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Member, American Dental Association
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Honors/Awards

Member, Omnikron Kappa Upsilon (OKU), Dental Honor Society, 1992
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Publications

Berg JH, Bryers J, Milgrom P, Slayton R. Biotechnology and biomaterials to reduce the caries epidemic. BMC Oral Health 2006;6(Suppl 1):S1.
Berg JH. Dental caries disease in children: management by risk assessment. Alpha Omegan 2005;98(4):9–12.
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Berg, JH. Glass ionomer cements. Pediatr Dent 2002;24(5):430–8.
Berg JH. Emerging trends in oral care: moving toward a new kind of dentistry. Sci Am 2002;Special Issue:2–5.

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Head of the scientific department
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Dental Caries Detection and Caries Management by Risk Assessment

JOEL H. BERG, DDS, MS*

INTRODUCTION

Treating the results of dental caries is something dental professionals spend most of their careers collectively doing. We are compelled to treat the results of this most prevalent disease in humans, dental caries, because we do not have yet at our disposal the detection tools to enable us to manage the disease well prior to its clinical manifestation in the form of cavitation. New developments will change this late approach dramatically. Although it will take many years to enable practitioners to manage dental caries as a disease prior to the need for restorative intervention, clearly the profession is traversing an inexorable course toward that end, and we must be prepared to understand what changes will occur, as well as what changes surrounding the profession must be put into place to allow these new ways of managing caries as a disease to happen.

EARLY CARIES DETECTION AND CARIES MANAGEMENT BY RISK ASSESSMENT

History of Caries Management

Although dental caries is the most prevalent infectious disease in humans, affecting 97% of the population in their lifetime, we primarily treat the effects of dental caries and not the disease itself. Most restorative dentistry, prosthodontics in adults, and endodontics is related to the results of dental caries, not to the disease process itself. We are, in general, limited to surgical restorative intervention because we have historically lacked the clinical caries detection tools that are sensitive enough to see a caries lesion so early that we can treat it with medicinal therapeutic approaches. Such remineralization techniques are well established scientifically in vitro, but have escaped routine clinical use because of the void of early detection methods that are clinically feasible.

In addition, when it comes to reducing the risk of caries within populations of patients or in groups of patients within a practice, we have, in general, provided empirical standardized recommendations such as "brush and floss" and "use fluoride toothpaste." Although such methods of intervention to reduce caries risk are extremely effective within populations at risk,

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these routine empirical measures do not target individual patients who may be at a much greater-than-average risk. New ways of thinking, combined with new technologies, will dramatically change the way we deal with dental caries. Managing the disease process by mitigating the risk instead of identifying the disease at a later stage when it already requires surgical restorative intervention will progressively move us forward into the zone of standard of care.

What Is Available Today?

The caries detection devices in greatest use today are extremely insensitive. Visual examination, using an explorer and/or a mirror, usually can identify caries lesions only when restorative intervention is needed. An exception to this is with the diagnosis of deep pits and fissures needing sealants, which will be discussed later. Radiography is also extremely insensitive. We can only see caries lesions interproximally on bitewing radiographs when they are at least halfway through the enamel histologically. This limitation will result in us missing many lesions at the earliest stages when remineralization techniques might still be effective. Transillumination to identify caries lesions in anterior teeth has been used for a long time; however, such detection is limited to identifying lesions that are already extensive in their progress through the enamel on the way to cavitation.

In summary, we have been historically unable to detect caries lesions early and subcategorize our patients into various risk categories. The changes that have happened and that will transpire in this arena will change dentistry perhaps more than any change to date will.

Sensitivity, Specificity, and Reliability

When assessing new caries detection tools, one must evaluate them based on several important criteria, including sensitivity and specificity. I will not provide a complicated mathematical definition of these terms, but will rather provide a working definition that is important to the way clinicians should think about such tools.

Sensitivity refers to the ability of the tool or device to identify the presence of the condition when it does indeed exist. In other words, are there any false negatives? By this measure, as previously mentioned, we know that all of the tools that have historically been available to us are extremely insensitive. Included in this list of insensitive dental caries detection tools are (1) visual examination, (2) radiography, and (3) unaided transillumination.

Specificity refers to the ability of the tool or device to be accurate in its identification of a condition when it detects such condition. In other words, are there false positives? There are two parts of the specificity equation to think about. The first is, is what I have detected indeed what I believe it to be? If a radiograph or visual examination detects what is believed to be a caries lesion, how certain can one be that what is detected is indeed a caries lesion?

