Appendix

Criteria Manual

International Caries Detection and Assessment System (ICDAS II)

Workshop held in Baltimore, Maryland, March 12th-14th 2005

Sponsored by the National Institute of Dental and Craniofacial Research, the American Dental Association, and the International Association for Dental Research

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This report summarizes the key decisions and clinical criteria which were discussed by the participants (Appendix) in the ICDAS II, which was held in Baltimore, Maryland, USA, on March 12 through 14, 2005. The workshop was funded by the National Institute of Dental and Craniofacial Research (NIDCR) and the American Dental Association (ADA). The International Association for Dental Research (IADR) provided administrative support for the workshop.

The objective of the workshop was to develop consensus on clinical caries detection criteria among experts in cariology, clinical research, restorative dentistry, pediatric dentistry, public health, biological sciences, and dental organizations. This goal was achieved by the end of the workshop. Additionally, the participants have (1) defined the stages the caries process that can portray the concept of demineralization at the non-cavitated stage as well as the caries process overall; and (2) defined clinically relevant validation methods and research agenda for the newly developed detection system. No definitive conclusion was reached regarding how to measure caries activity and research of this important concept will continue. The final outcome of the workshop was the revision of the ICDAS criteria developed in 2002. The new criteria for the detection and assessment of dental caries will be referred to as ICDAS II. The workshop participants concluded their deliberation by recognizing that the ICDAS system will continue to evolve as new information and tools are developed and validated. The ICDAS II presents a foundation upon which new caries assessment tools could be embedded to aid in making more accurate decisions for clinical practice as well as for clinical and epidemiological research. The ICDAS II system strives to achieve integration and coordination of the emerging field of caries assessment.

Coronal Primary Caries Detection Criteria

Overview

The ICDAS detection codes for coronal caries range from 0 to 6 depending on the severity of the lesion. There are minor variations between the visual signs associated with each code depending on a number of factors including the surface characteristics (pits and fissures versus free smooth surfaces), whether there are adjacent teeth present (mesial and distal surfaces) and whether or not the caries is associated with a restoration or sealant. Therefore, a detailed description of each of the codes is given under the following headings to assist in the training of examiners in the use of ICDAS: Pits and fissures; smooth surface (mesial or distal); free smooth surfaces and caries associated with restorations and sealants (CARS). However, the basis of the codes is essentially the same throughout:

Code	Description
0	Sound
1	First Visual Change in Enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure)
2	Distinct Visual Change in Enamel
3	Localized Enamel Breakdown (without clinical visual signs of dentinal involvement)
4	Underlying Dark Shadow from Dentin
5	Distinct Cavity with Visible Dentin
6	Extensive Distinct Cavity with Visible Dentin

Coronal Primary Caries Codes

Pits and fissures

Sound tooth surface: Code 0
There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (suggested drying time 5 seconds)). Surfaces with developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as **sound**. The examiner should also score as sound a surface with multiple stained fissures if such a condition is seen in other pits and fissures, a condition which is consistent with non-carious habits (e.g. frequent tea drinking). Table 1 provides a useful guide for differential diagnosis for carious opacities versus other opacities.

First visual change in enamel: Code 1
Code 1 is assigned for the following pits and fissures:

When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying (approximately 5 seconds is suggested to adequately dehydrate a carious lesion in enamel) a carious opacity or discoloration (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel
OR
When there is a change of color due to caries which is not consistent with the clinical appearance of sound enamel and is limited to the confines of the pit and fissure area (whether seen wet or dry). The appearance of these carious areas is not consistent with that of stained pits and fissures as defined in code 0.

Distinct visual change in enamel: Code 2
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 (Note: the lesion must still be visible when dry).

Localized enamel breakdown due to caries with no visible dentin or underlying shadow: **Code 3**
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. This will be seen visually as evidence of demineralization (opaque (white), brown or dark brown walls) at the entrance to or within the fissure or pit, and although the pit or fissure may appear substantially and unnaturally wider than normal, the dentin is NOT visible in the walls or base of the cavity/discontinuity.

If in doubt, or to confirm the visual assessment, the WHO/CPI/PSR probe can be used ***gently across a tooth surface*** to confirm the presence of a cavity apparently confined to the enamel.

This is achieved by sliding the ball end along the suspect pit or fissure and a limited discontinuity is detected if the ball drops into the surface of the enamel cavity/discontinuity.

Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4
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). The shadow appearance is often seen more easily when the tooth is wet. The darkened area is an intrinsic shadow which may appear as grey, blue or brown in color. The shadow must clearly represent caries that started on the tooth surface being evaluated. If in the opinion of the examiner, the carious lesion started on an adjacent surface and there no evidence of any caries on the surface being scored then the surface should be coded "0".

Code 3 and 4, histologically may vary in depth with one being deeper than the other and vice versa. This will depend on the population and properties of the enamel. For example more translucent and thinner enamel in primary teeth may allow the undermining discoloration of the dentin to be seen before localized breakdown of enamel. However, in most cases code 4 is likely to be deeper into dentin than code 3.

Distinct cavity with visible dentin: Code 5
Cavitation in opaque or discolored enamel exposing the dentin beneath.

The tooth viewed wet may have darkening of the dentin visible through the enamel. Once dried for 5 seconds there is visual evidence of loss of tooth structure at the entrance to or within the pit or fissure – frank cavitation. There is visual evidence of demineralization (opaque (white), brown or dark brown walls) at the entrance to or within the pit or fissure and in the examiner judgment dentin is exposed.

The WHO/CPI/PSR probe can be used to confirm the presence of a cavity apparently in dentin. This is achieved by sliding the ball end along the suspect pit or fissure and a dentin cavity is detected if the ball enters the opening of the cavity and in the opinion of the examiner the base is in dentin. (In pits or fissures the thickness of the enamel is between 0.5 and 1.0 mm. Note the deep pulpal dentin should not be probed)

Extensive distinct cavity with visible dentin: Code 6
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.

<u>Smooth surface (mesial and distal)</u>

This requires visual inspection from the occlusal, buccal and lingual directions.

Sound tooth surface: Code 0
There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (suggested drying time 5 seconds)). Surfaces with developmental

defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as **sound**.

First visual change in enamel: Code 1
When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying a carious opacity (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel. This will be seen from the buccal or lingual surface.

Distinct visual change in enamel when viewed wet: Code 2
There is a carious opacity or discoloration (white or brown lesion) that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry). This lesion may be seen directly when viewed from the buccal or lingual direction. In addition, when viewed from the occlusal direction, this opacity or discoloration may be seen as a shadow confined to enamel, seen through the marginal ridge.

Initial breakdown in enamel due to caries with no visible dentin: Code 3
Once dried for approximately 5 seconds there is distinct loss of enamel integrity, viewed from the buccal or lingual direction.

If in doubt, or to confirm the visual assessment, the CPI probe can be used gently across the surface to confirm the loss of surface integrity.

Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4
This lesion appears as a shadow of discolored dentin visible through an apparently intact marginal ridge, buccal or lingual walls of enamel. This appearance is often seen more easily when the tooth is wet. The darkened area is an intrinsic shadow which may appear as grey, blue or brown in color.

Distinct cavity with visible dentin: Code 5.
Cavitation in opaque or discolored enamel (white or brown) with exposed dentin in the examiner's judgment.

If in doubt, or to confirm the visual assessment, the CPI probe can be used to confirm the presence of a cavity apparently in dentin. This is achieved by sliding the ball end along the surface and a dentin cavity is detected if the ball enters the opening of the cavity and in the opinion of the examiner the base is in dentin.

Extensive distinct cavity with visible dentin: Code 6
Obvious loss of tooth structure, the extensive cavity may be deep or wide and dentin is **clearly visible** on both the walls and at the base. The marginal ridge may or may not be present. An extensive cavity involves at least half of a tooth surface or possibly reaching the pulp.

Free Smooth surface (buccal and lingual and direct examination of mesial and distal surfaces (with no adjacent teeth)

Sound tooth surface: Code 0
There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (approximately 5 seconds)). Surfaces with developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as sound.

First visual change in enamel: Code 1
When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying a carious opacity is visible that is not consistent with the clinical appearance of sound enamel

Distinct visual change in enamel when viewed wet: Code 2
There is a carious opacity or discoloration that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry). The lesion is located in close proximity (in touch or within 1 mm) of the gingival margin

Localized enamel breakdown due to caries with no visible dentin: Code 3
Once dried for 5 seconds there is carious loss of surface integrity without visible dentin.

If in doubt, or to confirm the visual assessment, the CPI probe can be used with NO digital pressure to confirm the loss of surface integrity.

Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4
This lesion appears as a shadow of discolored dentin visible through the enamel surface beyond the white or brown spot lesion, which may or may not show signs of localized breakdown. This appearance is often seen more easily when the tooth is wet and is a darkening and intrinsic shadow which may be grey, blue or brown in color.

