Knowledge and Management of First Permanent Molars with Enamel Hypomineralization among Dentists and Orthodontists

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Purpose: *Molar Incisor Hypomineralization (MIH) is a developmental enamel anomaly of systemic origin affecting the first permanent molars and often the permanent incisors. Despite MIH being a prevalent anomaly, its diagnosis and management are challenging for practitioners; including poor anesthesia, failure of restorations, rapid enamel breakdown, poor resin adhesion, and related child anxiety. This study aimed to evaluate knowledge regarding and management of MIH amongst orthodontists and dentists.* ***Study design:*** *The study was performed from March to September 2017 and included 336 dentists and 32 orthodontists. Questionnaires comprised questions on MIH diagnosis, socio-demographic characteristics of the subjects, and photographs of a case of MIH with related questions regarding management.* ***Results:*** *Our results showed that 48% of dentists and 25% of orthodontists misdiagnosed MIH; with misdiagnosis associated with graduation prior to 1986 ($p < 0.001$). Amongst dentists, 59% applied a fluoridated product and 34% applied fissure sealants in the case of moderate MIH. The application of fluoride was associated with graduation after 1986 ($p < 0.0001$).****Conclusion:*** *Large disparities about knowledge and management of MIH exist between dental practitioners in France. Education regarding diagnosis and management of MIH is necessary.*

Keywords: *MIH, Molar, hypomineralization, dental enamel, education*

INTRODUCTION

Molar Incisor Hypomineralization (MIH) was defined in 2001 as a qualitative defect of tooth enamel affecting at least one first permanent molar (FPM), often affecting permanent incisors[1]. The European Academy of Pediatric Dentistry (EAPD) agreed on MIH diagnosis criteria characterized by at least one of these factors affecting one or more FPMs: demarcated enamel opacity, post-eruptive enamel breakdown, atypical restoration, or atypical extraction due to MIH[2]. Loss of initially formed surface enamel after tooth eruption is often associated with a pre-existing demarcated opacity[2]. Currently, in the absence of identified cause(s), no preventive actions can be implemented to decrease risk[3]. MIH constitutes a public health problem, with consequences that are not only health-related but also economic. MIH may impact on the well-being of young individuals in a crucial period of development[4, 5]. Today, the worldwide prevalence of MIH is estimated to be approximately 14% of children[6, 7]. Given the difficulties involved in treating MIH (hypersensitivity, child anxiety, difficulties with anesthesia, poor aesthetics, carious lesion development with fast progression, failure of restorations), early diagnosis and protective treatment for affected enamel are essential[8, 9]. Without early diagnosis, post-eruptive structural damage may occur quickly and eventually lead to FPM extraction in severe cases.

Furthermore, in some cases, planned extraction of first permanent molars severely affected by MIH, in the presence of well-positioned developing third molars, can result in a healthy dentition without the legacy of MIH affected molars; although sometimes necessitating orthodontic intervention. Unfortunately, the misdiagnosis of MIH may complicate the dialogue between practitioners.

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Our study aimed to evaluate knowledge and management of MIH by dentists and orthodontists in south-west France.

MATERIALS AND METHOD

The present study included a subsample of dentists and orthodontists from south-west France between March and September 2017. A questionnaire link was emailed to addresses provided by the Dental Council of Southwest France and the orthodontists were emailed *via* the Society of South Western Orthodontists (SOSO). Practitioners were informed about study aims and data were anonymized. Questionnaires were sent to 2208 dentists and 152 orthodontists.

Two different questionnaires were used: one for dentists and one for orthodontists. Questionnaires were sent by means of 'Google forms' (Google LLC, CA, USA), including a consent form and diagnosis of a MIH clinical case with related photographs and radiographs. The title of the questionnaire was "Evaluation of the current knowledge of southwest French orthodontists' (or dentists') management of structural anomalies" in order to avoid any bias in the diagnoses.

