

## Diagnosis, prevention and treatment of root caries

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إن الإهتمام بمشاكل نخر جذور الأسنان قد تضاءل في القرن الأخير مما أدى إلى وجود تحديات سريرية عدة وتماشى مع تطورات الحياة، خاصة أن عدد الأشخاص الذين يعيشون لسن متقدمة في تزايد مستمر وكذا لك فإن إدراكهم لأهمية الحفاظ على أسنانهم الطبيعية قد ازداد هذه الدراسة تشمل مراجعة لمعظم الدراسات المتعلقة بموضوع نخر جذور الأسنان وما يترافق معه من عوامل مختلفة أدت إلى حدوثه، إضافة إلى أنواع التشخيص وإتباع الطرق الوقائية والعلاجية منه.

Concerns and issues about root caries have increased in the last decade. This represents a clinical challenge today as an increasing number of individuals are now living to an advanced age, and their awareness of the importance of maintaining their natural teeth has increased. This article reviews the literature concerning root caries lesions, along with the risk factors associated with their origin, diagnosis, prevention and treatment methods.

### Introduction

**D**ental caries is an ancient disease that has been found in skulls from all over the world where primitive man lived in isolated areas and the diet lacked refined and carbohydrate-rich food.<sup>1,2</sup> During the 17th century, sugar became more available and cheaper in Europe and the diet changed to more refined food. As a result, caries became an endemic problem that persisted through the ensuing centuries.<sup>3</sup> Today, demographic predictors view root caries as an emerging significant patient management issue of the next decade as more elderly population retain their natural teeth.<sup>4,5</sup>

Ettinger<sup>6</sup> reviewed the studies on caries rate and distribution in the 20th century and concluded that it had different patterns in the world, which are related to the degree of development and level of industrialization. Populations in the industrialized countries have decreasing caries rates in children and an increasing number of retained teeth in the elderly, while the opposite situation is found in the developing countries. This result can be directly correlated with the population, profile, gender, diet, education, presence of preventive measures and technological advances in the industrialized countries compared to the developing countries. In the latter countries a higher caries rate exists in urban areas than in rural communities due to availability of sugar in the former areas.

### Prevalence and Incidence

Miller,<sup>7</sup> a clinician and professor of conservative dentistry, addressed the subject of

this review paper nearly a century ago in three articles that discussed what he termed the "wasting of tooth tissue" and its causes. Root caries was once considered a disease for which the elderly population had their teeth extracted and replaced with removable prostheses.<sup>8</sup> At present, root caries is becoming a new area of focused research in dentistry, as more people are living to an advanced age and retaining their natural teeth. With advanced age, there is more gingival recession, which leaves the root surface exposed to the oral environment and leads to an increase in the root caries rate. Ettinger,<sup>6</sup> who has reviewed many studies related to the prevalence and incidence of root caries in different areas of the U.S., found that more than half of the elderly people have had root caries and that root caries increase with age.

The true prevalence of root caries is difficult to assess. Interpretation of data from prevalence and incidence studies is complicated due to differences in diagnostic criteria, treatment decisions, and lack of homogeneity of the observed population.<sup>8,9</sup> Nevertheless, it has been definitely established that the prevalence of root caries increases with age and is greater in the elderly population than in younger adults.<sup>8,10</sup> Katz<sup>10</sup> has critically reviewed the variables related to root caries and has made firm recommendations about how future studies should be conducted to provide a root caries index. In Saudi Arabia, a developing country with a population of 21 million, fifty percent of the population is under the age of 19 years.<sup>11</sup> It has recently been found that children in Saudi Arabia have an increased caries rate.<sup>12,13</sup> This is of great

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importance in putting more emphasis and concentration on preventive programs by the public health workers to increase the level of dental health awareness and to prevent caries at an early age. This allows retaining more natural teeth and avoiding coronal caries where cervical caries can be initiated. Studies have indicated that patients who have coronal caries are more likely to develop root caries.<sup>14</sup> Root caries in the elderly population of Saudi Arabia has not been reported. Research in this field would be of great help in encouraging these elderly individuals to maintain a better dental care in their life style.

### Root Surface Lesions

Root caries can occur in areas of abrasion, erosion, and abfraction, or as primary root caries and recurrent decay.<sup>15</sup> This mode of caries occurs at or apical to the cemento-enamel junction (CEJ). It is important to have a full understanding of the nature of and the different root surface lesions that may occur, so definitions of the various root caries lesions are now summarized.

