Biofilm and Osteitis in Refractory Chronic Rhinosinusitis

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KEYWORDS

• Biofilm • Osteitis • Refractory rhinosinusitis • Endoscopic surgery

KEY POINTS

- Biofilm is a sessile colony of bacteria with unique phenotypic expressions that interacts with the immune system, producing inflammation and contributing to the disease's refractory nature.
- Osteitis is predominately an inflammation of bone that is associated with refractory chronic rhinosinusitis (CRS).
- Both osteitis and biofilm are poor prognostic markers and are part of the inflammatory load.
- Surgery is currently the cornerstone of treatment for CRS; reducing inflammatory load with maximal ventilation of the affected paranasal sinuses facilitates postoperative medical treatment.
- Adjunctive treatments are currently being investigated with topical antibiotics being shown to be effective against biofilm.

BIOFILM IN REFRACTORY CHRONIC RHINOSINUSITIS

Definition of Biofilm

Chronic rhinosinusitis (CRS) is a multifactorial inflammatory condition of the upper respiratory tract that results from a complex interplay between the host immune response and multiple extrinsic environmental and disease-causing factors.[1] Bacteria and fungi have long been implicated as pathogens in the development of CRS, although the specific mechanism remains unclear. These microbes can exist either as a planktonic "free-floating" state or as a biofilm.

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Biofilm is defined as a microbial-derived sessile community characterized by cells irreversibly attached to a surface or to each other, embedded within a matrix and exhibiting an altered phenotype with respect to growth and gene transcription.[2] Within a biofilm, the microbes are surrounded by an extracellular matrix of polysaccharides, nucleic acids, and proteins. The bacteria and the extracellular polymeric substance form microcolonies with water channels conveying fluid and nutrients.[3] This matrix confers characteristics of biofilm that allows it to adhere to surfaces, evade the immune response, increase resistance to antimicrobials, and provide a reservoir for recalcitrant infections.[2] The ability of the biofilm to evade the host immune response and confer antibiotic resistance are some of the key pathologic features of a biofilm. Not only does the extracellular matrix provide a physical barrier to antibiotics, some of the bacteria in biofilm exists in a hypometabolic, slow-growing state making them more resistant to antibiotic treatment.[4] The bacteria within a biofilm communicate via quorum sensing with small signal molecules that allow for rapid coordination of behavior to the environment.[5,6] The close proximity of the bacteria within the biofilm also allows frequent gene transfer that, combined with recurrent antibiotic exposure, leads to the development of antibiotic resistance.[6]

Biofilm in CRS was first discovered in 2004 using scanning electron microscopy[7] with subsequent studies showing confocal scanning microscopy to be the best method of detection.[8] Since then, numerous studies have demonstrated the presence of biofilm in CRS patients, with the reported prevalence ranging from 44% to 92%.[9]

Detection of Biofilm

In terms of detection of biofilm, current techniques include the use of scanning electron microscopy, transmission electron microscopy, confocal laser scanning microscopy using BacLight staining, fluorescence in situ hybridization, and molecular techniques. Confocal scanning laser microscopy has been shown to have the greatest sensitivity and specificity for biofilm detection (**Fig. 1**).[8]

Characterization of biofilm

Identification of the microorganism that forms the biofilm has been demonstrated by using fluorescence in situ hybridization probes (**Figs. 2** and **3**). *Staphylococcus aureus*[10] biofilms are the most commonly identified bacterial biofilm. *Pseudomonas aeruginosa*, *Haemophilus influenza*,[9] and *Streptococcus pnuemoniae* may also be

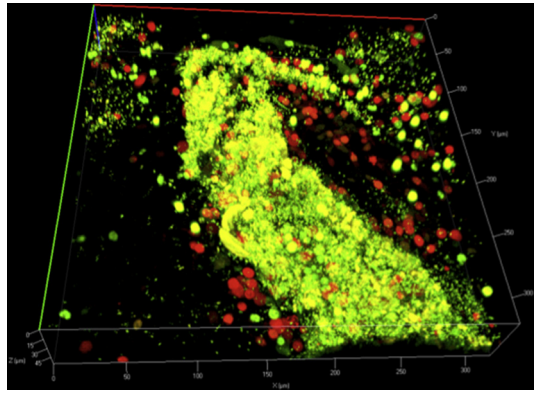

Fig. 1. Example of BacLight detection of biofilm. Red dots indicate sinonasal epithelium and green dots indicate bacterial colonies and biofilm matrix. Notice the concentration of the microcolonies with the extracellular matrix.