

# **How well do conventional or potentially available tests work to diagnose root caries?**

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Conrad Rodrigues  
Haleh Javadi  
Florin Tudurescu  
Phalguni Sougajam  
Puneet Bath  
Sameh Gad  
Shabnam Khosravi  
Violeta Moldovan

# How well do conventional or potentially available tests work to diagnose root caries?

## ***ABSTRACT***

*The purpose of this review is to evaluate the information that exists today regarding the diagnosis of root caries in both clinical and research settings.*

*The traditional method for diagnosing root caries is the clinical observation (visual and tactile). It has been shown that clinical assessment can produce a correct diagnosis but not until the lesion is at an advanced stage. Color of the lesion has been shown to have little validity. The reliability of diagnosis is affected by variability in examiner assessment. Key problem areas with existing tools include confusion in terminology as well as the lack of valid measurements against a valid gold standard.*

*Because there is a high level of uncertainties associated with the diagnosis of root caries, clinicians have looked to other diagnostic tests for assistance.*

*Radiographic assessment of root caries is limited to proximal surfaces. There are now detection technologies available to help detect carious lesions in an early stage. However, there is no clinical sufficient data yet to support this method. Further in vivo studies are needed along with validation against a valid gold standard.*

## **INTRODUCTION**

The prevalent definition for a root caries lesion is:” a soft, irregularly shaped lesion either totally confined to the root surface or involving the undermining of enamel at the CEJ, but clinically indicating that the lesion initiated on the root surface [1].”

The overall prevalence of root caries among adults is 17.6 percent, but it is distributed unevenly over the age groups. The prevalence is 9.4% in young adults (20 -39 years), 17.8% among 40-50 year olds and 31.6% in people older than 60 years of age [2].

As older adults are now retaining more teeth, the higher prevalence of root caries has become a major problem [3][4].

The clinical identification of root caries utilizes visual (color, contour, surface cavitation) and tactile (surface specifications) cues. This method of diagnosing root caries may produce a correct diagnosis but usually not until the lesion is at advance stage.

Researchers are looking for diagnostic tests for root caries that may be more reliable than visual-tactile methods. Most of these tests are in the in vitro study stage and have not been evaluated

under normal clinical conditions. The tests include the use of dyes, fluorescence, electrical resistance and endoscopic visualization.

## **MATERIALS AND METHODS**

A systematic review of literature was conducted to obtain potentially relevant articles related to the research question: “How well do conventional or potentially available tests work to diagnose root caries?”

### **SEARCH STRATEGY:**

The literature was searched using the keywords: “root caries diagnostic tests, root caries diagnosis, radiology, sensitivity, specificity, reliability ”on online search engines- PubMed, Ovid Medline, Cochrane Library database, and Google Scholar, yielding 783, 522, 3160, and 4 articles respectively. The University of Michigan and WHO websites were also checked. In addition to the electronic search, restorative textbooks were reviewed. Members of Restorative Dentistry, Preventive Dentistry and Radiology departments at the Faculty of Dentistry, University of Toronto were consulted and a researcher from Sweden was contacted regarding a yet to be published article, to get more information relevant to the topic.

### **Table -Review of literature**

<b>Articles matching the search criteria in PubMed</b>	<b>783</b>
<b>Articles matching the search criteria in Ovid Medline</b>	<b>522</b>
<b>Articles matching the search criteria in Google Scholar</b>	<b>3160</b>
<b>Articles matching the search criteria in Cochrane</b>	<b>4</b>
<b>Articles rejected at title stage</b>	<b>4426</b>
<b>Articles rejected abstract stage</b>	<b>19</b>
<b>Articles rejected at first reading</b>	<b>16</b>
<b>Included articles</b>	<b>7</b>

### **DETERMINATION OF RELEVANCE:**

The inclusion criteria were:

- Strong study design such as meta-analysis, systematic review, clinical trial or case control studies. The articles that were case reports, reviews, and commentaries were rejected.
- Compared a diagnostic test against a valid gold standard
- Studies in the English language
- In vivo studies scoring high on the checklist

