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Knowledge, Perception, and Clinical Management Strategies of US Pediatric Dentists on Molar Incisor Hypomineralization

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

By

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Abstract

KNOWLEDGE, PERCEPTION, AND CLINICAL MANAGEMENT STRATEGIES OF US PEDIATRIC DENTISTS' ON MOLAR-INCISOR HYPOMINERALIZATION

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Purpose: The purpose of this cross-sectional, survey-based study is to determine current US pediatric dentists' knowledge, perceptions, and clinical management strategies for patients with molar incisor hypomineralization (MIH).

Methods: Following appropriate protocol and authorizations, all active pediatric dentists, general dentists, and post-doctoral student members identified by the 2020 American Academy of Pediatric Dentistry's membership list were invited to partake in an anonymous email survey. Data regarding participants sociodemographic, education, and clinical backgrounds were collected in addition to information obtained from MIH-focused questions. Descriptive statistics and chi-square tests were used to compare and analyze data. A significance level was set at 0.05.

Results: A total of 594 out of 6623 responses were received (9%). Almost all participants have encountered MIH (98%). Majority (66%) reported a prevalence rate of <10% for MIH in their clinical practice. Yellowish-brown demarcations were the most observed clinical presentation (66%). Most clinicians (80%) perceived acute medical conditions affecting mother and baby to be an etiologic factor for MIH. The most commonly cited clinical challenge was long-term restoration success (72%). Over half of respondents (53%) were very confident when diagnosing teeth with MIH, but only a quarter (25%) were very confident in treating MIH ($p < 0.0001$). For a mild case of MIH, almost half (49%) of respondents said they would not recommend any preventative or restorative interventions. Most clinicians would use stainless steel crowns for treatment of a severe case of MIH (69%). Overall, majority of participants want more clinical training (76%).

Conclusion: MIH is a well-recognized dental condition by U.S. pediatric dentists. Discrepancies and challenges identified in treatment interventions and management strategies, paired with low

confidence levels regarding treatment necessitate the need for continued research and subsequent training of dental practitioners involving MIH.

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Introduction

Molar-incisor hypomineralization is a development defect of dental enamel frequently encountered by dentists worldwide.[1,2] Prior to 2001, terminology used in the literature to describe MIH was inconsistent resulting in a number of different terms to describe the condition including hypomineralised FPM[3], idiopathic enamel hypomineralization [4,5], non-fluoride hypomineralization[6,7], and even "cheese molars"[8]. To help simplify and avoid further confusion, Weerheijm et al.[9] developed a formal term and standardized definition to describe these developmental defects of dental enamel. The term 'molar-incisor hypomineralisation' was defined as 'hypomineralisation of systemic origin, presenting as demarcated, qualitative defects of enamel of one to four permanent first molars (PFM) frequently associated with affected incisors'. In 2003, Weerheijm et al.[10] went on to describe MIH even further as a developmental qualitative enamel defect caused by reduced mineralization and inorganic enamel components which leads to enamel discoloration and fractures of the affected teeth. Characteristics of MIH depend on its severity and include sharply demarcated areas of enamel opacities that can range from creamy-white to yellow-brown in color. These areas may or may not present with post-eruptive enamel breakdown (PEB). In order to be classified as MIH, the presence of this demarcated enamel must be present on at least one permanent first molar. Demarcations on incisors, alone, are not considered diagnostic as they could be attributed to other etiologies.

Prevalence

Globally, epidemiological studies show a wide variation in the prevalence of MIH, which ranges anywhere from 2.4-40.2%.[11] Such a wide range could be attributed to lack of standardized indices and diagnosis criteria for MIH leading to an underestimation of the prevalence.[11–13] In 2015, Ghanim et al.[14] introduced a standardized scoring system based on the European Academy of Paediatric Dentistry (EAPD) evaluation criteria. To facilitate and standardize future epidemiological studies, a manual has recently been published.[13] It was also suggested to have a minimum of 300 subjects involved in any future studies.[12] Currently, it is estimated that this condition affects one in six children worldwide.[1]

Etiology

At present there have been no definitive etiologic factors linked to the occurrence of MIH, but a number of potential factors have been proposed. In general, the condition is believed to be idiopathic and is thought to follow a multifactorial pathogenesis which may include environmental and/or systemic factors such as exposure to environmental pollutants or acute or chronic illnesses during the third trimester of pregnancy up to the first three years of childhood.[15–24] A number of systematic reviews have determined that no specific factor(s) with a high-quality of evidence have been identified[15,16], however, a stronger body of evidence exists supporting early childhood illnesses, in particular fever, asthma, and pneumonia as contributors to MIH. More recently a multifactorial genetic inheritance for MIH has been proposed versus an idiopathic condition.[25]

Environmental Pollutants

A number of environmental contaminants have been identified as risk factors for MIH. A study of Finnish children conducted in 2014[26], demonstrated an almost two times greater prevalence of MIH in children who lived in urban areas versus those who lived in more rural areas. Results

were attributed to an increased exposure of these children to environmental toxins subsequent to the greater amount of industrialization found in urban areas. Exposure to environmental pollutants, such as polychlorinated biphenyls (PCBs)[27,28], dioxins[29–31], and bisphenol A (BPA)[32,33], have all been implicated as potential putative factors for MIH. Chronic fluoride ingestion has also been investigated. While strong evidence exists that fluoride exposure is related to diffuse defects of enamel, as seen in dental fluorosis, evidence is weak for its involvement in the etiology of demarcated defects more typical of MIH. The vast majority of the studies report no association between the prevalence of demarcated defects and fluoride exposure making it an unlikely risk factor for MIH.[16,17]A few studies have even suggested that fluoride may have a somewhat protective factor for developing MIH or that the remineralization effect could reduce the severity of the defect after eruption.[26,34,35] Results from these studies raise the question of the positive effect of fluoride in drinking water and should be further investigated.

Pre-, Peri-, and Post-Natal Complications

Proposed risk factors for MIH include prenatal (maternal smoking or maternal illness/infection), perinatal (infant hypoxia, low birthweight with/without premature birth, caesarian delivery, birth complications, or calcium shortage), and postnatal factors (breastfeeding, nutrition, dioxins, childhood illnesses, medications), none of which can be considered causative due to a lack of high quality evidence.[16,36,37] Silva et al.[15] published a systematic review of the etiology of MIH. They found only a limited number of them showed any significant associations between MIH and pre-and perinatal factors such as maternal illness, medication used in pregnancy, prematurity, and birth complications. The review went on to highlight the existence of a stronger body of evidence implicating early childhood illness, particularly fever, asthma, and pneumonia as etiological factors in MIH.

Peri-natal events such as premature birth, caesarean section, and complications during birth have shown conflicting results regarding association with MIH. In a systematic review and meta-analysis, Wu et al.[38] found an increased prevalence of MIH in both infants born prematurely and those born with low birth-weight. However, they admitted to high variability amongst their data and possible publication bias for papers reporting a positive association as limitations. Results from a recent cohort study conducted in France stated correlations between hypoxia during delivery and caesarean section with increased occurrence of MIH were observed.[39]

Early Childhood

Multiple illnesses and a number of health-related factors such as asthma and fever occurring during early childhood to approximately 3 years of age have been widely investigated.[15] Lack of a standardized definition of general health/illness across the various studies limits the conclusions that can be drawn. Despite this limitation, several studies found associations between specific illnesses and MIH. Early childhood fever was shown in a number of retrospective studies to increase the odds for MIH development.[15] In addition, a significant association was found when fever was accompanied by other symptoms such as ear and/or chest infections versus fever alone.[40] Studies implicating asthma as a putative factor for MIH exhibited conflicting results.[15,23,41–44] However, an association between respiratory disease and a more severe form of MIH which presents with incisor involvement was demonstrated.[15,43] Additionally, pneumonia was also linked to an increased susceptibility for MIH.[15,40,44] Several other illnesses such as measles, chicken pox, otitis media, renal disease, gastrointestinal disease, bronchitis, tonsilitis, and adenoiditis have been proposed as contributing factors for MIH, though there is lack of supporting evidence from the existing literature.[15]

Medications

Despite numerous publications, a lack of association between specific childhood medications and MIH remains. Numerous medications including anti-asthmatic, chemotherapeutic drugs, and antibiotics, such as amoxicillin and erythromycin, have been investigated. A recent systematic review concluded that there are currently no specific drugs that have been identified as causing MIH.[20,21,45,46] The main barrier of the majority of these studies is the inability to separate the effect of the disease from the effect of the resultant medication since the studies themselves tend to be retrospective or cross-sectional in nature.

Genetic Influences

The focus of most etiologic studies regarding MIH has been on environmental and systemic influences with very few relating to the contribution of genetic factors. Although limited in number, these should not be overlooked. A recent study[47] found approximately 20% of MIH variation is explainable by genetics. Additionally, family and twin studies have been conducted to further investigate the genetic contribution to the disease. A Brazilian study including 167 pairs of twins aged 8-15 years old reported identical monozygotic twins were more susceptible for MIH versus dizygotic twins, suggesting a strong genetic influence.[48] In contrast, another twin study conducted in Australia failed to show a correlation.[49] DNA-based studies have also shown evidence of possible genetic etiologic factors contributing to MIH, although the quality of evidence is low.[50–53] More epigenetic studies are needed to further investigate genetic factors associated with MIH.

Diagnosis

Though MIH is frequently encountered[1,2], its diagnosis may be challenging and can often be confused with other developmental defects such as fluorosis or chronologic hypoplasia. Diagnosis can be further complicated if the affected tooth begins to decay as the tooth is

erupting. Although difficult, accurate diagnosis of MIH is essential to ensure appropriate clinical management strategies are determined and achieved.

As previously mentioned, MIH is a qualitative defect of dental enamel of systemic origin that affects one to four permanent first molars (PFM) and is frequently associated with affected permanent incisors.[9] It is important to note from this definition that molars are always involved in the phenomenon and that involvement of the incisors is possible, but not necessary.[10] MIH should not be considered or assigned to opacities presenting on incisors alone or in dentition presenting with generalized opacities of all teeth, such as in fluorosis or several forms of amelogenesis imperfecta.[10]

Clinically, MIH-affected teeth show a wide spectrum of severity ranging from demarcated white to yellow, or brown opacities to large areas of exposed dentin secondary to destruction of enamel shortly after eruption. The latter is termed post-eruptive breakdown (PEB) and considered the most severe MIH presentation.[10,54] Molar defects may present asymmetrically, however, the more severely affected the permanent molar the more likely the contralateral molar will also be affected. Affected permanent incisors often show less severe defects compared to those of molars. Demarcated opacities are defects of altered enamel translucency of normal thickness with a smooth surface.[10] Borders of these demarcated opacities are always sharp, well-defined, and distinct from sound enamel.[55] The porous, brittle enamel may easily chip off under masticatory forces. Opacities are usually limited to the incisal or cuspal one-third of the crown and rarely involve the cervical one-third.[3] Defects of MIH-affected teeth also have a tendency to progress over time lending itself more susceptible to severe breakdown of the affected enamel. A good predictor for PEB or severity of MIH-affected teeth is the color of the enamel opacities. For example, enamel that is yellow-brown tends to have less mineral compared to white opacities

and is at a higher risk for PEB.[56] This reinforces the necessity for early detection, intervention, and appropriate treatment to prevent more severe complications, in addition to improving function and esthetics.

