Root Caries and its Diagnostic Modalities – A Review

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Abstract: Root caries is a multifactorial disease that primarily affects the exposed root surfaces of teeth following gingival recession and the loss of periodontal attachment. Unlike the coronal caries, root caries involves the softer tissues of cementum and dentin, which are more prone to demineralization due to the lower mineral content and increased organic content. The rising prevalence of root caries, particularly among the aging population is attributed to factors such as poor oral hygiene, reduced salivary flow, systemic health conditions, and limited dexterity, which all hinder effective plaque control. The microbial flora in root caries is distinct, involving not only commonly known cariogenic species like Streptococcus mutans and Lactobacillus but also organisms such as Actinomyces, Olsenella, and Atopobium. Clinically, the lesions may range from yellowish or light brown in active cases to darker brown or black in arrested ones, with varying degrees of cavitation and texture.

Accurate diagnosis of root caries remains a clinical challenge. This review focuses on the etiology, microbial aspects, clinical presentation, and most importantly, the evolving diagnostic modalities for root caries from traditional visual and tactile assessment using a dental explorer to advancements in caries detection with the help of laser fluorescence, fiber-optic transillumination based imaging systems. Integrating these diagnostic modalities into routine practice can improve early intervention, guide minimally invasive treatments, and ultimately enhance the long-term oral health outcomes.

1. Introduction:

With continuous advancements in medicine and dentistry, global life expectancy has been consistently increasing. In 1950, the average global life expectancy was approximately around 46 years; by 2025, it has increased to around 72 years and is estimated to reach nearly 85 years by 2100 (1). As birth rates decline, the proportion of

elderly individuals in the general population continues to rise. With this demographic shift, the retention of the teeth in the mouth is expected to stay longer than usual.
The two primary oral health care challenges that can have significant impact among the geriatric population are dental caries and periodontal diseases. Dental caries remains a condition that needs attention (2).
Root caries is influenced by multiple factors. Root caries is a slowly advancing lesion thatdevelops on the surface of the root once the connective tissue attachment is lostand the root surfacebecomes exposed to the oral environment (3).

2. Prevalence:

Although a significant reduction in untreated decay was observed between 1999–2004 and 2011–2016, nearly **1 in 6 elderly had untreated dental decay**. During 2011–2016, approximately **96.4% of adults aged 65 and above** had at least one decayed, missing, or filled permanent tooth. The incidence of annual root caries is reported to be 10.1 – 40.6% (4)
There is a considerable variation among different studies on the prevalence rate of root caries, ranging from **10.53% to 89.67%**. (5 6), with higher rates observed in populations with a larger proportion of elderly individuals. Root caries typically affects **root surfaces which are exposed** or at the **cemento-enamel junction (CEJ)**(7)

3. Etiology:

There are several risk factors which influences root caries. These include improper oral hygiene, variation in the oral micro environment,periodontal and gingivaldisease, decreased salivary flow, certain medications, habits (e.g., tobacco and alcohol use), frequent intake ofcarbohydrate, insufficient fluoride exposure, presence of partial dentures, reduced manual dexterity impacting plaque control and others (7).

3.1. Salivary Flow rate

Adequate flow rate of saliva is one of thefactors to maintain oral health. As the age advances, the immune system weakens and there are few immunoglobulins found in the salivary composition (8). Certain drugs, radiotherapy, systemic disorders like diabetes, rheumatic diseases like Sjogren's syndrome are all linked to xerostomia which will significantly change the flow rate and properties of the saliva and will change the oral micro environment (9).

3.2. Dietary Changes

Diet involving high intake of sweetened snacks, foods rich in carbohydrates are a greater risk to develop caries as they can dramatically spile the microbial load which produces caries. In addition, malnutrition is also a consideration among the elderly (10)

3.3. Oral Hygiene

Maintaining oral hygiene plays a crucial role in the initiation and progression of oral health issues. As people age, the health begins to decline which can lead to increase in dependence on others, reduced manual dexterity. These changes significantly contribute to the decline in the dental health of the patient (11).

3.4. Systemic Diseases:

Diabetes and periodontal disease exhibit a two-edged sword. Poorly controlled diabetes can alter the oral environment which is favourable for the bacterial growth. Rheumatic arthritis is a condition where salivary glands are damaged and affects the salivary flow rate (12).