From the initial list of 4469 articles most were eliminated at the title stage. From the 43 articles that remained, an additional 19 articles were eliminated at the abstract stage based on the previously mentioned criteria (A list of excluded articles reasons for that can be found in Appendix II). The 24 articles that remained were read and scored independently by at least two

members of the research group using the “Checklist for Assessing a Diagnostic or Predictive Test” (Appendix III), for in vivo studies only. To critically appraise the in vitro studies, we modified the above checklist by removing the sections involving human participation in the study to better fit in vitro studies (Appendix IV)

Disagreement in the scoring was resolved by discussion. After critical appraisal of the articles, 2 in vivo and 5 in vitro articles were finally accepted. Each in vivo study scored 6 on the diagnostic checklist used to assess the in vivo studies. The minimum score for the in vitro studies was 6 on the modified checklist used to assess in vitro studies.

These articles were used to construct a table of evidence to present the relevant findings in a concise manner (Appendix I).

#### LIMITATIONS:

There are no strong design in vivo studies reported in the literature regarding diagnosis of root caries. Most of the studies were conducted in vitro, under ideal conditions.

Unfortunately there are no in vivo studies reported in the literature that compare visual-tactile diagnosis to a histologic assessment of the lesion (gold standard). Although disappointing, it is not surprising because of the difficulty of conducting studies where teeth have to be removed and histologically examined following clinical examination. [5]

The in vivo studies used ‘clinical criteria’ as gold standard, which is a weak criterion where as the in vitro studies used either histological sectioning and /or transverse micro-radiography (TMR).

The in vitro studies were not tested clinically and different gold standard and statistical variables were used to report the results posing problems in interpretation and comparison of the results. The check list used for in vivo studies is not suitable to use for in vitro studies.

## RESULTS AND DISCUSSION

An in vivo study done by Lynch et. al [6], 395 primary root caries lesions were assessed, lesions in each color group (light brown, yellow, dark brown and black) were identified in each texture category (soft, leathery and hard), except for black lesions which were recorded as only soft or leathery. Black soft and black leathery lesions had a significantly greater area and harboured more lactobacilli than all other types of lesions while black leathery lesions also harboured significantly more yeasts. There were no significant differences in the number of bacteria or mutans streptococci isolated from soft or leathery lesions irrespective of lesion color.

Another in vivo study by Rosen et al. [7] showed there was little difference between intra and inter examiner comparisons (kappa: 0.73 to 0.92) at a patient level. The total number of lesions showed coefficients ranging from 0.55 to 0.77. At a tooth surface level inter-examiner reproducibility was generally slightly lower than intra-examiner reproducibility. This study determined that all intra and inter examiner comparison indicated that the most common shift was that from a diagnosis of any type of caries to a diagnosis of a sound surface. Three criteria

were used for initial and manifested caries and for active and inactive carious lesions, i.e. signs of cavitation, surface structure and discoloration

There were several in vitro studies done using different diagnostic measures. Pretty et al study using quantitative light induced fluorescence [8], showed that QLF effectively monitored demineralization of root dentine as represented by fluorescein penetration. TMR analysis showed good correlations with QLF after demineralization ( $r=0.89$ ). This study has shown that QLF can detect and quantify the penetration of fluorescein into artificial root caries lesions in vitro.

In Newitter et al study, where six examiners used the modified explorer [9] to detect primary root caries lesions and showed a significantly higher sensitivity using the modified explorer (74%) as compared to conventional explorer (44%), while specificity showed no statistically significant difference (67% Vs 77%). The kappa values for the modified explorer were statistically higher than for the conventional explorer. Mean reliability scores for the modified and the conventional explorers were 69% and 67% respectively. Tactile sensation was the major method of detection for root caries. Overall, the modified explorer was superior for diagnosing the presence of root caries when root caries was actually present but was not accompanied by a parallel decrease in the ability to truly diagnose the absence of root caries.

The study using macroscopic and radiographic examination [10] found agreement between the results in 79 of the total 104 proximal root surfaces (76%). Disagreement in diagnosis was more frequent (13 cases) in the recordings of secondary caries because radiographic contrast between root surface and white fillings is not readily detected and axial extensions of cavities on the buccal and lingual surface might be interpreted radiographically as secondary caries of an approximal filling.

