Box 1. Questions a Dentist Should Consider Before Offering Referral for Dental Genetic Testing

- Is a genetic test available for this dental disorder?
- How accurate is testing and where is it offered?
- How would a diagnosis affect dental or medical treatment?
- Could a diagnosis affect dental or medical insurance?
- Who would inform other at-risk relatives?
- How will the patient and family react to knowing they carry a genetic condition?
- Do you have a duty to inform other at-risk relatives?
- Could the diagnosis affect family planning?
- How can you protect patient privacy and confidentiality?

(Courtesy of Harrison M, Bushell C-J, Irving M: 32 and you—genetic testing for dental disorders. *Br Dent J* 224:829-832, 2018.)

is an extremely sensitive area, and all practitioners should recognize the need for confidentiality. Still lacking is a determination of how much of the information obtained in a dental diagnostic investigation should be given to the family dentist and how the information must be kept.

Disclosure to Other Parties

The disclosure of genomic disease information to insurance companies has been a topic engendering considerable fear and distrust regarding the possibility of its use to discriminate against the patient. The ownership of personal genomic data remains problematic. It's likely that such issues will be detailed in medical and dental insurance policies at some point.

Commercial companies currently can reserve the right to use personal genomic data to sell personally relevant products and services. The wholesale sharing of anonymized data could potentially be extremely lucrative. Therefore caution must be exercised regarding how much will be disclosed. In addition, assurances should be in place to dictate how the patient's privacy will be protected.

Implications for Dental Training

Dental genomic education is designed to equip dental team members to be able to provide accurate diagnosis of a dental condition, to identify what is abnormal, and to take good family histories and perform pedigree analyses. Patients can then be selected for genetic investigation. Dental professionals will require training to be able to explain the implications of the tests, but could potentially offer a more relevant dental explanation than a medically trained genetic counsellor could.

For the dental team members to be able to provide a clinically relevant interpretation of genetic dental diagnoses, they will require training in human genetics and genomics. These courses have been proposed for inclusion in the dental curriculum. However, to date, the offer of genetic education has been limited to just a few institutions.

Clinical Significance

It's easy to become enthusiastic about the possibilities related to having genetic testing done for dental developmental disorders. This enthusiasm must be tempered by a clear understanding of the profound implications related to what is actually uncovered in genetic testing. Both dentists and the dental research community must work with and learn from medical genetics services, especially in the areas of genetic counselling, disclosure of findings, and confidentiality of the results. Further research is needed in the areas of how dental genetic information is generated, interpreted, and communicated.

Harrison M, Bushell C-J, Irving M: 32 and you—genetic testing for dental disorders. *Br Dent J* 224:829-832, 2018

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ORAL MICROBIOME

Manipulating the oral microbiome

Check for updates

BACKGROUND

The oral microbiome consists of microorganisms that interact dynamically with the host in an intimate relationship. In health, the oral microbiome is made of dental biofilms that positively affect one's health, with many of the bacteria delivering important benefits. The interdependency that exists contributes to maintaining stability and resistance to change. Should the conditions of the environment change, the intimate relationship can be disrupted and lead to deleterious consequences for the host and result in disease (dysbiosis). A review of the changes that can disrupt the healthy symbiotic relationship and possible ways to manipulate the conditions in the oral biofilm was offered.

DYSBIOSIS

The symbiotic relationship between the oral microbiome and the host can break down when frequent intake of sugar and/or reduced salivary flow result in extended periods when the biofilm has a low pH, which favors the growth of bacteria of an acid-producing/acid-tolerating phenotype. This dysbiosis increases the risk of caries.

The biofilm overlying caries lesions differs from the biofilm seen overlying healthy tissues. The cariogenicity of the bacteria associated with dental caries is related to their ability to rapidly convert dietary sugars to acid, lowering the pH and demineralizing the tooth structure. They can continue to grow and metabolize sugars under these acidic conditions. In addition, intracellular and extracellular polysaccharides can be synthesized from sucrose, which contributes significantly to the plaque matrix. If these conditions of low pH occur regularly, the acidogenic/aciduric species can eventually drive the plaque pH even lower, which reduces the numbers of beneficial species still further.

Originally mutans streptococci were shown to be the primary species seen in a caries-prone oral microbiome. More recent molecular-based techniques show that there is a much wider diversity of species associated with caries. However, the bacteria present share their biochemical functions. In the future, oral biofilms will be characterized by metabolic activity rather than by predominant species, and their plaque biofilms will be defined in this way in health and disease.

MANIPULATING THE MICROBIOME TO PROMOTE HEALTH

Because caries, unlike many disease states, is associated with a dysbiotic shift in the natural microbiome rather than with a specific pathogen, it's likely that disease could be prevented by targeting the organisms involved and reducing or interfering with the facilitators of dysbiosis. Approaches have been formulated to modify the microbiota and promote the growth of beneficial bacteria (Table).

Modifying the Microbiome

Probiotics are live microorganisms that deliver health benefits. Gut biology is aided by probiotic agents such as lactobacilli and bifidobacteria. These dairy strains are not adapted for growth in the mouth and remain there for too short a time to have a beneficial effect on the oral microbiome. Currently, some probiotics have benefited the management of gingivitis and periodontitis, but not caries.