4. Characteristics:

4.1. Dental hard tissue composition and structure:

The inorganic content of the enamel is around 96% and is durable.Cementum consists of nearly 45– 50% of mineralcontent while organic contentsconstitute about 50%of its dehydrated mass,with type I being the primary component in organic matrix (13). Like cementum, dentin also has a complex structure and contains high portion of organic contentscompared to enamel. Dentin consists of 70% mineralcomponents, 18% collagen matrix, and 12%water(14). As the critical pH of the root cementum and the dentin is approximately 6.4 when compared with the pH of enamel which is 5.5, the root cementum and dentine are more susceptible to caries attack. These structural and compositional variation makes the root surface more prone to mechanical damage than enamel (15).

5. Progression of the disease:

5.1. Gingival recession:

Gingival recession refers to the downward shift in the margin of the gingivacaused by the periodontal attachment loss.As the root surface gets exposed, a new microbiological niche is established (15). The surface which was previously protected under the gingiva in an anaerobic microenvironment, transits into aerobic microenvironment with vast nutrient availability. The cervical cementum in these area ranges between 54 – 128 µm and this permits early bacterial penetration. This process initially begins in the fissure in the cementum thereby allows the bacteria to invade and infiltrate and initiate the development of caries lesion.

5.2. Mineral dissolution phase:

As the gingival recession progresses, the areas where Sharpey's fibres were once attached becomes gradually exposed and these may transform into channels which facilitates microbial penetration towards the underlying tissues (16). When a cariogenic biofilm is present, the normal balance is disturbed and the dietary carbohydrate are

broken down to organic acids which plays an important role initiating root lesion. Starch products which are resistant to enamel demineralization is sufficient to cause root caries. This process results in demineralization of the root surface (17).

5.3. Matrix degradation:

Dentin primarily contains I collagen which contributes in maintaining the molecular integrity and the mechanical strength. The breakdown of these matrix significantly contributes to the progression of the disease which are usually mediated by the enzyme called collagenases. After the collagen is cleaved the exposed collagen becomes susceptible to breakdown and denaturation occurs.Matrix degradation occurs only after the process of demineralization (18).

6. Microbiota associated:

The microbial community associated with root caries differs from that found in supragingival caries lesions. The composition of the microbial colonywhich are involved in the root caries are more diverse than previously presumed. While *S. mutans*, lactobacilli, and *Actinomyces* are the commonly found in root caries, few additional species like *Atopobium* spp., *Olsenella* spp., *Pseudoramibacter alactolyticus*, and *Propionibacterium* sp. strain FMA5 are identified and are prevalent in root caries lesions(19).

7. The role of diagnosis:

Identifying the root caries lesions intheir early stage enables to focus and implement the preventive strategies to halt the progression of the disease. Early tissue may facilitate in preserving the remaining tooth structure and also mean reduce the financial burden to the patient. Early-stage root caries lesions have the potential to arrest or undergo remineralization, whereas advanced, cavitated lesions—especially in patients with inconsistent plaque control—often require restorative treatment. These are various diagnostic modalities to diagnose root caries lesion and often they are combined together to provide an accurate diagnosis.

7.1.1. Visual-tactile method

One of the most common methods to diagnose root caries is by observing the visual changes and assessing the texture of the lesion through tactile sensation. There are different categories to be taken into consideration but there might be lot of variability. These include Colour, Texture, Cavitation. A study reported an estimate of sensitivity of 0.75 and specificity of 0.38 (20 21 22).

7.1.2. Colour:

Colour has been considered as a diagnostic criterion in detection of root caries which was supported by many authors. The activity of the lesion is determined by the

variation in the colour. Anactive lesiontypically presents with a yellowish to brown hue indicating the ongoing demineralization. In contrast, an inactive lesion will present a little darker ranging from dark brown to black suggesting that the decaying process has halted. Few studies reported variability as few hard lesions appeared yellow. All discoloured non cavitated lesions are not considered as root caries as discolouration can also be due to intrinsic staining of the lesion from several causes like tetracycline stains, bloodborne stains, certain materials in a previously treated lesion (23).

7.1.3. Texture:

As universally described, the active lesion usually described as soft. The dental explorer remains a standard tool for diagnosing root caries due to the subtle visual signs compared to coronal caries, making tactile feedback essential. Concerns have been raised about its reliability and the risk of damaging the tooth surface. Modified explorers with 30-degreeangled tips improve detection in interproximal areas (24). Gentle use of a blunt probe is advised to avoid iatrogenic damage, particularly when managing early, non-cavitated lesions conservatively.Certain authors describe the lesion as leathery which denotes slowly progressive lesion. However arrested lesion is usually hard in consistency so that the penetration of the explorer is quite difficult (23).