The study using Laser Fluorescence and Electrical Resistance (ECM) [11] revealed that laser fluorescence had high values for dark, stained, soft lesions and lesions  $>0.5$  mm in depth as well as high reliability (0.96 intraclass coefficient) and high reproducibility. ECM had high values for yellow, hard, shallow/non-cavitated lesions ( $<0.5$ mm depth) and low scores for brown, black, leathery, soft and lesions ( $>0.5$  mm depth) while showing high reliability (0.95) and good reproducibility. Laser fluorescence discriminated between sound and decayed tooth tissue with high reproducibility, higher validity and reliability while moderately correlating with histological depth measurement. ECM measurement measured early signs of demineralization and remineralisation on the surface of root lesions. Cavity depth showed strong relation with decreased surfaces hardness and no correlation with color of lesions.

Another in vitro study by Baysan et al [12] revealed there was poor but significant negative correlation between ECM ( $r=0.16$ ) and RCM( $r=0.16$ ), ( $p<0.05$ ). Significant differences in ECM between yellow, light brown and dark lesions ( $p<0.05$ ) were found while RCM values were significantly different between all color groups. Significant differences existed between soft, leathery and hard lesions and sound root tissue ( $p<0.05$ ) with lowest values for soft lesions and highest for hard lesions, with leathery lesions being intermediate. The pattern was reversed for RCM values. RCM failed to show significant difference between hardness groups ( $p>0.05$ ). Correlation coefficients for ECM( $r=0.52$ ) and RCM( $r=0.20$ ) were significant ( $p<0.05$ ). ECM values correlated highly with the size of the lesions for all types of lesions. Small lesions

presented higher ECM readings than large ones-there was an inverse relation( $r=0.44$ ). RCM failed to correlate with size of the lesions for all types of lesions( $r=0.05$ ). ECM showed significant differences between all five classes of lesion severity (0.76) and sound root tissue ( $p<0.05$ ). RCM ( $r=0.22$ ) values showed poor but significant correlation with the clinical severity( $r=0.17$ ). ECM had high detection accuracy, was non invasive, and highly correlated to clinical criteria, dark brown lesions (inactive) had low resistance and light brown or yellow lesions (active) had high resistance values. There was a significant correlation between RCM and ECM values. ECM values and clinical criteria such as severity, hardness, color, cavitation and size of lesion had a significant correlation.

Many extrinsic factors might influence the appearance of root lesion including the uptake of stains from dietary foodstuffs, smoking and perhaps the presence of chromogenic of bacteria amongst the lesion's microflora. The stability of the color of individual lesions might be subject to variation with time. Microbiological results show that the color of primary root caries lesions has only limited diagnostic value and should not be used as the sole criterion.

Further, identification of decayed surfaces and their specific diagnoses do not seem meaningful since lesions observed at one examination are often overlooked at a repeated examination. There is low to moderate reproducibility for root caries diagnostic in vivo.

The QLF offers the possibility of a non-destructive, quantifiable, archivable, longitudinal and objective method for root caries assessment in vivo.

Both conventional and modified explorers were equally reliable, though the modified explorer fared better under specific conditions.

Under-recording of the carious lesions may easily occur under routine clinical conditions with both macroscopic and radiographic examination. However, radiographic examination may record proximal root surface carious lesions missed during routine clinical examination.

Laser fluorescence detected dark, stained, soft lesions and lesions  $>0.5$  mm in depth with high reliability and reproducibility. ECM detected yellow, hard, shallow/non-cavitated lesions ( $<0.5$ mm depth) and brown, black, leathery, soft lesions ( $>0.5$  mm depth) with high reliability and good reproducibility.

ECM had high detection accuracy, while being non invasive, objective and highly correlated to clinical criteria. Dark brown lesions (inactive) had low resistance and light brown or yellow lesions (active) had high resistance values. ECM detected lesions, which remained unobserved during clinical visual examination. RCM, which measured surface resilience, was a less reliable than ECM.

The studies were not able to provide any strong evidence with regard to sensitivity/specificity and likelihood ratios.

