

Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice

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Abstract

Background Despite clear assessment criteria, studies of molar incisor hypomineralisation (MIH) and hypomineralised second primary molars (HSPM) are marked by inconsistency in outcome measurements. This has detracted from meaningful comparisons between studies and limited interpretation.

Aim To provide a comprehensive manual as a companion to assist researchers in planning epidemiological studies of MIH and HSPM, with particular reference to outcome measurement.

Methods This manual begins with a succinct review of the clinical problems and evidence for management of the conditions. The subsequent sections guide researchers through diagnosis of MIH and HSPM and implementation of both the long and short forms of a recently proposed grading system. MIH and HSPM can often be confused with fluorosis, enamel hypoplasia, amelogenesis imperfecta, and white spot lesions but can be distinguished by a number of unique clinical features. Based on the grading system, a standardised protocol is proposed for clinical examinations. Intra and inter-examiner reliability is of key importance when outcome measurement is subjective and

should be reported in all epidemiological studies of MIH. The manual concludes with an exercise forum aimed to train examiners in the use of the grading system, with answers provided.

Conclusion The use of a standardised protocol, diagnostic and grading criteria will greatly enhance the quality of epidemiological studies of MIH.

Keywords MIH · HSPM · Charting sheet · Scoring method · Calibration · Enamel hypomineralisation · EAPD · Epidemiologic studies

Introduction

Since Molar Incisor Hypomineralisation (MIH) was defined by Weerheijm et al. (2001), global awareness of the condition has increased, reflected by an increasing number of studies on the condition (Weerheijm et al. 2001; Elfrink et al. 2015). Distinct from other developmental defects of enamel, MIH presents with demarcated, qualitative defects of enamel of systemic origin affecting one or more first permanent molars (FPMs) with or without incisor involvement (Weerheijm et al. 2001). Reports exist on prevalence of MIH lesions in all teeth, and have showed that the second primary molars (SPMs), which form at a similar time as the FPM, can also be affected, with the condition defined as Hypomineralised second primary molar (HSPM) (Elfrink et al. 2012; Ghanim et al. 2013). Affected FPMs, permanent incisors and SPMs are MIH/HSPM index teeth (Ghanim et al. 2015).

In the recent past, clinical measures for MIH based on scientific criteria were established. These European Academy of Paediatric Dentistry (EAPD) assessment criteria

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allowed and facilitated comparisons between the findings of different studies (Weerheijm et al. 2003). The estimated prevalence of MIH ranges between 2.8 and 40.2% although the available data are still scarce, particularly in regions such as North America, Africa and the Middle East with the majority of studies clustered in Europe (Jalevik 2010; Elfrink et al. 2015). Despite the extensive use of the EAPD criteria, prevalence rates of MIH reported in epidemiological studies still differ considerably. There is some difficulty in comparing the prevalence data reported in different studies due to the different criteria used to define cases of MIH, but this is likely to have led to under rather than over-estimation. A number of investigators failed to include MIH teeth with extensive break down that required atypical restorations or even extraction, in which case the prevalence of MIH was likely to be substantially underestimated (Jalevik 2010).

A recent systematic review of the prevalence of MIH revealed a lack of standardisation, which was attributed to the lack of a standardised tool to record MIH (Elfrink et al. 2015). The review suggested preparation of a well-defined method for data collection is of utmost importance to improve consistency and enable better comparison between results of different studies (Elfrink et al. 2015). As a consequence, a standardised scoring system based on the EAPD evaluation criteria was formulated and recommended for use in future research (Ghanim et al. 2015). In order to enable future examiners to use the standardised assessment criteria efficiently, the present paper provides guidance for training and calibration of future examiners in the use of the standardised assessment criteria for field studies of MIH.

Note: This manual does not replace the calibration of evaluation criteria for patients in a clinical setting. However, it aims to explain the concepts and tools required to conduct epidemiological surveys of MIH and thereby improve the methodological consistency of such studies. This manual acts as a practical guide for researchers planning on undertaking epidemiological studies of MIH to assist with all aspects of outcome measurement, and in particular, accurate application of MIH scoring criteria.

The manual is organised into the following modules:

- Module I: Clinical problems and management of MIH-affected teeth.
- Module II: Differential diagnoses.
- Module III: Examination protocol and standardisation.
- Module IV: Kappa statistics calculation.
- Module V: Exercise forum.

Module I: clinical problems and management of MIH-affected teeth

Molar incisor hypomineralisation defects can influence children's general health and quality of life and their treatment may have a large financial impact upon patients, their parents and society. Affected teeth often develop advanced carious lesions requiring substantial restorative care and repeated treatments. This module aims to:

- Describe the clinical problems present in MIH patients.
- Give guidance to clinicians on the different treatment options available for MIH teeth, depending on the age of the patient and the severity and location of the affected teeth.

Clinical problems in MIH

Patients with MIH have several clinical problems that have been adequately studied and verified:

- Affected teeth present with sensitivity to cold air, warm/hot water and food and tooth brushing, resulting in poor oral hygiene and increased susceptibility to dental caries.
- Behaviour management problems (dental fear and anxiety) related to pain experienced by the patients during multiple treatment appointments. Affected children receive much more dental treatment than unaffected children.
- Local analgesia problems, possibly related to chronic pulpal inflammation resulting from bacterial penetration into the dentine underneath the porous and exposed enamel.
- Aesthetic problems in anterior teeth.
- In posterior teeth, rapid wear/enamel loss and finally post-eruptive breakdown and exposure of the porous sub-surface enamel and the dentine. Teeth left untreated may eventuate with pulp involvement and subsequently be lost early.
- Occasional eruption difficulties of molars related to enamel roughness.

References for the above are included in the reviews by Willmott et al. (2008) and Lygidakis (2010).

Treatment options in MIH

The treatment options are related to the dental age of the child. For example, caries prevention is always important in the early post-eruptive stage as the defective teeth are more likely to develop carious lesions and post-eruptive breakdown due to increased porosity. In later

developmental stages, the enamel becomes more mature and if prevention has succeeded and the enamel surface remained intact, the relative importance of prevention decreases comparative to the necessity of restorative treatment.

Prevention and early management

Intense prevention should start as soon as MIH teeth erupt as they are more vulnerable to breakdown and carious lesion development.