The second important part of specificity, which will become even more important to us as we begin to detect caries lesions at a very early stage, is, will the detected lesion progress if untreated? This is perhaps the more difficult challenge when asking about the specificity of detecting lesions early. The earlier we detect caries lesions, the greater the risk that we will detect lesions that may not have ever progressed to a stage requiring surgical restorative intervention. The natural compensatory remineralization process might allow routine "reversal" of very small lesions by "naturally occurring" remineralization of these small lesions. This second aspect of specificity—will the lesion progress if untreated?—is important to understand. Having said this, this author and most experts in these areas are not too concerned about having this opportunity and actually employ remineralization or other minimal-intervention techniques for early detected small lesions, even at the risk of treating

some that may not have progressed if untreated. The greater concern is if these early lesion are treated via surgical restorative interventions when they either (1) might not progress at all or (2) might be (in the near future) treatable with medicinal remineralization approaches. As we become able to detect caries lesions early via highly sensitive techniques, databases will be built that will enable the careful characterization of caries lesions to allow logical systems to be employed to be able to predict which early-detected lesions will progress and which ones will not.

Lesion-Specific Detection versus Caries Risk Assessment

There are at least two specific and distinct aspects to caries management.[1] The first is the detection, diagnosis, and management of individual caries lesions. This is what we do when examining a patient for caries lesions with visual examination, radiography, or other means. We detect, make a diagnosis, and chart lesions to be included in a treatment plan for restorative intervention. Separate from this, we must evaluate each patient in order to determine the risk of caries within that patient. This is a much more complex process, yet a very important one. Although only a small percentage of patients fall within the highest-risk group for experiencing significant problems with dental caries in the future, it is important that clinicians identify these high-risk patients at a very early stage. By isolating and carefully managing "the caries balance" at a very early stage, we can avert the progression of what otherwise might be a devastating condition.

Caries Detection versus Caries Diagnosis

With the implementation of new highly sensitive technologies that "detect" caries lesions at earlier stages, it is critical that clinicians understand that these devices detect and do not make a diagnosis. Clinicians make a diagnosis. We must gather information from a variety of sources,[2] including some of the new technologies that provide important assistance; however, only the practitioner can make the decision, based on all available data, that caries is present and that it requires specific interventions.

Caries Detection Devices

DIAGNOdent (Kavo USA, Lake Zurich, IL, USA; Figure 1) is a caries detection tool that has been available in the United States for several years. This device uses a laser light to fluoresce the enamel and collect the emitted fluorescent frequency, and analytically determine the level of demineralization. This level of demineralization is converted into a numeric score, ranging from 0 to 99, providing the clinician with a guide as to the extent of progression of the caries lesion. DIAGNOdent is exceptionally useful as an adjunctive detection device in combination with other information, such as visual examination that sees shadowing beneath a well-coalesced occlusal fissure. In isolation, without corroborative evidence to proceed with surgical restorative intervention, the DIAGNOdent device might give "false positives," as can any singular detection device.

DIFOTI (Electro-Optical Sciences, Inc., Irvington, NY, USA) employs digital fiber-optic transillumination to detect dental caries lesions. A high-intensity white light is transmitted through the tooth and an image is collected by a digital camera device and projected onto a computer screen. This digital image can be stored in the patient's record. The DIFOTI system uses disposable intraoral tips through which the light is transmitted and the image is collected. The technology functions by virtue of the fact that intense visible light scatters differentially in the presence of demineralized tooth structure. Several in vitro studies have shown that DIFOTI has the potential to be even more sensitive than radiography in detecting lesions occlusally or interproximally. Studies are currently underway to evaluate this potentially

Figure 1. DIAGNOdent Pen—cordless and fully self-contained.

Figure 2. Inspektor Pro quantitative light-induced fluorescence unit.

important caries detection device within the context of clinical studies in children.

Quantitative light-induced fluorescence (QLF, Inspektor Research Systems, Amsterdam, The Netherlands; Figure 2) offers another very interesting technology in the early detection of dental caries. This device is on the market, but is primarily in use within a variety of laboratories and clinical trials to identify caries lesions at a very early stage. Like DIAGNOdent, this device employs the use of light transmitted to evoke fluorescence, with a collection component that receives the fluoresced tooth data and calculates demineralization. In the case of QLF, the device uses a halogen light within the visible frequency and "scans" the entire tooth surface providing an image of the entire tooth, not a point source as in DIAGNOdent. The intellectual property of this device resides in its analytic software that can provide a very detailed analysis of the demineralization level of very early lesions. When perfected clinically, this device may be exceptionally important to clinicians in the early detection and individualized management of caries lesions with remineralization approaches.