Characteristics of diagnostic tests, which include analysis of test quality, test efficiency, should be identified so that they can be compared against each other. Validity of visual-tactile clinical

signs needs to be compared to the histological gold standard. All in vitro methods or potential diagnostic tests should undergo in vivo study and be assessed against clinical and histological standards to establish their usefulness in clinical situations.

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Under-recording of the carious lesions may easily occur under routine clinical conditions with both macroscopic and radiographic examination. However, radiographic examination may record proximal root surface carious lesions missed during routine clinical examination.

Laser fluorescence detected dark, stained, soft lesions and lesions >0.5 mm in depth with high reliability and reproducibility. ECM detected yellow, hard, shallow/non-cavitated lesions (<0.5mm depth) and brown, black, leathery, soft lesions (>0.5 mm depth) with high reliability and good reproducibility.

ECM had high detection accuracy, while being non invasive, objective and highly correlated to clinical criteria. Dark brown lesions (inactive) had low resistance and light brown or yellow lesions (active) had high resistance values. ECM detected lesions, which remained unobserved during clinical visual examination. RCM, which measured surface resilience, was a less reliable than ECM.

At present, diagnosis of root carious lesions is based purely on clinical signs [13], despite its limitations. Accurate diagnosis of root caries lesions is hence a challenge to every clinician.

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## **CONCLUSION**

At present, clinical diagnosis of root caries still remains the most commonly used method despite its limitations. There is a lack of evidence for the accuracy of diagnostic methods (13). Accurate diagnosis of root caries lesions is still a challenge to every clinician.

Even if promising studies with new methods of diagnosis were conducted under in vitro settings, in vivo validation is required.

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## REFERENCES

1. Summit, JB. Hilton, TJ. Schwartz, RS. "Fundamentals of Operative Dentistry: A Contemporary Approach." (3<sup>rd</sup> Edition).
2. Glick M. "A job well done but still a long way to go." J Am Dent Assoc, 2005 Nov; 136 (11): 1506, 1508.
3. Cautley, AJ. "Root caries: some clinical aspects." New Zealand Dental Journal, 1993; 89, 132
4. Hawkins, RJ. "Functional status and untreated dental caries among nursing home residents aged 65 and over." Special Care Dentistry, 1999; 19, 158.
5. Banting, DW. "The Diagnosis of Root Caries." J Dent Educ 2001, 65(10): 991-996
6. Lynch, E. Beighton, D. "A comparison of primary root caries lesions classified according to color." Caries Res, 1994; 28: 233-239
7. Rosen, B. Birkhed, D. Nilsson, K. Olavi, G. Egelberg, J. "Reproducibility of clinical caries diagnoses on coronal and root surfaces." Caries Res 1996; 30: 1-7(1996)
8. Pretty, A. Ingram, GS. Agalamanyi, EA. Edgar, WM. Higham, M. "The use of Fluorescein-enhanced quantitative light-induced fluorescence to monitor de- and re- mineralization of in vitro root caries." Journal of Oral Rehabilitation, 2003; 30: 1151-1156
9. Newitter, DA. Katz, RV. Clive, JM. "Detecton of root caries: Sensitivity and specificity of a modified explorer." Gerodontics, 1985; 1: 65-67
10. Nordenram, G. Bergkvist, A. Johnson, G. Henriksson, CO. Anneroth, G. "Macroscopic and radiographic examination of proximal root surface caries." Acta Odontol Scand, 1988; 46:95-99
11. Wicht, MJ. Haak, R. Stutzer, H. Strohe, D. Noack, MJ. "Intra- and Interexaminer Variability and Validity of Laser Fluorescence and Electrical Resistance Readings on Root Surfaces Lesions." Caries Res, 2002; 36:241-248.
12. Baysan, A. Prinz, JF. Lynch, E. "Clinical criteria used to detect primary root caries with electrical and mechanical measurements in vitro." Am J Dent, 2004; 17:94-98
13. Leake, JL. "Clinical decision-making for caries management in root surfaces." Journal of Dental Education, 2001 Oct; 65(10); 1147-53