The thesis commission of the University of Bordeaux (Department of Odontology) approved the study methodology.

Clinical case

The patient came from a public dental hospital (Pellegrin, CHU de Bordeaux, France) and consented for the use of their photographs and radiographs. White opacities were present on teeth 11 (Fig. 1-A) and 31 (Fig. 1-B). Brown hypomineralized lesions with post-eruptive enamel breakdown were present on teeth 16 (Fig. 1-C) and 26 (Fig. 1-D). A creamy opacity affected the occlusal surface of tooth 46 (Fig. 1-E). An atypical restoration is present on tooth 36 (Fig. 1-F). Radiographs indicated lesion proximity to the pulp (Fig. 2-A, B and Fig. 3). Other teeth were clinically sound.

Figure 2 – a – Radiograph of maxillary right posterior quadrant. – b – Radiographs of mandibular left posterior quadrant.

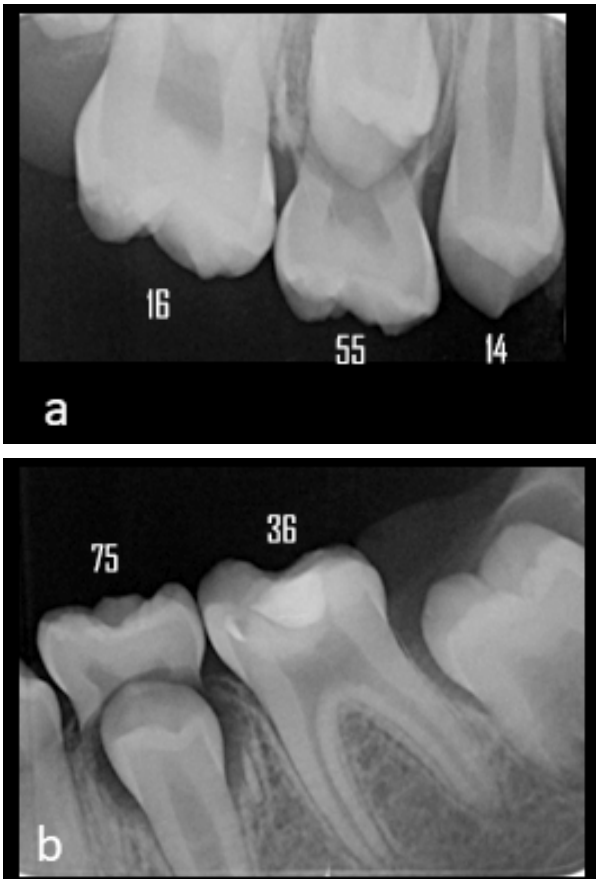

Figure 1 – Images from an MIH affected individual: a – Facial view of maxillary incisors; b – Facial view of mandibular incisors; c – Maxillary right posterior quadrant; d – Maxillary left posterior quadrant; e – Mandibular right posterior quadrant; f – Mandibular left posterior quadrant.

Figure 3 – Panoramic radiograph of an MIH-affected individual used in the questionnaire – note lesion in tooth 36.

Questionnaires

The dentist questionnaire was developed by a dental student and two pediatric dentists; the orthodontist questionnaire was piloted before use by a dental student, an orthodontist and a pediatric dentist. The questionnaires included three sections: socio-demographic characteristics, diagnosis and management. The first sections also included data on practitioner sex, practice location and year of graduation.

The diagnostic section included three multiple choice questions common to both dentists and orthodontists related to diagnosis of developmental defects of enamel (DDE); prevalence of MIH in their practice; and whether MIH prevalence has increased over the past 20 years.

The management section included four multiple choice questions which differed depending on practices (orthodontics or dentistry). Concerning the dentist questionnaire, therapeutic options are included in Figure 4. The orthodontist questionnaire included questions on tooth extraction or preservation depending on timing or characteristic of patients.