**Root surface abrasion** is a hard, smooth, sharply demarcated and shiny lesion, which contains scratches and is free of plaque. It is caused by mechanical abrasion, such as from toothbrushing (Fig. 1), while root surface erosion is a hard and relatively smooth lesion that occurs on areas free of plaque. This lesion is undemarcated and is formed where acids etch away the mineralized tissue, such as occurs from the extensive consumption of fruits or juices containing phosphoric or citric acid (Fig. 2).<sup>9,16, 17</sup>



**Fig. 1.** Abrasion lesions on the root surface of teeth with gingival recession in a patient exercising meticulous plaque control.

**Abfraction** is a mechanical process involving tooth deformation and flexure by eccentric forces, which results in the loss of tooth structure at the

cervical area and the development of a V-shaped notch that causes the tooth structure to become weaker (Fig. 3).<sup>18</sup>

Root surface caries is a soft, irregular, progressive lesion occurring at or apical to the CEJ. It is caused by the presence of bacterial plaque and the repeated consumption of sugars, which results in the dissolution of minerals from the calcified tissue.<sup>9,16</sup> Root surface caries are initiated when there is periodontal attachment loss and the root surface become exposed to the oral environment (Fig. 4).



**Fig. 2.** Teeth with heavy occlusal wear and erosion lesions due to the extensive use of acidic juices in a 58 years old male.



**Fig. 3.** V-shaped abfraction lesions in a 48 years old male.



**Fig. 4.** Active root caries lesion on a tooth with gingival recession.

A region where root caries has occurred may be round or oval in shape, and may begin at one or more sites on a tooth. One such region then may spread radially and join other regions of root caries. These regions may appear as white or discolored (brown or black) areas of irregular outline, with or without a cavity at an exposed root surface or at the margins of existing restoration.<sup>17</sup> Root caries are more common in males than females. Mandibular molars are the most susceptible teeth to root caries, followed by premolars, canines and incisors, which are rarely involved; this order is reversed in the maxilla.<sup>19,20</sup> The facial surfaces of teeth are the most susceptible to these lesions.<sup>20</sup>

### Etiology of the Caries

Root caries is initiated when bacteria and fermentable carbohydrates attack the root surface. Since the 1970's, studies have been conducted to identify the microflora responsible for root caries,<sup>21</sup> and *Streptococcus mutans* was found to be the primary initiating microorganism.<sup>22</sup> *Lactobacillus* and *Actinobacillus* are believed to have adjunctive roles<sup>23</sup> *Candida albicans* has been identified in soft lesions but is not considered to have a role in initiating these lesions.<sup>24</sup>

Microorganisms metabolize simple sugars into organic acids, which dissolve through plaque that is harbored on the tooth surface. These acids then pass through the root structure and start the process of demineralization that removes calcium and phosphate ions. This process takes place as the pH reaches the critical value of 6.4 for demineralization of cementum and dentin, and 5.5 for demineralization of enamel.<sup>25</sup> Dramatic effects occur during this process, with the collapse of collagen due to dissolution of inorganic minerals and the formation of cavities. The rate of root demineralization is much faster than that of enamel and occurs at higher pH, because the mineral content in the root (55%) is much less than that in enamel (99%).<sup>26</sup> Remineralization can be enhanced by the application of a fluoride, and once the pH at the root surface has been restored to neutrality, remineralization by the deposition of calcium and phosphate ions can take place.

### Risk Factors

The frequency at which root caries occurs can be correlated with that of coronal caries, and the factors associated with enamel caries have great

importance in determining the initiation of root caries.<sup>27</sup> Root caries has been found to be associated with both intraoral and extraoral factors, which are now listed.<sup>9</sup> An appreciation of the causes of root surface lesions will lead the clinician to a better diagnosis and prevention for the patient.

### Intraoral Factors for Root Caries

1. Low salivary flow resulting in xerostomia. Low salivary buffer capacity.
2. Poor oral hygiene resulting in high plaque score and calculus deposition.
3. Periodontal disease and periodontal surgery.
4. Attachment loss and gingival recession.
5. Elevated salivary levels of microorganisms.
6. Frequency of carbohydrate intake and percentage of tooth surfaces harboring plaque.
7. Unrestored and restored coronal and root caries.
8. Overdenture abutments and removable partial dentures, since clamps and connectors contribute to food retention.
9. Malocclusion, abfraction, drifting, and tipping, which makes areas of teeth inaccessible for patients to maintain proper oral hygiene.