## APPENDIX I: TABLES

Author	Study design	Sample Size	Diagnostic Test	Compared to Gold Standard	Level of Reliability*	Critical Appraisal Comments	Conclusion	Evidence Level
<b>Pretty, I.A et al 2003</b>	In vitro	14 teeth	Fluorescein-Enhanced Quantitative Light-Induced Fluorescence (QLF)	Yes Transverse Micro Radiography (TMR)	very good agreement (r=0.89)	<ul style="list-style-type: none"> <li>• small sample size (14)</li> <li>• cementum was removed from all root surfaces</li> <li>• blinded single examiner</li> </ul>	<ul style="list-style-type: none"> <li>• QLF represents a possible non-destructive method for root caries assessment in vivo</li> <li>• TMR analysis showed good correlation with QLF after demineralization</li> <li>• QLF can detect and quantify the penetration of fluorescein into artificial root caries lesions in vitro</li> </ul>	6/10
<b>Baysan, A et al 2004</b>	In vitro	200 teeth	Clinical visual/tactile  Electrical Caries Monitor (ECM)  Resilience Caries Monitor (RCM)	<ul style="list-style-type: none"> <li>• Clinical criteria</li> <li>• Compared sound teeth with those having various severities of root caries</li> </ul>	Clinical criteria: poor agreement (r=0.17)  ECM: good agreement (r=0.76)  RCM: fair agreement (r=0.22)	<ul style="list-style-type: none"> <li>• Uses extracted human teeth with primary root carious lesions</li> <li>• Controlled drying was used and may be a problem when /if the tests have to be used clinically</li> <li>• Mechanical, electronic problems must be solved-as voltage fluctuations, temperature, humidity may affect the readings</li> <li>• The load and angle at which the instrument probe is applied need to be standardized</li> <li>• Need studies comparing these tests against microradiography to validate the true efficacy of RCM</li> </ul>	<ul style="list-style-type: none"> <li>• Clinical:</li> <li>• Color is not a reliable detection criteria</li> <li>• Shape and cavitation are not conclusive</li> <li>• Texture appears to be the most reliable clinical method</li> <li>• ECM:-is promising in detection accuracy</li> <li>• Dark brown lesions had lower resistance than light brown or yellow lesions;</li> <li>• yellow /light brown lesions were active and vice versa</li> <li>• Poor but significant correlation between RCM and ECM values and clinical criteria.</li> <li>• Non invasive, accurate ,objective and highly correlated with clinical criteria-severity, hardness, color, cavitation, size of the lesions, in fact it may detect lesions which may remain unobserved with conventional visual exam</li> <li>• RCM measures the surface resilience –but is not a very reliable test as of now</li> </ul>	8/10