Distinct cavity with visible dentin: Code 5
Cavitation in opaque or discolored enamel exposing the dentin beneath.

If in doubt, or to confirm the visual assessment, the CPI probe can be used with NO digital pressure to confirm the presence of a cavity apparently in dentin. This is achieved by sliding the ball end along the surface and a dentin cavity is detected if the ball enters the opening of the cavity and in the opinion of the examiner the base is in dentin.

Extensive distinct cavity with visible dentin: Code 6
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.

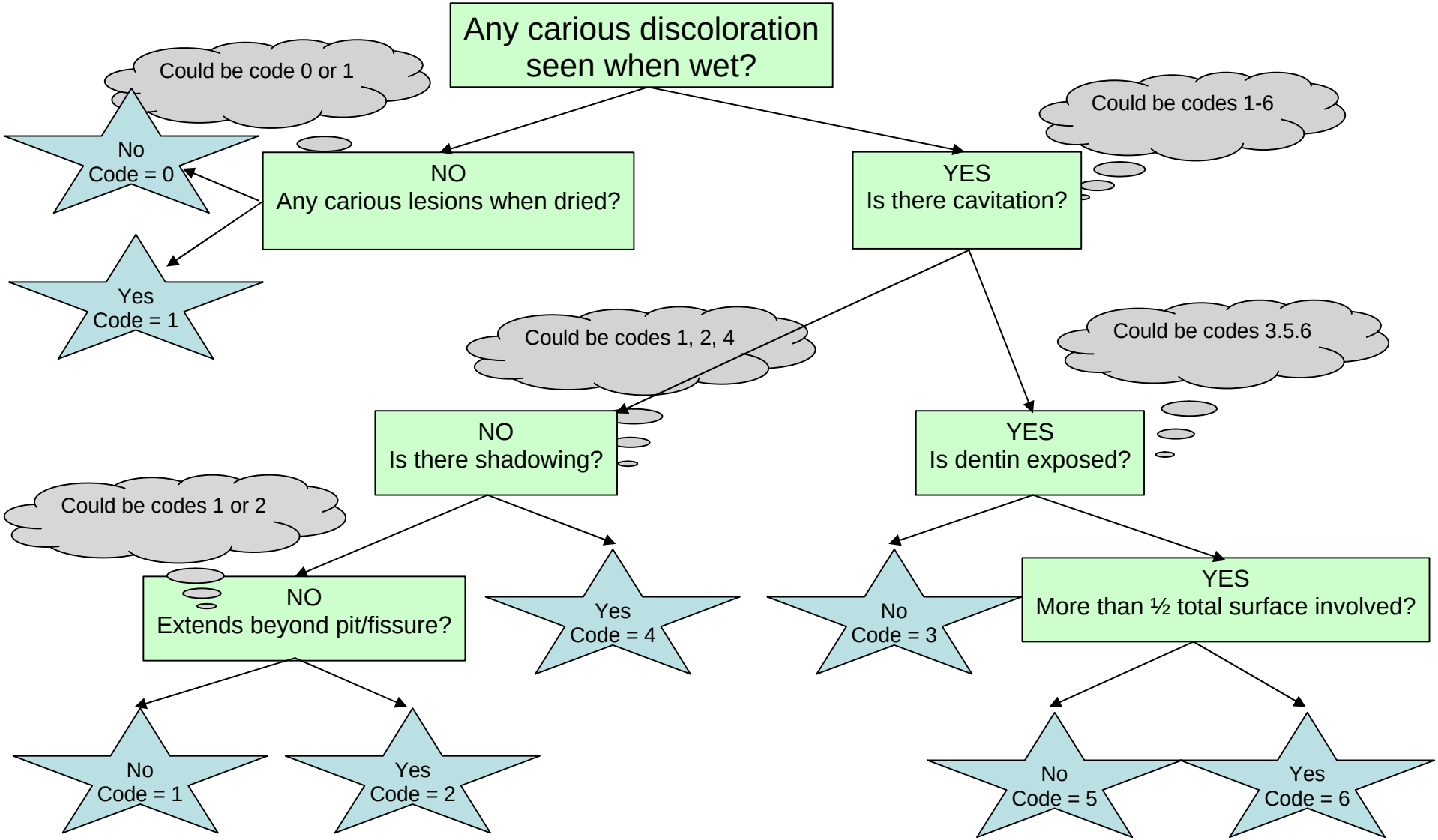
Figure 1 depicts a simple decision tree for applying the 7-code for classifying coronal tooth surfaces following the ICDAS criteria.