Studies have already shown that QLF might be useful in monitoring lesions while engaging in remineralization therapies.

Risk Assessment Tools

There are a variety of means available today to assess the risk of patients for dental caries. Some of these tools gather historical and environmental data and determine the risk level using an algorithm determined from validated outcomes data. Other types of risk assessment tools employ various forms of technology by assessing one or more distinct outcome measures as validated determinants of risk.[3,4]

History and Environment Tools

Featherstone and others[5–7] have developed a risk assessment tool that offers separate sections for adults and children. This tool includes historical and environmental factors, and also uses technology to assess bacterial counts and salivary flow rates. The American Academy of Pediatric Dentistry has published a caries assessment tool (CAT)[8] that allows the clinician to assign a relative risk to children by virtue of historical and environmental data collection. The greatest risk factor for caries is a history of caries. Even if a child has had a single-surface caries lesion, the risk for future caries is dramatically increased.[9] Additionally, a history of caries in the family, in particular within the mother, will increase the caries risk in the child. This CAT is a very useful tool in caries risk assessment for children, although it does require several minutes in the office to gather the needed data.

Acid Production Detection

While there is no technological magic bullet in predicting caries risk in children, the use of technologies that allow the measurement of "acid production potential" appears quite promising. Regardless of the quantity or strain of organisms within a plaque biofilm, it is essential that the biofilm is capable of producing acid upon being challenged with sucrose in order for the caries process to progress. Therefore, any device that uses technology to assess the acid production potential of the biofilm as an "in vitro diagnostic" might be quite useful in dentistry for children.

A product referred to as "Cariostat" (Dentsply Sankin, Tokyo, Japan), available in Japan but not in the United States, resides in this category. Shimono and his colleagues at the Okayama University have studied this interesting risk assessment tool and have been able to reliably predict caries risk as measured by the decayed and filled surfaces outcome measure.[10–12] The Cariostat test has reliably predicted caries experience in the short term in toddlers, and in the long term by sampling as early as age 3 and predicting outcomes as long term as age 10. Additionally, Shimono's group has shown that aggressive intervention within a Cariostat-elicited high-risk group can prevent the subsequent caries experience in such high-risk kids. Tools such as this will likely become prevalent in practice when validated outcomes measures are available for both adults and children.

Other technologies are currently being developed in the category of acid production potential. When technologies within this category are validated via caries outcome measures, these tools may be extremely useful in a variety of environments not limited to dental offices. Pediatricians are now required to perform an oral health assessment at 6 months of age,[13] given that they see children so often at a very young age (15 times or more before age 3). If technology can provide them with a rapid screening tool that is reliable, then it might easily be determined which of the millions of children they see each year need more immediate referral for intervention and prevention of dental caries.

CARIES MANAGEMENT WITH FLUORIDE INTERVENTIONS

The focus of this article is on caries detection and caries risk assessment. The obvious question that surfaces when identifying dis-

ease or risk for disease early is, "now what do I do?" There are a variety of intervention measures that are currently available, and many more that are being developed.[14–16] Many of these interventions are using products we have in our possession such as fluorides in various forms. Fluoride varnish, a new member of the preventive armamentarium, might be the precursor to soon-to-be-available varnish-type interventions employing other agents instead of, or in addition to, fluoride. We may also see the development of lesion-specific treatments that are professionally applied, in combination with individually tailored home-care programs for the parents and the child.[17–27] By detecting caries lesions and/or caries risk at the earliest stages, we can better empower families to manage their children's oral health in concert with the professional office team and its efforts. When technology routinely allows us to inform parents of their child's risk level, as well as inform them of the specific locations where early caries activity is occurring, it is certain that families will feel a greater sense of obligation to take part in preventing the progression of the disease.

CONCLUSION

These are exciting times ahead in dentistry and, in particular, in caries management. One of the features of this exciting present and future is the increased facility of managing caries as a disease, and not merely treating its results. In order for the changes in the way we practice the management of caries as a disease, as opposed to waiting to treat the symptoms of that disease, to be fully implemented into our practices, several changes must occur. First, reimbursement must be corrected so that practitioners are compensated for "advice" in addition to only "treatment." Additionally, more behavioral research must take place to learn how to better motivate patients to change their behaviors in what is a behaviorally mediated disease. Finally, expectations of our patients must be redirected so that they seek our "advice" as much as our treatments. It is clear that the years ahead will bring better and more powerful caries risk assessment tools and detection devices, all yielding more effective therapeutic interventions.

DISCLOSURE

The author does not have any financial interest in the companies whose materials are included in this article.

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