Clinical examination for MIH should be carried out on clean, wet teeth as soon as it is clinically apparent in the permanent dentition or ideally around 8 years of age. By this point, the 4 PFMs and 8 permanent incisors have typically erupted or partially erupted. Each tooth should be examined for demarcated opacities, PEB, and atypical restorations. Failure of eruption of a PFM or incisor and extraction/absence of a PFM should also be noted.[10] In addition to clinical appearance, signs and symptoms that may aid in diagnosing MIH include rapid caries progression, hypersensitivity, and/or difficulty anesthetizing affected teeth.[57] Careful evaluation with a corresponding judgement for each individual tooth (all PFMs and incisors) should be recorded to help aid in the correct diagnosis.[9] If at least one PFM is affected, a diagnosis of MIH can be made.

Differential Diagnosis

The developmental defects of enamel seen in MIH may present similarly to a number of other conditions. It is critical to be able to correctly identify and distinguish MIH from these other developmental abnormalities. In addition to understanding the key features of MIH, a thorough patient history is essential for an accurate diagnosis and to aid in determining a possible etiology.[58]

Amelogenesis Imperfecta (AI) is a developmental disturbance that interferes with normal enamel formation in the absence of a systemic disorder. AI has several phenotypic presentations resulting in enamel that may appear hypoplastic, hypomature, or hypomineralized depending on the stage of enamel formation affected by the defect. Due to the large amount of variability seen

with the clinical presentation of AI, it may be difficult to differentiate from MIH.[13] However, unlike MIH, AI presents in a generalized manner and often affects both the primary and permanent dentitions. A positive family history of AI is also typical and can help in distinguishing between the two conditions.[59]

Enamel Hypoplasia is defined as a quantitative enamel defect associated with reduced, localized thickness of enamel including pits, grooves, and/or irregular areas of missing enamel.[60] In contrast, hypomineralization is a qualitative enamel defect affecting enamel translucency.[3] In more severe presentations of MIH, the enamel surface of molars may quickly breakdown shortly after eruption resulting in lesions that resemble enamel hypoplasia. However, margins of hypoplastic enamel are usually regular and smooth, whereas borders of MIH-affected enamel are sharp and irregular due to post-eruptive shearing of the weakened enamel.[13]

Dental fluorosis is a result of excessive fluoride absorption during mineralization.[61] Teeth affected by dental fluorosis show diffuse white, yellow, or brown opacities with no clear boundary between the affected area and enamel. Areas may appear linear, patchy, or continuous.[60] When comparing the clinical appearance of dental fluorosis to that of MIH, the diffuse nature of the opacities in fluorosis is well-differentiated from the sharp, demarcated opacities of MIH. In addition, enamel affected by fluorosis is caries resistant compared to caries prone, MIH-affected enamel.[57] A thorough patient history, focusing on fluoride exposure can also aid in distinguishing between the two conditions.[13]

White spot lesions are areas of decalcification that represent early signs of tooth decay. These lesions appear as a result of prolonged plaque accumulation on the enamel surface of the tooth. Location of white spot lesions occurs on surfaces vulnerable to plaque buildup, such as the cervical or gingival margin of the tooth. These are unlikely locations for MIH.[13]

Association between MIH and HSPM

Demarcated opacities, similar to those seen in MIH, have also been observed on primary second molars and primary canines. Recently, presence of hypomineralization of the second primary molars (HSPM) and primary canines (HPC) has been cited as predictors for MIH.[12,62–71] This association could be explained by the temporal coincidence of mineralization between the PFMs and primary second molars.[72] While initiation and completion of mineralization of the primary second molars occurs earlier than the PFMs, there is a period in which the two developmental periods may overlap. The period of overlap is typically around the 18th gestational week until approximately 10 months of age.[73] Therefore, if a risk factor occurs during this time, hypomineralization in both the primary and permanent dentitions may be observed.[25,68,72,74] Thus, exposures associated with HSPMs could also be associated with MIH. The presence of HSPMs and/or HPCs could also be helpful predictors for MIH. Due to the poorly understood etiology of MIH and lack of strong, evidence-based treatment guidelines that can effectively prevent more severe defects, such as PEB, investigating factors that can assist clinicians in identifying children who are more at risk for development of MIH is of great importance. These discoveries could aid in timelier and more effective preventive and treatment interventions. Although reported prevalence rates for MIH are higher, HSPMs remain a commonly encountered phenomenon. Prevalence of HSPMs shows great variation ranging between 0%[75] to rates as high as 20.1%.[74] A recent systematic review[68] reported a mean HSPM prevalence rate of 11.17%; however, none of the studies included data from the United States. Studies regarding prevalence rates for HPC are even more limited in terms of number and geographic location, however, a study conducted in a suburban area of Brazil reported an estimated prevalence rate of 2.22%.[76]

Additionally, a generalized consensus as to whether HPCs are associated with MIH cannot be made due to the lack of available studies.[63]

Although limited association between MIH and pre-natal and peri-natal events has been reported, a small number of well-designed studies investigating HSPM have revealed a potential association.[62,64,77] Elfrink et al.[64,77] reported potential associations between maternal alcohol consumption, ethnicity of the child, low birthweight, and fever during the first year of life and HSPM. Furthermore, the study also concluded that maternal antibiotic use during pregnancy was an unlikely source for HSPM. This agrees with findings from a more recent systematic review[78] investigating drugs used during pregnancy and infancy. Results from this study found no clear evidence that the use of drugs during the pregnancy or the first year of life is associated with HSPM, however, they stressed the need for further, well-designed prospective research. Additionally, studies have shown some evidence of association regarding in vitro fertilization and maternal smoking in later stages of pregnancy with incidence of HSPM.[15–17,49] It is important to note maternal smoking during pregnancy has not been found to be associated with MIH.[15]

Clinical Management Problems

In addition to diagnosis, recent studies[2,79–81] have shown clinical management of patients with MIH to be another challenge that many pediatric dentists face. Due to the increased porosity of the hypomineralized enamel, chronic inflammation of the pulp is often seen resulting in increased hypersensitivity and difficulties in anesthetizing.[82,83] This increased enamel porosity also makes the affected teeth more prone to breakdown, which creates problems with adequate bonding and retention of certain restorative materials. Due to increased sensitivity of MIH-affected teeth, difficulties in obtaining adequate anesthesia, and necessity for multiple restorative

appointments, behavior management problems (BMP) and dental fear and anxiety (DFA) are also common hurdles that must be frequently navigated.[84,85]

Treatment Options

Clinical management and treatment of patients presenting with MIH proves to be one of the toughest challenges practitioners face. Due to the extensive variability in clinical presentation and severity of MIH, a wide variety of treatment options exist. These treatments range from preventative care, desensitization strategies, and restorative approaches to, in the most severe cases, extraction(s) of affected teeth with or without subsequent orthodontic intervention.[10,86,87] There are a number of factors that a clinician must consider when determining suitability of the varying treatment modalities. Appropriate treatment decisions should be made on an individual, case-by-case basis, taking into account MIH severity, presence of symptoms, patient's dental age, and patient and parental expectations.[86] In addition, up-to-date knowledge of the appropriateness for the various treatment options regarding their success rates, long-term survival, ability to accomplish individual patient needs, and financial implications is needed to make the most comprehensive, evidence-based clinical assessment.[83,86] To date, no evidence-based recommendations or guidelines are available regarding treatment and management strategies for MIH.

Preventive Treatment Approaches

Efforts should be made to identify children at greater risk for developing MIH prior to PFM eruption, based upon a relevant history of putative etiological factors in the first 3 years, assessment of primary second molars and canines for hypomineralization, and careful radiographic examination. Early detection and diagnosis of MIH can yield more conservative and effective treatment strategies.[70,83] Following a diagnosis of MIH, enhanced preventive

measures should be individually tailored to each patient based on their severity of MIH, caries risk, personal/parental expectations, and symptoms and should begin as soon as the affected teeth erupt. Due to defective enamel, MIH teeth are more prone to post-eruptive breakdown putting these individuals at an increased risk for developing dental caries.[13,24] A shorter recall period should be considered alongside any required therapeutic measures.[36] Preventive guidance and advice is extremely important and should begin by providing age-appropriate diet, oral hygiene, and fluoride recommendations to affected children and their parents.[66,83] They should be encouraged to use fluoridated toothpaste with a minimum of 1000ppm F twice per day.[66]

Studies have shown that remineralization of MIH-affected teeth is clinically possible, however, complete resolution of symptoms cannot be guaranteed.[88–90] Recent evidence from clinical studies have found several materials, including over-the-counter fluoride toothpaste, might be effective in remineralization and desensitization of MIH-affected teeth.[90] These include arginine-containing toothpastes, fluoride varnishes, bioactive glass-containing toothpastes, and casein phosphopeptide amorphous calcium phosphate (CPP-ACP).[91] Presently there is a lack of sufficient comparative studies to deem one material superior to another; however, a very limited amount of evidence suggests that both fluoride varnishes and CPP-ACP pastes may be more effective than usual oral care.[90]

Pit-and-Fissure Sealants

In addition to the preventive approaches previously mentioned, pit-and-fissure sealants may be of benefit in fully-erupted, asymptomatic PFMs with mild MIH defects and a sound enamel surface. Based on findings from a limited number of clinical studies, resin-based fissure sealants with 5th generation adhesive application and adequate isolation prior to placement are recommended for intact hypomineralized molars.[13,24,86] For partially erupted molars or inability

to obtain adequate isolation, glass ionomer (GI) cements should be considered as an interim preventive option and replaced once the tooth is fully erupted and adequate isolation can be achieved.[24,86,92] Sealants should be regularly monitored and replaced when lost.

For molars with hypomineralized defects extending into the pits-and-fissures, mechanical fissure preparation using a no. ¼ round bur in a slow handpiece prior to the conventional etch and seal technique has been suggested. Although mechanical cleaning of fissures prior to sealant application has shown conflicting results for better retention in sound molars[93], its use in MIH molars may considerably enhance retention rates. By removing potentially defective enamel from the fissures of affected teeth, adhesive is allowed better access and ability to flow to the depth of the pits and grooves allowing for better overall retention.[58,94–96]

Following mechanical cleaning and etching, recent studies have also suggested application of 5% sodium hypochlorite (NaOCl) for 60 seconds. By removing excess protein content from the tooth surface, an increase in bond strength of resin sealants to the hypomineralized enamel comparable to that of sound enamel was found.[97–100] Conversely, some studies have shown no difference in bond strength versus the conventional etch and bond technique.[101–103] Due to conflicting results, no definitive conclusions can be drawn regarding implementing its regular use for sealants in MIH-affected molars.

Restorative Interventions

Microabrasion, Bleach, and Sealants for Anterior Teeth

Esthetics is often a common concern for patients with MIH-affected incisors and has been shown to have an impact on the child's quality of life and socio-psychological state.[86,104] Depending on the severity of the defect a variety of treatment options are available to help address this

problem. For mild yellow or yellowish-brown defects, favorable results from carbamide peroxide may be achieved.[85] More creamy-yellow or white opacities may respond better to surface microabrasion with 18% hydrochloric acid or 37.5% phosphoric acid and abrasive paste.[105] However, both of these techniques are often limited in their ability to camouflage the discolored lesions, especially with more pronounced enamel defects. A recent technique involving a combination of etching, bleaching, and sealing has had acceptable clinical results and may provide another treatment approach.[102,106] Because of the increased porosity of hypomineralized enamel, hypomineralized incisor lesions may be suitable for the resin infiltration technique designed for carious lesion. However, initial studies have reported unpredictable results. It should be noted that the degree of esthetic lesion improvement varies drastically between individuals and even between teeth in the same mouth.[103,107] Resin infiltration should be considered as the last resort of noninvasive options and can be combined with composite layering for a more optimal esthetic result.[108] For more severely discolored lesions, consideration should be made for vital nightguard bleaching prior to the resin infiltration procedure. In patients with MIH incisor hypersensitivity, application of desensitizing agents (CPP-ACP combined with ozone) demonstrated marked improvement of symptoms.[109]

Indirect and Direct Restorations

Multiple restorative options, both direct and indirect, are available for the treatment of patients with MIH. However, lack of official guidelines regarding appropriate restorative therapy recommendations for MIH-affected teeth can make treatment planning challenging. Decisions regarding appropriate restorative intervention will depend on the severity of the defect, patient/parental expectations, the child's age and cooperation level.[85,110] Moderate to severe

cases of MIH with dental caries can be treated with direct or indirect restoration techniques. Both options have a number of advantages and disadvantages.