Table 1. Differential Diagnosis between Milder Forms of Dental Fluorosis (Questionable, Very Mild, And Mild) and Nonfluoride Opacities of Enamel.

Characteristic	Milder Forms of Fluorosis	Nonfluoride Enamel Opacities
Area affected	Usually seen on or near tips of cusps or incisal edges.	Usually centred in smooth surface; may affect entire crown.
Shape of lesion	Resembles line shading in pencil sketch; lines follow incremental lines in enamel, form irregular caps on cusps.	Often round or oval.
Demarcation	Shades off imperceptibly into surrounding normal enamel.	Clearly differentiated from adjacent normal enamel.
Color	Slightly more opaque than normal enamel; paper-white. Incisal edges, tips of cusps may have frosted appearance. Does not show stain at time of eruption (in these milder degrees, rarely at any time).	Usually pigmented at time of eruption often creamy-yellow to dark reddish-orange.
Teeth Affected	Most frequent on teeth that calcify slowly (cuspids, bicuspids, second and third molars). Rare on lower incisors. Usually seen on six or eight homologous teeth. Extremely rare in deciduous teeth.	Any tooth may be affected. Frequent on labial surfaces of lower incisors. May occur singly. Usually one to three teeth affected. Common in deciduous teeth.
Gross hypoplasia	None. Pitting of enamel does not occur in the milder forms. Enamel surface has glazed appearance, is smooth to point of explorer.	Absent to severe. Enamel surface may seem etched, be rough to explorer.
Detection	Often invisible under strong light; most easily detected by line of sight tangential to tooth crown.	Seen most easily under strong light on line of sight perpendicular to tooth surface.

Russell AL. The differential diagnosis of fluoride and non-fluoride enamel opacities. J Public Health Dent 1961;21:143-6.

Figure 1. DECISION TREE FOR PRIMARY CORONAL CARIES DETECTION



Caries-Associated with Restorations and Sealants (CARS) Detection Criteria

Caries Associated with Restorations and Sealants Codes

Sound tooth surface with restoration or sealant: Code 0
A sound tooth surface adjacent to a restoration/sealant margin. There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying for 5 seconds). Surfaces with marginal defects less than 0.5mm in width (i.e. will not admit the ball end of the CPI Probe), developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as sound. Stained margins consistent with non-carious habits (e.g. frequent tea drinking) and which do not exhibit signs consistent with demineralization should be scored as sound

First visual change in enamel: Code 1
When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying (for approximately 5 seconds) an opacity or discoloration consistent with demineralisation is visible that is not consistent with the clinical appearance of sound enamel.

Distinct visual change in enamel/dentin adjacent to a restoration/sealant margin: Code 2

- **If the restoration margin is placed on enamel** the tooth must be viewed wet. When wet there is an opacity consistent with demineralisation or discoloration that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry).

- **If the restoration margin is placed on dentin: Code 2** applies to discoloration that is not consistent with the clinical appearance of sound dentin or cementum.

Carious defects of <0.5 mm with the signs of code 2: Code 3
Cavitation at the margin of the restoration/sealant less than 0.5mm, in addition to either an opacity or discoloration consistent with demineralisation that is not consistent with the clinical appearance of sound enamel or with a shadow of discolored dentin.

Marginal caries in enamel/dentin /cementum adjacent to restoration/sealant with underlying dark shadow from dentin: Code 4
The tooth surface may have characteristics of code 2 and has a shadow of discolored dentin which is visible through an apparently intact enamel surface or with localized breakdown in enamel but no visible dentin. This appearance is often seen more easily when the tooth is wet and is a darkening and intrinsic shadow which may be grey, blue, orange, or brown in color. Note: view tooth wet and then dry. This lesion should be distinguished from amalgam shadows.

Distinct cavity adjacent to restoration/sealant: Code 5
Distinct cavity adjacent to restoration/sealant with visible dentin in the interfacial space with signs of caries as described in code 4, in addition to a gap > 0.5mm in width.
OR
In those instances where margins are not visible, there is evidence of discontinuity at the margin of the restoration/sealant and tooth substance of the dentin as detected by 0.5mm ball-ended probe run along the restoration/sealant margin.

Extensive distinct cavity with visible dentin: Code 6
Obvious loss of tooth structure, the extensive cavity may be deep or wide and dentin is **clearly visible** on both the walls and at the base.