(A) At home

- Dietary advice and fluoride toothpastes of at least 1450 ppm F, for minimising caries-risk and defective teeth hypersensitivity.
- For patients with mild pain to external stimuli, home application of a CPP-ACP (casein phosphopeptide-amorphous calcium phosphate) containing crème or sugar-free chewing gum may help mineralise, desensitise and act as a source of bio-available calcium and phosphate for the MIH erupting teeth. Although there is limited clinical information for the use of CPP-ACP (Ozgül et al. 2013), in vivo and in vitro studies have reported its possible effectiveness in MIH teeth (Baroni and Marchionni 2011; Crombie et al. 2013).

(B) At the dental clinic

- For patients with porous enamel surface, early enamel loss and breakdown during eruption–fissure sealants using glass-ionomer cement. For intact hypomineralised molars, resin-based fissure sealants with adhesive application prior to placement.
- For patients with spontaneous hypersensitivity of posterior teeth, sealants and professional application of fluoride varnishes.

Treatment of anterior teeth

Aesthetic concerns are common for the child with MIH incisors but any intervention should be performed with caution as young patients have immature anterior teeth with large and sensitive pulps. In addition any aesthetic treatment should be postponed as anterior enamel opacities often become less profound in the long term. It is also important to remember that the yellow/whitish creamy defects are generally less severe than the yellow/brownish defects.

(A) Conservative

- Microabrasion with 18% hydrochloric or 37.5% phosphoric acid and pumice especially for creamy-whitish defects may produce reasonable results. More profound enamel defects might be dealt with by combining microabrasion with bleaching as described below.
- ‘In office’ bleaching with 10% carbamide peroxide, for brownish-yellow defects may be considered *but only in adolescents* to avoid side-effects such as sensitivity. Some recent reports indicate better results following combination of bleaching agents with CCP-ACP (Mastroberardino et al. 2012).
- The etch-bleach-seal technique may occasionally help. Whilst the use of the resin infiltration technique in MIH incisors has been proposed recently, this is however, still controversial as initial studies have shown unpredictable results (Crombie et al. 2014).

(B) Operative

Removal of defective enamel and composite resin built-up using opaque resins to avoid excessive enamel reduction (Lygidakis et al. 2012). Use of adhesives as described in the following section.

References for the above are included in the reviews by Willmott et al. (2008) and Lygidakis (2010).

Treatment of posterior teeth

(A) Restorations

- Glass-ionomer or resin modified glass-ionomer cements restorations may be considered only as an intermediate approach until a definite restoration is placed (Fragelli et al. 2014).
- Restorations using resin composite are recommended for up to three surface build-ups.
- Cavity design should include removal of all the porous (but not necessarily discoloured) enamel, until resistance to the bur or to the probe is felt. Cavity design plays a crucial role, as defective enamel remnants compromise the final result.
- Adhesion to MIH enamel is possible despite various concerns, while self-etching adhesives appear, in vitro, superior compared to all-etch single-bottle adhesives. Alternatively, acetone containing adhesive systems have shown good performance in long-term clinical studies of resin composite restorations and sealants in MIH cases.

References for the above are included in the reviews by Willmott et al. (2008) and Lygidakis (2010).

(B) Full or partial coverage

- Preformed metal crowns can be used successfully in severely damaged MIH molars with high long-term survival rates. Non-precious metal, gold or tooth-coloured indirect onlays can be used in older children (Gaardmand et al. 2013), although their application is more time consuming and expensive.

References for the above are included in the reviews by Willmott et al. (2008) and Lygidakis (2010).

(C) Extraction of severely affected molars

- For severely affected molars, extraction might be considered at the dental age of 8.5–9 years. A thorough clinical, radiological and orthodontic examination and evaluation will help to identify particular contributory signs for acceptable results (Williams and Gowans 2003).
- Complete crown formation and initiation of the calcification of the bifurcation of the permanent second molar usually helps its eruption into the extracted FPM site, especially in crowded cases. Consideration may be given to further FPM extractions for balancing and compensation, although this should be seen in the context of the whole orthodontic situation (Williams and Gowans 2003).

References for the above are included in the reviews by Willmott et al. (2008) and Lygidakis (2010).

Module II: differential diagnosis

Molar incisor hypomineralisation may be mistaken for a range of other conditions. Understanding the key features that distinguish MIH from diffuse opacities, hypoplasia, amelogenesis imperfecta (AI) and carious white spot lesions is essential for accurate diagnosis and optimal management of individuals with MIH. This module aims to:

- Summarise the clinical presentation of MIH; and to list key features that differentiate MIH from other enamel defects and white spot lesions.

MIH Clinical presentation of MIH can vary depending on severity (Weerheijm 2004). White or creamy opacities reflect the mildest involvement whereas yellow–brown opacities indicate a greater degree of hypomineralisation. Following eruption and especially upon contact with the

opposing teeth, lesions may appear as irregular areas of post-eruptive breakdown, which can be mistaken for hypoplasia. The onset of caries can lead to development of atypical caries, on surfaces not usually prone to caries, often in the absence of caries in other teeth (Elfrink et al. 2009).

Diffuse opacities Diffuse opacities refer to hypomineralised defects of tooth enamel induced by fluoride ingestion during enamel development (Rozier 1994). Affected enamel has linear, patchy or confluent white opacities without a clear boundary. The lesions may range from barely perceptible striations in the enamel to gross disfigurement with almost complete loss of the external part of the enamel (FDI 1992). Severe pitting and larger enamel surface loss are post-eruptive characteristics that increase in severity with age.

MIH, with its demarcated lesion margins, is different to the diffuse opacities in fluorosis. In addition, the affected teeth in MIH/HSPM are very specific, whereas diffuse opacities will affect the dentition in a symmetrical, bilateral manner and the structure of the enamel is relatively caries resistant (Weerheijm 2004). Consideration of the patient's fluoride history together with the clinical signs may be helpful to distinguish fluorotic lesions from opaque lesions of mild severity.

Enamel hypoplasia Enamel hypoplasia describes quantitative defects, presenting as reduced enamel thickness including pits, grooves and/or irregular areas of missing enamel (FDI 1992). Clinically, hypoplasia may show great variation in the number of teeth affected and is rarely of regular shape (Elcock et al. 2006). The borders of hypoplastic enamel lesions are mostly regular and smooth, indicating a developmental, pre-eruptive lack of enamel matrix formation. In contrast, the margins of MIH/HSPM lesions with PEB are sharp and irregular due to the post-eruptive shearing of weakened enamel.

