Caries detection in dentine. Development from tactile to technology-assisted methods.

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Abstract: Assessing a carious lesion in dentine is difficult and highly subjective using traditional methods like probing. Additional adjuncts like carious staining has not proven to be advantageous. Since 15 years fluorescent methods have been introduced to diagnose caries. Today, those methods are used additionally to facilitate caries removal in dentine, called FACE (fluorescence aided caries excavation). Actual studies show, that these methods provide an easy and reliable supplementary tool in assessing the endpoint of caries excavation in dentine with the advantage of enabling data to be digitally visualized and stored.

Keywords: Dentine caries, Fluorescence based caries detection, Caries removal, Fluorescence aided caries excavation

Dental caries is probably one of the most common chronic diseases in the world. In history, caries has been strongly connected to the level of civilization and dietary changes. Even if we can see a reduction of caries prevalence in developed countries, caries is still a polarized disease affecting mainly the lower socio-economic groups. As the result of caries is tooth loss, pain and cosmetic defects, caries creates an enormous cost to society.

W.D. Miller has recognized caries as a chemo-parasitic process in 1889. Bacteria in oral biofilms (plaque), described by G.V. Black and J.L. Williams in 1898, can metabolize refined carbohydrates and produce organic acids, mainly lactic acid, as a metabolic by-product. These acids are able to demineralize calcified hard tooth substances. During periods of low bacterial metabolic activity, remineralization can occur. If the balance of demineralization and remineralization is shifted to demineralization, an irreparable loss of tooth substance is inevitable which leads to the formation of cavities.

Today, caries is recognized as a transmissible multifactorial disease. Clinically, the aims are to identify caries in a very early stage to minimize damage and treatment cost. If a cavity has developed, the aim is to minimal invasively restore the defect.

If a cavitation has occurred in a tooth, bacteria will invade this new environment and continue the carious process of demineralization. Especially in dentine, which is a composition of a collagen matrix with incorporated crystallites of hydroxyapatite, bacteria can invade the tissue, mainly through the microscopic tubules that provide a direct pathway into the pulp of the tooth. The main characteristics of carious dentine are:

- Demineralization,
- Destruction of the collagen network,
- Presence of bacteria
Presence of bacterial metabolic by-products.

Traditionally, dentists want to remove the carious tissues before restoring the material loss, because it has been found that leaving too much carious material can result in the development of a recurrent carious lesion. For this, dentists have to identify the carious material and remove it with appropriate instruments.

Generally all the characteristics of carious dentine can be used to determine the amount of the carious tissue. The traditional method is probing the hardness of the tissue with a pointy device called "probe". Due to mineral loss, the Knoop hardness of the dentine drops from around 60 for sound dentine to around 10 for carious dentine, which can be detected by tactile means in conjunction with evaluation of the texture of the tissue [1]. Tactile detection of caries is a difficult and highly subjective procedure. Dental students usually need at least 6-12 month to get competent in carious detection and excavation in dentine.

Other methods are aiming at the presence of bacteria. Staining bacteria has been attempted since 1972 using a basic fuchsine red solution. Later, this was replaced with an acid red solution following the research of T.Fusayama [2]. The so called caries detector aims at providing a visual feedback for caries removal. Today, we know, that caries detector does not stain bacteria, but instead stains the organic matrix of less mineralized dentine. As this cariously “affected” dentine only contains a low amount of bacteria and is considered less problematic than the bacterially “infected” dentine, the result could be an overtreatment in terms of removing too much substance and thus increasing the risk of a pulpal exposure which complicates the restorative therapy. A significant low specificity of caries detector has been confirmed in a couple of studies [1].

The use of electrical methods has been demonstrated for initial caries diagnostics as well as for checking the dentine quality and thickness in deep cavities. The method called ECM (electrical caries monitoring) quantifies the impedance of alternating currents of different frequencies. Measurements are limited to one single spot of a tooth or cavity surface.

Fluorescent methods are used for the initial detection of carious lesions. One method called QLF (QLF, Inspector, Amsterdam, Netherlands), quantitative light–induced fluorescence, uses a halogen lamp with an exciting wavelength of 405 nm [1]. This creates a yellow fluorescence above 520 nm at the enamel dentine junction, which is scattered in the carious tissue and can be picked up with an intraoral camera.

Probably the most widely used system is the Diagnodent (Diagnodent, KaVo, Biberach, Germany), which uses a punctual diode laser source for an exciting wavelength of 655 nm. This creates a detection wavelength in the near-infrared range. The emitted fluorescence is detected and translated into a numerical range of 0 to 99 for analysis. Carious tissue fluoresces more strongly than sound dentine, mainly due to the presence of porphyrines as by-products of the bacterial metabolism [1].
A similar approach was realized with an excitation wavelength of 407 nm (VistaCamiX, Dürr-Dental, Bietigheim-Bissingen, Germany), which is emitted by diodes (Fig 1). The fluorescence is detected with an intraoral camera [3].

![Fig 1: Camera head of VistacamiX (Dürr-Dental, Bietigheim-Bissingen, Germany)](image)

Using an excitation wavelength of 405 nm, especially the fluorescence in the orange-red wavelengths are interesting, because they can be detected visually without a camera just by using a 530 nm high-pass filter. A new device (SIROIinspect, Sirona, Bensheim, Germany) has been introduced recently [4].

Apart from QLF, all these methods can also be used to assist caries removal in dentine, which is called FACE (fluorescence aided caries excavation) [1]. As the Diagnodent device only provides punctual measurements and is also limited by the inflexible and short light conductor of its measurement tip, camera systems or direct systems are recognized more versatile and adaptable to the use in a tooth cavity (Fig 2).
Fig 2: Clinical view of approximal caries lesions in two adjacent premolars (left), both cavities have been opened, but not completely excavated. The right side shows the same view in the fluorescent image disclosing the location of infected dentine.

Fig 3: ROC curve for fluorescence value from VistaCamiX for dentine samples evaluated by an expert as gold standard. The area under the curve is 0.954. (Figure taken from [5])

Comparing these systems to gold standards like histology, bacteria counts, DNA presence or expert caries excavation proves, that fluorescence based methods can be a useful supplementary tool in assessing the endpoint of caries excavation in dentine (Fig 3) [5]. This may be helpful for experienced practitioners as well as for the learning process of dental students.
References


Short Vita for Prof. R. Stoll

Having completed the higher education path in Germany, Richard Stoll finished a 3.5 year apprenticeship as certified dental technician and started to study dentistry in 1981. The national board exam as dentist was in 1986. In 1990 Richard Stoll finished his dissertation on the topic of computerized determination of impression precision and received a price of the DGZMK for the best doctoral thesis. He was appointed as chief instructor in 1991 and finished his qualifying thesis for professorship in 2003. In 2008 he was appointed as Associated Professor and in 2009 he served as department Co-Chairman in executive position at the University of Marburg (department of restorative dentistry). In 2010 he was appointed full professor of restorative dentistry at JCU in Cairns. The clinical fields of Prof. Stoll are direct and indirect aesthetic restorations and endodontic therapy. In all those fields he has done clinical teaching and research.

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