?**
   You have been chosen since you are a qualified dentist who has been working with paediatric patients, multiple dentists in their Dental Foundation Training (DFT) and dentists undergoing the MSc Paediatric Dentistry Program in UCL have been approached for this research.

3. **Do I have to take part?**
   Participation is entirely voluntary, and you have the right to refuse participation; that would not involve any penalties or loss of any benefits and would not affect your university course nor your DFT training negatively in any way nor your relationship with your department and/or supervisors. If you wish to participate you will be given this information sheet to keep and be asked to sign a consent form, you have the right to withdraw at any time before your interview, if you were to participate, without needing to give a reason and without any penalties.

4. **What will happen to me if I take part?**
   You will be asked to participate in a single online interview on Microsoft Teams that would last for a maximum of 30 minutes.

5. **Will I be recorded and how will the recorded media be used?**
   The interviews will be recorded, and the audio will be transcribed and analysed as part of the research. The information taken from the interviews will aid the development of the prognostic tool which is part of the thesis for author M. A. DDent Paediatric Dentistry Program. The information may be used for presentation in lectures, conferences, and future publishing. The recording will be destroyed and only the anonymised transcription would be stored in the UCL N-Drive for the duration of the research and later archived on the UCL N-Drive, if needed the UCL Data Safe Haven would be used.

6. **What are the possible disadvantages and risks of taking part?**
   There is a risk of repeating the interview if any technical issues arise during or after the interviews are undertaken.

7. **What are the possible benefits of taking part?**
   There might not be any immediate benefit from taking part in this project. The intended overall benefit of the project is to formulate a prognostic tool for MIH which would aid determining the prognosis and management in the future.

8. **What if something goes wrong?**
   If you feel you would like to raise a complaint or discuss a matter you may contact the Principal Researcher (mees.alkandari.22@ucl.ac.uk) or one of the Supervisors (p.ashley@ucl.ac.uk or s.parekh@ucl.ac.uk) and if you feel the complaint has not been handled to your satisfaction you may contact the Chair of the UCL Research Ethics Committee (ethics@ucl.ac.uk).

9. **Will my taking part in this project be kept confidential?**
   Any information collected about you will be kept strictly confidential during the course of the research and you will not be identified. The recorded interviews will be analysed, and information will be shared between the researcher and the supervisors. The collective information that is obtained from the interviews will be used to guide the formulation of a prognostic tool.

   Confidentiality will be respected throughout the research project.

10. What will happen to the results of the research project?

The research project is part of the thesis of author M.A. for their DDent Paediatric Dentistry Program and therefore would be presented within the university as part of their course. It might also be published, presented in conferences, or included in lectures.

11. Local Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice:

For participants in health and care research studies, click here

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices.

The categories of personal data used will be as follows:

- Job role

The lawful basis that would be used to process your *personal data* will be performance of a task in the public interest.

Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

14. Contact for further information

Susan Parekh – s.parekh@ucl.ac.uk

You will be given a copy of the information sheet to keep. Thank you for reading this information sheet and for considering taking part in this research study.

APPENDIX 3: CONSENT FORM FOR CONDUCTING INTERVIEWS

CONSENT FORM FOR GENERAL DENTISTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: An MIH prognosis guide to be used in the primary care setting.

Department: Paediatric Department, Eastman Dental Hospital, UCLH

Name and Contact Details of the Researcher(s): Mees Alkandari, mees.alkandari.22@ucl.ac.uk .

Name and Contact Details of the Principal Researcher: Paul Ashley, p.ashley@ucl.ac.uk **. Susan Parekh,** s.parekh@ucl.ac.uk **.**

Name and Contact Details of the UCL Data Protection Officer: Alexandra Potts data-protection@ucl.ac.uk

This study has been approved by the UCL Research Ethics Committee: Project ID number: 27527/001

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box below I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes means that I DO NOT consent to that part of the study. I understand that by not giving consent for any one element that I may be deemed ineligible for the study.

