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# Occlusal caries detection in permanent molars according to WHO basic methods, ICDAS II and laser fluorescence measurements

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Abstract – This epidemiological study aimed to compare the diagnostic outcome of the WHO criteria, ICDAS II criteria, laser fluorescence measurements, presence of plaque and roughness as activity scores on occlusal fissures and buccal/palatal pits of the first permanent molars. The study involved 311 children between 8 and 12 years of age from the Ennepe-Ruhr District in North Rhine-Westphalia, Germany. The surface-related caries status was registered according to the WHO basic method criteria (1997). Additionally, pit and fissure sealants, the ICDAS II visual criteria, the DIAGNOdent reading, plaque retention and surface roughness were documented. Caries experience was 1.0 (±2.5) DMFS. About 70% of the examined students had no obvious dentin caries in the permanent dentition (DMFS = 0). Sealants were registered on 1.4 (±1.7) occlusal fissures and 0.4 (±0.9) palatal/buccal pits. Noncavitated caries lesions were recorded as ICDAS II score 1–4 on 1.8 (±1.6) fissures and 1.5 (±1.4) pits. The comparison of the diagnostic methods suggests a relationship between higher ICDAS II scores/DIAGNOdent values and a proportional increase in the occurrence of plaque as well as in the number of rough surfaces. In conclusion, this study showed the diagnostic potential of the ICDAS II criteria in comparison to the traditional WHO criteria by means of the noncavitated caries lesions additionally detected. The DIAGNOdent use in field studies that already apply detailed visual criteria seems to bring limited additional information. While the presence of plaque provides information for the caries activity assessment more work is required to provide information about the contribution of surface roughness.

Key words: caries detection; dental caries; epidemiology; pits and fissures

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In recent decades, epidemiological studies have shown a general drop in the caries prevalence together with a concentration of lesions in the pits and fissures of permanent molars in children and young adults in many industrialized countries (1). While progression of caries lesions generally appears to slow down with increasing age (2), dentists diagnose young patients and adults with occlusal lesions at the noncavitated level more frequently (3, 4). Therefore, the early detection, assessment and correct diagnosis of those lesions are key targets in the overall effort to move away from operative towards nonoperative preventive dentistry (5). The method used in the majority of epidemiological caries screenings is based on the DMF Index, which was established as early as in 1938 (6). With this index, the caries status is typically determined according to the level of

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cavitation. Current WHO basic methods criteria (7) score a caries lesion in a pit or fissure only, when ''a manifest cavity, undermined enamel, or a detectably softened floor or wall is detectable; the CPI probe should be used to confirm visual evidence of caries''. In contrast, detailed visual examination methods (8–11) record early visible signs of the carious process such as opacities, brown discolorations, enamel breakdowns or microcavities without an obvious cavity. These visual signs have proven to be good indicators of the presence of enamel and/or dentin lesions (9, 12). The changing disease patterns with a general caries decline associated with a relatively high number of non-cavitated caries lesions was one of the reasons that led to the development of the harmonised International Caries Detection and Assessment System II (ICDAS II) in recent years (13–15). Since there is a need to understand better the diagnostic outcome of this visually based system in an epidemiological setting, this study was aimed to compare the caries ratings for occlusal fissures and palatal/buccal pits of 8- to 12-year-olds according to both WHO basic methods (7) and ICDAS II detection criteria. In addition, laser fluorescence measurements (DIAGNOdent 2095, KaVo, Biberach, Germany) were carried out to investigate to what extent the current DIAGNOdent recommendations (16) align with the ICDAS II criteria *in vivo*. The plaque index and surface roughness of the occlusal fissures and palatal/buccal pits were also assessed as possibly significant factors in the activity of caries lesions.

## Materials and methods

### *Study population*

The epidemiological study involved 311 children between 8 and 12 years of age from the Ennepe-Ruhr District (EN) in North Rhine-Westphalia, Germany. One hundred and forty two 8-year olds (78 male/64 female), fifty-four 10-year olds (26/28) and one hundred and fifteen 12-year olds (61/54) were examined. The children went to primary schools in socially deprived areas or to ''Hauptschulen'' – secondary modern schools with a low academic level. The choice of schools was based on epidemiological data obtained from annual caries screenings in the whole EN district. The individuals of the selected sample therefore may be a group with a higher caries risk. Altogether 1226 molars from these children were available for the clinical examination. With the parents' consent, a total of 72% of the pupils were willing to take advantage of the intensive prevention scheme, which included extended caries checks and preventive care. In the end, 70% of the students at the schools participated in the scheme in the school year of 2004/2005; 46% of the children came from an ethnic minority background (51% in the group of 8-year olds, 39% of the 10-year olds, and 42% of the 12-year olds).