ICDAS two-digit coding method

A two-number coding system is suggested to identify restorations/sealants with the first digit, followed by the appropriate caries code, for example a tooth restored with amalgam which also exhibited an extensive distinct cavity with visible dentin would be coded 4 (for an amalgam restoration) 6 (distinct cavity), an unrestored tooth with a distinct cavity would be 06. The suggested restoration/sealant coding system is as follows:

0 = Sound: i.e. surface not restored or sealed (use with the codes for primary caries)
1 = Sealant, partial
2 = Sealant, full
3 = Tooth colored restoration
4 = Amalgam restoration
5 = Stainless steel crown
6 = Porcelain or gold or PFM crown or veneer
7 = Lost or broken restoration
8 = Temporary restoration
9 = Used for the following conditions
- 96 = Tooth surface cannot be examined: surface excluded
- 97 = Tooth missing because of caries (tooth surfaces will be coded 97)
- 98 = Tooth missing for reasons other than caries (all tooth surfaces will be coded 98)
- 99 = Unerupted (tooth surfaces coded 99)

Special considerations

1. In case of doubt the examiner should score low.
2. It may be necessary to distinguish among unerupted teeth, teeth extracted because of caries and those extracted or missing for other reasons.
3. Non-vital teeth should be scored in the same manner as vital teeth.
4. Banded or bracketed teeth. All visible surfaces should be examined as well as possible and scored in the usual manner. When a surface is completely covered by a band or bracket and there is no evidence of caries the tooth status code is “0”.
5. In the case of supernumerary teeth, the examiner should decide which tooth is the legitimate occupant of the space. Only that tooth should be scored.
6. When both a primary and permanent tooth occupy the same space, only the permanent tooth is coded.

7. All surfaces restored with full coverage should be coded as crowned. If a tooth has been restored with anything less than full coverage, the surfaces involved in the restoration will be scored separately.
8. If part of a restoration is lost on a surface, the surface should be coded as "7" (first number), even when not all the restoration is missing.
9. It is important that there is a code to record the instances where there are non-carious cavities, i.e. where a restoration has been lost. It could be argued that such cases are analogous with temporary restorations although it is the convention in some epidemiological studies to record these in a way that means that they are recorded within the "filled" rather than "decayed" element of the study findings. .
10. Where more than one carious lesion exists on a surface, the worst lesion should be scored, though scoring pits and fissures separately to free smooth surfaces is an option.
11. If a pit or fissure on an occlusal surface is not included in a distinct shadow originating from the mesial or distal surface, then the occlusal surface should be scored as sound. However, in all other instances the examiner should not determine the surface origin of a carious lesion and each tooth surface should be scored separately as it appears. A tooth surface is bounded by the line angle when viewed in a perpendicular direction.
12. For determining whether there is an enamel cavity (code "3") the ball point of the CPI probe should detect a ditch on a tooth surface that partially covers the ball end of the probe. If all of the ball end of the probe can enter the ditch then the area should coded a "5", unless the examiner concludes that the lesion is in enamel, then the code is a "3".
13. A shadow underneath a marginal ridge or surrounding a pit or fissure must be distinct and colored grey before it is classified with code "4".
14. Whenever both the coronal and root surface are affected by a single carious lesion that extends at least 1 mm or more past the CEJ in both cervical-incisal and cervical-apical directions, both surfaces should be scored separately. For a lesion affecting both crown and root surfaces with extension from the CEJ of less than 1 mm, only that surface of tooth with the greater portion (more than 50%) of the lesion involvement should be scored. When it is impossible to invoke the 50% rule (i.e., when both coronal and root surfaces appear equally affected), both surfaces should be scored as carious.
15. A root surface adjacent to a crown margin that is free of decay should be scored sound.
16. If more than one lesion is present on the same root surface, the most severe lesion is scored.
17. All tooth surfaces of retained roots should be scored as (06).

Root Caries Criteria

Codes for the detection and classification of carious lesions on the root surfaces

One score will be assigned per root surface. The facial, mesial, distal and lingual root surfaces of each tooth should be classified as follows:

Code E
If the root surface cannot be visualized directly as a result of gingival recession or by gentle air-drying, then it is excluded. Surfaces covered entirely by calculus can be excluded or, preferably, the calculus can be removed prior to determining the status of the surface. Removal of calculus is recommended for clinical trials and longitudinal studies.

