The oral biofilm: What you should know

By DTI

As research into the complexities of the oral microbiome—the community of microorganisms that exist in the mouth—continues to progress, so too should our own knowledge of it. Though the existence of dental plaque has been known about for decades, dental caries nevertheless remains the most common chronic disease globally. The World Health Organization estimates that 60 to 90 per cent of school-aged children worldwide suffer from caries and that 15 to 20 per cent of adults between the ages of 35 and 44 have severe periodontal disease. Clearly, our approach to this issue needs to change.

What is a biofilm?

A biofilm is a dense accumulation of bacteria, fungi or protozoa that adhere to each other and to solid surfaces. In our bodies, biofilms develop on teeth, tissue cells and the exterior of implants. Though they can have a positive role in many environments, the presence of certain biofilms may also lead to negative outcomes, such as infection.

Once a microbial cell has attached itself to a surface, it produces an extracellular polymeric matrix. This matrix essentially helps not only to bond these cells together, but also to protect the cells from external attacks. This community of microbes, together with their extracellular product, constitutes a biofilm.

The microbial cells in biofilms in the human body are generally resistant to antibiotic treatments and natural immune system responses, allowing them to subsequently thrive. Because of this, biofilms are considered to be an ideal state of existence for microbes.

Biofilm and infections

Biofilms are estimated to be the cause of somewhere between 60 and 80 per cent of all bacterial infections in the human body. Though there are certain strategies to treat these infections that can prove successful, the diversity of the oral microbiome and its habitats means that special consideration must go into maintaining its balance.

The composition of oral biofilms

Our mouths play host to a variety of biofilms, both good and bad. Socransky et al. attempted to define this bacterial distribution in a 1998 study of the oral biofilms of individuals both with and without periodontitis. In collecting over 13,000 dental plaque samples, they found that there were six major complexes that could be consistently observed together. These complexes were then colour-coded into red, orange, yellow, green, purple and blue groups.

The blue, green, yellow and purple Socransky complexes were found to correlate to periodontal health, whereas orange and red complexes generally indicated the presence of periodontal disease. When present by itself, *Porphyromonas gingivalis*—one component of the red complex—can cause the loss of alveolar bone. When found alongside *Tannerella forsythia* and *Treponema denticola*, it often leads to periodontal disease, which has itself been linked to a variety of systemic diseases.

Dental plaque biofilm

Dental plaque biofilm is most commonly found on the surfaces of our teeth. It is most widespread when there is a lack of correct oral hygiene. This biofilm is the primary causative factor for dental caries, periodontitis and peri-implantitis.

If dental plaque biofilm is not removed via mechanical or chemical control within 24 hours of forming, it will release virulent, acid-producing and acid-tolerating bacteria, triggering an inflammatory response—gingivi-
tis, the initial stage of periodontitis—from the gingiva and the periodontium. Left alone, the bacteria can eventually initiate alveolar bone loss, soft-tissue destruction, implant failure, and other potential systemic issues.

Since dental plaque biofilm’s antagonistic behaviour takes place in an environment with an incredibly diverse microbiota, and because its cariogenic traits are not emblematic of a particular species, its bacterial composition is somewhat unclear at this point. Despite this, our understanding of other elements of dental plaque biofilm continues to improve—indeed, its recognition as a biofilm only occurred in the twenty-first century.

Removing dental plaque biofilm is still not that simple, however. For example, the fact that its cells have the ability to express multiple types of adhesin (surface structures that facilitate attachment) means that several avenues of attachment might still be available to it, even if a main method of adhesion were to be blocked.

Microbiomes

A microbiome is simply the community of microorganisms existing in a specific environment, particularly in the human body.

The oral microbiome

The oral microbiome is, along with the gut microbiome, one of the two most diverse microbiotas in the human body. The Human Oral Microbiome Database states that there are approximately 700 prokaryotic taxa that have been identified as existing in the oral cavity.

The oral cavity is different to other human microbial environments, as it contains several types of surfaces for microbial colonisation, such as the teeth, mucosa, tongue, attached gingiva and implants in cases of tooth loss. In addition, teeth are the only non-shedding natural surface in the human body. This allows for biofilm to accumulate on them relatively easily, a feature that is shared by dental restorations, implants and other oral prostheses.

“There is a natural symbiotic relationship between the host and the oral microbiome,” says Dr Phil Marsh, Professor of Oral Microbiology at the University of Leeds in the UK. “The host provides a warm and favourable environment for microbial growth, and the oral microbiome acts as a barrier to colonisation by exogenous microbes, modulates the host’s immune response to prevent unwanted inflammation, and contributes to the regulation of the cardiovascular system and other physiological activities.”

In a 2017 study published in the Journal of Clinical Periodontology, Marsh and Zaura sought to describe the range of microbial interactions that take place in biofilms in the oral microbiome. They found that these biofilms display “emergent properties”, meaning that their characteristics cannot be understood by simply studying individual organisms. Instead, analysing how they function and interact with one another proves to be more fruitful.

Maintaining a healthy, balanced oral microbiome involves processes that are, admittedly, still not entirely understood. However, there are certain factors that clearly benefit oral health. Saliva, for example, is well known for its rinsing function in the oral cavity and for its role in initiating the digestive process by enabling chewing and swallowing of food. So what exactly causes dysbiosis—a microbial imbalance between harmful and protective bacteria—to occur?

Dysbiosis and its causes

“There are various factors that can disturb the symbiotic relationship between the host and oral microbiota, leading to dysbiosis and disease,” says Dr Thuy Do, a lecturer in microbiology at the University of Leeds. “Changes in the conditions at oral sites, such as the accumulation of dental biofilms from a lack of oral hygiene, may lead to an inflammatory response from the host immune cells.”
“The frequent intake of fermentable sugars in the diet, along with a reduction in the flow of saliva, can lead to dysbiosis,” adds Marsh. These sugars, by initiating the development of dental caries, are metabolised into acid, which generates a low pH level in the biofilm. As Peterson et al. demonstrated in a 2013 study, this low pH can constrain the growth of many bacteria responsible for the health of tooth enamel, decreasing the diversity of the oral microbiome.