Direct Restorations

Amalgam restorations demonstrated high failure rates and poor performance when placed in cavity preparations of MIH molars. Due to amalgams poor retention in shallow, atypical cavity preparations, their inability to protect remaining tooth structure, and need for retentive preparation design amalgams restorations for treatment of MIH is not recommended.[66,83,85,111]

In the early, post-eruptive stages when adequate moisture control is compromised, GI or resin-modified glass ionomer (RMGI) can serve as an interim restoration until conditions for adequate isolation are achievable, at which point replacement for a definitive restoration would be warranted.[86,87] GI or RMGIs require little to no tooth preparation and can be applied overtop affected, but not infected, dentin making them ideal for patients who are unable to cooperate for more complex treatment.[112] Diligent monitoring of these restorations is necessary. The purpose of the interim restoration is to buy time until adequate moisture control is obtainable, teeth are fully erupted, and to avoid complex treatment under general anesthesia. An adequately placed GI or RMGI restoration should last approximately 1-4 years.[58,113] Because of GI/RMGI's less favorable adhesion to hypomineralized enamel and low flexural strength, restorations often require repair or replacement due to voids, chipping, and marginal fractures.[10,83] Placement of GI or RMGI in stress-bearing areas, such as occlusal surfaces of hypomineralized molars is not recommended.[110,111,114] For these reasons, placement of a definitive, long-term restoration like composite resin is the treatment of choice in the vast majority of MIH-affected molars when ideal isolation can be obtained. Currently, adequate longevity of direct composite restorations can only be achieved when margins are within sound enamel. For MIH-affected teeth, this often

requires more aggressive removal of defective enamel so that sound margins can be achieved to allow for optimal bonding and strength. MIH defects that are well-demarcated, limited to one or two surfaces with no cusp involvement, and supra-gingival margins are ideal candidates for composite resin restorations.[85] Increased risk of composite restoration failure is found with more extensive enamel defects and larger restoration size.[115]

More extensive MIH defects, especially involving PEB of the cusps, may lack adequate tooth structure to support composite restorations. In cases of severely MIH-affected molars with cuspal involvement, preformed metal crowns, more commonly known as stainless steel crowns (SSC), are a practical and effective restorative solution that can be utilized from early to late post-eruptive stages.[86] Studies evaluating treatment of MIH molars with SSCs showed high success rates.[116,117] Furthermore, their ability to prevent further tooth loss and control sensitivity, potential cost-effectiveness, and ease of use make them an ideal treatment option for restoring moderate to severe MIH-affected molars.[87]

Indirect Restorations

Another treatment option to consider for hypomineralized molars in the late mixed and permanent dentition are partial and full coverage indirect restorations.[110] This treatment approach is not ideal for newly erupted permanent first molars due to difficulties with placement secondary to short clinical crowns, large pulps horns, long treatment time, and limited cooperation of most children.[58,83]Additionally, partial and full coverage indirect restorations should only be considered once a patients definitive adult occlusion has been established.[58]

Extractions

In cases of severe MIH, where long-term prognosis of affected teeth is poor, extraction may be warranted. A dental age of 8 to 11.5 years old is the ideal window for timing of these extractions, as this coincides with the calcification of the permanent mandibular second molars bifurcation. This signifies the most favorable time period for spontaneous space closure by the permanent second molar (PSM) shifting forward and into ideal alignment to occur.[66] Clinical studies evaluating orthodontic extraction therapy of PFMs found that when extractions were timed prior to complete eruption of the second molars, good or acceptable space closure was achieved in majority of patients (up to 87%).[118,119] Studies have also shown that extractions timed between 8 and 10.5 years of age have demonstrated spontaneous space closure rates in approximately 81% of maxillary dentition cases and 50% in mandibular dentition cases. However, in patients aged 10.5 to 11.5 years old, spontaneous space closure was only shown to occur in 55-59% of cases.[120] Prior to making a definitive treatment decision regarding extractions, comprehensive orthodontic records are required. This includes obtaining a thorough medical, dental and orthodontic history, clinical exam, radiographs, intraoral photos, diagnostic casts, functional status, and photo-static analysis.[121] Timely consultation with an orthodontist specialist should also be obtained.[66] Several additional factors including but not limited to timing of extractions, likelihood of spontaneous space closure of PSMs, potential need for orthodontic space closure, impact on esthetics and function, and prognosis of third molars should also be considered. If extraction of a PFM is indicated, necessity for a balancing or compensatory extraction should also be considered.[66,121] Similar to recommendations for other treatment modalities, more high-quality, prospective research studies are needed to determine treatment outcomes of extractions in patients with MIH.

Knowledge, Experience, and Perception Regarding MIH

Diagnosis and management of these patients tends to be a common challenge many pediatric dentists face due to variability of clinical appearance and treatment modalities. Several studies have been conducted in numerous countries evaluating the perception and knowledge of practicing clinicians regarding MIH, however, significant variation in knowledge and perceptions exists.[58] Despite the clinical significance of MIH, few studies have been conducted to assess perception of US Pediatric Dentists' regarding MIH. Therefore, the aim of this study is to determine the current US pediatric dentists' knowledge, perception, and clinical management strategies for patients with MIH. Results from this study will give us a general consensus to help answer a number of different clinical questions in regards to how current US pediatric dentists are handling this frequently encountered condition ranging from their confidence in diagnosing to what specific treatment strategies they are utilizing and finding successful. By identifying areas of pediatric dentists' concerns and weaknesses involving MIH, as well as, identifying areas of success and confidence, future studies into MIH can be directed in a more successful and efficient manner. Similar studies have been conducted in other countries, but only one has been conducted in the US in which only pediatric dentists in the Midwestern region were investigated.[80] To date, no research has evaluated the US as a whole.

Methods

Ethical approval for this cross-sectional study of pediatric dental providers was obtained from the Institutional Review Board of Virginia Commonwealth University, Richmond, Virginia, USA (study IRB no. hm20018385). After authorization was obtained from the American Academy of Pediatric Dentistry (AAPD), unique survey invitations were sent to 6,623 active (pediatric dentists), affiliate (general dentists), and post-doctoral student members of the 2020 AAPD registry on July 15th, 2020. Forty-five of these were undeliverable addresses leaving 6,578 possible participants. A reminder email was sent to 6,272 who had not yet participated the following week (July 22nd, 2020). A final email reminder invite was sent to the remaining 6,085 members on August 5th, 2020. Names and other identifying information were not collected and participation was voluntary.

Following an extensive literature search, a questionnaire was developed based on adaptions from previous surveys to allow for comparison (Appendix 1).[2,79–81,122–128] The questionnaire was piloted among Pediatric Dentistry faculty members and residents to ensure quality and clarity of the questions. The questionnaire was divided into three main sections and was not expected to take longer than 15 minutes to complete. The first section included sociodemographic characteristics of the respondents concerning age, gender, provider qualifications, AAPD district location, years in practice, average number of daily patients, practice type, and area of practice. The second section included questions regarding respondents' knowledge, experience, and perceptions regarding MIH. This included questions pertaining to MIH prevalence, incidence, confidence in diagnosing and treating, prevalence of defects in primary dentition, clinical appearance, location, and etiology. One question in this section asked participants to voluntarily enter a free-text response listing any significant medical history factors occurring from birth to age three that they felt may have contributed to MIH. Two questions contained clinical image(s)

that respondents were asked to evaluate in order to answer the subsequent questions. The first question consisted of three pairs of clinical photos[129–132]. Each pair of images represented PFMs and/or permanent incisors representative of the varying degrees of severity of MIH. Respondents were asked to select which pair of images they most commonly encountered in patients presenting to their office with MIH. In the second question, a clinical image[24] of MIH-affected PFMs and permanent incisors was shown and participants were asked during which time period they believed the insult to have occurred. Participants were also asked to assess their personal confidence level regarding both diagnosis and treatment of MIH. The third section included three sets of colored clinical images showing the clinical features of MIH-affected incisors and PFMs, followed by a series of questions assessing how respondents would best manage the case. Case 1 presented an image[131] of a moderately MIH-affected PFM, Case 2[131] a severely MIH-affected PFM with PEB, and Case 3[131] mildly MIH-affected permanent maxillary central incisors facial surfaces with no compromise of the surface enamel. Additionally, participants were given a list of clinical challenges associated with MIH and asked to select those they most commonly encounter. Survey participants were also given the opportunity to provide a free-text response for two questions in this section. The first regarding any additional treatment techniques or strategies they have found successful for MIH-affected teeth and the second to describe any additional challenges in managing MIH patients. The questionnaire concluded by asking participants if they felt the need for additional training with MIH. Participants that answered yes were then prompted to select all the specific areas they would like more training in given the provided answer choices of diagnosis, etiology, and treatment.

Responses were summarized using counts and percentages. Chi-squared tests were used to determine if respondent sociodemographic characteristics were associated with MIH experience

or treatment choices for the case scenarios. The significance level was set at 0.05. SAS EG v8.2 (SAS Institute, Cary, NC) was used for all analyses

Results

A total of 594 providers responded to the questionnaire indicating a response rate of 9%. The respondent demographics were representative of the AAPD members. The majority were between the ages of 30 and 60 years old, 55% were female, 70% were board certified pediatric dentists and 78% reported working in solo or group private practices. There was roughly equal representation across the five AAPD districts (16-23% for each district). Complete demographics are given in Table *1*.