Code 0
The root surface does not exhibit any unusual discoloration that distinguishes it from the surrounding or adjacent root areas nor does it exhibit a surface defect either at the cemento-enamel junction or wholly on the root surface. The root surface has a natural anatomical contour, OR

The root surface may exhibit a definite loss of surface continuity or anatomical contour that is not consistent with the dental caries process. This loss of surface integrity usually is associated with dietary influences or habits such as abrasion or erosion. These conditions usually occur on the facial surface. These areas typically are smooth, shiny and hard. Abrasion is characterized by a clearly defined outline with a sharp border, whereas erosion has a more diffuse border. Neither condition shows discoloration.

Code 1
There is a clearly demarcated area on the root surface or at the cemento-enamel junction (cej) that is discoloured (light/dark brown, black) but there is no cavitation (loss of anatomical contour < 0.5 mm) present.

Code 2
There is a clearly demarcated area on the root surface or at the cemento-enamel junction (cej) that is discoloured (light/dark brown, black) and there is cavitation (loss of anatomical contour = 0.5 mm) present.

The following diagram (Figure 2) will serve as a useful prompt for examiners in deciding on appropriate coding of root caries:

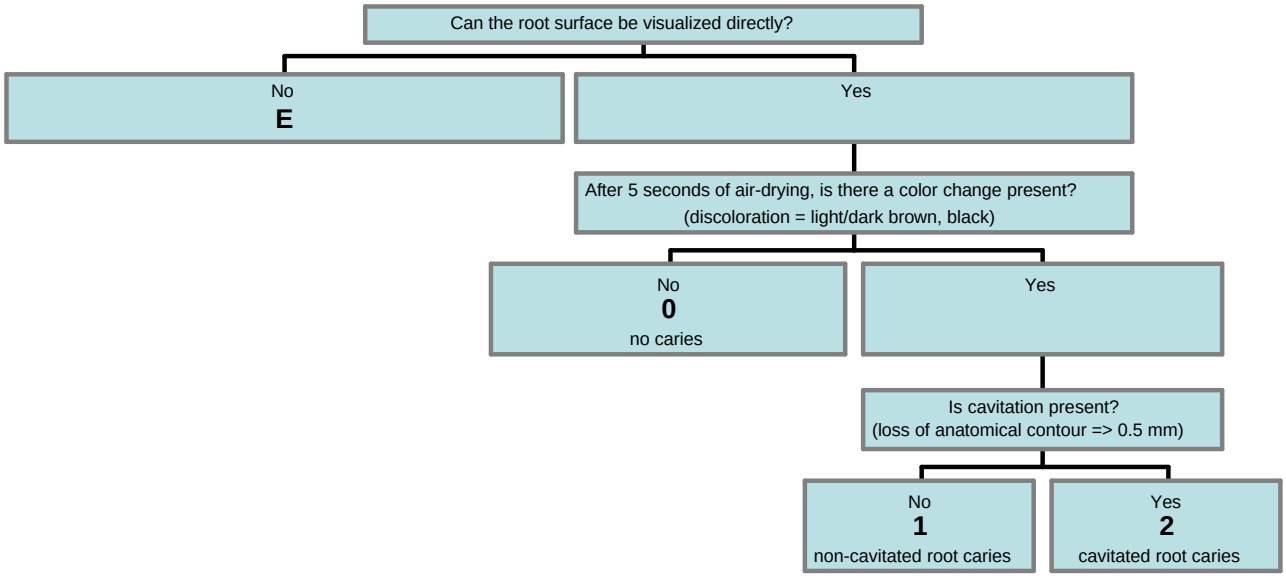


Figure 2. *Decision tree for primary caries on the root surface*

Caries associated with root restorations

When a root surface is filled and there is caries adjacent to the restoration, the surface is scored as caries. The criteria for caries associated with restorations on the roots of teeth are the same as those for caries on non-restored root surfaces.

