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ORIGINAL SCIENTIFIC ARTICLE

Molar incisor hypomineralisation: prevalence and clinical presentation in school children of the northern region of India

N. P. Mittal · A. Goyal · K. Gauba · A. Kapur

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Abstract There is rarity of prevalence data on molar incisor hypomineralisation (MIH) for the Indian population and the majority of data originated from European countries.
Aim To report on prevalence and defect characteristics of MIH for school children of the northern Indian region.
Methods A cross-sectional survey including 1,792, 6–9-year-old school children of Chandigarh, India was carried out using European Academy of Paediatric Dentistry (EAPD) 2003 criteria for diagnosis of MIH. In addition to descriptive analysis for distribution of various defects, comparative data analysis was carried out for inter-comparison of distribution and type of defect amongst two phenotypes, MH [first permanent molar (FPMs) involvement] and M + IH (simultaneous involvement of molars and incisors). Similar comparative analysis was performed for four subgroups on the basis of number of affected surfaces/subjects.
Results A prevalence of 6.31 % was reported. FPMs (2.83 ± 0.874/subject) were more commonly affected than permanent incisors (1.19 ± 1.614/subjects). White/creamy opacity without post-eruptive breakdown (PEB) was the most common lesion, seen in 85 % of subjects. MH phenotype was seen in 44 % of subjects and 56 % exhibited M + IH phenotype. A trend toward greater severity was seen in M + IH phenotype when compared to MH phenotype. A greater number of surfaces presented with white/creamy opacities without PEB ($p < 0.05$). With an increase in the number of surfaces involved the severity of MIH also increased with more frequent presence of brown defects with PEB.
Conclusion With concomitant involvement of incisors, more severe presentation of MIH was seen. Also, with increase in number of affected surfaces a parallel increase in severity as well as extent of lesions was observed.

Keywords MIH prevalence · MIH defects · MIH severity · Enamel defects

N. P. Mittal (✉)
Department of Pedodontics and Preventive Dentistry, Santosh Dental College and Hospital, No. 1, Santosh Nagar, Ghaziabad 201009, Uttar Pradesh, India
e-mail: dr.neetipgi@gmail.com

A. Goyal · K. Gauba · A. Kapur
Unit of Pedodontics and Preventive Dentistry, Oral Health Sciences Centre, PGIMER, Chandigarh, India

Introduction

Molar incisor hypomineralisation (MIH) is a clinical entity described as hypomineralisation of one to four first permanent molars (FPMs) and is frequently associated with similarly affected permanent incisors (Weerheijm 2004). Various terminologies have been used to describe MIH such as hypomineralised FPMs (Jälevik and Norén 2000), idiopathic enamel hypomineralisation (Koch et al. 1987), non-fluoride hypomineralisation (Leppäniemi et al. 2001) and cheese molars (van Amerongen and Kreulen 1995). Clinical presentation of the defect varies on a continuous spectrum ranging from demarcated creamy white or yellow opacities to brownish defects with or without loss of enamel (Weerheijm et al. 2001). It is very common for the affected tooth structure to break down soon after eruption (post-eruptive breakdown, PEB). Molars are more prone to undergo PEB when compared to anterior teeth (Weerheijm 2004).

A wide disparity in the prevalence rate of MIH has been reported ranging from a prevalence of as low as 2.8 % in Hong Kong (Cho et al. 2008) to as high as 40.2 % amongst Brazilian subjects (Soviero et al. 2009). Most of the literature originated in European countries with prevalence

rates ranging from 3.6 to 37.5 % (Koch et al. 1987; Wogelius et al. 2008). Further, only two studies have been reported on primary teeth (Elfrink et al. 2008; Ghanim et al. 2013).

This reported disparity in prevalence rate might be due to real differences in prevalence rate. On the other hand, this can also be attributed to methodological differences such as sampling (different birth cohorts in different studies, recruitment of population or convenience samples) or non-uniform methods of clinical examination (Weerheijm and Mejare 2003). Another possible reason could be previous recording methods such as the developmental defects of enamel (DDE) index which might have led to deviating findings due to inclusion of divergent indicators for determination of this condition (FDI Commission on Oral Health Research & Epidemiology 1992).