### *Clinical examination (WHO/ICDAS II)*

The caries status according to the WHO standard was determined as DMFS index (7) for each tooth surface by a calibrated examiner (H.S.). The examination took place in the school using a dental mirror with a plane surface, a CPI probe (CP-11.5B6, Hu-Friedy, Chicago, IL, USA) and a halogen lamp (Mach Miniflex, Dr. Mach, Ebersberg, Germany).

The scoring according to ICDAS II visual criteria (Table 1) was carried out by a second calibrated examiner (S.B.) in a mobile dental unit (Mercedes-Benz Sprinter, Daimler Chrysler AG, Stuttgart, Deutschland) with dental treatment facility (1300HK, Ultradent, Munich, Germany). Prior to a professional tooth cleaning with a small rotating brush (Miniature Prophy Brushes, Hawe Neos Dental, Bioggio, Switzerland) the entire occlusal fissure pattern as well as the lower buccal and the upper palatal pits of the first molars were examined for plaque retentions. The visual evidence of plaque was confirmed using a CPI probe without applying pressure. After cleaning, isolating and prolonged air-drying (5 seconds), each molar was assessed according to ICDAS II criteria (14, 15) using a head loupe (four-fold magnification, Lactona, American Opticals, USA). Sealants, both intact and partially retained, were likewise registered. In cases where fillings did not cover the whole fissure pattern, as well as in cases of partially sealed fissures and pits, the uncovered fissure system was also assessed, thus sometimes leading to multiple results for the same tooth surface. Rough surfaces of the fissures and pit areas were detected by gentle passing of the CPI probe over the fissure pattern. The tooth surface was classified as 'rough' if slip resistance was felt to be increased. On the whole, a (partially) complete pit and fissure pattern showed 840 occlusal fissures and 1088 palatal/buccal pits and were accessible for all diagnostic methods. All other occlusal surfaces ($n$ = 386) and palatal/buccal pits ($n$ = 138) were completely filled or sealed.

Table 1. ICDAS II criteria for primary caries detection on pits and fissures (15)

| Score | Clinical description of occlusal pits and fissures |
|---|---|
| 0 – Sound | There should be no evidence of caries after prolonged air-drying (5 seconds). Surfaces with developmental defects (enamel hypoplasia, fluorosis), attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as sound. |
| 1 – First visual change in enamel | When seen wet there is no evidence of any change in colour attributable to carious activity, but after prolonged air-drying a carious opacity or discoloration (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel. |
| 2 – Distinct visual change in enamel | The tooth must be viewed wet. When wet there is a (a) carious opacity (white spot lesion) and/or (b) brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel. |
| 3 – Localized enamel breakdown due to caries with no visible dentin or underlying shadow | The tooth viewed wet may have a clear carious opacity (white spot lesion) and/or brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel. Once dried for approximately 5 seconds there is carious loss of tooth structure at the entrance to, or within, the pit or fissure/fossa. If in doubt, or to confirm the visual assessment, the CPI probe was used gently across a tooth surface to confirm the presence of a cavity apparently confined to the enamel. |
| 4 – Underlying dark shadow from dentin with or without localized enamel breakdown | This lesion appears as a shadow of discolored dentin visible through an apparently intact enamel surface which may or may not show signs of localized breakdown (loss of continuity of the surface that is not showing the dentin). |
| 5 – Distinct cavity with visible dentin | Cavitation in opaque or discoloured enamel exposing the dentin beneath. |
| 6 – Extensive distinct cavity with visible dentin | Obvious loss of tooth structure, the cavity is both deep and wide and dentin is clearly visible on the walls and at the base. An extensive cavity involves at least half of a tooth surface or possibly reaching the pulp. |

Table 2. Data of the intra- and inter-examiner-reproducibility of the used methods

| | Reproducibility | | |
|---|---|---|---|
| | Statistical method | Intra examiner | Inter examiner |
| Pit and fissure sealants | Kappa | 0.96 | 0.95 |
| ICDAS II | Weighted Kappa | 0.88 | 0.90 |
| Laser fluorescence measurements | Intraclass correlation coefficient | 0.96 | 0.92 |
| Plaque | Kappa | 0.78 | 0.76 |
| Roughness | Kappa | 0.87 | 0.84 |

Before the study, the operator (S.B.) was calibrated by an experienced examiner (R.H.-W.). All calibrations took place prior to the field study with a separate sample including 20 8- to 12-year olds under normal field conditions. The results can be seen in Table 2.

