ORIGINAL ARTICLE

Use of Images and Clinical Experience to Calibrate Dental Surgeons for the Diagnosis of Molar Incisor Hypomineralization

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ABSTRACT

Objective: To evaluate an imaging protocol for use as a diagnostic and calibration tool for dentists before and after practical activity. **Material and Methods:** Thirty photos of children's teeth with or without changes in dental enamel were selected and evaluated by a group of experienced dentists previously calibrated to establish the diagnosis defined as the gold standard. After instructions, the images were shown to a group of postgraduate dentists for free identification of dental changes. Subsequently, a lecture on molar incisor hypomineralization (MIH) was carried out, and, at 14 days and all calibration was performed using the criteria previously. The retest was performed at 28 days. After experience in clinical activity in the following two weeks, the post-test was performed at 49 days. Data were analyzed using Cohen's *kappa* coefficient. **Results:** Theoretical learning on the subject showed low inter-examiner agreement when the diagnosis of defects was made from images obtained from intraoral photographs. After clinical practice, there was greater intra-examiner agreement. After theoretical training, dentists started to identify different types of enamel alteration, although with low agreement between them. **Conclusion:** Clinical experience in theoretical and imaging training favored the identification of defects. However, it is necessary to improve the protocol to establish a reliable and viable diagnostic method for calibration in MIH.

Keywords: Diagnosis; Education, Professional; Dental Enamel Hypoplasia; Calibration.

Introduction

Defined as hypomineralization that affects the permanent first molars often associated with affected incisors, molar incisor hypomineralization (MIH) is characterized by major clinical problems, making the treatment of these teeth difficult because first molars with this condition are fragile and are susceptible to caries disease [1]. Enamel defects with MIH are characterized by alterations of different severities of hypomineralization, which follow the natural incremental lines of enamel formation, in which the more occlusal outer part is more affected than, the deeper part of the defect, located cervically [2]. The combined prevalence of MIH is 12.9% [3] to 14.2% [4] in the world population and 13.48% in Brazil [5], which can reach 40.2% [6]. However, many dentists still don't know the different clinical manifestations of the disease.

According to a recent systematic review, the etiology of MIH is still uncertain due to the lack of consistency and confounding factors of scientific evidence, in which a limited number of studies have reported associations between perinatal and neonatal changes and the development of MIH, such as alcohol consumption, fever and medications in pregnancy, as well as childhood illnesses [7]. MIH also has a genetic component, which results in lower expression of some genes during the formation of tooth enamel [8]. More recently, it has been hypothesized that an interaction between genetic factors and environmental modifiers may be involved in the occurrence of MIH [9]. Due to the period of concomitant mineralization of the deciduous second molars, first molars and permanent incisors, and the prevalence of MIH-type opacities in 2 or more teeth, the occurrence of these opacities in deciduous second molars can be termed as hypomineralization of the second primary molars (HSPM) [10,11] and represents an important predictor of the occurrence of MIH [12,13].

Due to the common subjectivity in the diagnosis of most oral pathologies, it is common that there are variations between oral exams repeated by the same professional (intra-examiner) or between professionals that make up the team (inter-examiner) [14,15]. To minimize these variations, it is recommended that calibration be carried out between examiners to ensure uniformity and consistency in the interpretation, understanding and application of the criteria and codes determined to assess the disease [14-16]. A well-defined training and calibration method is extremely important for the development of scientific studies and field research [17]. Team training processes offer the opportunity to reconcile different opinions resulting in better agreement among its participants [18]. If significant discrepancies are detected, the assessment should be repeated and the results reassessed [14,15].

The agreement rate between examiners is a simple method to reveal the results obtained in the calibration processes; however, it does not take into account the agreement due to chance [15]. In this context, the *kappa* test has been widely used to adjust the percentage agreement statistic [14]. We believe that the use of images associated with clinical experience may favor MIH diagnosis training. Thus, the aim of this study was to assess a protocol for use as a calibration instrument for dentists for the diagnosis of MIH. The protocol was developed and tested at the Dental Enamel Clinic at the School of Dentistry of Ribeirão Preto at University of São Paulo, Brazil.

Material and Methods

Initially, the study was submitted and approved by the Research Ethics Committee of the School of Dentistry of Ribeirão Preto at University of São Paulo (CAAE 12161019.2.0000.5419). To support the preparation of the MIH protocol, an international literature review was carried out in the PubMed database, with articles in English, to identify existing evidence on the subject and the development of calibration protocols.