		Tick Box
1.	*I confirm that I have read and understood the Information Sheet for the above study. I have had an opportunity to consider the information and what will be expected of me. I have also had the opportunity to ask questions which have been answered to my satisfaction and would like to take part in - an individual online interview	

2.	*I understand that I will be able to withdraw my participation prior to the interview.	
3.	*I consent to participate in the study. I understand that no personal information will be used apart from my job role, of which there will be at least one other person included in the research with the same job role to ensure anonymity. I understand that according to data protection legislation, 'public task' will be the lawful basis for processing.	
4.	**Use of the information for this project only** *I understand that all personal information will remain confidential and that all efforts will be made to ensure I cannot be identified. *I understand that the data will be stored anonymously and securely and that only soft copies will be kept securely in the UCL N-Drive. *I understand it won't be possible to identify me in any publications.	
5.	*I understand that my information may be subject to review by responsible individuals from the University for monitoring and audit purposes.	
6.	*I understand that my participation is voluntary and that I am free to withdraw at any time before the interview without giving a reason. I understand that if I decide to withdraw, any personal data I have provided up to that point will be deleted unless I agree otherwise.	
7.	I understand the potential risks of participating and the support that will be available to me should I become distressed during the course of the research.	
8.	I understand the direct/indirect benefits of participating.	
9.	I understand that the data will not be made available to any commercial organisations but is solely the responsibility of the researcher(s) undertaking this study.	
10.	I understand that I will not benefit financially from this study or from any possible outcome it may result in in the future.	
11.	I agree that my anonymised research data may be used by others for future research. [No one will be able to identify you when this data is shared.]	
12.	I understand that the information I have submitted will be published as a report and I wish to receive a copy of it. Yes/No	
13.	I consent to my interview being audio/video recorded and understand that the recordings will be: - destroyed immediately following transcription. - the transcription would be kept the UCL N-Drive.	
14.	I hereby confirm that I understand the inclusion criteria as detailed in the Information Sheet and explained to me by the researcher.	
15.	I hereby confirm that: (a) I understand the exclusion criteria as detailed in the Information Sheet and explained to me by the researcher; and (b) I do not fall under the exclusion criteria.	

16.	I am aware of who I should contact if I wish to lodge a complaint.	
17.	I voluntarily agree to take part in this study.	
18.	Use of information for this project and beyond: I would be happy for the information to be archived on the UCL N-Drive, if needed the UCL Data Safe Haven would be used. Any consent forms that have been signed as hard copies will be kept in a locked locker and scanned onto the UCL N-Drive. After scanning, the hard copy would be discarded of in the confidential waste. I understand that other authenticated researchers will have access to my anonymised data.	

If you would like your contact details to be retained so that you can be contacted in the future by UCL researchers who would like to invite you to participate in follow up studies to this project, or in future studies of a similar nature, please tick the appropriate box below.

	Yes, I would be happy to be contacted in this way	
	No, I would not like to be contacted	

_____	_____	_____
Name of participant	Date	Signature

APPENDIX 4: FIRST INTERVIEW QUESTIONS

Interview Questions

1. Where do you work and what is your job title?
2. Year of qualification
3. In one month how often do you see patients with MIH (Molar Incisor Hypomineralisation) in your clinic?
4. How confident do you feel when determining the prognosis of First Permanent Molars (FPMs) affected by MIH?
5. Are you aware of any specific prognostic guidelines or tools?
6. Are there specific prognostic tools you use?

   If yes,

   - What are they?
   - What do you like about the prognostic tool(s) you use?
   - What do you not like about the prognostic tool(s) you use?
7. Do you feel you need to discuss the prognosis of first permanent molars with a colleague before finalising the treatment plan? If yes,
   - How often, if you were to have an MIH case a week would it be once a month or 4 times a month?
   - What is their role?
8. Do you face any challenges when determining the prognosis of molars with MIH?
9. * Are the following images of:
   - Good long-term prognosis
   - Moderate long-term prognosis
   - Poor long-term prognosis but can be stabilised
   - Poor long-term prognosis and cannot be stabilised?

   And why?
10. Any other thoughts or comments.