### *Laser fluorescence measurements*

Maintaining the isolation of the teeth, the visual assessment was followed by laser fluorescence measurement with the DIAGNOdent device (DIAGNOdent 2095, KaVo, Biberach, Germany). For all measurements, the same conical probe A was used. Prior to the daily measurements, the device was calibrated following the manufacturer's instructions. The calibration was repeated hourly to rule out internal device errors as well as to ensure uniform results. The calibration was checked at the end of the daily measurements; no deviations greater than 3 against the ceramic standard occurred during the study period.

The measurement of each occlusal site consisted of a brief air-drying for about 5 seconds with the air syringe of the dental unit. The inherent fluorescence of each tooth was adjusted by holding the tip against the sound smooth surface of the mesiobuccal cusp and pressing the ring button until the calibration was completed. The DIAGNOdent tip was then placed on the occlusal fissure and slightly tilted circular movements were performed along the entire fissure pattern. The examiner was encouraged to re-measure carefully the sites with doubtful readings. The maximum reading for each surface was recorded. The analysis of the DIAGNOdent readings used the cut-off values recommended by Lussi et al. (16) for dried and cleaned occlusal surfaces. Prior to the epidemiological study, a separate calibration training for the laser fluorescence measurement was performed; the results can be taken from Table 2.

### *Statistical analysis*

The data was analysed with SPSS 12.0 (SPSS Inc., Chicago, IL, USA) and Excel 2000 (Microsoft Corporation, Redmond, WA, USA). In addition to the calculation of the overall DMFS index (mean, standard deviation), the DF values for the fissures and pits were determined separately. The ICDAS II results and data relating to sealed fissures and pits were analysed by surface. Cross tabulations were used to compare the ICDAS II criteria with the measured DIAGNOdent values. Here, the various ICDAS II categories were set against the DIAGNOdent categories according to Lussi et al. (16). The following parameters were determined: number of molars, DIAGNOdent means and corresponding standard deviation (SD). The intra- and inter-examiner reproducibility was established by calculating Kappa values, weighted Kappa values and intraclass correlations coefficients (Table 2).

## Results

About 70% of the 8- to 12-year-old children had no obvious dentin caries in the permanent dentition (DMFS = 0). Caries experience among the children corresponded to 1.0 (±2.5) DMFS on average. The mean DFS values amounted to 0.4 (±1.0) for the occlusal fissures, 0.2 (±0.6) for the palatal/buccal pits and 0.4 (±0.9) for all other teeth respectively. Sealants were registered on a mean of 1.4 (±1.7) occlusal fissures and 0.4 (±0.9) palatal/buccal pits. 55.6% of the students had at least one sealed fissure and/or pit. Noncavitated caries lesions were recorded as ICDAS II score 1–4 on 1.8 (±1.6) fissures and 1.5 (±1.4) pits. Only 15% of the children showed no manifestations of the carious process in their pits and fissures. The diagnostic potential – expressed as ratio in comparison to the WHO basic method – of the ICDAS II criteria and the laser fluorescence measurements for occlusal caries detection is shown in Fig. 1.

Table 3 shows the distribution for all molars according to the cross tabulation between the ICDAS II and the DIAGNOdent categories. They include frequency and DIAGNOdent means (SD). The results for the plaque and roughness recordings can be seen in Tables 4 and 5. The overall data suggest a relationship between higher ICDAS II scores and higher DIAGNOdent values as well as a proportional increase in the occurrence of plaque as well as in the number of rough surfaces with increasing ICDAS scores and DIAGNOdent values.