### Extraoral Factors

1. Advanced age, since the incidence of root caries is higher in older adults.
2. Infrequent dental check up.
3. Lower educational and socioeconomic levels.
4. Gender, since males are more affected than females.
5. Physical disability (e.g., Parkinson's disease) where patients have limited manual dexterity that makes the removal of plaque during toothbrushing difficult.
6. Medications that decreases the salivary flow.
7. Diabetes, autoimmune disorders (e.g., Sjogren's Syndrome), or radiation therapy.
8. Antipsychotics, sedatives, barbiturates, and antihistamines.
9. Limited exposure to fluoridated water.
10. Addiction to alcohol or narcotics.

### Diagnosis

The key to any successful dental procedure begins with the proper diagnosis that allows the practitioner to provide patients with the necessary treatment and preventive measures. It is the

clinician's responsibility to record an accurate medical history and examination keeping in mind the intraoral and external risk factors.

Clinical examination to assess the presence of root caries is best carried out with an explorer that can detect differences in the surface character (e.g., soft or hard) and surface contours.<sup>28</sup> Teeth surface should be cleaned since plaque covers the lesions and they may be misdiagnosed (Fig. 5). Both transillumination and direct vision should be employed. It is important to remember that pain is not a common complaint from patients with root caries. Accurate radiographs are very important diagnostic tools and should be free from overlapping or burnout.<sup>29</sup> Special dyes can be useful for detecting root caries, which sometimes exhibits similar color to dentin. These dyes stain the infected dentin and allow the clinician to detect hidden caries. Intraoral cameras can be essential tools in educating patients and showing



**Fig. 5.** Multiple active root caries lesions on teeth with gingival recession covered by plaque in a 62 years old male.

them their teeth.

### Prevention

Root caries prevention requires proper assessment and observation of the caries risk level for the patient. Proper preventive measures of plaque removal, diet modification, and the use of topical fluoride<sup>22,30</sup> has demonstrated significant results in arresting active carious lesions.

Preventive measures include educating patients and people assisting them to avoid high sugar-containing meals, maintaining a proper toothbrushing technique and oral hygiene measures, and having regular dental checkups. Elderly patients (especially those with limited manual dexterity) need to be educated about plaque control with the use of an interproximal brush or electrical oral hygiene devices. Many

elderly patients are on medications with anticholinergic side effects. Their physicians need to provide advice to these patient about the side effects of such medications, so that the necessary preventive measures can be followed. The clinician should direct special attention to root caries-prone patients who are wearing dental prostheses. This is achieved by proper management of soft tissues during fixed prosthesis procedures (e.g., design, contours, and polish) and avoiding placing the margins of a restoration coronal to the surrounding tissue to eliminate plaque accumulation. For removable prostheses, retainers and guide planes should be placed in cleansing areas that allow salivary flow.

As stated previously, fluoride is an appropriate agent for prevention of root caries because it promotes the remineralization process and reduces the rate of demineralization.<sup>25,31</sup> There are numerous methods by which fluoride can be supplied. Exposure to fluoride in drinking water results in increasing resistance to root caries, and people living in areas with fluoridated water are less prone to caries in general than those who live in areas lacking fluoridated water.<sup>32</sup> Topical fluoride products are available as 0.05% sodium fluoride rinse, 0.12% chlorhexidine rinse, and as 1.1% neutral sodium fluoride gel in a 5-minute tray technique, with 4 applications over 2-4 weeks.<sup>31,33</sup> Other products are dentrifices containing 1100 ppm sodium fluoride,<sup>34</sup> fluoride chewing gum which is effective especially in patients with low salivary flow and xylitol-containing chewing gum which stimulates salivary flow and decreases plaque formation, although studies have not shown its effectiveness in preventing adult caries.<sup>31</sup> Fluoride-containing varnishes have also been effective against root caries.<sup>22</sup> Application of dentin adhesives can have the adverse effect of demineralizing the root surface.<sup>35</sup>

### Treatment of Root Caries

The treatment provided for patients should depend on classifying them into risk groups. Table 1 shows the patient risk level and treatment option.<sup>3,9,36</sup> This classification can allow the dentist to use the most appropriate method for treating patients according to their needs.

Treatment strategies for root caries rely on the clinical examination and findings, and are determined by the size, type, extent, and location of the lesion, esthetic requirements as well as the physical and mental condition of the patient.