Wicht, M.J, et al 2002	In vitro	103 teeth	<p>Laser fluorescence device DIAGNOdent</p> <p>Electrical caries monitor(ECM)III</p> <p>Clinical criteria</p>	Yes. Histology	<p>DIAGNOdent: very good agreement (ICC**=0.96)</p> <p>ECC III: very good agreement (ICC=0.95)</p> <p>Clinical: very good agreement (ICC=0.85)</p>	<ul style="list-style-type: none"> <li>• Freshly extracted (extracted due to periodontal problems or root caries) human teeth with various forms of root carious lesions were used</li> <li>• Cementum was removed to large extent because of ultra sonic scaling was used</li> <li>• Operators were trained in the use of laser fluorescence device but not trained for use of the ECM</li> <li>• Standards measuring the mineral content such as microradiography would be more appropriate to validate ECM readings</li> <li>• Artificially stained lesions may lead to overestimated fluorescence readings and interpretation</li> </ul>	<ul style="list-style-type: none"> <li>• Dark coloured lesions showed high fluorescence than yellow ones</li> <li>• ECM scores were high in yellow lesions and low in brown and black lesions</li> <li>• There were no differences between color and cavitation depth</li> <li>• Hard tissues gave higher ECM scores than leathery or soft lesions</li> <li>• Soft lesions showed higher DIAGNOdent readings</li> <li>• Decreased surface hardness showed good correlation with increased penetration depth</li> <li>• Higher laser fluorescence and lower ECM values were seen with cavitation of more than 0.05 mm as compared with shallow/non cavitated lesions</li> <li>• Intraclass correlation of 0.96 (DIAGNOdent ) and 0.95 (ECM) show high reliability for both systems</li> <li>• High correlation was found with penetration depth with both tests</li> <li>• Histologically deeper lesions were associated with lower ECM and higher DIAGNOdent values</li> </ul>	8/10
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<b>Rosen , B. et al 1996</b>	In vivo, cross sectional	20 patients	Clinical examination	No	moderate agreement (ICC=0.46-0.56)	<ul style="list-style-type: none"> <li>All intra and inter-examiner comparisons indicated that the most common shift was from a diagnosis of any type of caries (initial active/inactive, manifested active/inactive) to a diagnosis of a sound surface (a problem in detecting the surfaces having lesions)</li> <li>Lack of consistency in detecting carious lesions</li> <li>Some root surface lesions hidden by gingival tissues seemed difficult to detect</li> <li>Calibration of the examiners was restricted to a discussion about the criterion and practice on one patient</li> <li>Radiographs were not used</li> </ul>	<ul style="list-style-type: none"> <li>Lower reproducibility for root caries diagnosis possibly explained by increased difficulties associated with fewer exposed root surfaces.</li> <li>Difficult diagnostic criteria used</li> <li>Total counts of the number of initial lesions and manifest lesions in each subject show sufficient reproducibility for use</li> <li>For analysis at a surface level kappa scores are low since lesions observed at one examination are often overlooked at a repeated examination</li> <li>Three clinical criteria used signs of cavitation, surface structure, discoloration</li> </ul>	6/10
<b>Lynch, E. et al 1994</b>	In vivo cross sectional	117 patients	Clinical criteria  Microbiological testing	No	Clinical-color: good (negative) agreement  Microbiology: fair agreement	<ul style="list-style-type: none"> <li>Color is not a useful criteria for diagnosing the severity of primary root caries.</li> <li>Cavitation associated with carious process must be distinguished from cavitation caused by erosion, abrasion, or as a result of dental treatment</li> <li>There are many extrinsic factors that might influence the appearance of root lesions including the uptake of stains from diet, smoking and perhaps the presence of chromogenic bacteria.</li> </ul>	<ul style="list-style-type: none"> <li>The present microbiological results support the earlier observations that the color of primary root caries lesion has only limited diagnostic value and should not be used as the sole criterion to determine the treatments needs of individual lesions</li> </ul>	6/10

\*Interpretation of Reliability: poor agreement: under 0.2  
fair agreement: 0.20-0.40  
moderate agreement:0.40-0.60  
good agreement:0.60-0.80  
very good agreement:0.80-1.00

\*\*ICC= intra class correlation

Author	Study design	Sample Size	Diagnostic Test	Compared to Gold Standard	Sensitivity (Sn)	Specificity (Sp)	Level of Reliability	Critical Appraisal Comments	Conclusion	Evidence Level
<b>Nordenram, G. et al. 1988</b>	In vitro Cross-sectional	52 teeth 104 proximal surfaces	Radiology	No	74	87	good agreement (Kappa=0.62)	<ul style="list-style-type: none"> <li>• Root caries prevalence in the examined teeth was not representative and was probably too low</li> <li>• Only teeth with well maintained crowns were selected for the study</li> <li>• Macroscopic and radiographic techniques were more conducive to accurate recording than routine clinical examination</li> <li>• There are no generally acceptable clinical diagnostic criteria for root surface caries</li> </ul>	<ul style="list-style-type: none"> <li>• Fairly good agreement between macroscopic assessment, gentle probing and the depth of the lesion measured on the radiograph (76% agreement)</li> <li>• Disagreement was more frequent in the recording of secondary caries</li> <li>• Under-recording of superficial lesions may easily occur under routine clinical conditions</li> </ul>	8/10
<b>Newitter, D.A, et al. 1985</b>	In vitro	6 teeth	Modified Explorer	No (compared with visual examination)	44	67	fair-to-moderate agreement (Kappa=0.21-0.60)	<ul style="list-style-type: none"> <li>• Small sample size, in vitro study</li> <li>• No gold standard used</li> <li>• Decreased ability of modified explorer to truly diagnose the absence of root caries</li> </ul>	<ul style="list-style-type: none"> <li>• Modified explorers were shown to have considerably higher sensitivity than the conventional explorers</li> <li>• The overall specificity was slightly higher for the conventional explorer, although this was not statistically significant difference</li> <li>• Conventional and modified explorers were equally reliable (67% and 69%)</li> <li>• The modified explorer was a better diagnostic instrument under the conditions of this experiment</li> </ul>	7/10
			Conventional Explorer	No	74	77	poor agreement (Kappa=0.00-0.20)			