## Discussion

The chosen study design allowed a number of detailed assessments (DFS, ICDAS II, pit and fissure sealants, plaque accumulation und roughness) for the first permanent molars and their occlusal fissures and buccal/palatal pits as part of a comprehensive epidemiological survey. In addition to the conventional assessment of the caries status according to WHO basic methods criteria (7), ICDAS II criteria were applied for the first time in this local cross-sectional study. The positive experiences collected from this investigation essentially confirm that this visually based diagnostic system has a number of benefits: While the examination

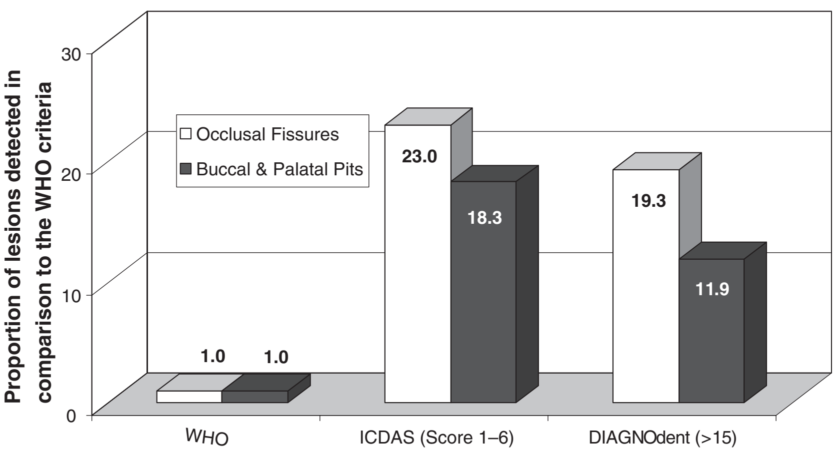


*Fig. 1.* The diagram shows the proportion of occlusal caries lesions detected by the ICDAS II criteria (score 1–6) and the laser fluorescence measurement (DIAGNOdent value >15) in comparison to the WHO basic methods (the number of decayed surfaces on fissures and pits was set as 1).

Table 3. Distribution of ICDAS II scores on occlusal fissures and palatal/buccal pits related to DIAGNOdent categories

| | | | DIAGNOdent categories according to Lussi et al. (16) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0–15 Sound | | 16–17 Enamel caries | | 18–31 Dentin caries | | >31 Deep dentin lesion | | Σ | |
| | | | *N* (%) | Mean (SD) | *N* (%) | Mean (SD) | *N* (%) | Mean (SD) | *N* (%) | Mean (SD) | *N* (%) | Mean (SD) |
| ICDAS II | Occlusal fissures | 0 | 228 (27.1) | 6.2 (3.6) | 4 (0.5) | 16.0 (0.0) | 9 (1.1) | 22.7 (24.3) | – | – | **241 (28.7)** | **7.0 (4.9)** |
| | | 1 | 28 (3.3) | 10.0 (3.8) | 7 (0.8) | 16.4 (0.5) | 45 (5.4) | 23.4 (3.7) | 20 (2.4) | 51.8 (16.2) | **100 (11.9)** | **24.8 (16.6)** |
