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Validity of scoring Deciduous Molar Hypomineralisation on intra-oral photographs

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Based on:

Validity of scoring caries and deciduous molar hypomineralization (DMH) on intraoral photographs

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ABSTRACT

Aim: The aims of this study were to assess whether intra-oral photographs could be used to score caries and hypomineralisation on primary molars (Using adapted Molar Incisor Hypomineralisation (MIH) criteria), and also to assess the reliability and validity in 3-7 year-old Dutch children of these scores by comparing them to direct clinical scorings.

Materials and methods: In this cross-sectional study 62 children (38.7% girls) with a mean age of 4.96 years (SD±1.27) participated. The children were rated clinically by their own dentist (JV or ME) for caries reaching the dentine in their primary molars and also for Deciduous Molar Hypomineralisation using the adapted MIH-criteria.
For the intra-oral photographs, a digital intra-oral camera was used. The two paediatric dentists rated all the intra-oral photographs on caries and hypomineralisations on the second primary molars, using the same criteria for the clinical scoring as for the scoring of the photographs. They scored independently, at least 2 weeks after the initial clinical scoring to avoid observational bias with the clinical scoring.
This clinical observation was used as the gold standard from which sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and the Positive and Negative Likelihood Ratio (LR+, LR-) were computed. To test the intra-observer agreement 25% of the photographs was scored again, at least 2 weeks after the initial scoring of the images. Inter- and intra-observer agreement were tested using Cohen's Kappa.

Results: The mean prevalence of clinically detected caries at tooth level was 46.7% and the mean prevalence of clinically detected hypomineralisations in second primary molars at tooth level was 21.8%. The sensitivity of assessing caries using intra-oral photographs was 85.5%, the specificity 83.6%, the positive likelihood ratio 5.2 and the negative likelihood ratio was 0.17. For Deciduous Molar Hypomineralisation (DMH) the sensitivity was 72.3%, the specificity 92.8%, the positive likelihood ratio 10.1 and the negative likelihood ratio was 0.30. The inter-observer agreement yielded the following Cohen's Kappa scores: for caries 0.76 and for DMH 0.62. The intra-observer agreement was for caries 0.80 (ME) and 0.72 (JV) and for DMH 0.95 (both ME and JV).

Conclusion: From this investigation it was concluded that the sensitivity, specificity and the likelihood ratio of scoring caries and DMH on photographs made with an intra-oral camera were good. The inter- and intra-observer reliability for caries and DMH were good to excellent. These findings suggest that intra-oral photographs may be used in clinical practice and large epidemiological studies.

INTRODUCTION

Enamel hypomineralisation is defined as a qualitative defect of the enamel visually identified as an abnormality in the translucency of the enamel and also denominated as a demarcated opacity of enamel (1). Developmental defects of dental enamel are common, both in primary and permanent dentition (1-4). Assessment of this defect is usually done in a clinical setting under direct observation. An alternative way is offered by the use of intra-oral photographs, either conventional (non-digital) or digital and with an intra-oral camera or an extra-oral camera in combination with a mouth mirror. Digital photography has been available since 1981 and in 1999 the first mega-pixel cameras became available (5). The image quality of digital photographs can be related to the pixels (photograph elements) the photograph is made up of three colours of light used (green, red and blue) and each colour can be set at a level between 0 and 255. If all colours are set at 0, black is the result, and if all colours are set at 255, white is the result. By varying the level of each of the colours, 16.7 million different colours are possible. The numerical values for the colours are stored on a charged couple device (CCD), which is made up of pixels. The number of pixels and the degree of compression determine the quality of the photograph (5). In general, the extra-oral cameras make photographs with more pixels than the intra-oral cameras.