Another important fact to be borne in mind is the inclusion of various phenotypes of MIH in studies conducted prior to publication of the policy document from the European Academy of Paediatric Dentistry (EAPD) (Lygidakis et al. 2010). MIH has recently been defined as involvement of at least one first permanent molar with a demarcated opacity, enamel disintegration or atypical restoration. Whereas the terminology "Molar Incisor Hypomineralisation" suggests that only simultaneous involvement of permanent molars and permanent incisors should be classified as MIH. This confusion could have led to inclusion of different phenotypes such as involvement of only permanent molars or any permanent tooth. This may have attributed to the wide disparity in reported prevalence rates. Furthermore, only a handful of studies have been conducted after establishment of EAPD evaluation criteria for MIH. The data on MIH are deficient globally and especially in India where a single study has reported the prevalence using EAPD evaluation criteria in western India (Parikh et al. 2012). Bearing these facts in mind, the present study was planned to report the prevalence, distribution and defect characteristics of MIH in Chandigarh, India.

Two different phenotypes were recognised such as molar hypomineralisation (involvement of FPMs) and simultaneous involvement of FPMs and incisors. For sake of simplicity, the former was labelled as MH and latter as M + IH. The other objective was to compare the characteristics and distribution of defects amongst the two phenotypes, MH and M + IH.

It has been previously reported by many authors that with an increase in the number of affected teeth per subject, a concomitant increase in severity (in terms of lesion size and clinical presentation) of defects was observed (Wogelius et al. 2008; Lygidakis et al. 2008a; Soviero et al. 2009; Ghanim et al. 2011; Parikh et al. 2012). Another objective was to find out how true this was for the study population.

Materials and methods

Ethical approval

The institutional ethical committee and review board approved the study protocol and informed parental consents were obtained.

Study location

The present study was conducted in Chandigarh located in northern India and spread in an area of 114 km^2, with community water supply fluoridated at 0.3 ppm. The total population of the city is 900,635 (Census of India 2011).

Sample selection

The sample consisted of 6–9 year-old children studying in government schools of Chandigarh from all socio-economic backgrounds. Schools were selected randomly according to number of schools in each area to target a sample size of 2,000. Principals of schools were contacted via written communication explaining the condition MIH and its consequences whilst placing emphasis on early diagnosis and treatment. Permission was sought to allow the investigator (*N*) to conduct the survey in their schools. A similar letter explaining the condition and seeking consent was circulated amongst parents/guardians. Cohorts of children born between 2000–2003 attending the selected schools in the academic year 2009–10 were included in the study. Schools for children with special health care needs were excluded.

Inclusion and exclusion criteria of the study population

Inclusion criteria

Children aged 6–9 years, born and brought up in Chandigarh and having at least one first permanent molar erupted.

Exclusion criteria

Children having amelogenesis imperfecta, dentinogenesis imperfecta, tetracycline staining or diffuse hypoplastic lesions on index teeth were excluded from the study. Also, absenteeism on the day of examination and failure to obtain written informed consent from parents resulted in exclusion from the study.

Training and calibration of examiner

The examination of the entire study sample was performed by a single examiner (*N*), who was trained by an experienced Paedodontist (AG). The investigator (*N*) was oriented to the index during patient evaluation in the outpatient department and by showing old patient records. Inter-examiner agreement of >0.61 (using kappa statistics) was a prerequisite to allow the investigator to start with the survey (Landis and Koch 1977). Using kappa statistics, an inter-examiner agreement of 0.71 and intra-examiner agreement of 0.83 was found.

Study setting and examination criteria

Children were examined at their respective school premises in adequate natural day light. Examination was performed using a dental mirror and a blunt ended probe without drying the teeth. Teeth were cleaned of loose debris by rinsing with plain water and any remaining debris was removed gently by scraping with the probe. Buccal, lingual/palatal and occlusal surfaces of the first permanent molars and the labial, lingual/palatal surfaces of upper and lower permanent incisors were examined. A tooth was considered erupted when more than half of the crown was visible in the oral cavity.

A positive diagnosis of MIH was made when a subject presented with a demarcated defect on at least one of the erupted first permanent molars. A 10-point scoring system based on the EAPD evaluation criteria (Ghanim et al. 2011) was used to score defects on index teeth (Table 1).