Table 1: Respondent Demographics

		n	%
Response Rate		594	9%
Age			
	Under 30	35	6%
	30-39	219	37%
	40-49	174	29%
	50-59	102	17%
	60 +	64	11%
Gender			
	Female	327	55%
	Male	261	44%
	Prefer not to say	4	1%
Provider Type			
	Non-board certified pediatric dentist	117	20%
	Board certified pediatric dentist	414	70%
	General dentist	32	5%
	Resident	30	5%
AAPD District			
	North Eastern	118	20%
	South Eastern	134	23%
	North Central	94	16%
	South Western	107	18%

	Western	134	23%
	Other	6	1%
Year in Practice			
	< 5 years	137	23%
	5-10 years	136	23%
	11-20 years	141	24%
	21-30 years	95	16%
	> 30 years	62	10%
	Current resident	23	4%
Practice Type			
	Solo Private Practice	190	32%
	Group Private Practice	275	46%
	Corporate Practice	36	6%
	Public Health	22	4%
	Government	9	2%
	University	47	8%
	Hospital	54	9%
	Dental Residency	46	8%
	Other	9	2%
Community			
	Rural	68	11%
	Suburban	354	60%
	Urban	172	29%
On average, how many pediatric patients (< 18 y/o) do you see per day? (Prior to COVID-19)			
	< 10 patients	44	7%
	10-20 patients	98	17%
	More than 20 patients	448	76%

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Virtually all respondents (576, 98%) reported encountering patients presenting with MIH in their practice. The percentage of patients presenting with MIH was perceived to be 1-5% for 42% of respondents and 6-10% for 24% of respondents (Table *2*). Forty-four percent reported that they believe the incidence of MIH has increased in the period they have been practicing while 35% felt it has remained the same (Table *2*). The perceived prevalence of MIH was not significantly associated with the community in which a provider practices (i.e. urban, suburban, rural) (p-value=0.4261). Over half reported that they perceived that MIH appears less frequently

in the primary canines (53%). Forty-five percent selected less than 10% as the rate of defects in the primary second molars and 30% selected 10-25% for the permanent incisors. Almost half (49%) said that molars seem to be equally affected on maxilla and mandible and 32% felt they were more often affected on mandibular. Sixty-six percent reported the clinical presentation is most commonly yellowish-brown opacities. When asked to select the perceived medical conditions and factors most likely to cause MIH, 80% selected an acute medical condition affecting mother or baby followed by both chronic medical conditions affecting mom/baby (67%) and antibiotics or other medications (65%). Only 15% indicated fluoride exposure as a possible factor (Table *2*). Respondents reported that the most common clinical challenges with MIH are long-term restoration success (78%), managing hypersensitivity (69%), and achieving adequate local anesthesia (61%), (Table *2*)

Table 2: Experience with MIH in Practice

	n	%
When did you first learn about molar-incisor hypomineralization (MIH)?		
Pre-doctoral DDS/DMD training	211	36%
Post-graduate residency	278	47%
While in practice	87	15%
Unsure	16	3%
I have never learned about this condition	2	0%
Have you encountered patients presenting with MIH in your dental setting/practice?		
Yes	576	98%
No	13	2%
Approximately what percentage of your patients present with MIH? (Prior to COVID-19)		
< 1%	40	7%
1-5%	242	42%
6-10%	140	24%
11-15%	71	12%
16-25%	45	8%
>25%	8	1%
Unsure	30	5%
Do you feel the incidence of MIH has changed in the period of your practice?		

Increased	252	44%
Decreased	5	1%
Remained the same	198	35%
Unsure	102	18%
Not applicable	16	3%
In patients presenting with MIH, approximately how often do you notice this defect in the primary canines?		
More frequently	33	6%
Less frequently	301	53%
Same frequency as 1st permanent molar	30	5%
Unsure	139	24%
I have never seen this condition on primary canines	70	12%
In patients presenting with MIH, approximately how often do you notice similar defects in the primary second molar(s)?		
< 10%	259	45%
10-25%	92	16%
25-50%	44	8%
>50%	16	3%
Same frequency as 1st permanent molar	11	2%
Unsure	130	23%
I have never seen this condition on primary second molars	22	4%
In patients presenting with MIH, approximately how often do you notice this defect in the permanent incisor(s)?		
< 10%	103	18%
10-25%	170	30%
25-50%	133	23%
>50%	88	15%
Same frequency as 1st permanent molar	40	7%
Unsure	36	6%
I have never seen this condition on permanent incisors	3	1%
Which molar teeth do you find are most often affected?		
Maxillary	79	14%
Mandibular	181	32%
Both	280	49%
Unsure	33	6%
Which clinical presentation of MIH do you see most commonly?		
White opacities	122	21%
Yellowish-brown opacities	376	66%
Immediate post-eruptive enamel breakdown	63	11%
Unsure	12	2%
Perceived Etiology (Check all that apply)		
Genetic Factors	358	61%

Chronic medical conditions affecting the mother and child	393	67%
Acute medical conditions affecting mother or child	473	80%
Antibiotics or medications	380	65%
Fluoride exposure	91	15%
Clinical Challenges		
Diagnosis of teeth with MIH	44	7%
Long-term restoration success	458	78%
Choice of restorative modality/treatment	258	44%
Achieving adequate local anesthesia	362	61%
Managing hypersensitivity	405	69%
Determining the extent or margins of the affected tooth	212	36%
Behavior management	184	31%
Financial concerns for families	86	15%
Other	9	2%

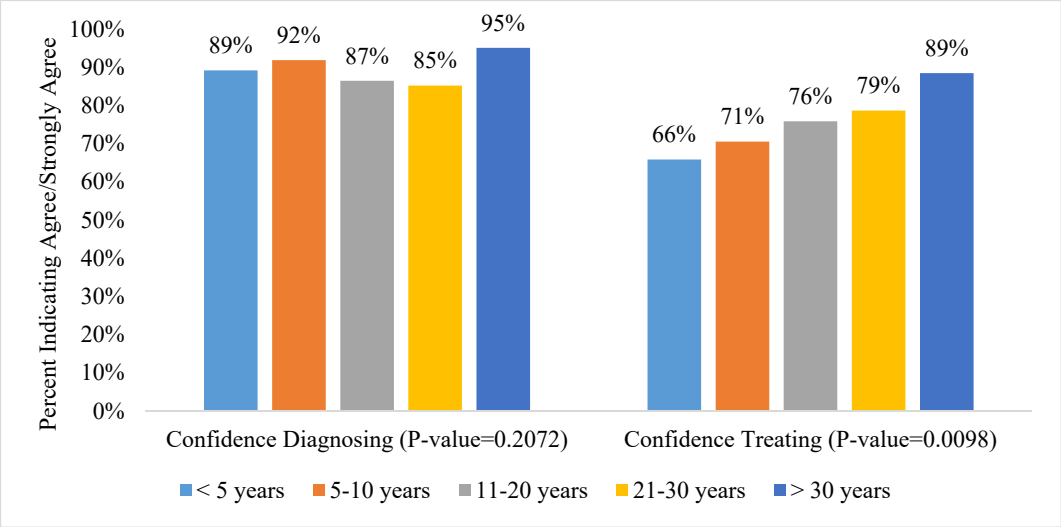
More than half of respondents were very confident in diagnosing MIH (53%, Table *3*). However, only 25% were very confident in treating MIH. This difference was statistically significant (p-value<0.0001). The confidence for distinguishing MIH from fluorosis was predominantly confident or very confident (75%) and less for distinguishing from chronologic hypoplasia (49%). Confidence diagnosing MIH was not significantly associated with years in practice (p-value=0.2072) but confidence treating was significantly associated with years in practice, with the percent who agreed or strongly agreed that they were confident treating increased as the years in practice increased from 66% with less than 5 years of experience to 89% with greater than 30 years (Figure *1*).

Table 3: Self-Reported Confidence with MIH

	Very confident	**Confident**	**Somewhat confident**	**Not at all confident**	**I have never diagnosed this condition**
How confident are you in diagnosing MIH?	317, 53%	205, 35%	61, 10%	6, 1%	5, 1%
How confident are you in treating MIH?	146, 25%	281, 48%	139, 24%	22, 4%	3, 1%

How confident are you in distinguishing MIH from fluorosis?	233, 39%	215, 36%	117, 20%	24, 4%	4, 1%
How confident are you in distinguishing MIH from chronologic hypoplasia?	101, 17%	189, 32%	165, 28%	81, 14%	53, 9%

Figure 1: Confidence Diagnosing and Treating MIH by Years in Practice



Overall, 76% of respondents indicated that they would like more clinical training regarding MIH (n=449). The desire for more training was significantly associated with treatment confidence (p-value<0.0001), diagnostic confidence (p-value=0.0155), years in practice (p-value<0.0001), and provider type (p-value=0.0075). These differences are displayed in Table *4* but overall the majority of respondents still wanted more training regardless of the category. The lowest rate was among those who had greater than 30 years in practice (58%). When asked what training respondents would like, 41% indicated they would like training on the diagnosis, 57% on etiology, and 71% on the treatment of MIH (note: respondents could check all that apply).

Table 4: Desire for More Clinical Training on MIH

	Would you like more clinical training regarding MIH?		
	Yes	**No**	**P-value**

Overall	449, 76%	142, 24%	
Treatment Confidence			<0.0001
Agree/Strongly Agree	303, 71%	124, 29%	
Somewhat or Not at all	146, 89%	18, 11%	
Diagnostic Confidence			0.0155
Agree/Strongly Agree	389, 75%	133, 25%	
Somewhat or Not at all	63, 88%	9, 13%	
Years in Practice			<0.0001
< 5 years	112, 82%	25, 18%	
5-10 years	98, 72%	38, 28%	
11-20 years	117, 83%	24, 17%	
21-30 years	66, 69%	29, 31%	
> 30 years	36, 58%	26, 42%	
Current resident	23, 100%	0, 0%	
Provider Type			0.0075
Non-board certified pediatric dentist	92, 79%	25, 21%	
Board certified pediatric dentist	304, 73%	110, 27%	
General dentist	26, 81%	6, 19%	
Resident	30, 100%	0, 0%	

For Case 1 (Figure *2*), which demonstrated a newly erupted permanent first molar with moderate hypomineralization, respondents were split between restorative (48%) and preventative (48%) treatment (Table *5*). The remaining 4% chose no treatment (3%) or unsure (1%). Of those who selected restorative treatment, 38% would do composite resin and 32% would use RMGI followed by GI (16%). Of those who selected preventative treatment, 64% indicated that they would visually monitor until change warrants treatment. Roughly 40% selected each of the following: 3-month recalls (40%), 6-month recalls (44%), prescribe fluoride toothpaste (44%), SDF (47%). Additionally, 25% indicated they would prescribe MI paste. The treatment plan for Case 1 was not significantly associated with self-reported confidence treating MIH (p-value=0.1851), self-reported confidence diagnosing MIH (p-value=0.1571), or the number of years in practice (p-value=0.7942) (Table *6*).