Amelogenesis imperfecta AI is a group of genetic developmental dental defects that results in enamel that is hypoplastic, hypomature or hypomineralised. Due to its diverse clinical presentation, some AI cases may be difficult to differentiate from MIH. However, the generalised involvement of both the primary and permanent dentitions and a common familial history can help distinguish AI. With a prevalence of 1 in 7000, the condition is also relatively uncommon compared to MIH (Crawford et al. 2007).

White spot lesions A white spot lesion (WSL) represents the early clinical signs of dental caries and is a result of the difference in the refractive index for light in demineralised and sound enamel. The lesions may appear chalkier, or more opaque than the adjacent sound enamel, and in more advanced lesions, an irregular rough surface (Fig. 1). WSL

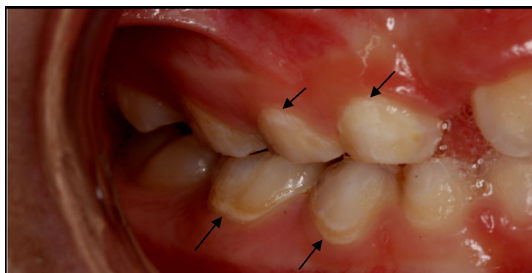


Fig. 1 White spot lesions

can be distinguished from MIH/HSPM because they occur in areas of plaque stagnation, such as the cervical/gingival margin of the tooth an area where enamel hypomineralisation rarely occurs (Seow 1997).

Module III: examination protocol and standardisation

Epidemiologic study of MIH has been complicated by the unavailability of an informative, well-accepted tool for summarising data gathered from field examinations. This module outlines the recently proposed standardised scoring method for MIH/HSPM observations recording by Ghanim et al. (2015). This module aims to:

- Provide an overview of the basic procedures involved in undertaking an oral health survey.
- Explain how MIH criteria are scored, including clinical presentation and extent.
- Provide recording sheets which facilitate the scoring of MIH in an oral health survey.

Procedures for clinical examination

Basic methods for oral health surveys

A trained examiner and (preferably) an assistant are required for the dental examination. The assistant should be positioned within easy hearing distance of the examiner. Instruments and other necessary material are placed on a table within easy reach of the examiner and assistant. The examiner and assistant should adhere to standard infection control protocol, including the use of protective glasses for both patient and clinicians and disposable gloves. If it is difficult to arrange for a dental assistant, the examiner may carry out the oral examination with the aid of a voice recorder device. Later, using the audio recording, a written record sheet is completed. The reader is referred to Oral Health Surveys–Basic Methods 5th ed. (WHO 2013), for further detail regarding standard procedures for oral health surveys.

Table 1 MIH/HSPM clinical data recording sheet (for clinical status, defect extent and tooth eruption status)—first permanent molars, permanent incisors and second primary molars (short form)

UPPER RIGHT					UPPER LEFT			
	16	55	12	11	21	22	65	26
Tooth								

LOWER RIGHT					LOWER LEFT			
	46	85	42	41	31	32	75	36
Tooth								

Table 2 MIH/HSPM clinical data recording sheet (for clinical status, defect extent and tooth eruption status)—permanent and primary dentitions (long form)

Surface	UPPER RIGHT		55	54	53	52	51	61	62	63	64	65	UPPER LEFT	
	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Buccal (labial)														
Occlusal (incisal)														
Palatal														

Surface	LOWER RIGHT		85	84	83	82	81	71	72	73	74	75	LOWER LEFT	
	47	46	45	44	43	42	41	31	32	33	34	35	36	37
Buccal (labial)														
Occlusal (incisal)														
Lingual														

Charting Criteria

Clinical status criteria (Short form)

- 0 = No visible enamel defect.
- 1 = Enamel defect, not MIH/HSPM.
- 2 = White/creamy or yellow/brown demarcated opacities.
- 3 = PEB.
- 4 = Atypical restoration.
- 5 = Atypical caries.
- 6 = Missing due to MIH/HSPM.
- 7 = Cannot be scored*.

Clinical status criteria (Long form)

- 0 = No visible enamel defect.
- 1 = Enamel defect, not MIH/HSPM
 - 11 = diffuse opacities
 - 12 = hypoplasia
 - 13 = amelogenesis imperfecta
 - 14 = hypomineralisation defect (not MIH/HSPM)
- 2 = demarcated opacities
 - 21 = White or creamy demarcated opacities
 - 22 = Yellow or brown demarcated opacities
- 3 = PEB
- 4 = Atypical restoration
- 5 = Atypical caries
- 6 = Missing due to MIH/HSPM
- 7 = Cannot be scored*

Lesion extension criteria (Index teeth only, scores 2 to 6)

- I = less than 1/3 of the tooth affected.
- II = at least 1/3 but less than 2/3 of the tooth affected.
- III = at least 2/3 of the tooth affected.

Eruption status criteria**

- A = not visible or less than 1/3 of the occlusal surface or of the crown length of incisor is visible.
- B = fully erupted or at least 1/3 but less than the total occlusal surface erupted and/or less than the total crown length of the incisor visible.

*Tooth with extensive coronal breakdown and where the potential cause of breakdown is impossible to determine.

**A missing tooth extracted due to MIH/HSPM *no need* to report its eruption status.

Examination for MIH

A dental chair with a dental light source is preferable, otherwise the subject is asked either to lie flat on a suitable table/desk or to sit in a chair with the head resting at 45° angle to the ground. For young children, the ‘knee to knee’ method is an option. The examiner should follow a consistent, systematic method for assessing the mouth for MIH, similar to that used for carious lesion detection. The recommended approach is to commence with index teeth in the maxillary right region (Quadrant 1) and proceed around to the maxillary left index teeth (Quadrant 2) and then continue with the mandibular arch beginning with the most posterior index tooth in the left quadrant (Quadrant 3) before finally moving around to the last index tooth in the mandibular right quadrant (Quadrant 4). If a voice recorder device is used, the starting point, midline and end of each quadrant should be named to aid tracking. Only labial/buccal, lingual/palatal and occlusal/incisal surfaces are required to be scored. Long and short data recording sheets as described by Ghanim et al. (2015) are recommended for use to record the examiner’s grading scores. Tables 1 and 2 delineate the sheets with their scoring points for each of MIH/HSPM clinical status, defect extent and tooth eruption status. The short charting sheet is basically used to score MIH/HSPM index teeth only namely FPMS, permanent incisors and SPMS, whilst the long charting sheet is used to score all teeth presented at the time of examination.