Nowadays, digital photographs are seen as an important part of the clinical documentation of paediatric dentists and orthodontists and they may serve as a tool in scoring dental defects (5). Advantages of intra-oral photographs compared with a clinical examination are that they are more objective, less invasive for the patient (6), more convenient for the investigator (6, 7). Records may be used for other investigations in the future (6) and photographs may be magnified (7). In addition, Tsuzuki et al. (8) concluded that intra-oral cameras may be useful if mouth opening is restricted. However, problems have also been reported in using the intra-oral camera. For example, there may be difficulties in focussing when the camera is positioned close to the teeth (8, 9), difficulty in capturing an image of the teeth in the molar regions due to the magnification factor (8). Problems may also occur involving colour tone due to excessive light (8, 9), the photographs are more difficult to reproduce (9) and show a poorer image quality (9).

In some studies the reliability of scoring intra-oral photographs has been assessed. Wong et al. (6) took 5 standardized photographs with a conventional Single Lens Reflex (SLR) camera, with built-in ring flash, of the incisors of a child and investigated the agreement between clinical diagnoses and the photographic examinations of developmental defects by using the Developmental Defects of Enamel (DDE) index. They found that the agreement between the methods was good to excellent (Cohen's Kappa = 0.73-0.86). For erosion, Al-Malik et al. (7) found good agreement (Cohen's Kappa = 0.64) between clinical and photographic evaluation.

They also used a conventional SLR camera with ring flash. Their conclusion was that photographs can be used as an alternative for measuring erosion, but the method may benefit from refinement. In addition, Tavener et al. (10) reported a moderate to good inter-examiner agreement for scoring dental fluorosis from photographs made with a digital SLR camera using the Thylstrup-Fejerskov fluorosis index (TFI) (weighted Cohen's Kappa varied from 0.40 and 0.71). They concluded that different investigators might interpret the criteria of the TFI differently. This may explain some of the variation found between earlier studies on the prevalence and severity of fluorosis (10). Smith et al. (9) compared a digital SLR camera and an intra-oral camera for scoring disclosed dental plaque. The photographs taken with the intra-oral camera had less quality (659x494 pixels), but scoring disclosed dental plaque was adequate in these photographs. They concluded that the digital SLR camera (1051x1524 pixels) was superior, because of the high reproducibility of the photographs, resulting in higher reliability (9). They used the Fleiss coefficient of reliability for the inter- and intra-observer agreement, which showed an excellent agreement (inter-observer: R= 0.830, intra-observer 1: R=0.899, intra-observer 2: R=0.924).

To conclude, two types of digital cameras (SLR or intra-oral) are available and were used to make intra-oral photographs of a variety of dental variables, both with their own advantages and disadvantages. The aims of this study were (i) to assess whether intra-oral photographs could be used to score caries and hypomineralisation on primary molars (Using adapted Molar Incisor Hypomineralisation (MIH) criteria), and (ii) to assess the reliability and validity in 3- to 7-year-old Dutch children of these scores by comparing them to direct clinical scorings.

MATERIALS AND METHODS

Participants. For this study a convenience sample of 62 children (mean age 4.96 years (SD±1.27), range 2.92-7.17 years; 38.7% girls) visiting two dental practices (JV and ME) between November 2007 and February 2008 were asked to participate. All invited children participated in the study. Consent for an intra-oral photograph was given by the accompanying parent. The Medical Ethics committee of the VU University Medical Centre (VUMC) gave permission for the study.

Measures. The clinical observations were carried out by two dentists (JV and ME). The teeth were examined wet; only debris and saliva were removed with a cotton pellet just before clinical scoring and taking of the photographs. The dentist who did the clinical observation also took the photographs. It took 1-2 minutes to take photographs of all primary molars of the child. For this purpose, an intra-oral camera was used [Poscam USB intra-oral camera (Digital Leader PointNix), 640 x 480 pixels]. An example of a photograph made with this camera can be seen in Figure 3.1. The minimal scene illumination is f 1.4 and 30 lx. The camera used had autofocus.