| | | 2 | 79 (9.4) | 11.0 (3.4) | 27 (3.2) | 16.5 (0.5) | 156 (18.6) | 23.8 (4.1) | 130 (15.5) | 51.3 (18.6) | **392 (46.7)** | **29.8 (19.4)** |
| | | 3 | 2 (0.2) | 11.0 (2.8) | – | – | 13 (1.5) | 26.5 (2.9) | 40 (4.8) | 56.2 (22.9) | **55 (6.5)** | **47.5 (24.3)** |
| | | 4 | 1 (0.1) | 13.0 (0.0) | 1 (0.1) | 16.0 (0.0) | 5 (0.6) | 24.0 (27.2) | 18 (2.1) | 55.5 (61.9) | **25 (3.0)** | **45.9 (25.7)** |
| | | 5 | – | – | – | – | 1 (0.1) | 28.0 (0.0) | 18 (2.1) | 73.9 (23.8) | **19 (2.3)** | **71.5 (77.7)** |
| | | 6 | – | – | – | – | – | – | 8 (1.0) | 79.5 (21.0) | **8 (1.0)** | **79.5 (21.0)** |
| | | Σ | **338 (40.2)** | **7.7 (4.1)** | **39 (4.6)** | **16.4 (0.5)** | **229 (27.3)** | **23.9 (4.0)** | **234 (27.9)** | **55.2 (21.3)** | **840 (100.0)** | **25.7 (22.7)** |
| | Palatal/ buccal pits | 0 | 587 (53.9) | 3.9 (3.1) | 1 (0.1) | 16.0 (0.0) | 4 (0.4) | 23.0 (3.4) | 3 (0.3) | 46.0 (5.3) | **595 (54.7)** | **4.3 (4.6)** |
| | | 1 | 59 (5.4) | 9.5 (3.8) | 4 (0.4) | 16.3 (0.4) | 29 (2.6) | 22.4 (4.0) | 11 (1.0) | 53.4 (59.1) | **103 (9.4)** | **18.0 (15.2)** |
| | | 2 | 117 (10.8) | 10.6 (3.4) | 26 (2.4) | 16.5 (0.5) | 96 (8.8) | 23.6 (4.2) | 71 (6.5) | 52.7 (20.5) | **310 (28.5)** | **24.8 (19.2)** |
| | | 3 | 2 (0.2) | 13.2 (2.1) | 2 (0.2) | 16.5 (0.7) | 10 (0.9) | 26.5 (2.6) | 28 (2.6) | 62.8 (24.7) | **42 (3.9)** | **49.6 (27.7)** |
| | | 4 | 1 (0.1) | 10.0 (0.0) | – | – | – | – | 10 (0.9) | 54.6 (28.3) | **11 (1.0)** | **50.5 (30.0)** |
| | | 5 | – | – | – | – | – | – | 26 (2.4) | 83.3 (22.7) | **26 (2.4)** | **83.3 (27.7)** |
| | | 6 | – | – | – | – | – | – | 1 (0.1) | 99.0 (0.0) | **1 (0.1)** | **99.0 (0.0)** |
| | | Σ | **766 (70.4)** | **5.4 (4.1)** | **33 (3.1)** | **16.6 (0.0)** | **139 (12.7)** | **23.5 (4.1)** | **150 (13.8)** | **60.3 (24.6)** | **1088 (100.0)** | **15.7 (25.6)** |