Enamel hypomineralisation only with diameters ≥2 mm were scored (Jälevik et al. 2001). Judicious identification of various other hypoplastic defects i.e. fluorosis, amelogenesis imperfecta and dentinogenesis imperfecta were made. Demarcated hypomineralisation related enamel defects were distinguished from diffuse opacities and hypoplasia as per FDI recommendations (FDI Commission on Oral Health Research & Epidemiology 1992).

Gradation of severity of defect

Defects with PEB were considered to be of greater severity than those without any PEB. Defects with yellow/brown demarcated opacities were graded as being of higher severity. Hence, the increasing order of severity was creamy/white opacity without PEB < yellowish/brown opacity without PEB < creamy/white opacity with PEB < yellowish/brown opacity with PEB.

Since no component of the EAPD evaluation criteria grades the extent of defect, we used our own criteria for recording the extent of defect. Defects were graded as involving <1/3rd of tooth surface (Defect 1), 1/3rd to 2/3rd of tooth surface (Defect 2), >2/3rd of tooth surface (Defect 3)

Table 1 Criteria for scoring molar incisor hypomineralisation (MIH) according to the European Academy of Paediatric Dentistry recommendations

Code	Criteria
0	Enamel defect free
EAPD 1	White/creamy demarcated opacities, no PEB
EAPD 1a	White/creamy demarcated opacities, with PEB
EAPD 2	Yellow/brown demarcated opacities, no PEB
EAPD 2a	Yellow/brown demarcated opacities, with PEB
EAPD 3	Atypical restoration
EAPD 4	Missing because of MIH
EAPD 5	Partially erupted (i.e. less than one-third of the crown height) with evidence of MIH
EAPD 6	Unerupted/partially erupted with no evidence of MIH
EAPD 7	Diffuse opacities (not MIH)
EAPD 8	Hypoplasia (not MIH)
EAPD 9	Combined lesion (diffuse opacities/hypoplasia with MIH)
EAPD 10	Demarcated opacities in incisors only

Source Ghanim et al. (2011)

(FDI Commission on Oral Health Research & Epidemiology 1992). In case of doubt, the less severe grade was assigned.

Restorative treatment needs (RTN)

PEB due to MIH was recorded as RTN due to MIH.

Methods of record keeping

The data for each patient was entered on pre-printed proformas which had the subject's demographic characteristics, status of eruption of index teeth, scores assigned as per EAPD criteria and post-eruptive breakdown (PEB).

Subgroups

The entire sample was divided into the following groups:

a. On the basis of phenotype, two groups were formed; MH and M + IH.
b. Four subgroups were formed on the basis of the total number of affected tooth surfaces per subject. These were subgroup 1: 1–4 surfaces involved, subgroup 2: 5–8 surfaces involved, subgroup 3: 9–12 surfaces involved and subgroup 4: 13–16 surfaces involved.

Statistical analysis

The collected data were analysed using the SPSS package version 17.0 (SPSS Inc., Chicago, IL, USA). A descriptive analysis of the prevalence and distribution of the clinical

recordings was performed. The 95 % confidence intervals were calculated for prevalence. Mann–Whitney tests were used for comparison. Significance was set at a p value of ≤ 0.05.

Results

Response rate

Overall response rate of participation was 94.9 % (1,898/2,000). However, the final sample available for examination was 1,792 (89.6 %) due to the children being absent on the day of clinical examination.

Prevalence (Tables 2, 3, 4)

A total of 113/1,792 (6.31 %) subjects were found to be affected. No significant gender differences were found regarding any observed parameter (Tables 3, 4) except extent of defect.

Distribution of defects

FPMs were more commonly affected than permanent incisors (Table 3). Most commonly involved surfaces were occlusal while lingual surfaces were least commonly involved (Table 3).

Characteristics of defects

'EAPD 1' was the most common lesion in the study population and was observed in 96 (84.96 %) subjects. The order of prevalence of different types of defects was EAPD1 (84.96 %) > EAPD2 (47.79 %) > EAPD2a (39.82 %) > EAPD1a (5.31 %) > EAPD9 (1.77 %). Different types of lesions were often seen in the same individual.

Surface-wise analysis also showed that EAPD1 was the most prevalent defect while the least prevalent defect was EAPD9 (Table 4). Most defects had 1/3rd of the surface area involved (Table 4).