- Participants are advised to brush their teeth before examination.
- Teeth should be examined wet (i.e. not air-dried before scoring), however, if needed, clean cotton-rolls may be used to clean the tooth surface to better visualise a tooth surface.
- Transillumination/fibre-optic light source with a disposable non-magnifying, front surface mirror head is recommended, as ambient room lighting is inadequate for accurate diagnosis.
- A ball-ended explorer can be used to gently draw across the tooth surface to check for surface irregularity and cavitation, being careful not to damage the tooth surface.

Criteria for scoring MIH/HSPM

The following key features, as listed in a consensus statement by the European Academy of Paediatric Dentistry are used to identify teeth affected by MIH as well as HSPM (Weerheijm et al. 2003; Ghanim et al. 2015). The information below is considered sufficient for training purposes in Module V; further details however can be obtained from Ghanim et al. (2015).

Demarcated opacities

- Having a clearly defined boundary from adjacent healthy enamel.
- Alteration in enamel translucency.
- Normal thickness of enamel.
- Colour ranges white–cream–orange–yellow–brown.

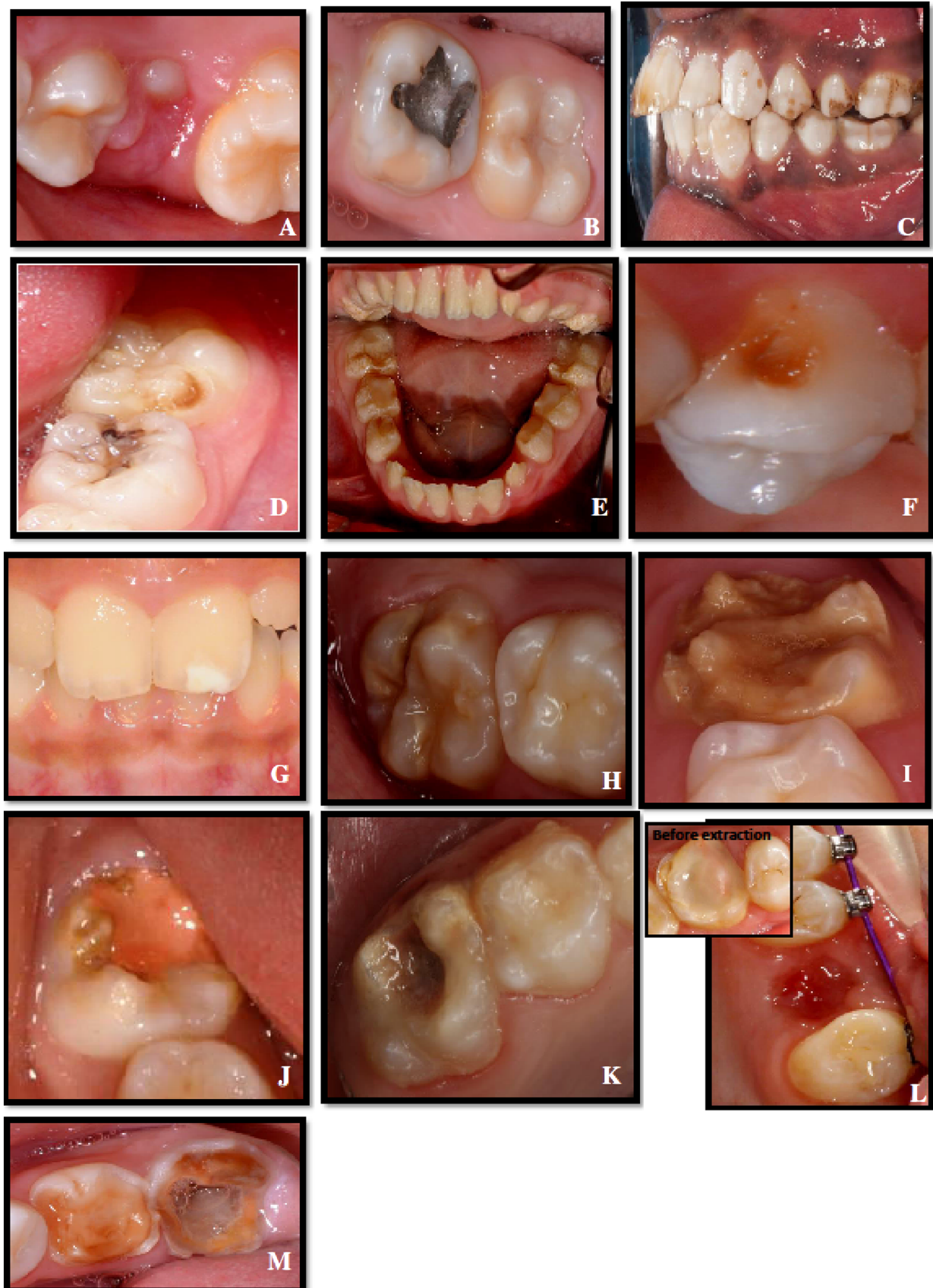


Fig. 2 A–M Various presentations of enamel defects recommended for use as reference photographs with long and short charting formats

Post-eruptive enamel breakdown (PEB)

- Loss of enamel from an initially formed surface after tooth eruption.
- The loss is often associated with a pre-existing demarcated opacity.
- Is characterised by sharp and irregular borders.

Atypical restoration

- Frequently extends to the buccal and palatal/lingual surfaces.
- Frequently associated with an opacity at the restoration margin.
- For incisors, there may be a buccal restoration not related to trauma.
- Often seen in otherwise caries-free mouths.

Atypical carious lesions

- The size and form of the carious lesion do not match the present carious lesion distribution in the child's mouth.
- The existing carious lesion is usually associated with demarcated opacities.

Extraction of molar due to MIH

- Absence of a FPM or SPM in an otherwise sound dentition and associated with opacities, PEB, atypical restorations or atypical carious lesion in at least one FPM or SPM.

Evaluation of MIH/HSPM defect extent

The extent of the defect in a tooth is measured according to the surface area of the enamel affected: less than 1/3 of a tooth surface (I); at least 1/3 but less than 2/3 (II); at least 2/3 of the tooth surface (III).