Figure 2: Case 1 Moderate MIH of PFM

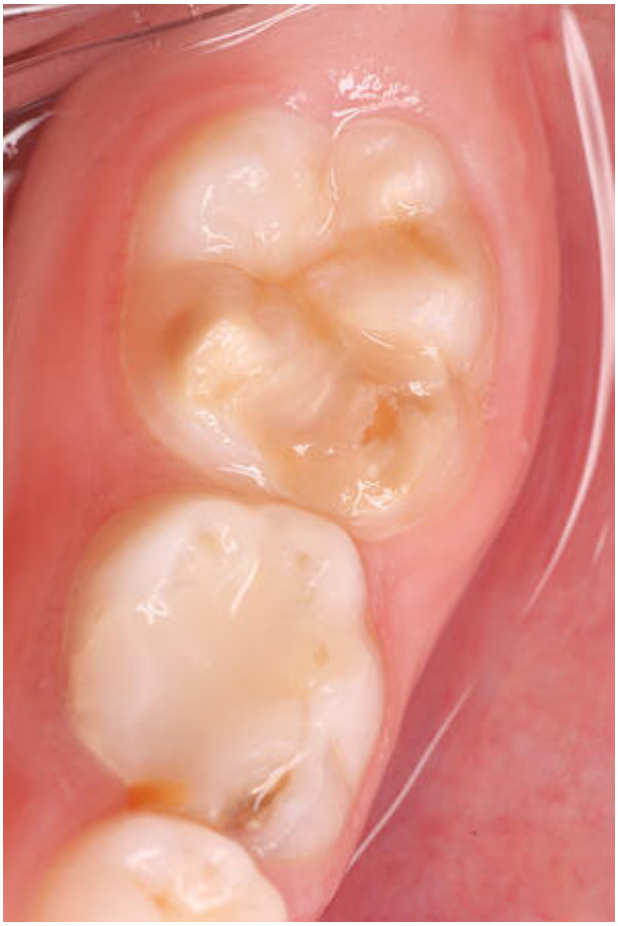


Table 5: Treatment Planning for Case 1

Case 1	
Restorative intervention	**286, 48%**
Fissure sealant	19,7%
Amalgam	2, 1%
Composite resin	108, 38%
Glass ionomer	45, 16%
Resin-modified glass ionomer	90, 32%
Stainless Steel Crown (SSC)	21, 7%
Preventative intervention (Check all that apply)	**287, 48%**
Recall every 3 months	116, 40%
Recall every 6 months	125, 44%
Prescribe MI paste	72, 25%
Prescribe Fluoride Toothpaste	127, 44%
Silver Diamine Fluoride	135, 47%
Visual monitoring until change warrants treatment	184, 64%

I would not recommend any treatment or interventions for this case	17, 3%
I am unsure of how to treat this case	3, 1%

Table 6: Associations with Treatment Plan for Case 1

	Restorative intervention	**Preventative intervention**	**I would not recommend any treatment or interventions for this case**	**I am unsure of how to treat this case**	**P-value**
How confident are you treating MIH?					0.1851
Agree/Strongly Agree	215, 50%	198, 46%	12, 3%	1, 0%	
Somewhat or NAA	70, 43%	87, 53%	5, 3%	2, 1%	
How confident are you diagnosing MIH?					0.1571
Agree/Strongly Agree	258, 49%	248, 48%	14, 3%	2, 0%	
Somewhat or NAA	28, 39%	39, 55%	3, 4%	1, 1%	
How many years have you been practicing as a pediatric provider?					0.7942
< 5 years	60, 44%	71, 52%	5, 4%	1, 1%	
5-10 years	65, 48%	68, 50%	2, 1%	1, 1%	
11-20 years	75, 54%	61, 44%	3, 2%	1, 1%	
21-30 years	45, 47%	44, 46%	6, 6%	0, 0%	
> 30 years	30, 48%	31, 50%	1, 2%	0, 0%	
Current resident	11, 48%	12, 52%	0, 0%	0, 0%	

For Case 2 (Figure *3*), which demonstrated a severely MIH-affected permanent first molar with PEB, 91% of respondents indicated they would treat with restorative treatment (Table *7*). Preventive intervention was indicated by 8% and 2% were unsure. For those who selected restorative treatment, 69% selected SSCs. Less than 10% selected each of the following restorative interventions: extraction (9%), resin-modified glass ionomer (7%), orthodontic band with GI/Resin cement (7%), and glass ionomer (6%). For those who selected preventative treatment, 74% would treat with SDF, 57% would monitor until change warrants treatment. In

terms of recall, 48% would recall every 3 months and 37% every 6 months. About 1/3 would prescribe fluoride toothpaste (33%) or MI paste (30%). Treatment for Case 2 was significantly associated with confidence treating MIH (p-value=0.0096), confidence diagnosing MIH (p-value=0.0200), and years in practice (p-value=0.0440) (Table *8*). For years in practice, those with less than 5 years in practice selected restorative at a higher rate (96% vs 86-91%). Those in the 11-20 years of experience had the lowest rate of indicating restorative treatment and highest for preventative (12% vs 0-9%).

Figure 3: Case 2 Severe MIH of PFM

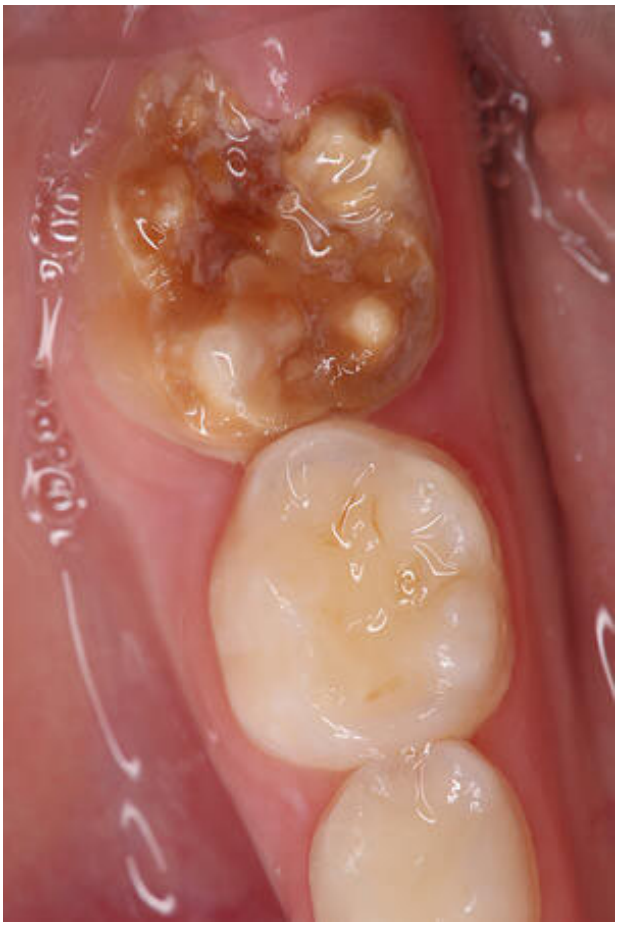


Table 7: Treatment Planning for Case 2

	Case 2
Restorative intervention	**538, 91%**

Fissure sealant	1, 0%
Amalgam	1, 0%
Composite resin	11, 2%
Glass ionomer	33, 6%
Resin-modified glass ionomer	35, 7%
Stainless Steel Crown (SSC)	373, 69%
Cast onlay or crown	2, 0%
Orthodontic band with GI/Resin cement	35, 7%
Extraction	46, 9%
Preventative intervention (Check all that apply)	**46, 8%**
Recall every 3 months	22, 48%
Recall every 6 months	17, 37%
Prescribe MI paste	14, 30%
Prescribe Fluoride Toothpaste	15, 33%
Silver Diamine Fluoride	34, 74%
Visual monitoring until change warrants treatment	26, 57%
I would not recommend any treatment or interventions for this case	0, 0%
I am unsure of how to treat this case	10, 2%

Table 8: Associations with Treatment Plan for Case 2

	Restorative intervention	**Preventative intervention**	**I would not recommend any treatment or interventions for this case**	**I am unsure of how to treat this case**	**P-value**
How confident are you treating MIH?					0.0096
Agree/Strongly Agree	389, 91%	35, 8%	0, 0%	3, 1%	
Somewhat or NAA	146, 89%	11, 7%	0, 0%	7, 4%	
How confident are you diagnosing MIH?					0.0200
Agree/Strongly Agree	474, 91%	42, 8%	0, 0%	6, 1%	
Somewhat or NAA	64, 89%	4, 6%	0, 0%	4, 6%	
How many years have you been practicing as a pediatric provider?					0.0440
< 5 years	131, 96%	5, 4%	0, 0%	1, 1%	
5-10 years	123, 90%	12, 9%	0, 0%	1, 1%	
11-20 years	121, 86%	17, 12%	0, 0%	3, 2%	
21-30 years	86, 91%	8, 8%	0, 0%	1, 1%	
> 30 years	56, 90%	4, 6%	0, 0%	2, 3%	
Current resident	21, 91%	0, 0%	0, 0%	2, 9%	

For Case 3 (Figure *4*), which illustrated permanent central incisors with mild MIH, almost half (49%) indicated that they would not recommend any treatment for this case (Table *9*). Twenty-nine percent indicated preventative intervention and 21% restorative treatment. For preventative treatment, 65% would visually monitor until change warrants treatment, 47% would recall every 6 months compared to 21% who would recall every 3 months. About a third would prescribe MI paste (35%) or fluoride toothpaste (28%). For those who selected restorative treatment, 64% would do resin infiltration, 19% composite resin, and 15% microabrasion. The selection of treatment plan for Case 3 was not significantly associated with years in practice (p-value=0.6551) but was associated with self-perceived confidence treating (p-value=0.0053) and diagnosing MIH (p-value=0.0019) (Table *10*). For confidence treating MIH, there was a higher rate of unsure among those who were less confident (4% vs 1%) and higher rates of restorative (22% vs 19%) and preventative treatments (30% vs 27%) for those with more confidence. Those with lower confidence also selected no treatment more (51% vs 48%). Similar trends were seen based on confidence diagnosing MIH, with a higher rate of unsure among those with less confidence (6% vs 1%). Those with less confidence diagnosing selected restorative treatment more (25% vs 21%) and preventative treatment less (24% vs 30%). Those with higher confidence also selected no treatment at a higher rate (49% vs 46%).

Figure 4: Case 3 Mild MIH of Maxillary Central Incisors

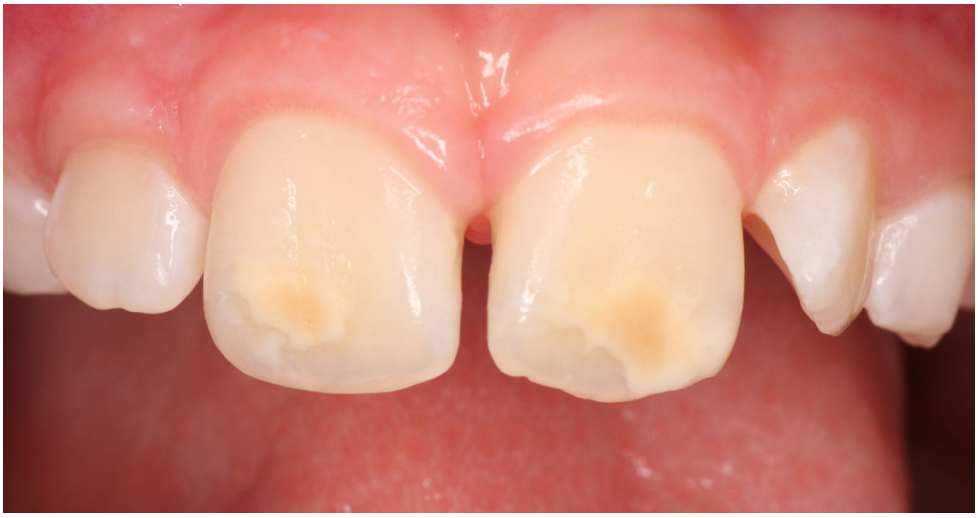


Table 9: Treatment Planning for Case 3

Case 3	
Restorative intervention	**125, 21%**
Microabrasion	19, 15%
Resin infiltration	80, 64%
Composite resin	24, 19%
Resin-modified glass ionomer	1, 1%
Preventative intervention (Check all that apply)	**173, 29%**
Recall every 3 months	36, 21%
Recall every 6 months	82, 47%
Prescribe MI paste	60, 35%
Prescribe Fluoride Toothpaste	48, 28%
Silver Diamine Fluoride	1, 1%
Visual monitoring until change warrants treatment	113, 65%
I would not recommend any treatment or interventions for this case	288, 49%
I am unsure of how to treat this case	7, 1%

Table 10: Associations with Treatment Planning for Case 3

	Restorative intervention	**Preventative intervention**	**I would not recommend any treatment or interventions for this case**	**I am unsure of how to treat this case**	**P-value**

How confident are you treating MIH?					0.0053
Agree/Strongly Agree	93, 22%	127, 30%	205, 48%	1, 0%	
Somewhat or NAA	31, 19%	44, 27%	83, 51%	6, 4%	
How confident are you diagnosing MIH?					0.0019
Agree/Strongly Agree	107, 21%	156, 30%	255, 49%	3, 1%	
Somewhat or NAA	18, 25%	17, 24%	33, 46%	4, 6%	
How many years have you been practicing as a pediatric provider?					0.6551
< 5 years	34, 25%	41, 30%	61, 45%	1, 1%	
5-10 years	26, 19%	39, 29%	67, 49%	4, 3%	
11-20 years	26, 18%	37, 26%	76, 54%	2, 1%	
21-30 years	23, 24%	31, 33%	40, 43%	0, 0%	
> 30 years	11, 18%	17, 27%	34, 55%	0, 0%	
Current resident	5, 22%	8, 35%	10, 43%	0, 0%	

Discussion

MIH has become an area of interest amongst dental practitioners, however, data is lacking regarding this condition in the US. This is the first study to report on the knowledge, perception, and clinical management strategies of US dental practitioners as a whole. This survey does replicate previous research regarding US pediatric dentists' perception of MIH[80]; which was limited to the Midwest region and was not representative of the US as a whole.