A screening was carried out with children from the city of Santa Rosa do Viterbo (SP, Brazil), selected those with alterations in tooth enamel and referred to the School of Dentistry of Ribeirão Preto, University of São Paulo. These children were assisted in the discipline of the Graduate Program in Pediatric Dentistry in the discipline *"Clínica do Esmalte Dental"*, where the clinical examination and diagnosis were performed. After the parents signed the Informed Consent Form, the children were photographed with a professional digital camera (Canon EOS Rebel T6i, Tokyo, Japan).

To constitute the calibration protocol, 30 photographs were selected. Of these, 17 images were related to MIH (atypical caries lesion, demarcated opacity, post-eruptive fracture, atypical restoration), 8 with non-MIH enamel alterations (amelogenesis imperfecta, hypoplasia, diffuse opacity, non-HMI hypomineralization), 4 had teeth no clinically visible changes and 1 not diagnosable (very little erupted tooth).

The images selected for the protocol were evaluated by a group of 10 dentists specialized in Pediatric Dentistry, trained in MIH diagnosis and previously calibrated to establish a diagnosis defined by consensus as the gold standard. Differences were discussed with the group until a 100% agreement was reached between them. In situations where the agreement has not occurred in 100% of cases, images were replaced by another's that presented the same clinical condition.

The mapping criteria (scores) were based on the protocol by Ghanim et al. [10,19], with adaptations to the clinical reality of the patients seen (Table 1). The exercises were performed following the instructions based on Ghanim et al. [19] and adapted as observed in Table 2.

Table 1. Mapping criteria (scores) adapted from Ghanim et al. [10,19].

Criteria
Eruption Status
A = non-visible tooth or less than 1/3 of the occlusal surface (or incisor length) visible.
B = visible tooth or greater than 1/3 of the occlusal surface.
Clinical Status
0 = No DEDs
1 = Defective enamel, but not MIH/HSPM
1c = Caries[1]
11 = Diffuse opacities
12 = Hypoplasia
13 = Imperfect Amelogenesis
14 = Hypomineralization (not MIH/HSPM)
2 = Demarcated Opacities
21 = White or cream demarcated opacity
22 = Yellow or brown demarcated opacity
3 = Post-eruptive fracture (PEB)
3e = enamel fracture
3d = Detin fracture
4 = Atypical restoration
5 = Atypical caries lesion
6 = Lost by MIH/HSPM
7 = Impossible to be rated[2]
Instructions
• Mark tooth surface on MIH/HSPM if at least 1/3 or more of tooth/surface is visible. Otherwise, use code A and there is no need to mark the clinical status.
• An enamel defect of one millimeter or less in diameter is considered healthy.
• Use codes 2 through 6 only for MIH/HSPM indexed teeth; i.e., permanent incisors, permanent first molars and deciduous second molars.
• Codes 0 and 1 are applicable to all teeth, including indexed ones.
• When there is doubt regarding the classification of the injury, the less severe classification should be recorded.

- When there is more than one MIH/HSPM lesion per surface, visually combine all areas affected by the lesion and mark the most severe presentation.
- ¹Tooth with caries (not related to MIH/HSPM) mark with code 1c.
- ²Tooth with extensive coronary destruction and where the potential cause of fracture is impossible to determine.

Table 2. Instructions for performing the calibration exercise.

Instructions
1. Answers must be recorded in an appropriate form.
2. Images will be specified by title, caption and/or indicated by a circle.
3. For each image, it will be necessary to determine the eruption status and the clinical status, separated by a comma (,).
4. The registration time will be approximately 30 seconds for each image.
5. The same physical conditions will be maintained for all calibration exercises (room lighting, projector screen brightness, image count time, etc.).
6. The exercises will be compared and inter- and intra-examiner reliability calculations (*kappa*) will be performed.

After instructions, the images were shown to a group of dentists in post-graduation (n=7), as a pre-test for diagnostic assessment, on the first day of the study [18,20]. The images were projected and a specific form was filled in for free identification of the alterations presented in the teeth. In the second week, a training program on calibration in relation to the diagnosis of MIH was carried out. This training was applied by an experienced calibrator and consisted of two lectures on the subject, available on a digital platform for one week, using images and theoretical content with an updated scientific basis. Etiology, diagnosis, treatment and training for filling out the calibration exercise form were addressed.

In the third week, the students performed the first calibration. The images with marked regions of interest were randomly displayed using the Nearpod digital platform to perform an interactive calibration and facilitate obtaining the results. After two weeks, the participants discussed the diagnosis of each image for comparison with the previously established gold standard, and the second calibration was also performed with random redistribution of images on the digital platform. Over the next two weeks, the group performed diagnoses and clinical care on children who had various dental enamel defects, with a predominance of MIH. After this period, a post-test was also performed with a random display on the digital platform to verify the results of the calibrations associated with the clinical experience in the discipline. The adopted scores were the same in all activities. The chronological scheme of activities is shown in Table 3.