The clinical success rate depends on the degree of recession and the defect.<sup>37</sup> Since root

**Table 1.** Root caries risk categories, prevention and restorative materials.<sup>3,9,36</sup>

Risk Level	Oral Hygiene	Root Caries	Preventive Option	Restorative Material
Low	Good	No caries in 3 years	Reinforce prevention, annual recall	No restrictions
Medium	Fair	1-2 lesions in 3 years	Diet counseling, fluoride toothpaste, fluoride mouth rinse, professional fluoride application, 6-month recall	Resin composites, resin-modified glass-ionomers, compomers
High	Normal	More than 2 lesions in past 3 years	Monitor microorganisms, modify diet, fluoride toothpaste, 1.1% neutral sodium fluoride gel daily and chlorhexidine rinse for 2-4 wk, xylitol chewing gum, 3-month recall	Materials that release fluoride

surface exposure caused by gingival recession can be attributed to factors resulting in cervical abrasion, root caries, sensitivity, and undesirable esthetics, soft tissue grafts can effectively treat this situation.<sup>38</sup>

Root caries lesions are difficult to restore because of their location, which is usually subgingival. Adequate access and isolation are important for the proper restoration. Access can be gained by the use of a retraction cord and proper clamp like the 212, which allows displacement of the soft tissue and exposes the lesion or by creating a miniflap. The decision to use a particular method of retraction depends upon whether the apical extension of the lesion is located 2 mm above the height of the alveolar crest.<sup>39</sup> When performing the clinical procedure, extreme care should be taken not to interrupt the biological width, otherwise, inflammation will occur.

Cavity preparation depends mainly on the extent of the lesion. The surface should be cleaned with fluoride-free pumice to ensure removal of plaque. Then the decayed tooth tissue is excavated, and the restoration walls are prepared. The margins and retention design depends on the restorative material used. As the functional *in vivo* load is minimal on the root surface, minimal but proper retention is required. When amalgam is the material of choice, where access and esthetics are not concerns, retention grooves are required occlusally and gingivally.

Materials that are used with adhesives require beveling of the coronal margins of the preparation to allow better micromechanical retention.

Proper access and isolation to treat root caries are very important, and ideally involve use of a rubber dam if the lesion is supragingival. However, this sometimes cannot be accomplished if the location of the lesion is near the gingival margin or is subgingival. In that case, other methods of isolation like cotton rolls and retraction cords can be used. Care must be taken not to use hemostatic agents that affect the bonding agent. If the lesion extends subgingivally and cannot be completely observed, even with the use of a retraction cord, a releasing incision maybe required for completing



**Fig. 6.** Loss of the tooth structure at the cervical area of teeth with gingival recession and formation of multiple abfraction lesions in a patient with bruxism and clenching habits.

the restorative procedure.<sup>9</sup>

### Restorative Materials

The dental practitioner should customize a treatment according to the needs of the patient and understand the causes for the particular oral disease, in order to provide the appropriate care. This is dependent on the extent of the decay, and its proximity to the pulp and soft tissues, which makes isolation difficult due to blood, saliva and surface fluids.

There are different restorative materials available but no one material possesses entirely ideal characteristics. Table 2 lists the restorative materials used for treating root caries. The clinician must match each restorative situation with the material that is most appropriate for it, keeping in consideration the location, accessibility, margins and oral hygiene.

Direct-filling gold was formerly the material of choice for its ability to achieve very close marginal adaptation and its compatibility. However, the application of direct-filling gold can be

**Table 2.** Restorative materials used for root caries lesion

Material	Flouride release	Adhesive	Aesthetics
Amalgam	None	No	Low
Glass ionomer	High	Yes	Moderate
Resin- modified glass ionomer	High	Yes	Moderately high
Resin composite	None	Yes, with bonding	High
Flouride-containing resin composite	Little	Yes, with bonding	High
Compomer	Moderate	Yes, with bonding	Moderately high

compromised when access is limited and isolation is difficult. Nowadays clinical use of this material is very limited because of the availability of newer materials with superior properties.

Dental amalgam has been available to the profession for the past 150 years, and it has long been the material of choice for posterior teeth restorations that are not excessively large. Dental amalgam, a material that is easy to manipulate, can be used in areas with difficult isolation or where the margins are self-sealing.<sup>40</sup> However, the properties of dental amalgam are technique-sensitive. Moreover, this material lacks aesthetic appearance, is brittle, has no therapeutic effect, and cannot bond to tooth structure. This latter deficiency requires the cutting of healthy tooth structure adjacent to the carious tissue for adequate retention of the restoration. The use of high-copper, spherical alloy and zinc-free amalgam is required in root surface lesions to insure adequate condensation and marginal integrity.<sup>17</sup>