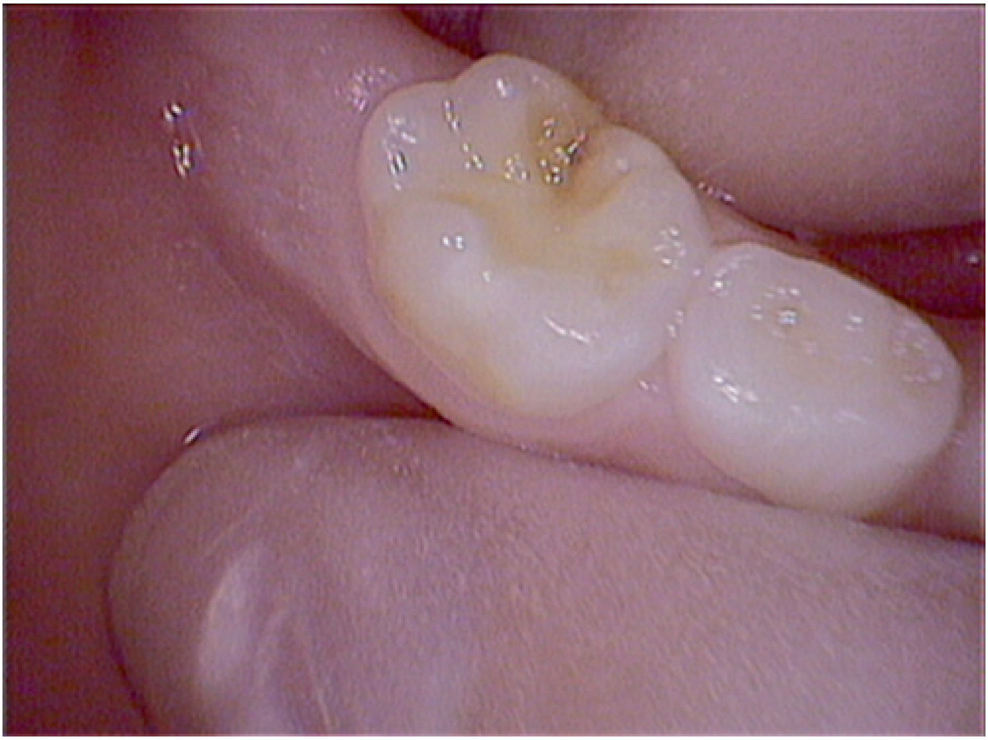

Figure 3.1: Intra-oral photograph made with an intra-oral camera [Poscam USB intra-oral camera (Digital Leader PointNix)], showing a lower right second primary molar with Deciduous Molar Hypomineralisation (DMH).

Calibration. The two dentists, JV and ME, were calibrated using intra-oral photographs taken earlier while trying to get used to handling the camera. The photographs were shown on a computer in full-screen mode and scored by both paediatric dentists independently at least two weeks after the photographs were taken to reduce recall bias. Dental caries and Deciduous Molar Hypomineralisation (DMH) were scored clinically and on the intra-oral photographs using the same criteria. With respect to caries (World Health Organisation (WHO) criteria), only the lesions on both first and second primary molars most probably reaching into the dentine were scored as carious. With respect to hypomineralisations, the second primary molars were scored by using the adapted MIH criteria (Table 3.1). A second primary molar was diagnosed as having DMH when one of the aspects in Table 3.1 or a combination of these characteristics was found.

Statistics. Using clinical investigation as the gold standard, the sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and the Positive and Negative Likelihood Ratio (LR+ and LR-) were computed (Table 3.2). Some 25 percent of the photographs were scored again, at least two weeks after the first scoring of the photographs. To test the inter- and intra-observer agreement, Cohen's Kappa was calculated.

Table 3.1: Scoring criteria for Deciduous Molar Hypomineralisation (DMH), adapted from the EAPD criteria on MIH (15).

Atypical caries	The size and form of the caries lesion do not fit in the caries distribution in the child's mouth.
Atypical restoration	The size and form of the restoration do not fit in the present caries distribution.
Opacity	The defect involves an alteration in the translucency of the enamel, variable in degree. The defective enamel is of normal thickness with a smooth surface and can be white, yellow or brown in colour. The demarcated opacity is not caused by caries, fluorosis or amelogenesis imperfecta etc.
Posteruptive enamel loss	A defect indicating a deficiency of the surface after eruption of the tooth, e.g. hypomineralisation-related attrition. Enamel loss due to erosion was excluded.