Consistent with the results of previous studies, [79–81,122–124,126–128] almost all participants (n=576, 98%) reported encountering patients with MIH in their dental practice. Over half (73%) self-

reported an estimated prevalence of less than 10%, which agrees with rates reported in studies in the Midwestern US and other countries worldwide.[79–81,126,128,133] Majority of respondents in this study also felt the incidence of MIH has increased (44%) or remained the same (35%) over their time in practice, which coincides with previous reports.[81,122,124,126,127] This perceived increase coupled with the high number of practitioners encountering this condition emphasizes the need for future epidemiological studies to determine the prevalence of MIH in the US child population.

Regarding clinical appearance of MIH, yellowish-brown opacities were the most frequently observed defects by survey respondents, mirroring findings from previous studies.[122–124,126–128] This finding could be a result of these particular lesions being easily distinguished from other alternative diagnoses, such as dental caries, fluorosis, white spot lesions, or dental hypoplasia.[127] PEB was the least cited clinical presentation reported by survey respondents; however, this may be due to extensive caries or atypical restorations masking the appearance of MIH as previously reported in the literature.[10,58,86,134,135]

Mixed responses were demonstrated regarding location and distribution of MIH defects in the permanent dentition. Majority of participants responses agreed with findings from previous studies[54,133,136] that molars and incisors were not equally affected. 86% reported they observed MIH defects less frequently in permanent incisors versus PFMs. Almost half (49%) of respondents reported molars in both maxillary and mandibular arches to be equally affected. Of those participants who reported discrepancies between arches, 70% reported the mandibular molars to be most often affected. While literature exists supporting this lack of difference between arches[137–140], a number of studies have demonstrated a higher propensity for a particular arch.[34,133,136,141–149] Inconsistencies and the wide variations amongst the existing literature

emphasize the need for subsequent studies for further comparison to better estimate and analyze the prevalence and characteristics of MIH.

More recently, similar defects to those seen in MIH have also been observed on the second primary molars (HSPM) and primary canines (HPC), and are considered a predisposing factor for MIH.[63,65,67–70,74,150,151] Current studies evaluating the level of recognition of hypomineralization in the primary dentition amongst dental clinicians are limited, with practitioners reporting its occurrence with a lower frequency compared to PFMs. In the current study, a large number of respondents reported observing these defects in the second primary molars (74%) and primary canines (64%). However, consistent with results from previous studies,[79,80,123,127] participants indicated they perceived HSPMs (45%) and HPCs (53%) less frequently compared to MIH in the permanent dentition. Although the majority reported observation of HSPMs or HPCs in patients who later presented with MIH, it was not possible to accurately assess the current knowledge of US dental practitioners regarding current evidence of HSPM and HPC as predictors for MIH. This points out one of the limitations to the current study, which is self-recall bias of the respondents. Either way, this opens the discussion regarding the importance of dental practitioners' attentiveness to HSPMs and/or HPCs, as these children are at an increased risk for developing MIH in the permanent dentition.[63,67–70,74,150,151]Additionally, due to the limited understanding surrounding the etiology of MIH and absence of high-quality evidence for effective treatment modalities, exploring factors that can assist clinicians in identifying children who are more prone to MIH is of great relevance. Identifying these red flags in the primary dentition would allow closer monitoring for defects in the permanent dentition along with guiding more appropriately timed treatment interventions. It

would also aid in dental practitioners providing anticipatory guidance to parents whose child may be at an increased risk of developing the condition.

The etiology of MIH is not well understood and is thought to be a multifactorial condition with systemic, environmental, and genetic components. Presently, no definitive etiological factor(s) have been identified, although a number of prenatal, perinatal, and postnatal factors have been proposed.[15–17,48,58,128] A recent systematic review[15] emphasized the stronger body of evidence regarding early childhood illnesses, in particular fever, asthma, and pneumonia as contributors to MIH. This is in comparison to the limited number of studies showing significant associations between MIH and prenatal or perinatal factors, such as maternal illness, medication used in pregnancy, prematurity, and birth complications.[15] Participants of the present study were given a list of conditions and asked to select all answer choices they believed to be involved in the etiology of MIH. Majority (80%) of respondents perceived acute medical conditions affecting mother and baby as contributory factors for MIH, with over half also attributing chronic medical conditions of both mother and baby (67%), antibiotics or medications (65%), and genetics (61%) as potential putative factors for the condition. It is clear that most participants associate MIH with a variety of maternal and/or early childhood illnesses or events. In addition, the vast majority (85%) also seemed confident that fluoride exposure does not contribute to the condition which coincides with the findings of the aforementioned studies. These results highlight what appears to be a generalized consensus amongst most US pediatric dentists' awareness of the current perplexity, uncertainty, and limited understanding of the multifactorial etiology of MIH. The necessity for more high-quality, longitudinal, and prospective studies of the etiology of MIH is clear.

The period of enamel mineralization occurs during pregnancy through the child's third year of life.[86] Interestingly, the majority of respondents (86%) did not identify the correct timing of insult occurrence for MIH. One-third (33%) of respondents selected pregnancy up to the first year of life as the most likely time period. Tagelsir et al[80], who surveyed US pediatric dentists in the Midwest region, also found majority of respondents underrated the time of insult occurrence. Conversely, findings from similar international surveys demonstrated agreement of practitioners for the timing of insult to occur anytime between pregnancy and the first three years of life.[126,128] These findings emphasize a possible gap in knowledge for US dental practitioners regarding the longer enamel mineralization period of the PFMs which has been shown to extend to an average of three years after birth.[152]

A significant difference between confidence in diagnosing versus treating MIH was reported in this study ($p < 0.0001$). With more than half (53%) of the respondents stating they were very confident in diagnosing MIH, results show that US pediatric dentists were more confident in diagnosing MIH compared to treating the condition. This could explain their request for more clinical training regarding MIH with majority of respondents (71%) requesting training courses in MIH treatment specifically.

The current survey identified long-term restoration success of MIH-affected teeth as the most common (78%) clinical challenge, which is consistent with findings from previous studies.[80,81,124–127,153] Presently, there are no standardized, long-term, evidence-based treatment guidelines which can be strongly recommended for all MIH-affected teeth. However, a number of different treatment modalities for MIH are available, ranging from preventive and restorative approaches to extractions.[36] The extensive variety of treatment options and lack of scientifically-backed treatment may explain the challenges clinicians face in this specific area. In addition, the

broad variation in clinical expression and tendency of MIH-affected teeth to accumulate more severe defects over time can make treatment decisions even more challenging. The present study substantiates the difficulties of MIH reported previously in the literature are also experienced by US clinicians.

A recent systematic review, proposed that the estimated mean annual failure rates of restorative materials used in the management of MIH were highest for GI and amalgam restorations and lowest for indirect restorations, SSCs, and composite restorations.[36] Consistent with findings from clinicians in the Midwestern US, India, Kuwait, and Australia/New Zealand, US practitioners showed the highest preferences for SSCs (69%, Case 2), composite resins (38%, Case 1) and RMGI (32%, Case 1) to treat moderate to severe MIH-affected molars.[80,81,123,124] In terms of preferred restorative approaches, the current study also helps to disprove a previous conclusion (2018) which noted US clinicians continued inclination toward the use of amalgam restorations.[80] In this study, a negligible number of participants selected amalgam as their treatment of choice for the clinical scenarios (1%, n=2), which, in contrast to findings reported in the previous study, demonstrates agreement between US clinicians and those from other countries.[79,81,122,126]

Treatment choices were fairly consistent amongst US clinicians for a mild case of MIH presenting with demarcated opacities on the facial surfaces of #8 and #9 (Case 3/Figure *4*). Close to one-half (49%) of respondents would not recommend treatment or intervention based on the clinical presentation. An additional 19% (n=113) of participants who initially opted for preventive intervention went on to select visual monitoring until change warrants treatment, bringing the total percentage of survey respondents who chose not to treat to 68%. Of the 21% of respondents who selected restorative intervention, majority (64%) indicated resin infiltration as

their treatment of choice demonstrating a more conservative, minimally invasive restorative approach amongst US clinicians.

Treatment decisions regarding a severe case of MIH presenting with PEB of #19 (Case 2/Figure *3*) exhibited even more consistency amongst respondents. Although significant associations between choice of treatment with self-reported confidence and years in practice were found in the study, an overwhelming percentage (91%) of clinicians indicated they would intervene restoratively. Majority (69%) of US practitioners preferred SSCs as their restorative treatment of choice, which is consistent with findings reported in previous studies.[81,123] This does not come as a surprise, as SSCs are generally recommended for teeth with multi-surface defects to provide full coverage protection and long-term retention. Treatment with SSCs for MIH-affected molars have been evaluated in a very limited number of studies, but have shown high success rates.[117,118] Surprisingly, the number of respondents selecting extraction as their treatment of choice was more than anticipated given the existing literature,[123,153]reflecting the possibility of a more aggressive treatment approach of US clinicians versus their international counterparts.

Treatment responses for a moderately MIH-affected molar (Case 1/Figure *2*) demonstrated the most disagreement among respondents with an almost even divide between clinicians choosing preventive strategies (48%, n=287) versus restorative approaches (48%, n=286). Most survey respondents who chose to treat using a restorative approach preferred composite resin (38%) which is consistent with findings from previous surveys.[79,80,123,154] Despite reports of high failure rates,[36,86,118] almost one-third (32%) of US clinicians reported relying on RMGI, which has also been a notable preference of clinicians in prior studies.[80,81,126,153] Although GI and RMGI materials are not recommended in the stress-bearing areas of permanent molar teeth, they are often used by practitioners as interim restorations.[66] Therefore, this may be a reflection of US

practitioners treatment strategy for interim restoration placement prior to definitive treatment. Participants who selected preventive interventions were given the option to select multiple responses since preventive strategies are often used in conjunction with one another. Majority (64%) of clinicians who opted for preventative management chose to visually monitor until change warranted treatment; however, less than half (40%) chose to recall patients on a more frequent basis than the routine six-month interval. This finding is unexpected given that the available clinical recommendations, although limited, suggest a shorter recall period based on patient's severity and/or symptoms.[36] Utilization of silver diamine fluoride (47%) and prescription fluoride toothpaste (44%) appeared to be well-accepted amongst US practitioners who elected for preventive management. Results from the current survey demonstrate clear discrepancies in treatment preferences amongst US pediatric dentists regarding management of moderately MIH-affected molars. While these noticeable inconsistencies were unrelated to both self-reported confidence and years in practice, they could be related to other individual factors. However, the more likely explanation may be attributable to the lack of high-quality, evidence-based treatment guidelines for MIH-affected teeth. The present study confirms that the significant clinical challenges associated with management of MIH reported previously in the literature are also experienced by US pediatric dentists.[80,81,123,124,128,153] The necessity for long-term clinical trials backed by laboratory studies for management of MIH-affected dentition cannot be understated.