* 10 clinical images were presented as below

APPENDIX 5: SNAPSHOT OF THE TRANSCRIPTS FROM THE INTERVIEWS IN CHAPTER 3

Transcript	Code	Theme
P: the conversation I have is that dentists find this difficult to diagnose and treat properly. And how can you expect, you know, a parent to understand all that you, on a consultation appointment.	Patient and parent expectations	assessment prior to plan
M: what do you like mostly about the EAPD and the one you have modified?		
P: EAPD is kind of recognised as the universal standard, more or less.	available tools	available tools/guidelines
P: I like that we're kind of fitting in with everyone else, particularly New Zealand, but also worldwide.	available tools	available tools/guidelines
P: I dislike sometimes the intricacies and complexities of it.	available tools	available tools/guidelines
M: you said you did work with a paediatric dentist, but they have retired. So, was it usually that you did liaise with them with a lot of the cases previously, would you say?		
P: 10-11 years depending how you make it up.	demographics	demographics
P: but I tend to go to an orthodontist with pretty much every case, not the really mild ones, but the moderate ones I tend to go to an orthodontist at least.	orthodontic referrals	assessment prior to plan
P: unfortunately, orthodontics is not free here, for some people that's not an option	availability of services	demographics
P: and those are the really hard ones where I have to kind of make decisions on my own	confidence	confidence
P: there's monetary factors here that aren't much of a factor in the UK	availability of services	demographics

APPENDIX 6: A SNAPSHOT OF THE THEME AND SUB-THEME ANALYSIS FROM THE INTERVIEWS IN CHAPTER 3

	Clinician confidence and experience		
Participant	**Confidence**	**Liaising with a colleague**	**Knowledge and experience**
Participant 1	I have to admit, prior to me doing my master, I'm doing my masters in specialising in paediatric dentistry ... and prior to that I wasn't very confident, but since … I feel fairly confident (9). Yes, more understanding, better understanding of the condition (11).	Not really, one out of every 10 cases, maybe once (39). [liaising with] my colleague, she is also a senior dental officer, and she has a master's in special care, and she's got 10 years' experience (40).	Moderate [prognosis] is a very grey area (50). [on prognosis of image] mild to moderate (57).
P2	I'm not 100% confident (17). I will explain everything to the parent, but I have no idea the absolute prognosis (18), maybe 75% confident, I can classify and then tell them what might happen as they age (19). . I don't think I am predictable in how I'm answering this (98). I think this is great because I went from not seeing MIH to now seeing a lot. We just see more of it now, or is just the practice and the demographics, I don't know (108). I certainly didn't have a reference or understanding a couple of years ago. I know I knew about it (109).	[on liaising with a colleague] not anymore (36), maybe like 2 years ago, maybe I did, but I kind of have a better idea now that I have seen it a lot more (37). I certainly haven't seen it all but more than when I came from general [practice] (38). [on when they first qualified] probably at least twice a week (40). [on whom they used to liaise with] The paediatric dentist. 25 years' experience (42). The principal dentist of the clinic (43).	I can't remember exactly how to find it, but I'll look it up often [on the guideline they use for prognosis] (22)
P4	[on confidence when determining prognosis] moderately confident, sometimes I need like an opinion from one of the consultants (11) ... Yeah, the more I get exposed to like cases, the more I feel confident (13).	[on liaising with a colleague] I'd say two out of four times (25).	[on using tools to determine prognosis] I don't use them; to be honest, I just know them (19). If it's borderline like poor prognosis. I find it a bit difficult to like to determine that this is poor (27).

APPENDIX 7: SECOND INTERVIEW QUESTIONS

Second Interview (toolkit pilot) Questions

1. Is the document easy to follow and does it flow well between concepts?

2. Within the flowchart, are there any points/areas that don't make sense or aren't always true?

3. Do you think the flowchart is reproducible? E.g. between you and a colleague or between you and someone who just graduated and is working in general practice?

4. Thinking of a typical day in general practice, are the toolkit and flowchart relevant? Do you see a place for them?

5. Is there anything you wish was included and wasn't?

6. Is there anything that you feel is irrelevant in the document and should be edited or removed?

7. Any other comments?