Restorative treatment needs (RTN)

A total of 51/113 (45.13 %) subjects presented with PEB due to MIH. Thus, the prevalence of RTN due to MIH was 2.85 % (51/1,792) in the study population.

Inter-comparison of distribution and characteristics of defects amongst two phenotypes (MH and M + IH) with respect to FPMs (Table 5)

A total of 50/113 (44.25 %) had all 12 index teeth erupted. A total of 22/50 (44 %) exhibited MH phenotype while 28/50 (56 %) exhibited the full spectrum such as M + IH. No significant differences were reported between the two groups with the exception of the EAPD1 defect, which was more common in the MH subgroup ($p < 0.05$).

Intercomparison of distribution and characteristics of defects amongst four subgroups (as per total number of affected surfaces/subject) (Table 6)

A significantly greater number of surfaces with defect EAPD1 (least severe defect) were found in subgroup 1 when compared to subgroup 4, which had the least number of surfaces with this type of defect ($p < 0.001$). Furthermore, significantly greater number of surfaces with EAPD2 (2nd most severe defect) were found in subgroup 4 when compared to the other groups ($p < 0.001$).

Discussion

There were good response (94.9 %) and final rates of participation (89.6 %), and therefore, the sample recruited for the study may be considered to be representative of the entire population of the age group examined.

Diagnosis

The introduction of EAPD criteria for evaluation of MIH was performed to address the reported disparity in clinical

Table 2 Baseline demographic characteristics

Characteristics	Overall distribution (mean ± SD) $N = 113$	Gender distribution		
		Male (mean ± SD) $N = 63$	Female (mean ± SD) $N = 50$	p value[†]
Age (in years)	7.66 ± 0.976	7.81 ± 0.931	7.94 ± 0.956	0.515
Number of erupted permanent molars	3.71 ± 0.696	3.78 ± 0.552	3.82 ± 0.596	0.402
Number of erupted permanent incisors	4.20 ± 2.759	5.19 ± 2.552	5.62 ± 2.702	0.247

[†] Calculated on the basis of Mann–Whitney U test

Table 3 Overall and gender distribution of affected teeth and surfaces

Characteristics	Overall distribution (mean ± SD) $N = 113$	Gender distribution		
		Male (mean ± SD) $N = 63$	Female (mean ± SD) $N = 50$	p value†
Affected teeth	4.04 ± 0.973	4.13 ± 1.972	3.92 ± 1.988	0.510
Affected permanent molars	2.83 ± 0.874	2.84 ± 0.987	2.84 ± 0.934	0.990
Affected permanent incisors	1.19 ± 1.614	1.29 ± 1.591	1.08 ± 1.652	0.319
Affected surfaces	4.99 ± 2.969	5.02 ± 2.762	4.96 ± 3.239	0.527
Affected occlusal surfaces	2.49 ± 1.330	2.65 ± 1.259	2.28 ± 1.400	0.151
Affected buccal surfaces	2.08 ± 2.032	2.00 ± 1.892	2.18 ± 2.210	0.863
Affected lingual surfaces	0.42 ± 0.854	0.37 ± 0.747	0.50 ± .974	0.415

† Calculated on the basis of Mann–Whitney U test

Table 4 Overall and gender distribution of type and extent of defects

Characteristics	Overall distribution (mean ± SD) $N = 113$	Gender distribution		
		Male (mean ± SD) $N = 63$	Female (mean ± SD) $N = 50$	p value†
White/creamy demarcated opacities, no PEB	2.40 ± 1.503	2.59 ± 1.387	2.16 ± 1.621	0.122
White/creamy demarcated opacities, with PEB	0.11 ± 0.488	0.10 ± 0.530	0.12 ± 0.435	0.284
Yellow/brown demarcated opacities, no PEB	1.23 ± 1.813	1.32 ± 1.683	1.12 ± 1.976	0.370
Yellow/brown demarcated opacities, with PEB	1.18 ± 2.080	0.98 ± 1.782	1.42 ± 2.400	0.260
Combined lesion (diffuse opacities/hypoplasia with MIH	0.07 ± 0.593	0.03 ± .252	0.12 ± 0.849	0.859
<1/3rd of surface area involved (Defect 1)	3.83 ± 2.083	4.21 ± 2.156	3.36 ± 1.903	0.024*
1/3rd to 2/3rd of surface area involved (Defect 2)	0.46 ± 1.018	0.35 ± 0.919	0.60 ± 1.125	0.153
>2/3rd of surface area involves (Defect 3)	0.65 ± 1.903	0.46 ± 1.584	0.90 ± 2.234	0.266