## APPENDIX II: EXCLUDED ARTICLES

<b>EXCLUDED ARTICLES</b>	<b>REASON FOR EXCLUSION</b>
Pitts et al. 1997	Review of articles
Hotz et al. 1996	Only abstract, German articlet not available
Warren et al. 2003	Explorer probing and effect of remineralization
Young et al. 2002	Review of articles
Stambaugh et al. 2002	Not enough evidence
Leake et al. 2001	Review of articles
Van der Veen et al. 1996	Score too low on checklist
Ritter et al. 2002	Review of articles
Berry et al. 2004	Review of articles
Haak et al. 2004	Not specifically about root caries
Petterson et al. 2004	Remineralisation of root caries
Inaba et al. 1997	Score too low on checklist
Kurihara et al. 2004	Score too low on checklist
Wilkinson et al. 1997	Score too low on checklist
Kidd et al. 2000	Not specifically about diagnostic
Fried et al. 2002	Not specifically about root caries
Katz et al. 1995	Review of articles
Banting et al. 1993	Review of articles
Newbrun et al 1993	Review of articles
Pitts et al. 1991	Review of articles
Katz et al. 1990	Review of articles
Moncada et al. 1989	Spanish article not available
Bauer et al. 1988	Review of articles
Almqvist et al 1988	Score too low on checklist
Ravald et al. 1986	Incidence and risk factors for root caries
Mojon et al. 1995	Not addressing the clinical issue in question
Lynch et al. 1994	Score too low on checklist
Beighton et al. 1993	Etiology and treatment of root caries
Schenin et al. 1994	Incidence and risk factors for root caries
Ravald et al. 1991	Risk factors for root caries
Sikri et al. 1991	Score too low on checklist
Baysan et al. 2005	Not addressing the clinical issue in question
Buchala et al. 2004	Focusing on dental calculus
Anusavice et al 2002	About risk assessment and treatment solutions

## APPENDIX III: CHECKLIST 1\*

University of Toronto  
Community Dentistry

Checklist for Assessing a Diagnostic or Predictive Test

Citation: \_\_\_\_\_  
\_\_\_\_\_

1. Was the study ethical? \_\_\_\_\_
2. Is the test clearly described (including the cut-off values)? \_\_\_\_\_
3. Was the test evaluated against a valid gold standard? \_\_\_\_\_
4. Were the test results and disease status determined independently? \_\_\_\_\_
5. Was the test evaluated using patients with a range of severity of disease? \_\_\_\_\_
6. Was the test evaluated among patients with diseases that might be confused with, or are closely related to, the disease of interest? \_\_\_\_\_
7. Is the test's performance reported using sensitivity/specificity, likelihood ratios \_\_\_\_\_
8. Is the effect of moving the cut-off reported, or is the ROC curve provided? \_\_\_\_\_
9. Does this test give better results than the current or standard test? \_\_\_\_\_
10. Is the test likely to be acceptable to patients? \_\_\_\_\_

Adapted from: Fletcher, Fletcher and Wagner. Clinical epidemiology – the essentials. 3<sup>rd</sup> ed. 1996, and Sackett et al. Evidence-based medicine: how to practice and teach EBM. 1997

- This checklist was used for the 2 in vivo studies only.

## **APPENDIX IV: CHECKLIST 2**

### A Modified Checklist for Critically Appraising In-vitro Studies

1. Are the objectives of the study clearly stated?
2. Is the study design suitable for the objectives?
3. Is the test clearly described?
4. Was the test evaluated against a valid gold standard?
5. Is the study large enough to achieve its objectives?
6. Is it clear what was measured, how it was measured and what the outcomes were?
7. Are the results presented clearly?
8. Are any statistics correctly performed and interpreted?
9. Are the results discussed in relation to existing knowledge on the subject and study objectives?
10. Are the conclusions justified by the data?