Statistical analysis included descriptive statistics using the Excel software (Microsoft Corp., WA, USA). Pearson's Chi-square tests were performed using Statistica software v.12 (Statsoft Dell Inc., OK, USA) between responses of dentists. Due to the small number of orthodontist responses (n=32), no statistical tests were performed.

Figure 4 – Proposed therapeutic options.

Control
Application of fluoride varnish twice-a-year
Pit and fissure sealing
Direct restoration (resin composite)
Direct restoration (glass-ionomer cement)
Indirect restoration (onlay, inlay, overlay, full-coverage)
Complete removal of stained enamel
Removal of enamel breaking under manual instrument pressure
Removal of enamel breaking under rotating instrument pressure (i.e. contra-angle handpiece with ceramic or tungsten carbide bur)
Removal of carious enamel
Direct pulp cap (Mineral Trioxide Aggregate (MTA) or Biodentine®)
Endodontic treatment
Prefabricated metal crown
Extraction

RESULTS

Total response was 336 of 2208 dentists (15.3%) including 7 pediatric dentists; 56% were male (Table 1). Dentists graduated between 1966 and 2017, with 57% graduating before 2001 (time of publication of MIH definition). Total orthodontist response was 32 of 154 (20.8%); 78% were female. Orthodontists graduated between 1981 and 2017, with 66% graduating after 2001.

From the photographs of the representative MIH case (Fig. 1), 52% of the dentists diagnosed MIH correctly, compared to 75% of orthodontists (Table 2). The most frequent differential diagnosis was *amelogenesis imperfecta* (AI; 43%); trauma-related hypomineralization (1%), *dentinogenesis imperfecta* (2%) and fluorosis (2%). Most orthodontists (81%) reported observing these defects in up to 20% of their patients whereas the majority of dentists (63%) observed it in fewer than 10%. A great proportion of orthodontists (69%) had not observed an increase in these defects in the last 20 years, compared to 50% of dentists.

Dentist responses are outlined in Table 3, and more than one response was possible. Concerning tooth 16, 59% proposed fluoride varnish application twice-per-year, 34% performed a pit and fissure sealant, 13% restored with resin composite, 15% restored with GIC, 3% performed an indirect restoration and 3% used a preformed metal crown (Table 3 Q1). No practitioner would extract the tooth.

The management of tooth 36 (with pain precipitated by exposure to cold) mostly involved a direct restorative approach, with 28% restoring directly with resin composite and 36% using GIC, whereas 16% chose an indirect restoration and 8.6% full coverage (crown) (Table 3 Q2). Among dentists, 60% performed a direct pulp cap using a dentine substitute such as MTA or Biodentine® (Septodont, Saint-Maur-des-fossés, France) or endodontic treatment (7%). The extraction of tooth 36 was planned by 1% of practitioners. In case of direct restoration, 69% of dentists removed carious enamel, 52% removed enamel with a manual excavator and 43% used rotary instruments (Table 3 Q3). Only 6% recommended the removal of all stained enamel. For indirect restoration, 27% removed all stained enamel (Table 3 Q4). Among the respondents, 83% stated that they would benefit from additional training for the management of individuals with MIH.

Orthodontist responses are outlined in Table 4. The most favorable outcomes for extraction of tooth 36 were the presence of tooth 38 on panoramic radiography (78%) and the poor prognosis of the tooth 36 (72%). One third (38%) of respondents considered that mineralization of the furcation of the tooth 37 is a favorable time to extract the 36. The best timing for this extraction is "now, because tooth 38 and the furcation of tooth 37 are being mineralized" (mentioned by 47% of respondents). In the case of 36 extraction in a patient with a skeletal Class I relationship and minor anterior crowding, the majority (72%) preserved the 46, 59% preserved the 16 and 26, one quarter recommended compensatory extraction of 26, 19% recommended extraction of 16 and 9% performed a balancing extraction of 46. In the case of extraction of 36 in a patient with a skeletal Class III relationship and mandibular anterior crowding, 75% of orthodontists chose to extract the 46, 56% preserved 26 and 50% preserved 16.