Scoring considerations

- In order for a surface to be included in the examination, at least 1/3 of the surface must be visible, otherwise it is assigned *Code A*.
- For a missing tooth extracted due to MIH/HSPM there is *no need* to report its eruption status.
- When two MIH/HSPM lesions exist per surface (example, creamy and brown opacities) the more severe score is assigned.
- Record extent of MIH/HSPM lesions.
- To record lesion extent, visually condense all areas affected by a defect to sum the extent of the lesion and then compare the total area affected to the total visible tooth surface area.

Table 3 Short and long form scores for Fig. 2A–M

Image	Tooth no.	Image description		Clinical status (code) ^a (code) ^b	MIH/HSPM lesion extent ^d
		Surface examined ^c	Eruption status		
A	25	Palatal	A		
B	46	Occlusal	B	0	
C	26	Buccal	B	1 11	
D	36	Buccal	B	1 12	
E	36	Buccal	B	1 13	
F	15	Buccal	B	1 14	
G	12	Labial	B	2 21	I
H	26	Occlusal	B	2 22	III
I	26	Occlusal	B	3 ^d	III
J	16	Occlusal	B	4 ^d	III
K	16	Occlusal	B	5 ^d	III
L	36	Occlusal		6 ^d	III
M	46	Occlusal	B	7 ^d	

^a Short form, ^b Long form, ^c Long form only, ^d Both forms

- When uncertainty exists regarding rating MIH/HSPM lesion severity (i.e. clinical status and extent) record the less severe rating.
- A sealant associated with demarcated opacities should not be considered as an atypical restoration, only demarcated opacities to be scored.
- Record eruption status first, followed by clinical status and finally, lesion extent, each separated by a comma (,).

Figure 2 and Table 3 illustrate clinical examples and readings of the different visual presentations of demarcated hypomineralised lesions as a standardisation exercise. Other enamel defects are included in order to help the trainee to distinguish between MIH/HSPM and other enamel defects.

Evaluation of severity

The severity of MIH can be deduced from the scores recorded and does not need to be identified at the time of the examination.

A tooth diagnosed with colour changes only (i.e. creamy, white, yellow, orange or brown) is considered as ‘Mildly affected’.

A tooth diagnosed with loss of enamel (PEB), and/or atypical restoration/caries/missing is considered as ‘Severely affected’.

Module IV: examination of reliability (kappa statistic)

The quality of the data from population surveys of oral health depends critically upon the ability of the clinical examiners to apply the diagnostic criteria and to do so consistently over time (intra-examiner reliability). It is usual to find that during the initial assessment of examiner reliability an over- or under-diagnosis of the defects may take place. In such instances correction of the problem can be made by reviewing the diagnostic criteria and the photographs. Further calibration exercises must be performed until satisfactory reliability is obtained. This module aims to:

- Provide researchers a guide for computing intra-observer agreements.
- Describe how to read and interpret kappa values.

It is proposed that the user has already reviewed and comprehended the relevant diagnostic criteria and becomes acquainted with the standardisation examples. A calibration example on MIH is included in this module and selected randomly.

How to calculate kappa statistic

Kappa is a statistical measure of agreement in ratings between two or more observers (inter-observer reliability) or between ratings made by a single observer on two or more occasions (intra-observer reliability). Kappa is such a measure of “true” agreement. It indicates the proportion of agreement beyond that expected by chance, it takes the form (Daly and Bourke 2000):

$$\frac{(\text{observed agreement} - \text{expected agreement})}{(1 - \text{expected agreement})}$$

Trainees who grade the clinical photographs available in Module V (*Exercise Forum*) may attempt to compute their intra-observer reliability. The following is an example for intra-observer reliability calculation using PSPP software—a free software program for the proprietary program SPSS® (<http://www.gnu.org/software/pspp/pspp.html>). However, any available statistical software can be used for this purpose.

- Assuming that all of the images in Module V were rated by the trainee twice with a time interval of one week between the two readings, scoring data for MIH/HSPM lesions clinical status (or extent) are entered into PSPP as shown in the figure below.

Case	Session_1_MIH_Clinical_Status	Session_2_MIH_Clinical_Status
1	3.00	3.00
2	12.00	12.00
3	14.00	14.00
4	21.00	21.00
5	13.00	12.00
6	5.00	5.00
7	4.00	4.00
8	3.00	3.00
9	11.00	11.00
10	3.00	3.00
11	7.00	7.00
12	22.00	21.00
13	21.00	21.00
14	12.00	12.00

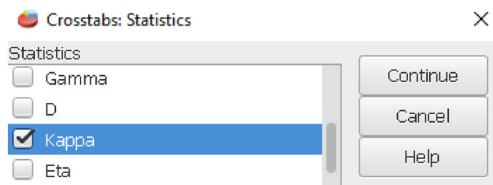
- To analyse this data, choose Analyze/Descriptive Statistics/Crosstabs.

Case	Session_1_MIH_Clinical_Status	Session_2_MIH_Clinical_Status
1	3.00	
2	12.00	
3	14.00	
4	21.00	
5	13.00	
6	5.00	5.00
7	4.00	4.00

- Place *Session 1* in the Row box and *Session 2* in the Column box.



- Click on the Statistics button, select the box next to Kappa and Continue.



- Click OK to display the results for the Kappa test as shown here:

Symmetric measures.

Category	Statistic	Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Measure of Agreement	Kappa	.835	.105	8.363	.000
N of Valid Cases		29			

The results of the intra-rater analysis are $Kappa = 83.5$ with $p < 0.001$. This measure of agreement is statistically significant and convincing. As a rule of thumb, values of Kappa from 0.41 to 0.60 are considered moderate, 0.61–0.80 substantial, and 0.81 onwards is considered outstanding (Landis and Koch 1977). If scoring is to be carried out over three sessions the average of kappa values is to be determined.

Module V: exercise forum

Standardised measurements of outcomes are critical for epidemiological surveys. This exercise forum is designed to assist with training and calibration of examiners prior to undertaking any such research.