The following diagram (Figure 3) will assist the examiner in deciding on the appropriate coding of caries adjacent to restorations on root surfaces:

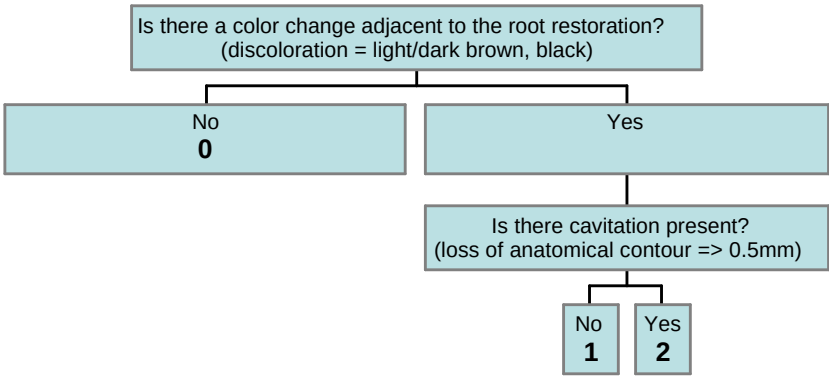


Figure 3. *Decision tree for caries associated with root restorations*

Root caries activity

The characteristics of the base of the discolored area on the root surface can be used to determine whether or not the root caries lesion is active or not. These characteristics include texture (smooth, rough), appearance (shiny or glossy, matte or non-glossy) and perception on gentle probing (soft, leathery, hard). Active root caries lesions are usually located within 2mm. of the crest of the gingival margin

The following diagram (Figure 4) will be helpful in making a determination regarding the activity of root caries:

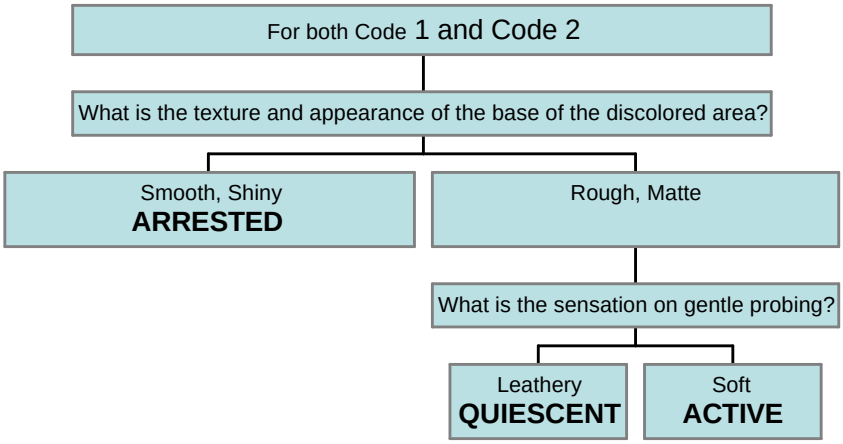


Figure 4. *Decision tree for root caries activity*

Special considerations

Whenever both a coronal and root surface are affected by a single carious lesion that extends at least 1 mm past the CEJ in both the incisal and apical directions, both surfaces should be scored as caries. However, for a lesion affecting both crown and root surfaces that does not meet the 1 mm or greater extent of involvement, only the coronal or root surface that involves the greater portion (more than 50%) of the lesion should be scored as caries. When it is impossible to invoke the 50% rule (i.e., when both coronal and root surfaces appear equally affected), both surfaces should be scored as caries.

When a carious lesion on a root surface extends beyond the line angle of the root to involve at least 1/3 of the distance across the adjacent surface, that adjacent surface also should also be scored as caries.

If more than one lesion is present on the same root surface, the most severe lesion is scored.

Non-vital teeth are scored the same as vital teeth.

Preliminary Plan for ICDAS Caries Lesion Activity Assessment

Working Definitions

An **Active Lesion** is considered to have a greater likelihood of transition (progress, arrest or regress) than an inactive lesion.

An **Inactive (arrested) Lesion** is considered to have a lesser likelihood of transition than an active lesion.

Clinical observations to be taken into consideration for assessing enamel lesion activity are based on a modification of the Nyvad et al. (1999) caries lesion activity assessment criteria and include visual appearance, tactile feeling and potential for plaque accumulation.

ICDAS Code	**Characteristics of Lesion**	
	Active Lesion	**Inactive Lesion**
1, 2 or 3	Surface of enamel is whitish/yellowish opaque with loss of luster; feels rough when the tip of the probe is moved gently across the surface. Lesion is in a plaque stagnation area, i.e.: pits and fissures, near the gingival and approximal surface below the contact point.	Surface of enamel is whitish, brownish or black. Enamel may be shiny and feels hard and smooth when the tip of the probe is moved gently across the surface. For smooth surfaces, the caries lesion is typically located at some distance from the gingival margin.
4	Probably active	
5 or 6	Cavity feels soft or leathery on gently probing the dentin.	Cavity may be shiny and feels hard on gently probing the dentin.