The misdiagnosis of MIH was correlated with dentist sex ($p = 0.0003$; $\chi^2=12.9$, df=1) with 43% of males correctly diagnosing MIH compared to 63% of females (Table 5). Practitioners who graduated after 2001 diagnosed MIH correctly more frequently than older graduates (70% vs 38% respectively; $p < 0.0001$). Assuming that a diagnosis of AI (a rare condition in France with a prevalence of 1 in 14,000) could lead to underestimation of the hypothetical prevalence of MIH[10], our study highlighted a significant correlation between a reported prevalence less than 10% and an AI diagnosis ($p = 0.001$; $\chi^2=10.8$, df=1). The experience of the practitioners concerning a perception of increasing prevalence of MIH during the last 20 years also had a significant influence on responses

Table 1 – Respondent characteristics.

Respondents	Male (n; %)	Female (n; %)	Graduated <2001 (n; %)	Graduated ≥2001 (n; %)
Dentists (n=336)	(188; 56%)	(148; 44%)	(192; 57%)	(144; 43%)
Orthodontists (n=32)	(7; 22%)	(25; 78%)	(11; 34%)	(21; 66%)

Table 2 – Common questions to dentists and orthodontists.

Q1	What is your diagnosis of the condition in figure 1?				
Answer	MIH	AI	Fluorosis	DI	Traumatic
Dentists	174 (52%)	143 (43%)	8 (2%)	7 (2%)	4 (1%)
Orthodontists	24 (75%)	8 (25%)	0	0	0
Q2	**How often do you experience this anomaly in your practice among children 6-18 years old?**				
Answer	< 10%	11-20%	21-30%	31-40%	41-50%
Dentists	213 (63%)	87 (26%)	26 (8%)	8 (2%)	2 (1%)
Orthodontists	13 (41%)	13 (41%)	6 (19%)	0	0
Q3	**Do you think that the prevalence of this anomaly has increased during the last 20 years?**				
Answer	Yes	No			
Dentists	168 (50%)	168 (50%)			
Orthodontists	10 (31%)	22 (69%)			

MIH: molar incisor hypomineralisation; AI: *amelogenesis imperfecta*; DI: *dentinogenesis imperfecta*

($p = 0.017$; $\chi^2=0.68$, df=1) as 38% of practitioners with more than 30 years of clinical experience (graduated before 1986) reported an increase in MIH cases compared to 53% of younger practitioners (graduated after 1986).

With regards to management of MIH, no correlation was established between fissure sealing and year of graduation ($p > 0.05$). Nevertheless, 67% of practitioners who graduated after 1986 performed a bi-annual fluoride varnish application compared to 33% of dentists who graduated before 1986 ($p < 0.0001$). There was no correlation between the correct diagnosis of MIH and the demand for continuing education on MIH.

Amongst younger orthodontists who graduated after 2001, only 36% diagnosed MIH correctly whereas amongst orthodontists who graduated before 2001, 95% diagnosed MIH. Amongst orthodontists with more than 30 years of experience, 33% reported an increase in the prevalence of MIH in the past 20 years compared to 72% of orthodontists with fewer than 30 years of experience ($p = 0.164$; $\chi^2=1.93$, df=1).

Table 3 – Reported management of MIH by dentists.