Table 4. Distribution of ICDAS II scores and DIAGNOdent categories on occlusal fissures and palatal/buccal pits related to absence (−) or presence (+) of plaque

| | | | DIAGNOdent categories according to Lussi et al. (16) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0–15 Sound | | 16–17 Enamel caries | | 18–31 Dentin caries | | >31 Deep dentin lesion | | Σ | | |
| | | N (%) | Plaque − | Plaque + | Plaque − | Plaque + | Plaque − | Plaque + | Plaque − | Plaque + | Plaque − | Plaque + | All |
| ICDAS II | Occlusal fissures | 0 | 204 (24.3%) | 24 (2.9%) | 3 (0.3%) | 1 (0.1%) | 8 (1.0%) | 1 (0.1%) | – | – | 215 (25.6%) | 26 (3.1%) | **241 (28.7%)** |
| | | 1 | 26 (3.1%) | 2 (0.2%) | 6 (0.7%) | 1 (0.1%) | 35 (4.2%) | 10 (1.2%) | 11 (1.3%) | 9 (1.1%) | 78 (9.3%) | 22 (2.6%) | **100 (11.9%)** |
| | | 2 | 76 (9.1%) | 3 (0.3%) | 24 (2.9%) | 3 (0.4%) | 138 (16.3%) | 18 (2.1%) | 86 (10.2%) | 44 (5.3%) | 324 (38.6%) | 68 (8.1%) | **392 (46.7%)** |
| | | 3 | 2 (0.2%) | – | – | 0 (0.0%) | 10 (1.2%) | 3 (0.4%) | 29 (3.5%) | 11 (1.3%) | 41 (4.8%) | 14 (1.7%) | **55 (6.5%)** |
| | | 4 | 1 (0.1%) | – | 1 (0.1%) | 0 (0.0%) | 5 (0.6%) | 0 (0.0%) | 12 (1.5%) | 6 (0.7%) | 19 (2.3%) | 6 (0.7%) | **25 (3.0%)** |
| | | 5 | – | – | – | – | 1 (0.1%) | 0 (0.0%) | 4 (0.5%) | 14 (1.7%) | 5 (0.6%) | 14 (1.7%) | **19 (2.3%)** |
| | | 6 | – | – | – | – | – | – | 2 (0.2%) | 6 (0.7%) | 2 (0.2%) | 6 (0.7%) | **8 (0.9%)** |
| | | Σ | **309 (36.8%)** | **29 (3.4%)** | **34 (4.0%)** | **5 (0.6%)** | **197 (23.5%)** | **32 (3.8%)** | **144 (17.2%)** | **90 (10.7%)** | **684 (81.4%)** | **156 (18.6%)** | **840 (100.0%)** |
| | | | **338 (40.2%)** | | **39 (4.6%)** | | **229 (27.3%)** | | **234 (27.9%)** | | **840 (100.0%)** | | |
| | Palatal/ buccal pits | 0 | 494 (45.4%) | 93 (8.5%) | 1 (0.1%) | – | 2 (0.2%) | 2 (0.2%) | – | 3 (0.3%) | 497 (45.7%) | 98 (9.0%) | **595 (54.7%)** |
| | | 1 | 42 (3.9%) | 17 (1.6%) | 3 (0.3%) | 1 (0.1%) | 19 (1.7%) | 10 (0.9%) | 5 (0.4%) | 6 (0.5%) | 69 (6.3%) | 34 (3.1%) | **103 (9.4%)** |
| | | 2 | 98 (9.0%) | 19 (1.7%) | 24 (2.2%) | 2 (0.2%) | 69 (6.3%) | 27 (2.5%) | 33 (3.0%) | 38 (3.6%) | 224 (20.5%) | 86 (8.0%) | **310 (28.5%)** |
| | | 3 | 2 (0.2%) | – | 2 (0.2%) | – | 5 (0.5%) | 5 (0.4%) | 8 (0.7%) | 20 (1.9%) | 17 (1.6%) | 25 (2.3%) | **42 (3.9%)** |
| | | 4 | 1 (0.1%) | – | – | – | – | – | 4 (0.4%) | 6 (0.5%) | 5 (0.5%) | 6 (0.5%) | **11 (1.0%)** |
| | | 5 | – | – | – | – | – | – | 4 (0.4%) | 22 (2.0%) | 4 (0.4%) | 22 (2.0%) | **26 (2.4%)** |
| | | 6 | – | – | – | – | – | – | – | 1 (0.1%) | – | 1 (0.1%) | **1 (0.1%)** |
| | | Σ | **637 (58.6%)** | **129 (11.8%)** | **30 (2.8%)** | **3 (0.3%)** | **95 (8.7%)** | **44 (4.0%)** | **54 (4.9%)** | **96 (8.9%)** | **816 (75.0%)** | **272 (25.0%)** | **1088 (100.0%)** |
| | | | **766 (70.4%)** | | **33 (3.1%)** | | **139 (12.7%)** | | **150 (13.8%)** | | **1088 (100.0%)** | | |

Table 5. Distribution of ICDAS II scores and DIAGNOdent categories on occlusal fissures and palatal/buccal pits related to the roughness