Table 3.2: Definitions of statistical terms (16)

Statistical term	Definition
Sensitivity	The ability of a diagnostic test to correctly identify the presence of disease. Calculation: True Positives / (True Positives + False Negatives)
Specificity	The ability of a diagnostic test to correctly identify the absence of disease. Calculation: True Negatives / (True Negatives + False Positives)
Positive Predictive Value (PPV)	Indication of the proportion of patients correctly identified by the test as having disease. Calculation: True Positives / (True Positives + False Positives)
Negative Predictive Value (NPV)	Indication of the proportion of patients correctly identified by the test as not having disease. Calculation: True Negatives / (True Negatives + False Negatives)
Positive Likelihood Ratio (LR+)	The likelihood that a given positive test result would be expected in a patient with the target disorder compared to the likelihood that the same result would be expected in a patient without that disorder. Calculation: sensitivity / (1-specificity)
Negative Likelihood Ratio (LR-)	The likelihood that a given negative test result would be expected in a patient with the target disorder compared to the likelihood that the same result would be expected in a patient without that disorder. Calculation: (1-sensitivity) / specificity

RESULTS

In this investigation, 62 children participated (mean age 4.96 years (SD±1.27), range 2.92-7.17 years; 38.7 % girls). At a tooth level, the prevalence of clinically scored caries was 46.7% and of clinically scored DMH 21.8%. In Table 3.3 the sensitivity, specificity, PPV, NPV, LR+ and LR- for the different scorings of caries and DMH are presented. For caries, the sensitivity and specificity were 85.5% and 83.6%, respectively; the PPV was 82.0% and NPV 86.8%. The Positive Likelihood Ratio was 5.2 and the Negative Likelihood Ratio was 0.17. For DMH the sensitivity and specificity were 72.3% and 92.8%, the PPV was 73.7% and the NPV was 92.3%, the LR+ 10.1 and LR- 0.30. The inter- and intra-observer agreements yielded the following Cohen's Kappa scores: for caries 0.76 (inter), 0.72 (intra JV) and 0.80 (intra ME), and for DMH 0.62 (inter), 0.95 (intra JV) and 0.95 (intra ME). Scoring atypical caries and atypical restorations gave rather high validity scores; on tooth level the sensitivity, specificity, LR+ and LR- for atypical caries were 53.7%, 92.5%, 7.1 and 0.5, respectively. For atypical restorations the corresponding parameters were 81.3%, 98.8%, 69.5 and 0.19 (see Table 3.3). The inter-observer agreement showed good agreement (Cohen's Kappa=0.68 for atypical caries and Cohen's Kappa= 0.77 for atypical restorations).

Scoring of post eruptive enamel loss and opacities gave low validity scores, especially for sensitivity and PPV, 26.1% and 38.7% at surface level and 38.5% and 58.8% at tooth level (Table 3.3). The Cohen's Kappa scores of the inter-observer agreement for post eruptive enamel loss also showed a poor agreement (Cohen's Kappa=0.11 at the surface level and Cohen's Kappa=0.21 at the tooth level). The Negative Predictive Values were high for all scorings. The intra-observer agreement showed a good to excellent agreement for most sites. All the above mentioned data are summarized in Table 3.4.