Table 3. Activity schedule for testing the calibration protocol in MIH.

Week	Activity
1st	Pre-test
2nd	Theoretical training
3rd	1st Calibration
4th	Break
5th	Discussion of the gold standard and 2nd Calibration
6th	Clinical care
7th	Clinical care
8th	Post-test

The data obtained were evaluated to compare divergences and agreements in comparison with the gold standard. Cohen's *kappa* coefficient was used to analyze all MIH diagnostic scores and to assess agreement in inter- and intra-examiner responses. The interpretation of the *kappa* coefficient indices determines the classification of the calibration according to the degree of agreement obtained, being proposed that: <0 = poor

agreement; 0 to 0.2 = slight agreement; 0.21 to 0.4 = fair agreement; 0.41 to 0.6 = moderate agreement; 0.61 to 0.8 = substantial agreement; 0.81 to 1 = almost perfect agreement [21,22].

Results

In the pre-test (assessment with discursive responses), there was wide variation in diagnoses between individuals, demonstrating the subjectivity of the assessments, mostly classifying MIH lesions as other alterations, such as amelogenesis imperfecta, fluorosis and non-MIH hypomineralization.

In the first calibration, after the video lessons, there was 46.2% agreement and 53.8% disagreement with the responses established as the gold standard. Individually, the agreement in the answers ranged from 36.7% to 66.7% among the participants. The inter-examiner *kappa* index showed variations, with almost all being less than or equal to 0, revealing poor agreement between the participants. Only one student had a fair agreement (κ =0.33) (Table 4).

Table 4. Agreement and *kappa* coefficient (κ) results after the first calibration (after video classes).

Criteria	First Calibration						
Participants	1	2	3	4	5	6	7
Total*	11	12	15	13	11	15	20
Hit (%)	36.7	40	50	43.3	36.7	50	66.7
κ inter-examiner	-0.27	-0.2	0	-0.13	-0.27	0	0.33

*For the gold standard, the total is equal to 30.

In the second calibration, after image-by-image discussion, 62.9% of agreement and 37.1% of disagreement with the gold standard were obtained, and agreement in the responses varied, individually, from 40% to 80% between the participants. Regarding the inter-examiner *kappa* index, only one participant had a negative value, two participants had values from 0 to 0.2, one participant had 0.27 and the others ranged between 0.47 and 0.6. Thus, a moderate agreement between the group responses was observed for almost half of the participants. On the other hand, intra-examiner agreement was found to be poor or slight, as the highest index obtained was 0.13 (Table 5).

Table 5. Agreement and *kappa* coefficient results after the second calibration (after discussion with gold standard image-by-image).

Criteria	Second Calibration						
Participants	1	2	3	4	5	6	7
Total*	12	17	24	23	22	19	15
Hit (%)	40	56.7	80	76.7	73.3	63.3	50
κ inter-examiner	-0.2	0.13	0.6	0.53	0.47	0.27	0
Agreement	36.7	56.7	56.7	46.7	30	40	50
κ intra-examiner	-0.27	0.13	0.13	-0.07	-0.4	-0.2	0

*For the gold standard, the total is equal to 30.

In the post-test, after clinical treatment of patients with MIH, there was 69.5% agreement and 30.5% disagreement with the gold standard, with only one participant showing agreement below 70%. There was a fair inter-examiner agreement in almost all cases, in which one participant had a *kappa* index of 0.27 and five participants had 0.4. In addition, there was a moderate agreement for one participant (κ =0.47). Regarding intra-examiner agreement, there was a slight agreement for three participants, with indices of 0.13 and 0.2; moderate agreement for three other participants, with indices of 0.47 and 0.53; and substantial agreement for one participant (κ = 0.7) (Table 6).

Table 6. Results of agreement and *kappa* coefficient in the post-test (after clinic).

Criteria	Post-test						
Participant	1	2	3	4	5	6	7
Total*	21	21	21	22	21	19	21
Hit (%)	70	70	70	73.3	70	63.3	70
κ inter-examiner	0.4	0.4	0.4	0.47	0.4	0.27	0.4
Agreement	56.7	73.3	76.7	76.7	70	60	60
κ intra-examiner	0.13	0.47	0.53	0.53	0.7	0.2	0.2

*For the gold standard, the total is equal to 30.