Q1	**How would you manage tooth 16 (asymptomatic)?**							
Answers	Supervision	Fluoride 2 x year	Fissure sealing	Composite restoration	GIC restoration	Indirect restoration	Prefabricated crown	Extraction
	228 (68%)	197 (59%)	113 (34%)	42 (13%)	52 (15%)	11 (3%)	9 (3%)	0

Q2	**How would you manage tooth 36 (pain precipitated by exposure to cold)?**								
Answers	Supervision	Fluoride 2/ year	Fissure sealing	Composite restoration	GIC restoration	Indirect restoration	Direct pulp cap	Endodontic treatment	Prefabricated crown
	63 (19%)	52 (15%)	4 (1%)	93 (28%)	120 (36%)	55 (16%)	203 (60%)	25 (7%)	29 (9%)

Q3	**In case of direct restoration of tooth 36, which tooth tissue would you remove?**			
Answers	All stained enamel	Enamel breaking under manual instrument pressure	Enamel eliminated with a rotating instrument	Enamel affected by a potential carious lesion
	19 (6%)	174 (52%)	145 (43%)	233 (69%)

Q4	**In case of an indirect restoration of tooth 36, what tooth material would you remove?**			
Answers	All stained enamel	Enamel breaking under manual instrument pressure	Enamel eliminating with a rotating instrument	Enamel affected by a potential carious lesion
	92 (27%)	139 (41%)	173 (51%)	210 (62.5%)

GIC: Glass-ionomer cement

Table 4 – Reported management of MIH by orthodontists.

Q1	**What factors do you think favor extraction of tooth 36?**								
Answers	Poor prognosis of 36	Presence of 38	Mineralization of furcation of 37	No mandibular anterior crowding	Bad oral hygiene	Patient motivation	Skeletal class III	Hypodivergent facial type	Patient age
	23 (72%)	25 (78%)	12 (38%)	2 (6%)	6 (19%)	13 (41%)	6 (19%)	1 (3%)	17 (53%)

Q2	**What is the best time to extract tooth 36?**		
Answers	Now, because tooth 38 is present and the furcation of tooth 37 are being mineralized	When second premolars is erupting	When second molar is beginning to erupt
	15 (47%)	8 (25%)	9 (28%)

Q3	**In the case of extraction of 36 in a patient who is skeletal Class I and minor anterior crowding; how would manage this patient?**					
Answers	Balanced extraction of 46	Preservation of 46	Compensatory extraction of 26	Preservation of 26	Extraction of 16	Preservation of 16
	3 (9%)	23 (72%)	8 (25%)	19 (59%)	6 (19%)	19 (59%)

Q4	**In the case of extraction of 36, a patient who is skeletal Class III and mandibular crowding; how would manage this patient?**					
Answers	Extraction of 46	Preservation of 46	Extraction of 26	Preservation of 26	Extraction of 16	Preservation of 16
	24 (75%)	8 (25%)	3 (9%)	18 (56%)	5 (16%)	16 (50%)

Table 5 – Comparison of responses of dentists and orthodontists.

Parameters	Dentists (n=336)	Dentists P value	Orthodontists (n=32)	Orthodontists P value
Male/diagnosis MIH	81/189 (43%)	**0.0003***	6/7 (86%)	0.458
Female/diagnosis MIH	92/147 (63%)	χ^2=12.9, df=1	18/25 (72%)	χ^2=0.55, df=1
Grad ≥ 2001/diagnosis MIH	101/145 (70%)	**< 0.0001***	4/11 (36%)	**0.0003***
Grad < 2001/diagnosis MIH	72/191 (38%)	χ^2=33.7, df=1	20/21 (95%)	χ^2=13.34, df=1
Prev. < 10%/diagnosis AI	105/213 (49%)	**0.001***	4/13 (31%)	0.533
Prev. > 10%/diagnosis AI	38/123 (31%)	χ^2=10.8, df=1	4/19 (21%)	χ^2=0.38, df=1
Grad > 1986/increase Prev.	137/257 (53%)	**0.017***	21/29 (72%)	0.164
Grad ≤ 1986/increase Prev.	30/79 (38%)	χ^2=0.68, df=1	1/3 (33%)	χ^2=1.93, df=1
Grad > 1986/fissure sealing	89/257 (35%)	0.489	-	
Grad ≤ 1986/fissure sealing	24/79 (30%)	χ^2=0.49, df=1		
Grad > 1986/fluoridation	171/257 (67%)	**< 0.0001***	-	
Grad ≤ 1986/fluoridation	26/79 (33%)	χ^2=28.17, df=1		
Diagnosis MIH/formation	150/173 (87%)	0.087	-	
Misdiagnosis MIH/formation	130/163 (80%)	χ^2=2.92, df=1		