7.1.4. Cavitation

Initially all cavitated lesion are believed to be active, but later it is revised to include the colour and texture of the lesion to enhance the diagnosis. “The loss of surface continuity” is also considered as a visual indicator in detecting root caries. When cavitation is included as the diagnostic criteria, it is essential to rule out other non-carious cervical lesions (25 26).

7.1.5. Position

Root caries lesions are most commonly found near the cemento-enamel junction or close to the margin of the gingiva. Most of the active root caries lesions are soft and are located near the gingival margin. Regarding the surface of the tooth affected, there is a great variability among the buccal and the proximal surfaces but many studies indicated that the proximal surface are mostly affected then the buccal surface (27 28).

7.2. Radiographic examination:

Radiographic diagnosis can be a diagnostic aid in diagnosing root caries when visual access is limited. Radiographs can lead to misdiagnosis as the radiolucency may confuse with non-carious cervical lesion and cervical burn out. Early caries lesion can go undetectable until the mineral loss of accounts to 30 – 40%. Carefully examining the enamel adjacent to the radiolucent areas can aid in increasing accuracy which interpreting the radiograph (29 30). It is recommended to correlate the clinical findings

with the radiographic interpretation. With radiographic examination, sensitivity is estimated to be between 0.40–0.63 and specificity ranges from 0.31–0.80 (22).

7.3. Caries risk assessment:

Rather than diagnosing a single tooth, an attempt to diagnose the patient with the risk factors will prevent multiple future lesions. Caries risk assessment helps identify individuals most likely to develop or experience progression of caries, especially root caries. Tools like cariogram can be used to evaluate the risk of developing caries as it weighs multiple factors such as diet, hygiene, salivary flow and others (31 32).

7.4. Fluorescence based devices:

Fluorescence based devices are available based on the colour of the light emitted and its wavelength as red, blue, green-yellow fluorescence devices. Fluorescence is generally higher with the carious tissue because of the presence of porphyrins as its bacterial products. Carious dentine appears red while sound dentine green (33 34). With the help of laser fluorescence, the diagnostic accuracy of laser fluorescence for detecting root caries, reporting sensitivity between 0.50–0.81 and specificity between 0.40–0.80 (22).

7.5. Fibre-optic transillumination

Fibre-optic transillumination (FOTI) involves directing light from a handheld device onto the tooth surface. Areas of demineralization appear as shadows because the altered tooth structure scatters the light, indicating possible carious lesions (34).

7.6. Indices:

7.6.1 Ekstrand Root caries scoring system

A reliable scoring system was devised by Ekstrand *et al* which is based on four variables: Texture, Contour, Colour, Position of the lesion in relation to the margin of the gingiva. The scoring criteria is mentioned below (35):

Texture: Hard (0): Leathery (2): Soft (3)

Contour of surface: No cavitation or the surroundings of the cavity – smooth on gentle probing (1) Cavitation with irregular borders (2)

Proximity of the lesion from the gingival margin: >1 mm from the gingival margin (1):<1 mm from the gingival margin (2)

Colour of the lesion: Dark brown/black (1):Light brown/yellowish (2)

If the total score adds up to 3–5 = arrested caries; 6–9 = active caries.

7.6.2 Root caries index

To overcome the limitations of the DMFS index, a new index system was devised by Katz in the year 1980. This index includes teeth with gingival recession. It was scored using the criteria below

RCI=(R-D)+(R-F)/(R-D)+(R-F)+(R-N) x 100

R-D: recession with decay root surface
R-F: recession with filled root surface.
R-N: recession with a sound root surface(normal)

7.6.3 Root surface caries severity Index

According to severity it is classified in to (23)
Grade 1: Incipient; no surface defect; need remineralizing therapy.
Grade 2: Shallow; surface defect <0.5mm; need recontouring.
Grade 3: Cavitation; surface defect >0.5mm; need filling.
Grade 4: Pulpal carious pulp exposure; need RCT + filling.

7.6.4 ICDAS scoring system for Root Caries

ICDAS classified root caries based on the colour, texture, probing and cavitation. Different codes were given to each surface from O, E and from 1 to 7 (36).
E = Excluded root surfaces (no gingival recession)
0 = Sound (no caries or restoration)
1 = Non-cavitated carious root surface- soft or leathery
2 = Non-cavitated carious root surface- hard and glossy
3 = Cavitated (greater than 0.5mm in depth) carious root surface-soft or leathery
4 = Cavitated (greater than 0.5mm in depth) carious root surface— hard and glossy
6 = Extensive cavity: an extensive cavity involves at least half of a tooth surface and possibly reaching the pulp.
7 = Filled root with no caries