Traditional glass-ionomer cements have the desirable properties of being biocompatible, achieving a chemical bond to enamel and dentin, and releasing fluoride over extended periods of time. These materials have the disadvantages of poor esthetics and excessive *in vivo* wear with time. Their use has become very limited with the development of newer materials that possess superior properties.<sup>41</sup>

Resin-modified glass-ionomers are indicated for high caries-risk patients.<sup>39</sup> They are biocompatible, bond to enamel and dentin, possess thermal expansion and contraction characteristics that match tooth structure well, and have an anticariogenic effect from the same type of fluoride release characteristic of traditional

glass-ionomers. The glass-ionomer materials are fluoride reservoirs and are well-known for reducing caries rate. They can also be recharged by uptake of fluoride ions from the oral environment. The glass-ionomer materials are technique-sensitive and must have no moisture contamination for optimal properties. Resin-modified glass-ionomers possess clinically acceptable properties, and are reasonably esthetic and less brittle than the traditional glass ionomers.<sup>9</sup> To achieve better esthetics *in vivo*, the use of a sandwich technique is indicated, where a layer of glass-ionomer lines the cavity preparation and is then covered by a layer of hybrid resin composite.<sup>42</sup>

Resin composites are highly esthetic materials, and bond to enamel and dentin, but do not have any anticariogenic effect since the traditional products do not contain any significant quantity of fluoride that can be released. Hybrid composites possess improved strength and improved esthetics compared with traditional resin composites. Microfilled composites can be highly polished to provide a high luster that is similar to enamel, and these materials give good results in low stress-areas (Fig. 7, 8a, 8b). The latter are recommended for root surface restorations, especially with abfraction lesions, as they have lower elastic modulus than hybrid composites. This is an important consideration, since the teeth flex during mastication and a flexible material will be a better choice to restore the root surface.<sup>39</sup> Resin composites are technique-sensitive materials and require proper isolation for the clinical success of the restoration. Polymerization shrinkage associated with the curing of resin composites is another concern, since this can result in discoloration of the resin around the margins and in microleakage that leads to tooth sensitivity and secondary caries. Use of the new bonding systems that seal the dentinal tubules has minimized this effect.<sup>43</sup> Placing a bevel on the enamel margin is desirable for better esthetics and retention.

Fluoride-containing resin composites release only small amounts of fluoride and have little ability to recharge from the oral environment. Therefore, they are not recommended for use with high caries-risk patients, but can be used where aesthetics is a concern.<sup>39</sup>

Compomers are polyacid-modified resin composites and thus possess properties of both glass ionomers and resin composites. They leach fluoride, but to a lesser extent than glass



**Fig. 7.** Resin composite restorations immediately after placement in a 67 years old female.

ionomers, and they bond to both enamel and dentin. The compomers can be used in low-stress areas where esthetics is a concern.<sup>44</sup>

It should be noted that, with the use of bonding agents, the etched dentin surface must not be desiccated to avoid collapse of the collagen web. This produces stronger bond strength<sup>45</sup> by allowing the hydrophilic primer and adhesive components in the bonding material to penetrate the etched dentin and surround the collagen to form a hybrid layer, which allows the resin material to bond to the tooth.

In severe cases where the caries encircles the root surface, full coverage maybe the treatment of



**Fig. 8a.** Tooth with old cervical amalgam restoration. Other teeth have deep cervical lesions that have been excavated and provisional restorations are placed for caries control (Courtesy of Dr. A. Ghassab).



**Fig. 9 a.** A 70 years old male with heavy stains, badly broken teeth with active root caries lesions on the upper teeth and abrasion lesions on the lower teeth (Courtesy of Dr. A. Ghassab).



**Fig. 8b.** Same patient one week later, provisional restorations replaced by resin composite restorations. (Courtesy of Dr. A. Ghassab).



**Fig. 9b.** Same patient required treatment by crowning his teeth. Note the gingival inflammation same day of cementation. (Courtesy of Dr. A. Ghassab).

choice (Fig. 9a, 9b).

### Conclusions

With more elderly people retaining their natural teeth, the need to understand the nature and causes of root surface lesions is of great importance. Preventive measures that include proper oral hygiene, plaque control, and fluoride therapy are required prior to and after dental treatment. There is no data currently available on the prevalence of root caries in the Kingdom of Saudi Arabia, which makes it an important area of research for health workers and clinicians. Treatment of root surface caries should be directed and customized to the individual case by classifying patients in risk groups to achieve maximum results. The use of resin-modified glass-ionomer materials is recommended for these restorations because of their cariostatic properties in patients with a high caries risk.

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