Discussion

Population's oral health is impacted by demographic conditions and oral conditions have worsen worldwide and leading to an increase in untreated dental problems [23]. In this context, and considering the relevant prevalence of MIH, the adequate training of dentists to identify and manage this enamel defect is essential since the wrong diagnosis can lead to an increase in individual and collective losses as related oral problems, decreased quality of life, psychological damage and greater need for dental and general health support for the population [24-27].

According to the World Health Organization, in training for epidemiological data collection, it is recommended that an experienced professional be defined in relation to the diagnostic methodology used to act as a gauge in epidemiological training [16]. This professional must analyze at least 25 individuals, who must also be evaluated by the examiners. In addition, the studies produced a valid and reliable tool for evaluating the MIH, providing training for professionals on this alteration and assisting in large epidemiological studies [19,28]. In this sense, the elaboration of the protocol sought, through photographs, enough samples so that there was no prejudice in the assessment of the group of dentists submitted to calibration.

When evaluating the professional calibration process, the results of the exams must be compared and if the variability is considerable, it is recommended that the examiner review the diagnostic criteria and carry out additional exams until acceptable consistency is reached. The evaluation of the consistency of each examiner (intra-examiner reproducibility) is made from the repetition of the exams and the subsequent comparison between each pair of exams [14], which supported the random use of the imaging protocol at each calibration step.

The *kappa* coefficient is recognized as a robust statistical method used to assess reliability between examiners among themselves and among the tested group. The indices used assume values ranging from -1 to +1, considering the occurrence of hits due to chance [20]. The closer to 1, the more agreement is characterized and the closer to zero, the greater the indicator of merely random agreement [29].

The analyzes showed better intra-examiner results in the post-test when, in addition to theoretical training and discussion of the gold standard, the participants also clinically experienced the diagnosis and treatment of enamel and MIH defects. This show that the clinical experience enabled the establishment of self-confidence to the examiners, promoting, for the most part, the ratification of the diagnosis that was previously based on the theoretical content. In addition, the increased agreement in responses compared to the gold standard highlights the importance of clinical experience in determining the proper diagnosis of dental alterations.

The clinical experience, after the dynamics of learning in MIH diagnosis, is essential to fix the various aspects of this defect and to train professionals to differentiate it from other alterations, especially when the MIH stage manifests easily whitish or yellowish spots confused with dental fluorosis. Thus, it is necessary to proceed with the continuation of clinical guidelines for understanding the changes, diagnosis and efficient treatment of children affected with MIH [27,30,31].

Studies that use photographs and video dynamics are the tools of choice when faced with ethical issues and present the best results for analyzing the knowledge of professionals [32,33]. In the tested protocol, the use of video classes promoted considerably poor agreement in the diagnosis of enamel defects among examiners, proving to be ineffective when applied as the only learning resource. On the other hand, the combination of instructional resources (video classes and discussion of photographic images), associated or not with clinical experience, revealed an improvement in the agreement of diagnoses, demonstrating the gradual consolidation of learning in the group of analyzed students.

In a recent study by Aguilar Gálvez et al. [34], training was developed for the diagnosis and control of MIH, being analyzed among undergraduate students and pediatric dentists. The training consisted only of visual resources, unlike our study, which had a clinical stage. Despite the methodological differences, the studies corroborated regarding the improvement of knowledge and understanding of the participants regarding the diagnosis of MIH after training.

The notable increase in the agreement of the answers with the gold standard observed in the post-test revealed the protocol created in this study as a useful teaching tool since the variation of the results obtained demonstrated a continuous evolution among students, from a complete subjectivity in the diagnosis of MIH to a more solid foundation, in accordance with the enhancement of learning. However, the inter-examiner reliability achieved proved to be insufficient for its recommendation as a safe instrument for MIH calibration. It is important to consider the low number of participants as the reason for this outcome, the main limitation of this study. Therefore, more studies are needed to improve the instrument to achieve satisfactory results that allow its use in the epidemiological training of MIH in the private and public spheres, impacting the advancement of population health policies. It is noteworthy that the degree of reliability must be continuously monitored through a periodic calibration exercise and an adjustment of the training programs must be carried out if a drop in these levels below total agreement is detected [18].

Conclusion

The calibration protocol for the diagnosis of MIH is a useful tool for the learning of dentists when used in conjunction with theoretical resources, discussion of diagnostic imaging and clinical experience. However, considering the ethical aspects involved, its improvement is necessary to establish reliable and viable diagnostic methods for calibration in MIH.

Authors' Contributions

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All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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