| | | | DIAGNOdent categories according to Lussi et al. (16) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0–15 Sound | | 16–17 Enamel caries | | 18–31 Dentin caries | | >31 Deep dentin lesion | | Σ | | |
| N (%) | | | Smooth | Rough | Smooth | Rough | Smooth | Rough | Smooth | Rough | Smooth | Rough | All |
| ICDAS II | Occlusal fissures | 0 | 225 (26.8%) | 3 (0.4%) | 4 (0.4%) | 0 (0.0%) | 9 (1.1%) | – | – | – | 238 (28.3%) | 3 (0.4%) | **241 (28.7%)** |
| | | 1 | 20 (2.4%) | 8 (1.0%) | 3 (0.4%) | 4 (0.5%) | 24 (2.8%) | 21 (2.5%) | 10 (1.2%) | 10 (1.2%) | 57 (6.8%) | 43 (5.1%) | **100 (11.9%)** |
| | | 2 | 68 (8.0%) | 11 (1.30%) | 26 (3.1%) | 1 (0.1%) | 122 (14.5%) | 34 (4.1%) | 56 (6.7%) | 74 (8.8%) | 272 (32.4%) | 120 (14.3%) | **392 (46.7%)** |
| | | 3 | – | 2 (0.2%) | – | – | 5 (0.6%) | 8 (1.0%) | 16 (1.9%) | 24 (2.9%) | 21 (2.5%) | 34 (4.1%) | **55 (6.5%)** |
| | | 4 | 1 (0.1%) | 0 (0.0%) | – | 1 (0.1%) | 4 (0.5%) | 1 (0.1%) | 7 (0.8%) | 11 (1.4%) | 12 (1.4%) | 13 (1.6%) | **25 (3.0%)** |
| | | 5 | – | – | – | – | – | 1 (0.1%) | 2 (0.2%) | 16 (1.9%) | 2 (0.2%) | 17 (2.0%) | **19 (2.3%)** |
| | | 6 | – | – | – | – | – | – | 1 (0.1%) | 7 (0.8%) | 1 (0.1%) | 7 (0.8%) | **8 (0.9%)** |
| | | Σ | **314 (37.3%)** | **24 (2.9%)** | **33 (3.9%)** | **6 (0.7%)** | **164 (19.5%)** | **65 (7.8%)** | **92 (10.9%)** | **142 (17.0%)** | **603 (71.7%)** | **237 (28.3%)** | **840 (100.0%)** |
| | | | **338 (40.2%)** | | **39 (4.6%)** | | **229 (27.3%)** | | **234 (27.9%)** | | **840 (100.0%)** | | |
| | Palatal/ buccal pits | 0 | 571 (52.5%) | 16 (1.4%) | 1 (0.1%) | – | 3 (0.3%) | 1 (0.1%) | 2 (0.2%) | 1 (0.1%) | 577 (53.1%) | 18 (1.6%) | **595 (54.7%)** |
| | | 1 | 20 (1.8%) | 39 (3.6%) | – | 4 (0.4%) | 4 (0.3%) | 25 (2.3%) | 1 (0.1%) | 10 (0.9%) | 25 (2.2%) | 78 (7.2%) | **103 (9.4%)** |
| | | 2 | 69 (6.3%) | 48 (4.5%) | 16 (1.5%) | 10 (0.9%) | 57 (5.2%) | 39 (3.6%) | 21 (1.9%) | 50 (4.6%) | 163 (14.9%) | 147 (13.6%) | **310 (28.5%)** |
| | | 3 | 2 (0.2%) | – | 1 (0.1%) | 1 (0.1%) | 3 (0.3%) | 7 (0.6%) | 4 (0.4%) | 24 (2.2%) | 10 (1.0%) | 32 (2.9%) | **42 (3.9%)** |
| | | 4 | 1 (0.1%) | – | – | – | – | – | 4 (0.4%) | 6 (0.5%) | 5 (0.5%) | 6 (0.5%) | **11 (1.0%)** |
| | | 5 | – | – | – | – | – | – | 2 (0.2%) | 24 (2.2%) | 2 (0.2%) | 24 (2.2%) | **26 (2.4%)** |
| | | 6 | – | – | – | – | – | – | – | 1 (0.1%) | – | 1 (0.1%) | **1 (0.1%)** |
| | | Σ | **663 (60.9%)** | **103 (9.5%)** | **18 (1.7%)** | **15 (1.4%)** | **67 (6.1%)** | **72 (6.6%)** | **34 (3.2%)** | **116 (10.6%)** | **782 (71.9%)** | **306 (28.1%)** | **1088 (100.0%)** |
| | | | **766 (70.4%)** | | **33 (3.1%)** | | **139 (12.7%)** | | **150 (13.8%)** | | **1088 (100.0%)** | | |

procedure is very similar to the WHO process, noncavitated caries lesions that would not be detected by the WHO assessment are recorded. Besides, the authors believe that the ICDAS II criteria are simplified compared to other visual diagnostic systems (11), and previous validated diagnostic studies provided clues about the diagnostic outcome of the individual scores (9, 17).

The number of noncavitated caries lesions detected – on average 1.8 fissures and 1.5 pits – in particular underlines the need for adding a simple visual diagnostic method to the established WHO criteria if a meaningful representation of the continuum of caries is to be obtained (18–20). This means that among the examined population approximately half of the molars showed clinically visible signs of a caries process. The prevalence of noncavitated caries lesions compared to cavitations (DFS) points out the limitations of the DMF index for populations where the main caries burden is concentrated on the occlusal surfaces in molars (21). Besides, the WHO criteria prove insufficient on their own in order to identify the preventive and/or therapeutic treatment needs for the examined molars (Fig. 1).