Table 3.3: Validity of scoring caries and DMH on primary molars

	Sensitivity [95%CI]	**Specificity [95%CI]**	**Positive Predictive Value (PPV) [95% CI]**	**Negative Predictive Value (NPV) [95% CI]**	**Positive Likelihood Ratio (LR+) [95% CI]**	**Negative Likelihood Ratio (LR-) [95% CI]**
Caries per surface	79.9% [69.9-89.9%]	94.8% [89.3-100%]	72.1% [61.0-83.2%]	96.6% [92.1-100%]	15.3 [15.2-15.4]	0.21 [0.20-0.22]
Caries per tooth	85.5% [76.7-94.3%]	83.6% [74.4-92.8%]	82.0% [72.4-91.6%]	86.8% [78.4-95.2%]	5.2 [5.1-5.3]	0.17 [0.05-0.29]
Atypical caries per surface	56.4% [44.1-68.7%]	97.1% [92.9-100%]	46.9% [34.5-59.3%]	98.0% [94.5-100%]	19.7 [19.6-19.9]	0.45 [0.33-0.57]
Atypical caries per tooth	53.7% [41.3-66.1%]	92.5% [85.9-99.1%]	41.5% [29.2-53.8%]	95.3% [90.0-100%]	7.1 [6.9-7.4]	0.50 [0.33-0.67]
Atypical restoration per surface	67.3% [55.6-79.0%]	99.5% [97.7-100%]	78.7% [68.5-88.9%]	99.1% [96.7-100%]	131.5 [131.2-131.8]	0.33 [0.14-0.52]
Atypical restoration per tooth	81.3% [71.6-91.0%]	98.8% [96.1-100%]	72.2% [61.0-83.4%]	99.3% [97.2-100%]	69.5 [69.1-70.0]	0.19 [0-0.71]
Posteruptive enamel loss per surface	26.1% [15.2-37.0%]	99.1% [96.8-100%]	38.7% [26.6-50.8%]	98.5% [95.5-100%]	30.5 [30.2-30.9]	0.75 [0.66-0.83]
Posteruptive enamel loss per tooth	38.5% [26.4-40.6%]	98.4% [95.2-100%]	58.8% [46.5-71.1%]	96.3% [91.6-100%]	23.5 [23.1-24.0]	0.63 [0.48-0.78]
Opacity per surface	36.2% [24.2-48.2%]	97.8% [94.1-100%]	33.8% [22.0-45.6%]	98.0% [94.5-100%]	16.3 [16.0-16.5]	0.65 [0.56-0.74]
Opacity per tooth	48.2% [35.8-60.6%]	92.7% [86.2-99.2%]	48.2% [25.8-60.6%]	92.7% [86.2-99.2%]	6.6 [6.4-6.8]	0.56 [0.43-0.69]
DMH	72.3% [61.2-83.4%]	92.8% [86.4-99.2%]	73.7% [62.7-84.7%]	92.3% [85.7-98.9%]	10.1 [9.9-10.3]	0.30 [0.13-0.46]

Table 3.4: The inter- and intra-observer agreement for scoring caries and DMH on primary molars.

	Inter-observer agreement	Intra-observer agreement ME	Intra-observer agreement JV
Caries per surface	0.76	0.86	0.75
Caries per tooth	0.76	0.80	0.72
Atypical caries per surface	0.64	0.96	0.58
Atypical caries per tooth	0.68	0.90	0.68
Atypical restoration per surface	0.53	*	0.56
Atypical restoration per tooth	0.77	*	0.65
Posteruptive enamel loss per surface	0.11	0.91	0
Posteruptive enamel loss per tooth	0.21	0.85	0
Opacity per surface	0.34	0.59	0.36
Opacity per tooth	0.33	0.80	0.34
DMH	0.62	0.95	0.95