Recommendations for Examiner Training

The ICDAS committee recommends the following training program:

1. One half day of slide presentations and discussions of the ICDAS codes and protocol for examination.
2. At least 2 days of examiner training which will include examination of a set of subjects providing balanced numbers of tooth surfaces with ICDAS codes 1-5. The examination findings of all examiners should be reviewed to identify differences in interpretation. Examinations are to be repeated until agreement is reached among the examiners. This exercise should be conducted by a "senior examiner". Part of the exercise may involve using extracted teeth; however, the training exercise must include examining live subjects
3. Two days of reliability assessment using live subjects presenting with carious lesions with severity ranging between 1 and 5 (ICDAS). At least 20 patients should be examined per examiner and the "senior examiner"
4. A senior examiner is a dentist with experience in using the ICDAS, has high degree (Kappa = 0.75+) of intra-examiner reliability, and has been calibrated and is reliable with another experienced ICDAS examiner. In some studies, a senior examiner may work concurrently with the other examiners to reach a final decision. The term "senior examiner" is used to refer to the standard which will be used to compare with the findings of the examiners in a study. The report of a study should provide details on the calibration exercise and the senior examiners(s).

Statistical Consideration for Analysis of the Reliability of ICDAS

The conventional method of analysis of reliability data has been to present aggregate kappa coefficients for either each examiner or all examiners participating in a study. Kappa coefficients have the following advantages over simple percent agreements: 1) they account for agreement by chance alone for binary and nominal ratings [Maclure and Willett, 1987], and 2) there are standards for evaluating the strength of the agreement using this method. However, kappa analyses have disadvantages as well. Kappa is more a measure of exact agreement instead of being a measure of the degree of approximate agreement [Maclure and Willett, 1987]. A simple kappa coefficient does not distinguish between the different sources and magnitudes of disagreement. This measure of agreement tends to treat all the cases of disagreement alike however large or small they might be [Maclure and Willett, 1987]. In other words, kappa does not consider the degree of disagreement between observers. Kappa may not be comparable across different studies as the statistic is influenced by trait prevalence or distribution and the disease categories [Spitznagel et al., 1985; Thompson et al., 1988a and 1988b; Feinstein et al., 1990]. The presence of bias between observers and the variations in the distribution of data across the categories may cause computational and interpretation problems in a kappa analysis [Byrt et al., 1993].

When continuous data are categorized to form ordinal categories, kappa becomes arbitrary and virtually meaningless [Maclure and Willet, 1987]. Sometimes the examiners may be consistent, but the kappa statistic may not display this agreement due

to large number of categories, lack of marginal homogeneity or marginal distribution of the data. In such cases, other flexible approaches like statistical modelling may have to be used [Uebersax, 1987a and 1987b].

In order to account for the degree of disagreement between observers and also to distinguish the disagreements, weighted kappa may be used. This statistic incorporates the factor of agreement by chance alone and also has a feature of weighted proportional agreement. This is obviously an improved measure over the simple Cohen's kappa, but the use of standard weights makes the new statistic of weighted kappa equivalent to intraclass correlation coefficient [Fleiss et al., 1973].

One important requirement for testing whether the kappa coefficients are statistically accurate is to test for marginal homogeneity of the distribution of codes for each examiner. Marginal homogeneity [Barlow, 1998; Bishop et al., 1975] means that the marginal frequencies or proportions of one or more categories are the same for both examiners. The Stuart-Maxwell (SM) statistic tests the homogeneity of marginal frequencies and is interpreted like a chi-squared test [Uebersax, 2005].

If the marginal distributions are not homogenous, then the kappa coefficients may not be accurate and may lead to erroneous conclusions. In such case, we recommend using other methods for analysis of reliability data. Log-linear modelling provides another approach for analysis of examiners' reliability [Uebersax, 1993; Kingman, 1986]. This approach is quite flexible in its assumptions of the distributions of the codes assigned by the examiners to tooth surfaces. Further, the general framework allows for simultaneous incorporation of multiple (more than two) examiners, each rating an arbitrary number of categories. Hence, the symmetry of categories required for computing the kappa coefficients is not required for log linear models [Tanner, 1985].

The users of ICDAS should provide the following reliability statistics.

1. Kappa coefficients for comparisons between the senior examiner and each examiner separately.
2. Kappa coefficients for intra-examiner reliability for each examiner.
3. Rows X Columns table should be included for all comparisons.

If possible, it is recommended that SM tests are also performed. However, computing the SM tests requires some advanced programming skills.

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