Exercise forum instructions

- For the purpose of scoring use the charting form illustrated in Table 4.
- To simulate the use of the short charting form, score images for MIH/HSPM index teeth only (i.e. FPM, SPM and permanent incisors), images with non-index teeth are clearly annotated and should be excluded. However, when employing the long form, all images of index and non-index teeth should be scored.
- The scoring system for short and long forms can be found under “*Charting Criteria*” (Tables 1, 2—module III).
- Score the entire tooth surface as shown in the image, as annotated in the image title and/or indicated by a circle.
- For each image you are required to score eruption status, clinical status and lesion extent (if required), each separated by a comma (.). However, there is no need to report the eruption status for a tooth extracted due to MIH/HSPM.
- Allow approximately 30–60 s to score each image.
- Please refer to module III “*Scoring Considerations*” for further instructions.
- It is recommended to repeat the scoring process three times, with at least one week interval between each scoring session. Use a new scoring sheet for each scoring session and do not alternate between the long and short forms.
- Maintain the same scoring conditions throughout all of the sessions (i.e. room lighting, computer screen brightness, score timing per image and use of spectacles, etc.).
- For each session to evaluate the accuracy of your readings, there are “*Reference Standard Readings*” provided at the end of this module to compare your readings with.
- For the purpose of calculating intra-examiner reliability please refer to module IV.

Table 4 MIH/HSPM calibration form for module V exercise

Date:	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Session:	1	2	3
	Day			Month			Year					(Please circle)		
Image number	Labial/buccal					Palatal/lingual					Occlusal/incisal			
1														
2														
3														
4														
5														
6														
7														
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29														



Image 1 Score labial. (Molar teeth have similar presentation)



Image 2 Score labial



Image 3 Score buccal (non-index tooth)

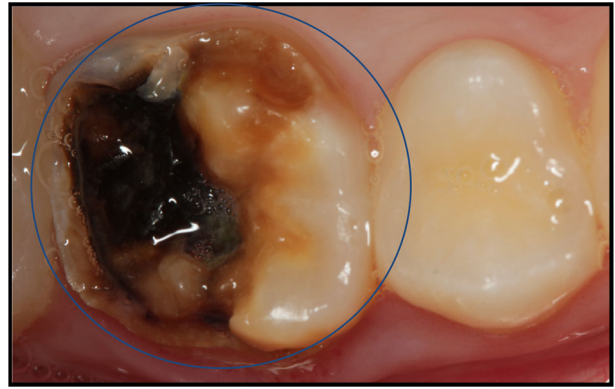


Image 6 Score occlusal



Image 4 Score labial. (Molar teeth have similar presentation)



Image 7 Score occlusal



Image 5 Score labial



Image 8 Score buccal



Image 11 Score occlusal



Image 9 Score labial

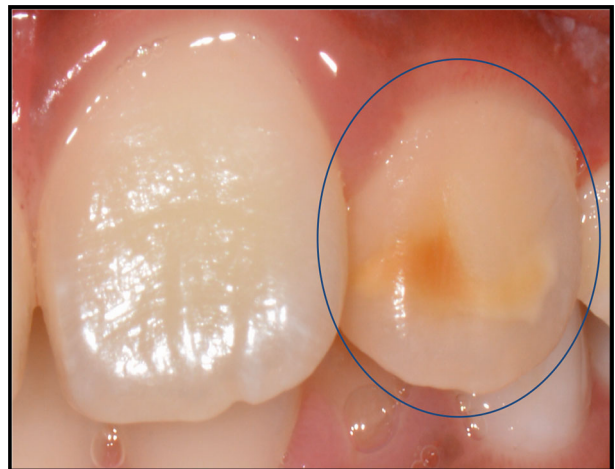


Image 12 Score labial. (Molar teeth have similar presentation)

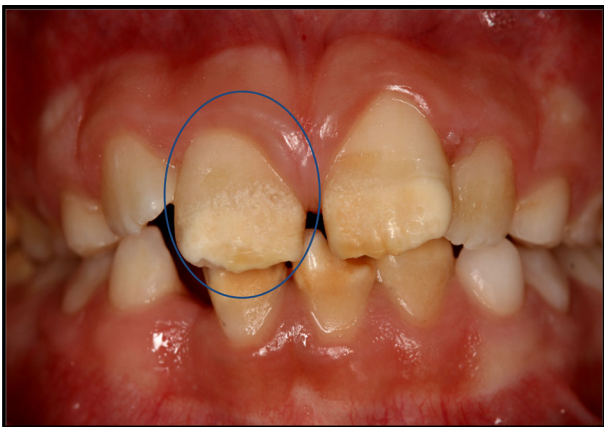


Image 10 Score labial. (Molar teeth have similar presentation)