* not seen in duplo-investigation

DISCUSSION

For developmental defects of dental enamel in primary teeth several names (e.g., Hypomineralised Second Primary Molars (HSPM) (4), enamel hypoplasia (11), enamel defects (12)) are used in the literature. This article follows the name and definition used for first permanent molars by Weerheijm et al. (13). As no detailed studies on the issue are available yet, the global name Deciduous Molar Hypomineralisation (DMH) is proposed. Thus, DMH is defined as idiopathic hypomineralisation of 1-4 second primary molars (4). The results of the present study showed that the validity of scoring DMH and caries on primary molars using intra-oral photographs with 640 x 480 pixels was good. It can be concluded that intra-oral photographs can be used as an alternative to score caries and DMH on primary molars. Furthermore, the reliability was high, as shown by the Cohen's Kappa scores for inter- and intra-observer agreement. A few of the disadvantages of the intra-oral camera, as described by Tsuzuki et al. (8) and Smith et al. (9), were encountered occasionally, but could be dealt with. For example, asking the child to open the mouth as wide as possible can prevent problems with focussing and magnification so that several teeth in the molar region could be captured on one photograph. Furthermore, the colour tone of the photographs was a bit different from the natural colour tone. Changes in colour tone due to excessive light can be influenced by a larger distance between the teeth and the camera and by adjusting the light in the room. Although changes in colour tone did not give problems in diagnosing DMH, it might explain some of the results of the present study. Firstly, the difficulty in seeing the difference between the criteria of scoring post eruptive enamel loss and opacities on the photographs might have resulted in the low validity and low Cohen's Kappa scores. Likewise, opacities due to caries and opacities due to DMH appeared more difficult to differentiate. And finally, the lower Cohen's Kappa scores for scoring atypical restorations could be explained in this way, because mostly tooth-coloured restorations were used. The Cohen's Kappa score for inter- and intra-observer reliability of caries and DMH showed good to excellent agreement. Our intra- and inter-observer reliability scores were better than those published by Tavener et al. (10) and almost the same as published by Al-Malik et al. (7) in their studies on fluorosis and erosion, respectively. Wong et al. (6) found a comparable high intra-examiner reliability for developmental defects (Cohen's Kappa = 0.88) as we did for DMH (Cohen's Kappa = 0.95). No other studies on the scoring of developmental dental defects from photographs have calculated sensitivity and specificity, so these outcomes could not be compared. We used the clinical examination as a gold standard. Other investigations on scoring dental defects also used the clinical examination as the gold standard to which the outcome of the photographs was compared (6, 7). A test is considered accurate when the sum of the specificity and the sensitivity is 160 or more (14). For caries and DMH in this investigation this was the case, so the intra-oral photographs seem to be a valid way to score caries and DMH.

Accurate scoring of enamel defects in primary teeth requires a reproducible and valid index. In the literature the Developmental Defects of Enamel (DDE) index and the Enamel Defects Index (EDI) are commonly used. The DDE index, however, is time consuming and post eruptive enamel breakdown can not be scored with it (15). The EDI does not show differences between diffuse and demarcated opacities. Diffuse opacities, caused by fluorosis, should not be incorporated in the scoring index for hypomineralised teeth, but demarcated opacities should (15). Therefore, Elfrink et al. (4) used the same criteria for scoring the hypomineralised second primary molars as was used for scoring Molar Incisor Hypomineralisation in the permanent dentition by Weerheijm et al. (15). The photographs taken with this digital intra-oral camera consisted of 640 x 480 pixels. This was less than a photograph made with a digital SLR camera (around 2000 x 2600 pixels). The amount of 640 x 480 pixels seems enough to score the photographs adequately. The advantage of this smaller size was that a lot of photographs could be stored on the computer and that they could easily be sent by e-mail to the other investigator.

The prevalence data for caries and DMH were relatively high in this convenience sample of 62 children, higher for example than in a previous study representative for the Netherlands in Dutch 5-year-old children (DMH: 3.6% at tooth level) (4). This was in fact predictable as both paediatric dentists were working in a secondary dental care setting, so their patients were referred for behaviour management problems, excessive caries or developmental defects, such as DMH. The children should therefore not be considered a random selection representative of the population.

CONCLUSION

This investigation has shown that the sensitivity and specificity of scoring caries and Deciduous Molar Hypomineralisation on intra-oral photographs made with a digital intra-oral camera are satisfactory. The inter- and intra-observer reliability are good to excellent. Also the likelihood ratios give moderate to large probabilities that caries or Deciduous Molar Hypomineralisation are either present or absent. Intra-oral photographs may be used in clinical practice and epidemiological studies. The technique clearly creates opportunities for epidemiological research and storing data in clinical settings.

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