Some other common causes of dysbiosis include the use of broad-spectrum antibiotics, smoking, physiological changes like pregnancy or puberty, and certain diseases that are associated with periodontitis, such as diabetes.

Dental implants and biofilm

As the popularity of dental implants continues to rise, their use has become more successful in terms of both aesthetics and function. However, even successful procedures can lead to peri-implant mucositis, an inflammatory lesion at the mucosal and bone level, which then can progress to peri-implantitis, an inflammatory lesion of the tissue surrounding the implant.

Peri-implantitis can develop for a number of reasons. One of the most common is the presence of periodontal disease when the implant is placed. If the patient has deep periodontal pockets filled with harmful bacteria, it can lead to colonisation of biofilm around the implant and possibly implant failure.

Dr Lisa Heitz-Mayfield is, among other roles, a university lecturer and a periodontist in private practice. As implant specialist, she says that infection control prior to and after implant placement is essential for control of biofilm and peri-implantitis.

“Having good infection control before placing implants is crucial, as it is the best way to prevent these infections occurring later on,” she says. “A preventive approach requires several elements to work effectively: regular monitoring and supportive periodontal therapy with professional biofilm control, a healthy and regular at-home oral hygiene routine, and controlling for other risk factors, such as smoking and uncontrolled diabetes.”

Orthodontic patients and biofilm

Despite the advances in technology that have made orthodontic appliances smaller and more comfortable than ever, intraoral problems often arise from their use. A 2014 study by Ren et al. published in Clinical Oral Investigations estimated that at least 60 per cent of all orthodontic patients develop at least one biofilm-related complication. These complications develop primarily because the presence of orthodontic appliances can impede toothbrushing and other oral hygiene activities, rendering these techniques less effective in disrupting the formation of dental plaque biofilm.

Chemical control

An alternative method of controlling dental plaque biofilm in orthodontic patients is chemical control through the use of antimicrobials. Chlorhexidine is considered to be the most effective antiseptic agent available, with numerous studies demonstrating its efficacy against dental plaque when present in mouthwash.

However, Valen et al. found that prolonged daily use of an antimicrobial might lead to resistance to not just the applied substance but other antimicrobials as well. With this in mind, they recommended that daily antimicrobial use for the control and eradication of biofilm should be limited to situations in which mechanical cleaning and patient behavioural change are inadequate or unachievable.
Controlling dental plaque biofilm

There are currently two primary ways of controlling dental plaque biofilm and establishing a healthy oral microbiome for the non-orthodontic patient: professional biofilm management and individual manual biofilm management.

Professional biofilm management commonly involves the removal of subgingival dental plaque and calculus with the use of hand scalers, followed by tooth surface polishing with rotary rubber cups and brushes. By removing this biofilm from periodontal pockets that have formed, hand scaling is able to reduce gingival inflammation that may be present and prevent further damage caused by its potential progression to periodontitis.

Dentists may choose to use an ultrasonic scaler instead if they wish to remove supragingival dental plaque biofilm. These scalers feature a metal tip that vibrates at 20–45 kHz and follows a curved linear, elliptical or figure eight path. The tip is cooled with a water spray, in which bubbles form and collapse as a consequence of the ultrasonic waves of energy passing through. This effect, called cavitation, facilitates removal of dental plaque and calculus.

When used by an experienced professional, an ultrasonic scaler can be faster and can cause less hand and wrist fatigue than with a manual hand scaler. If used incorrectly, however, it can cause heat damage to the tooth.

Recent developments

In the inaugural issue of prevention magazine, Dr Klaus-Dieter Bastendorf, a scientific adviser for the Swiss Dental Academy, outlined recent developments in the materials and technology for professional biofilm management. With the introduction of piezoceramic instruments and low-abrasion powders made of erythritol or glycine, Bastendorf argues, modern professional biofilm management is now safer, minimally invasive and more comfortable for both the patient and dental practitioner. In addition, the ability to disrupt both sub- and supragingival biofilm in one procedure improves the efficiency of these procedures, making it more likely that patients will return for regular professional cleaning.

Recommendations for oral self-care

The easiest way for individuals to remove dental plaque biofilm build-up themselves is through a consistent oral hygiene routine. Regular use of a soft-bristled toothbrush, dental floss and interdental brushes is essential. By disrupting the established layers of bacteria through effective cleaning, the protective layer of biofilm on the teeth—the pellicle—will be able to reorganise and perform more capably.

“Control of dental plaque biofilm begins with daily oral hygiene,” asserts Marsh. “Meticulous cleaning of the teeth and associated gingival tissue removes the bulk of the biofilm that has developed in the time since the last oral hygiene session.”

Working together

Regardless of the type of preventative measures taken in controlling biofilm, it is essential that dental professionals cooperate with and motivate their patients to take charge of their own oral health.

“The dentist and dental hygienist should work together as a team in evaluating, treating and maintaining the oral health status of the patients,” says Dr Rajiv Saini. “There should be a greater emphasis on the modification of behaviour of patients by providing them with education, scientific facts and research data.”

Do’s sentiments on this relationship strongly reflect Saini’s. “Dental professionals should advise patients about effective oral hygiene and the impact of their diet and lifestyle choices on their oral health, such as the risks of a high carbohydrate diet or smoking for tooth decay,” she recommends. “There is increasing evidence of the link between oral health and general health, and maintaining a good oral microbiome may be in our best interest.”