Data expressed as number of affected surfaces for particular lesion characteristic

* Denotes statistically significant difference

† Calculated on the basis of Mann–Whitney U test

evaluation and diagnosis of MIH. The simplicity of EAPD criteria aids in clinical reproducibility of recordings of defects. For this reason, we preferred to use EAPD criteria rather than other methods such as the DDE index. Further, to ensure uniformity of examination, only a single trained and calibrated investigator (N) carried out the examination of the entire sample.

Prevalence rate

We reported a prevalence of 6.31 %, while a recent study from western India reported a prevalence of 9.2 % using similar diagnostic criteria in natural day light. The reported difference could be due to the different age cohorts examined. We used a younger age group (6–9 years) and at this age, all index teeth were not erupted. On the other hand, in the study by Parikh et al. 2012 only subjects with all index teeth erupted were included. This could have led to a lower prevalence rate in our study. However, the reported difference can also be due to an actual difference in prevalence rate in the study populations.

MIH has been known for dynamicity of its lesions, as severity of defects tends to increase after eruption owing to masticatory forces. This is the reason we included younger subjects, so that we can examine affected teeth soon after eruption when no other superimposing defects such as caries or extensive restorations interfere with diagnosis of MIH.

Almost similar prevalence rates have been reported from Germany (5.6 % in Dresden and 5.9 % in central Hesse), Greece (10.2 %), Lithuania (9.7 %) and Turkey (9.2 %) (Dietrich et al. 2003; Preusser et al. 2007; Lygidakis et al. 2008a; Jasulaityte et al. 2007; Kuscu et al. 2009).

However, the prevalence rate reported in our study is very different from those reported in recent studies using similar evaluation criteria from various regions of Asia. These include prevalence rates of 2.8 % in Hong Kong, 17.6 % in Jordan and 18.6 % in Iraq (Cho et al. 2008; Ghanim et al. 2011; Zawaideh et al. 2011). An overall lower prevalence rate in our study could be due to use of natural day light rather than source of artificial light for diagnosis.

Table 5 Group characteristics for first permanent molars in subgroups 'MH' and 'M + IH'

Characteristic	Group				p value[†]
	MH ($N = 22$)		MIH ($N = 28$)		
	Mean	SD	Mean	SD	
Affected surfaces on molars	4.14	1.833	4.41	3.202	0.620
White/creamy demarcated opacities, no PEB	2.23	1.445	1.38	1.237	0.037*
White/creamy demarcated opacities, with PEB	0.00	0.00	0.00	0.00	1.000
Yellow/brown demarcated opacities, no PEB	0.77	1.152	1.07	1.944	0.923
Yellow/brown demarcated opacities, with PEB	1.14	1.670	1.86	3.056	0.662
Combined lesion (diffuse opacities/hypoplasia with MIH	0.00	0.00	0.14	0.581	0.213
<1/3rd of surface area involved (Defect 1)	3.05	1.838	2.59	1.918	0.355
1/3rd to 2/3rd of surface area involved (Defect 2)	0.59	1.098	0.55	1.152	0.776
>2/3rd of surface area involves (Defect 3)	0.50	1.185	1.28	2.724	0.459

Data expressed as number of affected surfaces for particular lesion characteristic

* Denotes statistically significant difference

[†] Calculated on the basis of Mann–Whitney U test

Table 6 Defect characteristics for subgroups on the basis of total number of affected surfaces/subject