LIMITATIONS

In addition to the limitations mentioned previously in the study, a low response rate was reported. However, the sociodemographic profile of the respondents in this study is comparable to that of the pediatric dentist population in the US; therefore, the recruited sample provides a

valid assessment of the knowledge, perceptions, and clinical experiences on MIH among the dental care practitioners in the US.

In the three case examples, responses were limited to those provided in the survey. Therefore, responses may not accurately represent treatment preferences for all respondents of the current survey. Following the case examples, participants were given a free-text option to list other methods utilized within their individual practices or clinics. It also seems an appropriate time to mention that pit-and-fissure sealants were listed under restorative interventions, which was identified by one survey respondent as being incorrectly categorized. The respondent believed sealants should have been listed as a preventative method versus restorative. Absence of this answer choice as a preventative intervention may have led to an inaccurate representation of practitioners' treatment and possibly an underreporting of clinicians who would utilize this treatment. According to evidence based research, dental sealants are universally accepted to serve as a primary preventive technique, but might also have therapeutic implications.[155] Assumption of dental practitioners being up to date on the current literature and practitioner preference for mechanical cleaning of fissures with a round bur and slow speed handpiece was also taken into consideration when determining which category to place the selection. A compromise for future studies could be to list pit-and-fissure sealants under both categories to avoid confusion.

Lastly, absence of a medical and dental history to accompany the clinical case examples may have influenced the results. Clinicians may have felt that they required more information to accurately answer the survey questions, as treatment strategies for asymptomatic versus symptomatic teeth varies.

Despite the validity problems accompanying this type of study in which survey respondents can under- or over-report specific details, the findings of the current survey serve as a baseline of data for MIH in the US and can aid in future investigations and research.

Conclusion

Based on this study's findings, the following conclusions can be made:

1. MIH is an enamel defect encountered by many US pediatric dentists
2. There was a generalized consensus amongst US pediatric dentists regarding treatment strategies for mild and severe cases of MIH; however, discrepancies were identified for treatment of moderate cases of MIH.
3. Majority of clinicians want more training (76%), especially related to the treatment of MIH (71%)
4. Further evidence-based guidance regarding appropriate treatment interventions is necessary for providers.

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Appendix

Molar-Incisor Hypomineralization Questionnaire

Dear Colleague and Fellow Member of the American Academy of Pediatric Dentistry,

My name is Courtney Brashier and I am a first-year pediatric dental resident at Virginia Commonwealth University (VCU), School of Dentistry in Richmond, VA . I am conducting a research project as part of my curriculum requirements for the Masters of Science in Dentistry program at VCU.

My research project is titled “Knowledge, Perception, and Clinical Management Strategies of United States Trained (US) Pediatric Dentists' on Molar-Incisor Hypomineralization.” As pediatric dental practitioners, the method in which we formulate a treatment plan for each specific patient differs according to their individual needs. How we choose the best treatment for a specific tooth, whether using preventive or restorative methods is influenced by a number different factors. The goal of my research project is to identify what those determining factors are and how they influence our treatment decisions. I also hope to reveal if years of practice or practice setting significantly affect the treatment that is rendered.

This study is supported by the Department of Pediatric Dentistry, and the study (HM20018385) has been approved by the Institutional Review Board at Virginia Commonwealth University.

Completion of this survey will take approximately 15 minutes. Participation in this research study is completely voluntary, and you may choose not to participate. All responses are anonymous, and no identifiers will be used. The results will be used for research purposes only. There is no compensation for completing this survey, and no risks for participating are anticipated. Completion of the survey will indicate your consent to participate in this research.

I sincerely appreciate your willingness to participate, as we all work together to further the successful management and care of our patients.

If you should have questions regarding this study, do not hesitate to contact me.

Sincerely,

Courtney Tremmel Brashier, DDS

VCU Pediatric Dentistry Resident brashierc@mymail.vcu.edu

Study PI: Patrice Wunsch, DDS, MS

pbwunsch@vcu.edu

Which of the following describes your age group?

◯ Under 30
◯ 30-39
◯ 40-49
◯ 50-59
◯ 60 +

With which gender do you identify?

◯ Female
◯ Male
◯ Non-binary/third gender
◯ Prefer to self-describe
◯ Prefer not to say

Self-describe gender:

_____

What is your current status as a dental practitioner?

◯ Non-board certified pediatric dentist
◯ Board certified pediatric dentist
◯ General dentist
◯ Resident

In which of the AAPD districts do you currently practice or are completing residency training?

◯ North Eastern (Connecticut, Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont; the Canadian Provinces of Newfoundland, Nova Scotia, Prince Edward Island, New Brunswick, and Quebec.)
◯ South Eastern (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia, and the Commonwealth of Puerto Rico)
◯ North Central (Manitoba, Ontario, Nebraska, Iowa, Minnesota, Ohio, Indiana, Michigan, North Dakota, South Dakota, Illinois, Wisconsin)
◯ South Western (Colorado, Kansas, Missouri, New Mexico, Oklahoma, Arkansas, Louisiana, Texas, Mexico)
◯ Western (Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming, and the Canadian Provinces of Saskatchewan, Alberta, British Columbia, Northwest Territories, Nunavut, and Yukon Territory)
◯ Other

How many years have you been practicing as a pediatric provider?

◯ < 5 years
◯ 5-10 years
◯ 11-20 years
◯ 21-30 years
◯ > 30 years
◯ Current resident

What is your primary practice setting? Check all that apply.

☐ Solo private practice
☐ Group private practice
☐ Corporate practice
☐ Public health
☐ Government
☐ University
☐ Hospital
☐ Dental residency
☐ Other

Describe other practice setting:

_____

Which of the following describes your primary area of practice?

◯ Rural
◯ Suburban
◯ Urban

On average, how many pediatric patients (< 18 y/o) do you see per day? (Prior to COVID-19)

◯ < 10 patients
◯ 10-20 patients
◯ More than 20 patients

When did you first learn about molar-incisor hypomineralization (MIH)?

◯ Pre-doctoral DDS/DMD training
◯ Post-graduate residency
◯ While in practice
◯ Unsure
◯ I have never learned about this condition

How confident are you in diagnosing MIH?

◯ Very confident
◯ Confident
◯ Somewhat confident
◯ Not at all confident
◯ I have never diagnosed this condition

How confident are you in distinguishing MIH from fluorosis?

◯ Very confident
◯ Confident
◯ Somewhat confident
◯ Not at all confident
◯ I have never diagnosed this condition

How confident are you in distinguishing MIH from chronologic hypoplasia?

◯ Very confident
◯ Confident
◯ Somewhat confident
◯ Not at all confident
◯ I have never diagnosed this condition

How confident are you in treating MIH?

◯ Very confident
◯ Confident
◯ Somewhat confident
◯ Not at all confident
◯ I have never treated this condition

Have you encountered patient's presenting with MIH in your dental setting/practice?

◯ Yes
◯ No

Approximately what percentage of your patients present with MIH? (Prior to COVID-19)

◯ < 1%
◯ 1-5%
◯ 6-10%
◯ 11-15%
◯ 16-25%
◯ >25%
◯ Unsure
◯ I have never seen this condition

Do you feel the incidence of MIH has changed in the period of your practice?

◯ Increased
◯ Decreased
◯ Remained the same
◯ Unsure
◯ Not applicable

In patients presenting with MIH, approximately how often do you notice this defect in the primary canines?

◯ More frequently
◯ Less frequently
◯ Same frequency as 1st permanent molar
◯ Unsure
◯ I have never seen this condition on primary canines

In patients presenting with MIH, approximately how often do you notice similar defects in the primary second molar(s)?

◯ < 10%
◯ 10-25%
◯ 25-50%
◯ >50%
◯ Same frequency as 1st permanent molar
◯ Unsure
◯ I have never seen this condition on primary second molars

In patients presenting with MIH, approximately how often do you notice this defect in the permanent incisor(s)?

◯ < 10%
◯ 10-25%
◯ 25-50%
◯ >50%
◯ Same frequency as 1st permanent molar
◯ Unsure
◯ I have never seen this condition on permanent incisors

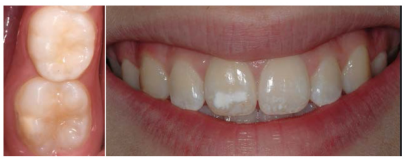
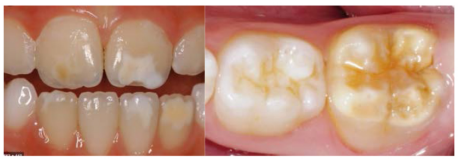
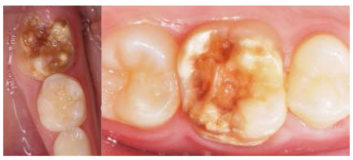
What is the most common clinical location of MIH seen in you dental practice/setting?

◯ 1 permanent first molar
◯ 2 permanent first molars
◯ 3 permanent first molars
◯ All 4 permanent first molars

Which molar teeth do you find are most often affected?

◯ Maxillary
◯ Mandibular
◯ Both
◯ Unsure

Please refer to the following image for the next question.

White Opacities	Yellowish-brown opacities	Immediate post-eruptive enamel breakdown
		

Which clinical presentation of MIH do you see most commonly? See the image above for examples of each choice

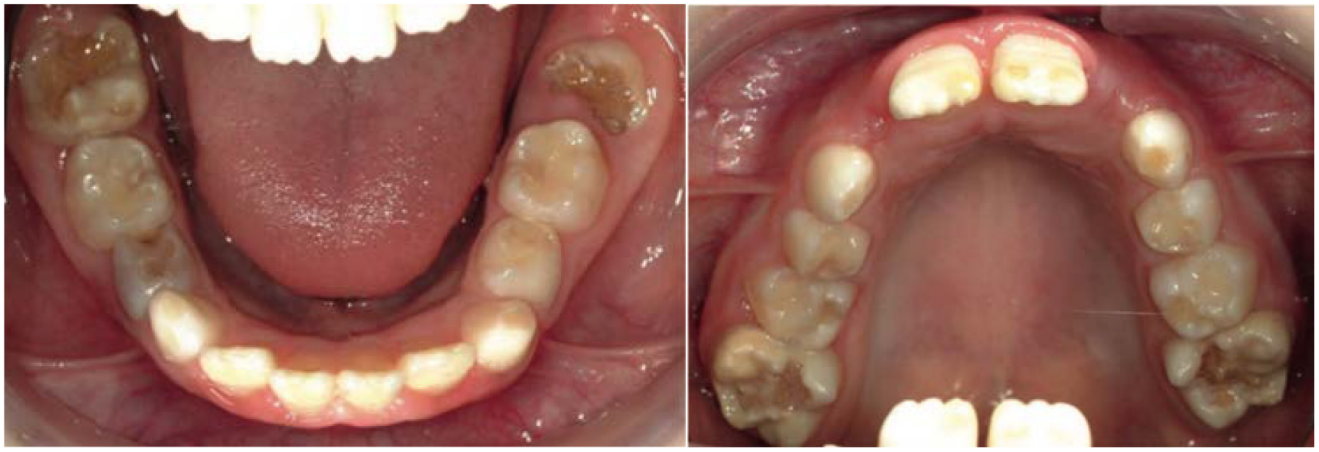
◯ White opacities
◯ Yellowish-brown opacities
◯ Immediate post-eruptive enamel breakdown
◯ Unsure

In patients presenting with MIH, please list any significant medical history that occurred from birth to ~3 years old that you may think contributed to MIH?