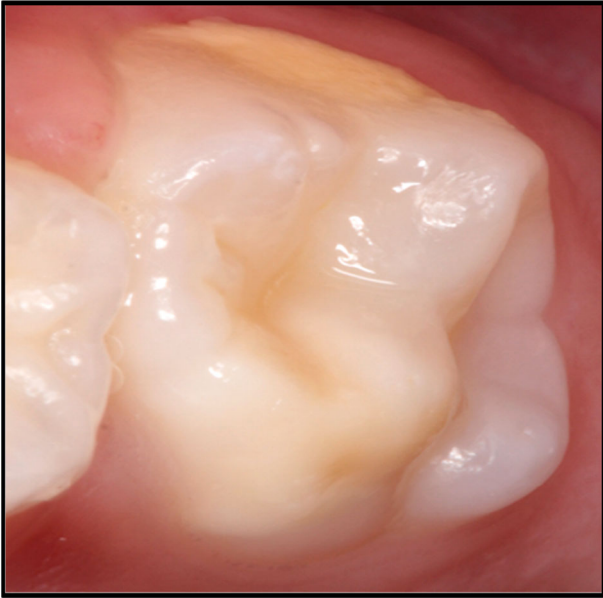


Image 13 Score occlusal

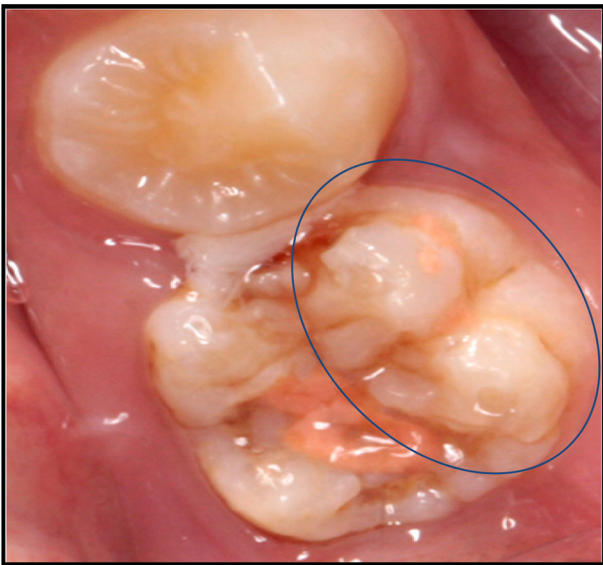


Image 14 Score buccal

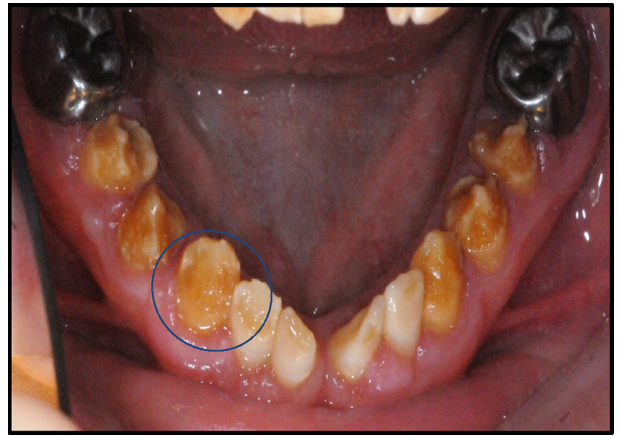


Image 15 Score labial (non-index tooth)

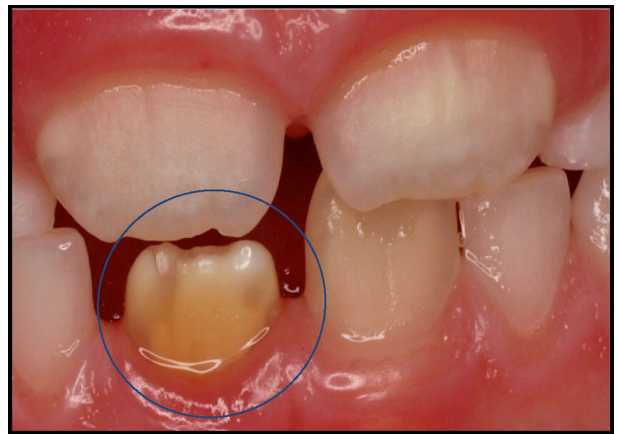


Image 16 Score labial. (Molar teeth have similar presentation)

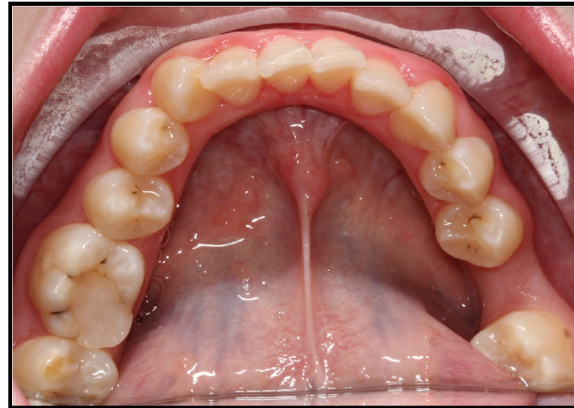


Image 17 Score tooth #36



Image 18 Score labial. (Molar teeth have similar presentation)

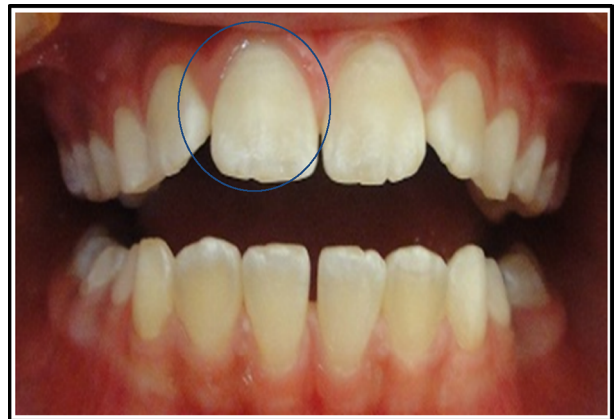


Image 20 Score labial

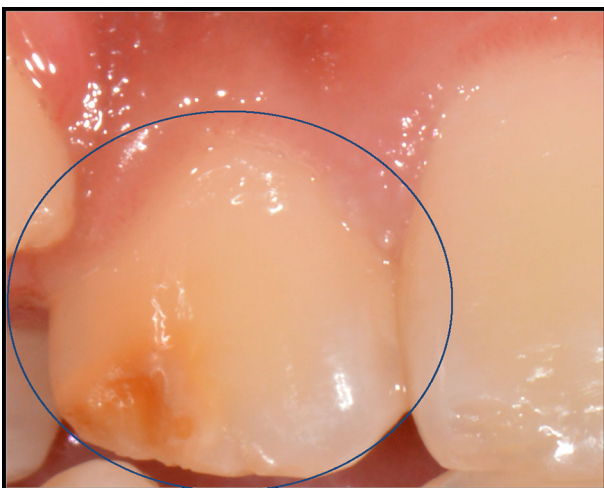


Image 19 Score labial. (Molar teeth have similar presentation)