Characteristic	Groups (Mean ± SD)			
	Group 1 (1–4 affected surfaces) ($N = 64$)	Group 2 (5–8 affected surfaces) ($N = 37$)	Group 3 (9–12 affected surfaces) ($N = 7$)	Group 4 (13–16 affected surfaces) ($N = 5$)
White/creamy demarcated opacities, no PEB	1.89 ± 1.261	1.89 ± 1.542	1.14 ± 1.07	0.40 ± .55
White/creamy demarcated opacities, with PEB	0.14 ± 0.53	0.08 ± 0.49	0.00 ± 0.000	0.00 ± 0.000
Yellow/brown demarcated opacities, no PEB	0.34 ± 0.74	1.49 ± 1.54	2.71 ± 1.89	2.40 ± 3.28
Yellow /brown demarcated opacities, with PEB	0.33 ± 0.80	1.24 ± 1.55	2.86 ± 0.900	8.20 ± 2.95
Combined lesion (diffuse opacities/hypoplasia with MIH	0.00 ± 0.000	0.05 ± 0.329	0.86 ± 2.268	0.00 ± 0.000
<1/3rd of surface area involved (Defect 1)	2.70 ± 1.094	5.27 ± 1.610	5.29 ± 2.289	5.60 ± 4.930
1/3rd to 2/3rd of surface area involved (Defect 2)	0.27 ± 0.597	0.46–0.900	1.29 ± 2.215	1.80 ± 2.168
>2/3rd of surface area involves (Defect 3)	0.11 ± 0.475	0.35 ± 1.033	2.86 ± 2.610	6.80 ± 4.087

Data expressed as number of affected surfaces for particular lesion characteristic

Distribution of different types of lesions

The most commonly observed lesion was EAPD1, which although considered the mildest of all defects, poses aesthetic concern, especially when present on incisors. PEB was seen in 45.13 % of subjects with MIH which indicates restorative treatment need. Often, such teeth develop caries due to their potential to allow plaque and debris accumulation. Once a carious lesion initiates in such teeth, its progression is very rapid due to poorly mineralised enamel in affected teeth (Mahoney et al. 2004).

Distribution of lesion type and extent in different phenotypes

In the present study, almost equal distribution of both phenotypes such as MH and M + IH were found. Whereas in previous studies, the reported proportion of subjects with MH phenotype ranged from 17.4–35 % (Jasulaityte et al. 2007; Chawla et al. 2008; Lygidakis et al. 2008a; Zawaideh et al. 2011).

Previous studies have reported that with concomitant involvement of incisors, the severity of defects increases,

especially in molars (Wogelius et al. 2008; Soviero et al. 2009; Ghanim et al. 2011). In the present study, although a trend toward greater severity was seen in M + IH phenotype, this did not reach statistical significance for all the lesion types. A significantly greater number of surfaces had creamy/white opacities without PEB (rated as being least severe type of defect) in MH phenotype when compared to M + IH phenotype. This finding can possibly be explained by assumption that incisors are concomitantly affected with molars when the aetiological insult is more severe. The increased severity of insults translates to a greater severity of defects (Jälevik and Norén 2000; Lygidakis et al. 2008b). It has also been reported that more molars are affected when incisors are also involved (Weerheijm et al. 2001). In this present study, for the two phenotypes compared, the total numbers of affected surfaces on molars were similar, which is not in agreement with previous reports.

Distribution of lesion type and extent in relation to total number of affected surfaces

Another interesting finding of the study was that with increase in number of affected surfaces, a concomitant increase in severity of MIH was noted. Similar findings have been reported where subjects with a greater number of affected teeth presented with increased severity and extent of individual lesions (Jälevik et al. 2001; Leppäniemi et al. 2001; Lygidakis et al. 2008a; Ghanim et al. 2011; Zawaideh et al. 2011; Parikh et al. 2012). This finding indicates that when the insult is severe enough to affect a greater number of teeth it also causes more severe lesions (Jälevik and Norén 2000; Lygidakis et al. 2008b). This also means that the total number of affected teeth can predict the severity of MIH.

This study was conducted in Chandigarh, which only represents a small part of the entire nation of India. The data obtained from this trial is not supposed to represent the whole country. There is a scarcity of reports on MIH in the Indian population, a nationwide survey to map the prevalence of MIH is required. Prospective studies are also needed to evaluate the prognostic outcomes and gain an insight into the aetiology of MIH.

Conclusion

MIH occurs in Indian children aged 6–9 years old at a prevalence rate of 6.31 %. Boys and girls are affected similarly. Molars are involved more commonly than incisors. White/creamy opacities without PEB were the most prevalent lesions. Restorative treatment needs were seen in 2.85 % (45.13 % of affected subjects). Concomitant involvement of incisors resulted in more severe presentation of defects in molars. Subjects with a greater number of affected surfaces had more severe lesions with a greater extent of lesions.

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