Of the following listed conditions, which do you believe are involved in the etiology of MIH? Select all that apply

☐ Genetic factors
☐ Chronic medical conditions affecting mother and child
☐ Acute medical conditions affecting mother or child
☐ Antibiotics or medications
☐ Fluoride exposure

Please refer to the following image for the next question.



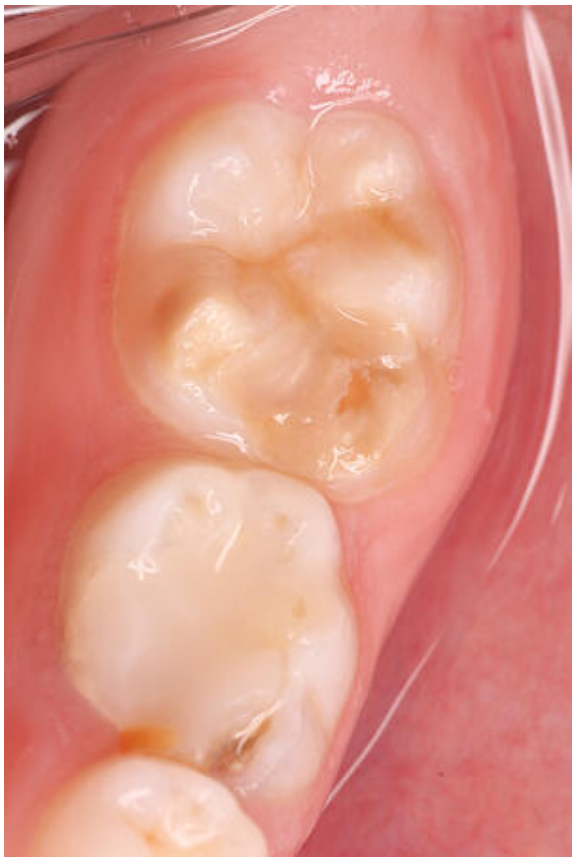
During what time period do you think the insult in the picture above occurred?

◯ During pregnancy only
◯ Pregnancy through 1st year of life
◯ Pregnancy through 3rd year of life
◯ Birth to 1st year of life
◯ Birth to 3rd year of life
◯ Not sure

Which of the following most accurately describes your treatment philosophy regarding MIH?

◯ I treat immediately in order to halt progression of further enamel deterioration
◯ I recall the patient frequently to monitor enamel breakdown
◯ I rarely treat this condition

Case 1



Case 1
Which of the following most accurately describes your treatment philosophy regarding the clinical presentation of MIH in the above picture?

◯ Restorative intervention
◯ Preventative intervention
◯ I would not recommend any treatment or interventions for this case
◯ I am unsure of how to treat this case

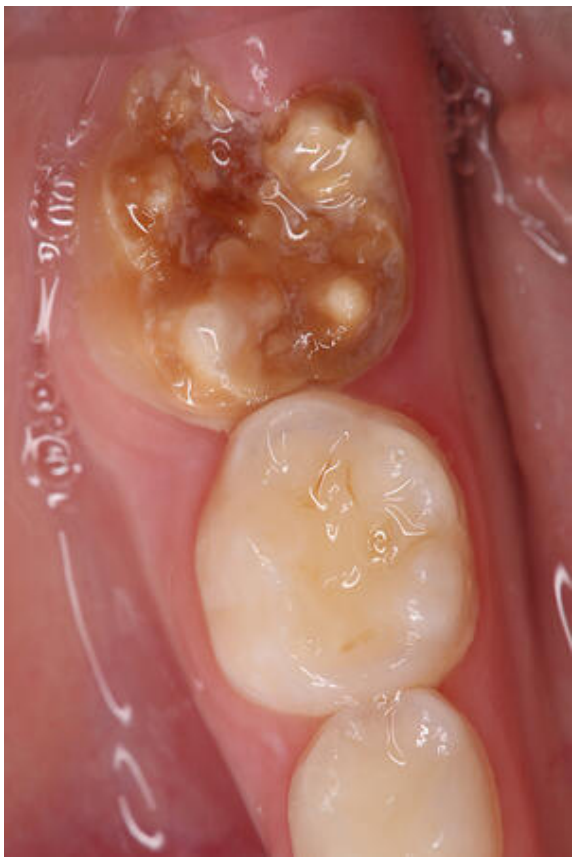
What restorative techniques would you most likely use for Case 1 pictured above?

◯ Fissure sealant
◯ Amalgam
◯ Composite resin
◯ Glass ionomer
◯ Resin-modified glass ionomer
◯ Stainless Steel Crown (SSC)
◯ Cast onlay or crown
◯ Orthodontic band with GI/Resin cement
◯ Extraction

Case 1: Preventative intervention
Select all the preventative interventions you would employ:

☐ Recall every 3 months
☐ Recall every 6 months
☐ Prescribe MI paste
☐ Prescribe prescription FL2
☐ SDF (Silver Diamine Fluoride)
☐ Visual monitoring until change warrants treatment

Case 2



Case 2
Which of the following most accurately describes your treatment philosophy regarding the clinical presentation of MIH in the above picture?

◯ Restorative intervention
◯ Preventative intervention
◯ I would not recommend any treatment or interventions for this case
◯ I am unsure of how to treat this case

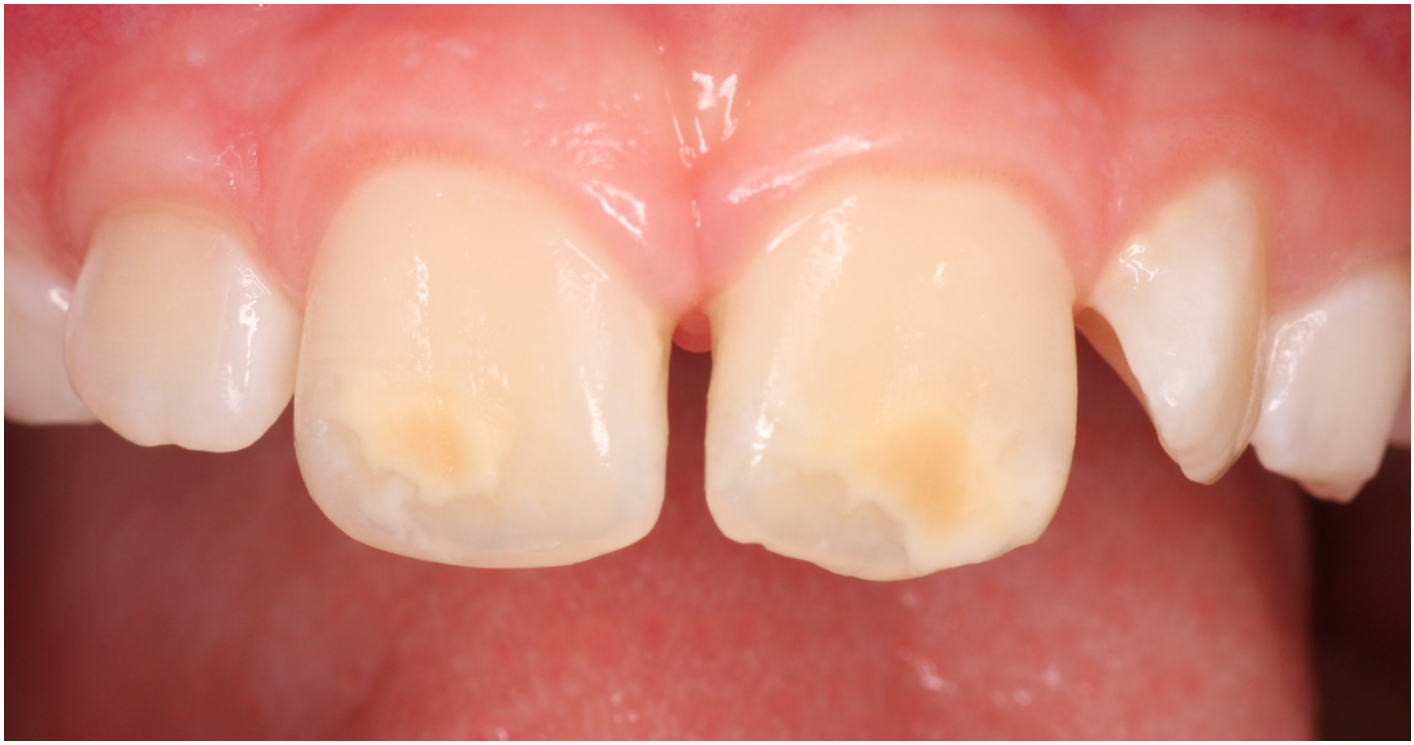
What restorative techniques would you most likely use for Case 2 pictured above?

◯ Fissure sealant
◯ Amalgam
◯ Composite resin
◯ Glass ionomer
◯ Resin-modified glass ionomer
◯ Stainless Steel Crown (SSC)
◯ Cast onlay or crown
◯ Orthodontic band with GI/Resin cement
◯ Extraction

Case 2: Preventative intervention
Select all the preventative interventions you would employ:

☐ Recall every 3 months
☐ Recall every 6 months
☐ Prescribe MI paste
☐ Prescribe prescription FL2
☐ SDF (Silver Diamine Fluoride)
☐ Visual monitoring until change warrants treatment

Case 3



Case 3
Which of the following most accurately describes your treatment philosophy regarding the clinical presentation of MIH in the above picture?

◯ Restorative intervention
◯ Preventative intervention
◯ I would not recommend any treatment or interventions for this case
◯ I am unsure of how to treat this case

What restorative technique would you most likely use for Case 3 pictured above?

◯ Microabrasion
◯ Resin infiltration
◯ Composite resin
◯ Glass Ionomer
◯ Resin-modified glass ionomer
◯ Full coverage crowns

Case 3: Preventative intervention
Select all the preventative interventions you would employ:

☐ Recall every 3 months
☐ Recall every 6 months
☐ Prescribe MI paste
☐ Prescribe prescription FL2
☐ SDF (Silver Diamine Fluoride)
☐ Visual monitoring until change warrants treatment

What other materials/restorative methods have you utilized to help restore/preserve MIH in your practice and how successful were these interventions?

What do you find to be the most common clinical challenge in managing patients with MIH? (Select all that apply) (Select all that apply)

☐ Diagnosis of teeth with MIH
☐ Long-term restoration success
☐ Choice of restorative modality/treatment
☐ Achieving adequate local anesthesia
☐ Managing hypersensitivity
☐ Determining the extent or margins of the affected tooth
☐ Behavior management
☐ Financial concerns for families
☐ I have never encountered MIH in my clinical practice
☐ Other

Please describe any other challenges managing patients with MIH

Would you like more clinical training in regards to MIH?

◯ Yes
◯ No

Which of the following subject areas would you like further training on regarding MIH? Check all that apply.

☐ Diagnosis
☐ Etiology
☐ Treatment

Please see the attached document for references for the images used in the survey.

[Attachment: "MIH Survey Image Sources.pdf"]