7.6.5 ICCMS Scoring Criteria

The ICCMS™ system also includes staging for root caries lesions, focusing on evaluating both the presence of cavitation and the lesion activity. Root caries lesions are categorized based on these clinical findings (37)
Code 0: Root surface appears normal with no discoloration or cavitation. Loss of surface integrity, if present, is smooth, hard, and due to non-carious causes like abrasion or erosion—typically shiny, with defined (abrasion) or diffuse (erosion) borders.
Code 1 (Initial): A clearly defined discoloured area (light/dark brown or black) is visible at the root surface or CEJ, but without cavitation (contour loss < 0.5 mm).
Code 2 (Moderate/Extensive): Discoloured area present with cavitation.
Moderate: Loss of contour 0.5–2 mm.
Extensive: Loss of contour > 2 mm.

8 Conclusion

Root caries is an increasingly relevant dental condition, especially in older adults. Accurate diagnosis is essential for early intervention and effective management.

Traditional methods like visual-tactile examination and radiographs remain commonly used, but each has limitations in sensitivity and accuracy. Advances in diagnostic technologies—such as laser and fluorescence-based tools—have improved detection, particularly for early and non-cavitated lesions. However, no single method is universally definitive. A combined approach, integrating clinical assessment, appropriate technology, and individual risk factors, offers the best strategy for identifying and managing root caries while supporting conservative, preventive care.

References:

1. UN, **World Population Prospects 2024** (United Nations, Department of Economic and Social Affairs, Population Division), processed by Our World in Data. Life expectancy at birth, 1950–2100 (medium variant projections)
2. P.A. Heasman, M. Ritchie, A. Asuni, E. Gavillet, J.L. Simonsen, B. Nyvad Gingival recession and root caries in the ageing population: a critical evaluation of treatments J. Clin. Periodontol., 44 (2017), pp. S178-S193, 10.1111/jcpe.12676
3. Katz RV. Assessing root caries in populations: The evolution of the root caries index. J Public Health Dent. 1980;40:7–16.
4. Hayes M, Burke F, Allen PF. Incidence, prevalence and global distribution of root caries. Monogr Oral Sci 2017;26:1–8.
5. Pretty IA. Caries detection and diagnosis: novel technologies. Journal of Dentistry 2006;34:727-39
6. Pentapati KC, Siddiq H, Yeturu SK. Global and regional estimates of the prevalence of root caries - Systematic review and meta-analysis. Saudi Dent J. 2019 Jan;31(1):3-15.
7. Krithikadatta J, Krishnan A. Root Caries: Etiopathogenesis and Management. J Oper Dent Endod 2022; 7 (2):38-43.
8. Taub DD, Murphy WJ, Longo DL. Rejuvenation of the aging thymus: growth hormone-mediated and ghrelin-mediated signaling pathways. Current Opinion in Pharmacology. 2010;10(4):408–424.
9. Carramolino-Cuéllar E, Lauritano D, Silvestre FJ, Carinci F, Lucchese A, Silvestre-Rangil J. Salivary flow and xerostomia in patients with type 2 diabetes. J Oral Pathol Med. 2018 May;47(5):526-530.
10. Volkert D. Malnutrition in older adults - urgent need for action: a plea for improving the nutritional situation of older adults. Gerontology. 2013;59(4):328-33. doi: 10.1159/000346142. Epub 2013 Feb 8. PMID: 23406648.
11. Janto M, Iurcov R, Daina CM, Neculoiu DC, Venter AC, Badau D, Cotovanu A, Negrau M, Suteu CL, Sabau M, Daina LG. Oral Health among Elderly, Impact on Life Quality, Access of Elderly Patients to Oral Health Services and Methods to Improve Oral Health: A Narrative Review. J Pers Med. 2022 Feb 28;12(3):372.
12. Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, Taylor R. Periodontitis and diabetes: a two-way relationship. Diabetologia. 2012 Jan;55(1):21-31.