* statistically significant

DISCUSSION

This is the first published study that has investigated the knowledge and experience of MIH amongst dentists and orthodontists in France. Moreover, this study included a large number of practitioners with 336 dentists and 32 orthodontists responding[11-17]. This study suffers from a nonresponse bias of 84.7% due to the low response rate of dentists (15.3%) which decreases the representativeness of the sample. Fincham argued that response rates to e-mail surveys have decreased since the late 1980s; and may only approximate 25% to 30% without follow-up e-mail and reinforcements[18, 19]. The increasing demand on dentists for participating in questionnaires and the one-time mailing could explain our low response rate.

Despite the MIH criteria being established in 2001, disparities on MIH diagnoses remain, as 48% of dentists misdiagnosed MIH. Orthodontists seem to have more sophisticated knowledge regarding MIH, with three-quarters making correct diagnoses, probably due to their longer educational experience. Moreover, orthodontic patients include more children and adolescents than general dentists, at which time MIH is easier to diagnose due to dental tissue preservation, as MIH increases the risk of carious lesion development, potentially masking the presence of MIH[20]. AI was the most common differential diagnosis; the difficulty of MIH diagnosis has been discussed in the literature, and is particularly confounded by AI, fluorosis and early carious lesions[15]. A misdiagnosis of AI may lead to fear for the patient and his family due to its genetic and hereditary nature; which will have an impact on all the dentition. The misdiagnoses were correlated to the practitioners' sex and an earlier graduation date; highlighting the need for continuing education for practitioners.

Most dentists (89%) estimated that MIH occurred in up to 20% of their patients, consistent with previous studies[11, 13, 17]. This trend is in accordance with worldwide prevalence values of 11.8–14.5%[6]. However, most dentists (63%) reported a prevalence less than 10%, possibly explained by the misdiagnosis of MIH for AI; with AI misdiagnosis correlated with a reported MIH prevalence less than 10%. Orthodontists reported a MIH prevalence closer to published prevalence in a meta-analysis (13.1%) than dentists probably because they deal mostly with children[6]. Similar differences were found between pediatric dentists and general dentists in other studies[11, 14, 21]. Half of the dentists and two thirds of the orthodontists did not report an increase of MIH prevalence during the past 20 years, supporting the results of Weerheijm and colleagues[22]. One of the first epidemiological studies on MIH determined prevalence figures of 3.6–15.4% including patients born in 1966-74[23] which is close to current figures of 11.8–14.5%[6]. Crombie and colleagues also mentioned that 47% of practitioners did not observe an increasing of this anomaly during the last 10 years. In the present study, it appears that few practitioners with more than 30 years of experience have seen an increase in the number of cases (18%), whilst 82% of practitioners with fewer than 30 years of experience have seen an increase in MIH prevalence. These results may be explained by the fact that there has always been talk of an increasing trend in the number of cases without proven scientific evidence. Thus, the "younger practitioners" were educated on this subject with the idea that the prevalence of MIH was constantly increasing, without supporting evidence.

A great challenge for dentists seems to be the restoration of MIH-affected teeth[24]. Comparable to Crombie and colleagues, in the present study, the most commonly used materials were GIC (36%) and resin composite (28%)[11, 17]. Few practitioners utilized prefabricated metal crowns (9%) in the management of MIH, consistent with similar studies[11].