Some oral streptococci offering potentially useful properties in caries-free individuals have been proposed as the source of more effective oral probiotics. In addition, some species of commensal streptococci generate energy from arginine, leading to ammonia production and a rise in the environmental pH. Arginine has been formulated into a toothpaste that has been

Table. Approaches to Manipulate the Oral Microbiome to Promote a Symbiotic Relationship with the Host and Prevent Caries (Dysbiosis)

Approach	Examples
Modify the oral microbiome:	
Probiotics	Dairy strains; *Streptococcus* A12; S. *dentisani*
Prebiotics	Arginine; N-acetyl-D-mannosamine
Manipulate local environment	
Boost saliva	Sugar-free chewing gum
Boost innate defenses	Oral care products containing innate defences
Modulate biofilm growth and metabolism	
Reduce acid production	Oral care products + antimicrobial agents*
Inhibit enzymes (GTF;enolase)	Oral care products + antimicrobial agents*
Reduce bacterial growth rates	Oral care products + antimicrobial agents*
Promote alkali production	Arginine or urea supplements
Reduce biofilm accumulation	Antiplaque agents

*The antimicrobial agents can deliver these effects at sub-lethal concentrations.
(Courtesy of Marsh PD: In sickness and in health—what does the oral microbiome mean to us? An ecological perspective. *Adv Dent Res* 29:60-65, 2018.)

associated with a favorable shift in the salivary microbiome and a reduced capacity to convert sucrose to lactate.

Among the molecules that can exclusively stimulate the growth of beneficial bacteria and inhibit or have a neutral impact on potentially pathogenic organisms are beta-methyl-D-galactoside and N-acetyl-D-mannosamine. The challenges that remain with this approach include identifying affordable compounds that can be formulated appropriately, delivering them, and retaining them in the mouth for sufficiently long periods of time so that the biofilm can be favorably altered.

Manipulating the Local Oral Environment

Saliva is central to maintaining oral health. Among its functions are acting as a buffer; maintaining a favorable pH for the oral microbiome; removing substrates, fermentation products, and loosely attached bacteria; delivering components of the innate and adaptive host defenses; and providing substrates that support the growth of beneficial oral bacteria. Reduced salivary flow is associated with a dramatic increase in the risk for dental caries.

Strategies to increase salivary flow include the use of sugar-free gums, encouraging patients to avoid snacking on sugar-containing drinks and food, and using products containing non-fermentable sweeteners. Erythritol and xylitol are sugar alcohols that are incorporated into various products, including some specifically designed for oral care and caries incidence reduction. These polyols stimulate salivary flow and may possess some antibacterial properties. Arginine added to oral care products can also contribute to a favorable oral environment. A new oral care product made with components of the innate host defenses—lactoferrin, lysozyme, lactoperoxidase system—and other proteins has been shown in a small study to significantly increase 12 taxa associated with dental health.

Modulating Biofilm Growth

Approaches that restrict the enrichment of microbes with acid-producing and acid-tolerating phenotypes will support the maintenance of a beneficial microbiome. Antimicrobial agents should be targeted to the oral biofilms and delivered via oral care products. This will allow them to be present in high concentrations for a relatively short period of time but at sub-lethal levels for a much longer period of time. Many antimicrobials at these lower concentrations can inhibit traits linked to cariogenicity, such as sugar transport, acid production, and glucosyltransferase activity. The potential favorable impact of small but regular inhibitory effects on biofilm composition has been modeled in computer simulations. Further investigation and application are needed.

DISCUSSION

The oral microbiome is natural and offers the host some extremely important benefits. When the composition and activity of the microbiome shift as a result of acid production from the metabolism of fermentable carbohydrates, especially sucrose, dental caries can result. More bacteria with an acid-loving phenotype and the suppression of beneficial species can result. New strategies are needed that will lead to the promotion of the natural microbiota and the reduction of factors that lead to dysbiosis.

Clinical Significance

Evidence suggests that there are ways to manipulate the oral microbiome in a way that can return it to a healthy status. Regular provision of interventions that deliver small but relevant benefits consistently over a prolonged period of time should offer a way to maintain a healthy oral microbiome or turn a dysbiotic one back to a balanced, beneficial profile.

Marsh PD: In sickness and in health—what does the oral microbiome mean to us? An ecological perspective. *Adv Dent Res* 29:60-65, 2018

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ORAL/SYSTEMIC CONNECTIONS

Avoiding ventilator-associated pneumonia

BACKGROUND

Among patients in intensive care units (ICUs), ventilator-associated pneumonia (VAP) is the most common hospital-acquired infection. Oral care is an important part of the protocols followed to prevent VAP from occurring. A new oral care program to prevent more cases of VAP and save costs was developed and tested for its cost-effectiveness.

METHODS

The 5 adult intensive care units of the Clermont-Ferrand University Hospital Center in France saw a total of 3086 patients, with 2030 of them intubated for a total of 2083 stays in the ICU over the 13 months of the study. The study was done in 2 stages, with the first from July 1 to December 31, 2014 and the second from February 1 to August 31, 2015. During the first period, standard oral care was performed 3 times a day with foam swabs and gauze soaked in a diluted antiseptic solution (chlorhexidine 0.5%). The ICU staff was then trained in the new intervention, which was accomplished using non-sterile single-use tools. These included a suctioning toothbrush with a long neck and soft bristles coupled with a suctioning swab for the care of fragile gums and tissues. During the second stage, care was delivered using the new tools 3 times a day, with tooth brushing twice and application of the chlorhexidine solution as used in the first period. Paramedical staff assessed the mouth's condition and quality of oral care provided using an oral assessment guide once a day after care over the course of two 3-month periods. In addition, a physician in each ICU recorded cases of VAP, with the diagnosis based on the physicians' clinical judgment, microbiological findings, and radiographic results. The number of ventilation days/intubation was used to calculate the incidence of VAP and the incidence density (cases per 1000 days of intubation). The medical economic study was conducted from the hospital's point of view and focused on making the use of the new tools a possible change in protocol. The budgetary effect of the new program was measured for each intervention. The financial assessment considered the cost for the new oral health devices and the chlorhexidine solution, along with the cost savings realized by reducing the number of cases of VAP and eliminating the expense of their management.