The high portion of noncavitated caries lesions in permanent molars can mainly be attributed to the post-eruptive onset of the caries process within up to 6 years after tooth eruption. Sporadic visits to the dentist and low utilisation of preventive measures may also play a part (22). Some dentists might be hesitant to seal noncavitated caries lesions while feeling more confident about sealing pits and fissures of sound molars immediately after the eruption of a tooth. However, from the point of view of caries prevention, a ''wait and see strategy'' is not beneficial in all cases as an average of 6.3% of the occlusal fissures and 3.5% of the palatal/buccal pits (ICDAS II criteria ≥4, Table 3) already exhibit dentin lesions and operative care should be considered particularly for those lesions.

In addition to the ICDAS II criteria, this study included the results of laser fluorescence measurements. 27.1% of the fissures and 53.9% of the pits were consistently classified as sound by both methods (Table 3). Not more than a few exceptional deviations were recorded for other categories. The difference only becomes clear in connection with apparent caries lesions needing restoration (DIAGNOdent value >31, ICDAS II ≥4): While 5.2% of the occlusal fissures and 3.4% of the palatal/buccal pits were put in this category with both methods, 22.7% of the fissures and 10.4% of the pits received a lower ICDAS II score (DIAGNOdent value >31, ICDAS II <4). Only 0.9% of the fissures and 0.1% of the pits were not in concordance with the expected DIAGNOdent value on the other hand (DIAGNOdent value <31, ICDAS II ≥4). Taking into account the used cut-off values (16) as well as the cut-off values published so far (23), it seems to be that noncavitated caries lesions could somewhat 'overscored' with the DIAGNOdent device as compared to the employment of the ICDAS II criteria. Especially the 22.7% of fissures and the 10.4% of pits which were found to have a first or distinct visual change in enamel as well as localized enamel breakdowns but rendered a DIAGNOdent value of >31 strike. This circumstance illustrates once again the difficulties in correctly assessing noncavitated caries lesions, which have already been reported by previous studies (24, 25). In consideration of the caries decline (1) and the slower rate of progression of carious lesions in developed countries (2), a careful diagnosis is required to avoid false-positive interpretations (26). The cross tabulation analysis (Table 3) shows that the DIAGNOdent readings may indicate a more progressed caries lesion when compared to the ICDAS II criteria and using the cut-off values defined by Lussi et al. (16). Although it was not possible to validate the caries extent or progression with the study design used, the application of the ICDAS II visual criteria seems more appropriate. Moreover, laser fluorescence measurements as part of routine epidemiological screening programmes have a limited practicability as they require a professional tooth cleaning, and are more time-consuming investigation than visual inspection alone.

The recording of plaque and rough surfaces on occlusal fissures and palatal/buccal pits was a pilot study. This was performed to determine to what extent these two parameters may play a role in the activity of noncavitated occlusal lesions. Tables 4 and 5 illustrate that higher ICDAS II and DIAGNOdent scores generally corresponded to a proportional increase in plaque and the number of rough lesion surfaces. This may be used as indicator when attributing a predictive value to both factors. While the correlation of plaque is easy to justify aetiologically as it can influence the activity of a lesion quite considerably (11, 27–29), roughness is not so clear-cut (17). First of all, it must be said that currently there is no unanimous consensus as to when a surface roughness should be rated as such. This diagnostic uncertainty was extensively discussed during the calibration training especially that there is no specific tool for this purpose available. Never the less the Kappa values were found to be good. Further, it should also be taken into account that in the course of the clinical investigation the operator is constantly aware of the visual condition of the examined tooth and hence biased when it comes to the classification of clinical roughness. From our point of view the above mentioned factors and findings suggest that plaque seems to be of higher significance than roughness.

In conclusion, this epidemiological study showed the potential of the ICDAS II criteria in comparison to the traditional WHO criteria by means of the number of caries lesions on occlusal fissures and palatal/buccal pits additionally detected. When using ICDAS II criteria *in vivo* the laser fluorescence device seems to bring no additional detection gain while incurring considerable extra work and expense. Hence its use in field studies that already apply detailed visual criteria should be considered carefully when there is a lack of personal and financial resources. While the presence of plaque provide aetiology-related information in context with the caries activity assessment more work is required about the contribution of surface roughness.

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