Regarding the choice of treatment for the 16, which had moderate involvement, only 59% chosen a bi-annual fluoridation, yet, it is recommended by the EAPD[25, 26]. In the present study, this tendency is correlated to a graduation year before 1986 ($p < 0.0001$). Hussein and colleagues highlighted that 58.8% practitioners used fluoride products as first-line treatment on MIH teeth (36). Pit and fissure sealants could have some benefits for mild MIH in molars, as they further assist the prevention of caries and enamel breakdown[27],

however, in our study only 34% of practitioners performed them on tooth 16. In case of a direct restoration, only 6% of dentists performed a total removal of stained enamel compared to 27% in the case of an indirect restoration despite the low quality of adhesion to affected enamel[28].

Orthodontic cases involving the extraction of the first permanent molars are usually more technically demanding compared with conventional premolar extraction or non-extraction treatment[29]. However, when prognosis is poor, extraction of FPM should be considered[30, 31]. Amongst our sample of orthodontists, the factors in favor of the extraction of the 36 were in majority: the presence of the 38 in the panoramic radiograph (78%), the poor prognosis of the 36 (72%) and the patient's age (53%). The disparities between the practitioners can be explained by the lack of information on facial and cephalometric data. The ideal timing for extraction of the 36 is when the 38 is observable and the furcation of 37 is mineralized (47%) which is in accordance with international studies[25, 30-33]. A problem caused by premature extraction of the mandibular first permanent molar is the risk of the second premolar drifting distally[30, 32]. If extraction is after 10 years-of-age, the possibility of failure of spontaneous space closure, poor angulation and an unsatisfactory contact point relationship with the second premolar increases[32]. In addition, consideration should be given to the need for compensatory extraction of the maxillary FPM antagonist in the case of mandibular FPM extraction[34]. Indeed, the FPM could limit the desired mesial migration of the second mandibular permanent molar thus hindering its eruption into the FPM position[32]. Also, a balanced extraction may be considered to prevent the development of midline asymmetry[25]; however, balancing extraction is not supported by strong evidence[29]. An alternative treatment is autotransplantation of third molars into FPM extraction sites. although few case reports have been published[35]. Therefore, dentists should always consider the orthodontic consequences of the FPM extraction and the orthodontists may require an opinion on the long-term prognosis of affected teeth, assuming that both have the requisite knowledge of MIH. Most dentists (83%) agreed that they would benefit from education on MIH. In other international studies more than two thirds would like to deepen their knowledge of MIH, particularly on diagnosis and treatment (62.9%)[12, 17, 36]. In response to this issue, a practical article was published in a French orthodontic journal[37].

Dentists and orthodontists have an important role in treating individuals affected by MIH, with implications including preventive actions such as oral health education, dietary advice, prescription of fluoride products and other remineralizing products such as casein phosphopeptide-amorphous calcium phosphate[38]. There are issues with bonding brackets to hypomineralized enamel due to decreased bond strengths, and subsequent enamel surface fracture when the bracket is removed[39]. Unpublished data indicates that 4% of orthodontic patients with MIH required extraction of a first permanent molar[40]. When FPM extraction is a possible treatment option, many factors must be considered, including the most suitable age for extraction, behavioral issues, cost of treatment, whether all six year-old molars should be extracted if not all are affected, balancing and compensating extractions, space loss after extraction, and the impact on length and success of orthodontic care[41]. In some patients intermediate restorative treatment can be considered, in the absence of any infectious or painful symptoms. This can include preformed metal crowns or orthodontic bands, which can also serve as support for intermediate restorations, waiting for a definitive treatment plan. Initial research on resin infiltration of hypomineralized enamel had mixed results, especially for lesions on posterior teeth, although the procedure has the potential to increase enamel hardness and improve aesthetics, especially in anterior teeth[42-45].

CONCLUSIONS

Disparities about knowledge and management of MIH exist between dental practitioners in France. Education on MIH diagnosis and treatment during the training of dental students and continuing education for dental practitioners on MIH are needed.

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