13. Abou Neel EA, Aljabo A, Strange A, Ibrahim S, Coathup M, Young AM, Bozec L, Mudera V. Demineralization-remineralization dynamics in teeth and bone. Int J Nanomedicine. 2016 Sep 19;11:4743-4763.
14. Goldberg M, Kulkarni AB, Young M, Boskey A. Dentin: structure, composition and mineralization. Front Biosci (Elite Ed). 2011 Jan 1;3(2):711-35.
15. Mellberg JR. Demineralization and Remineralization of Root Surface Caries. Gerodontology 1986;5(1):25–31.
16. Damé-Teixeira N, Parolo CCF, Maltz M. Specificities of caries on rootsurface. Root caries: From prevalence to therapy 2017;26. pp. 15–25.
17. Botelho JN, Villegas-Salinas M, Troncoso-Gajardo P, Giacaman RA, Cury JA. Enamel and dentine demineralization by a combination of starch and sucrose in a biofilm - caries model. Braz Oral Res. 2016 May 20;30(1):S1806-83242016000100250.
18. Takahashi N, Nyvad B. Ecological Hypothesis of Dentin and Root Caries. Caries Res. 2016;50(4):422-31.
19. Preza D, Olsen I, Aas JA, Willumsen T, Grinde B, Paster BJ. Bacterial profiles of root caries in elderly patients. J Clin Microbiol. 2008 Jun;46(6):2015-21.
20. Zhang W, McGrath C, Lo EC. A comparison of root caries diagnosis based on visual-tactile criteria and DIAGNOdent in vivo. *Journal of Dentistry* 2009;**37**(7):509-13.
21. Zhang W, McGrath C, Lo EC. ELectiveness of DIAGNOdentin detecting root caries without dental scaling among community-dwelling elderly. *Oral Health & Preventive Dentistry* 2016;**14**(6):555-61.
22. Fee PA, Macey R, Walsh T, Clarkson JE, Ricketts D. Tests to detect and inform the diagnosis of root caries.*Cochrane Database of Systematic Reviews* 2020, Issue 12. Art. No.: CD013806.
23. Hellyer, Paul & Lynch, Edward. (2006). The Diagnosis of Root Caries – A Review. Gerodontology. 9. 95 - 102. 10.1111/j.1741-2358.1990.tb00267.x.
24. Carvalho TS, Lussi A. Assessment of root caries lesion activity and its histopathological features. In: Carrilho MRO, editors(s). Root Caries: from Prevalence to Therapy. Vol. 26. Basel: Karger, 2017:63-9.
25. Ekstrand KR, Poulsen JE, Hede B, Twetman S, Qvist V, Ellwood RP. A Randomized Clinical Trial of the Anti-Caries Efficacy of 5,000 Compared to 1,450 ppm Fluoridated Toothpaste on Root Caries Lesions in Elderly Disabled Nursing Home Residents. Caries Research 2013;47:391-398.
26. Leske GS, Ripa LW. Three-year root caries increments: implications for clinical trials. J Public Health Dent. 1989 Summer;49(3):142-6.
27. Banting DW, Courtright PN. Distribution and natural history of carious lesions on the roots of teeth. Dent J. 1975 Jan;41(1):45-9. PMID: 1053745.
28. Nyvad B, Fejerskov O. Active root surface caries converted into inactive caries as a response to oral hygiene. Scand J Dent Res. 1986 Jun;94(3):281-4.

29. Secgin CK, Gulsahi A, Arhun N. Diagnostic challenge: instances mimicking a proximal carious lesion detected by bitewing radiography. *J Oral Health Dent Management* 2016; **15:** 1-5.
30. Berry HM Jr. Cervical burnout and Mach band: two shadows of doubt in radiologic interpretation of carious lesions. *J Am Dent Assoc* 1983; **106**: 622-625.
31. Hayes M, Da Mata C, Mc Kenna G, Burke FM, Allen PF. Evaluation of the Cariogram for root caries prediction. *J Dentistry* 2017; **62**: 25-30.
32. Brathall D, Hansel Petersson G. Cariogram - a multifactorial risk assessment for a multifactorial disease *Community Dent Oral Epidemiol*2005; **33**: 256-264.
33. Angmar-Månsson B, Ten Bosch JJ. Quantitative light-induced fluorescence (QLF): a method for assessment of incipient caries lesions. DentoMaxillo Facial Radiology 2001;30:298-307
34. Pretty IA, Ellwood RP. The caries continuum: opportunities to detect, treat and monitor the re-mineralization of early caries lesions. Journal of Dentistry 2013;41(Suppl 2):S12-S21.
35. Ekstrand K, Martignon S, Holm-Pedersen P. Development and evaluation of two root caries controlling programmes for home-based frail people older than 75 years. Gerodontology. 2008 Jun;25(2):67-75.
36. Gugnani N, Pandit IK, Srivastava N, Gupta M, Sharma M. International Caries Detection and Assessment System (ICDAS): A New Concept. Int J Clin Pediatr Dent. 2011 May-Aug;4(2):93-100.
37. Ismail, A.I., Pitts, N.B., Tellez, M. *et al.* The International Caries Classification and Management System (ICCMS™) An Example of a Caries Management Pathway. *BMC Oral Health* **15** (Suppl 1), S9 (2015).