Image 21 Score occlusal

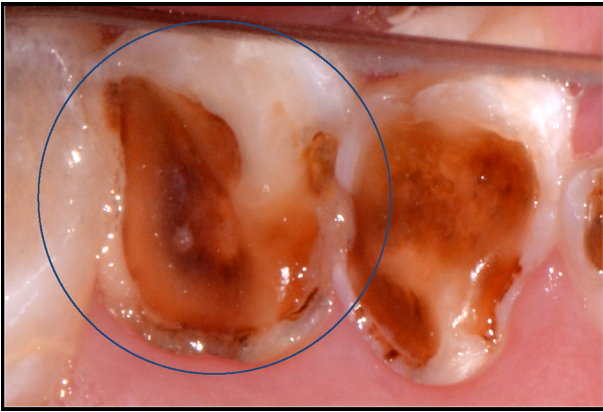


Image 22 Score occlusal

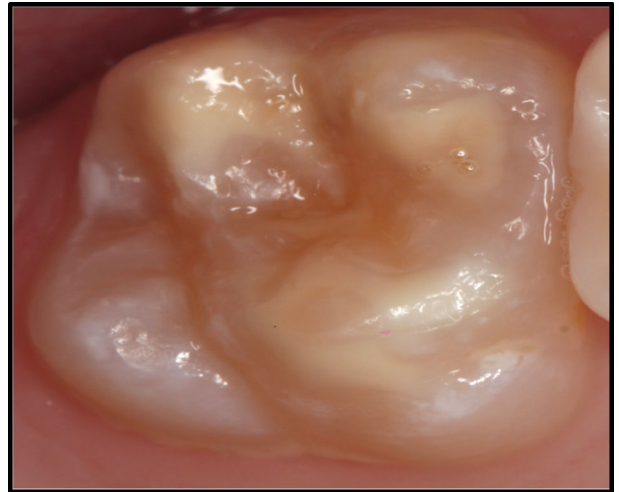


Image 25 Score occlusal

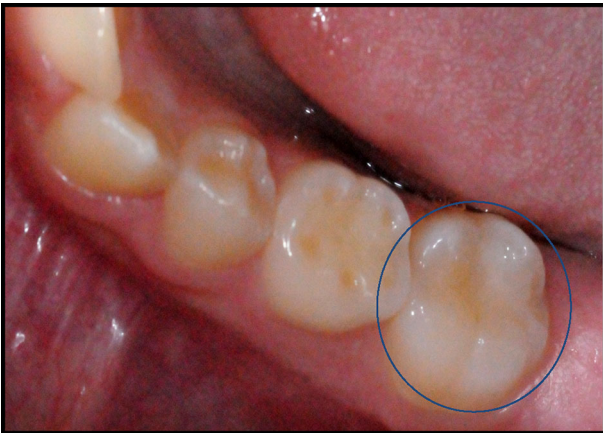


Image 23 Score occlusal



Image 26 Score labial. (Molar teeth have similar presentation)

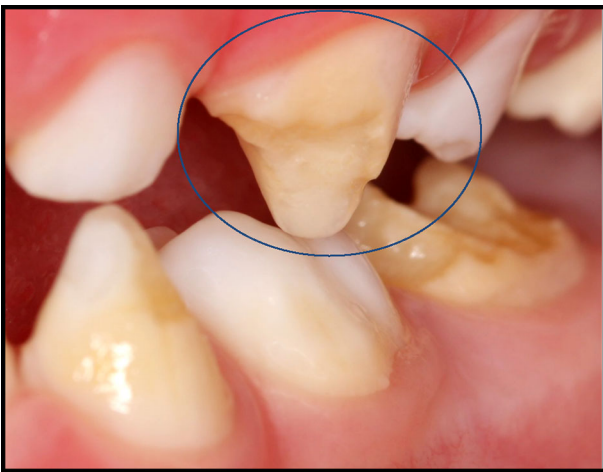


Image 24 Score labial (non-index tooth)



Image 27 Score occlusal

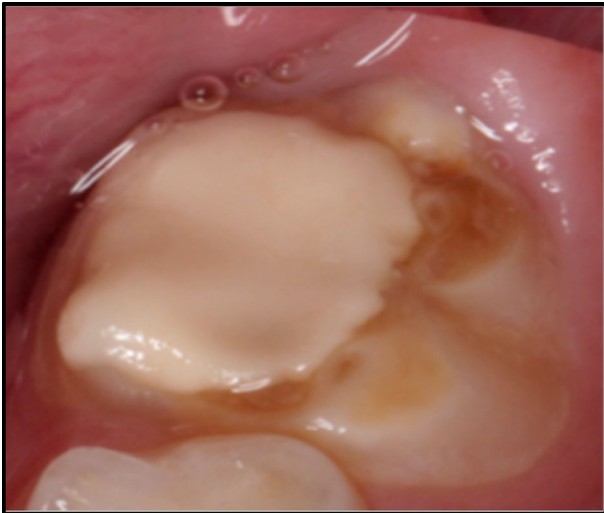


Image 28 Score occlusal

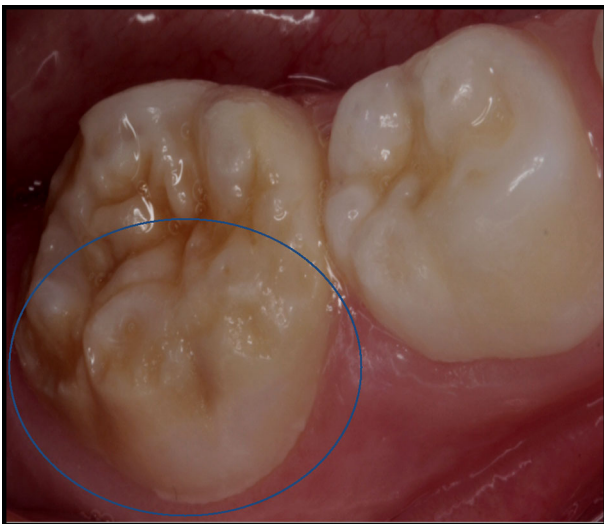


Image 29 Score buccal

Reference standard readings: Image number, eruption status, clinical status for short form (long form), MIH/HSPM lesion extent.

1) B, 3, II; 2) B, 1(12); 3) B, N/A (14); 4) B, 2(21), I; 5) B, 1(13); 6) B, 5, III; 7) B, 4, III; 8) B, 3, III; 9) B, 1(11); 10) B, 3, II; 11) B, 7; 12) B, 2(22), I; 13) B, 2(21), I; 14) B, 1(12); 15) B, N/A (13); 16) B, 2(22), III; 17) 6, III; 18) B, 2(22), II; 19) B, 3, I; 20) B, 1(11); 21) B, 4, III; 22) B, 7; 23) B, 0; 24) B, N/A (14); 25) B, 2(22), II; 26) B, 2(21), I; 27) A; 28) B, 4, III; 29) B, 3, III.

N/A: not applicable

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Compliance with ethical standards

Conflict of interest Dr. Aghareed Ghanim declares that she has no conflict of interest. Dr. Mihiri Silva declares that she has no conflict of interest. Dr. Marlies Elfrink declares that she has no conflict of interest. Dr. Nick Lygidakis declares that he has no conflict of interest. Prof. Rodrigo Mariño declares that he has no conflict of interest. Dr. Karin Weerheijm declares that she has no conflict of interest. Prof. David Manton declares that he has no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors. Approval was gained to use images from legal guardians of children involved.

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