Bacterial Biofilm Morphology on a Failing Implant with an Oxidized Surface: A Scanning Electron Microscope Study

Massimo Simion, MD, DDS
David M. Kim, DDS, DMSc
Stefano Pieroni, DDS
Myron Nevins, DDS
Clara Cassinelli

This case report provided a unique opportunity to investigate the extent of microbiota infiltration on the oxidized implant surface that has been compromised by peri-implantitis. Scanning electron microscopic analysis confirmed the etiologic role of the bacteria on the loss of supporting structure and the difficulty in complete removal of bacterial infiltration on the implant surface. This case report emphasizes the need to perform definitive surface decontamination on failing dental implants prior to a regeneration procedure. Int J Periodontics Restorative Dent 2016;36:485–488. doi: 10.11607/prd.2804

Peri-implantitis is a chronic destructive inflammatory disease that affects soft and hard tissue attachment to an osseointegrated implant in function. Thoughts differ as to whether the etiology relates to the mechanical force of the prostheses or inflammation relative to bacterial infection, but in either case it poses a catastrophic inconvenience. The purpose of this case report is to demonstrate the presence and describe the morphology of embedded colonies of oral bacteria on the oxidized surface of a failing implant using scanning electron microscopy (SEM).

Materials and methods

A 40-year-old patient who had a mandibular second premolar implant placed about 4 years previously in a private practice presented with peri-implantitis. The referring dentist had unsuccessfully treated the diseased site with multiple nonsurgical treatments using plastic scalers and local applications of 0.2% chlorhexidine. At the time of the present authors’ observation, clinical inflammation associated with bleeding on probing and purulent exudate were evident (Fig 1). Periodontal probing depth was 9 mm on the mesial aspect and 11 mm on the distal aspect. A periapical radiograph demonstrated bone loss to
the apical third of the implant (Fig 2). Due to lack of soft and hard tissue support for this implant, a recommendation was made to remove the implant and consent was obtained.

The failed implant was fixed in 5% glutaraldehyde (FLUKA, Sigma-Aldrich) in Dulbecco’s Phosphate-Buffered Saline (DPBS GIBCO, Life Technology) for 2 weeks. Following fixation, the implant was dehydrated by immersion for approximately 5 days in each step of an alcohol-water series (the final step being in absolute ethanol [FLUKA, Sigma-Aldrich]). The fixed and dehydrated sample was placed on sample holders on suitable conducting adhesive supports and coated with a thin layer of 99.99% gold (Agar Sputter Coater, Agar Scientific). SEM observations were performed using EVO MA10 instruments (Zeiss).

**Results**

SEM images of the smooth surface of the titanium abutment demonstrated minimal plaque accumulation and large areas free from bacteria (Fig 3). The implant-abutment interface revealed significant bacterial infiltrations on the rough oxidized implant surface, filling the porosity of the oxidized surface (Fig 4). Polymorphous aggregates of bacteria were visible immediately under the abutment-implant interface, filling the porosity of the oxidized surface (Fig 5). Cocci, rods, and filamentous bacteria were identified. In the middle portion of the implant, large aggregates of subgingival biofilm were visible, consisting mainly of rods and filamentous bacteria (Figs 6a and 6b). The porous oxidized surface appears to be a breeding ground for microbiota (Fig 6c). The apical portion of the implant surface, which was embedded in the bone until the time of removal, did not show bacterial infiltration (Figs 7 and 8).

**Discussion**

This is a case report describing the consequences of a failed implant with a moderately rough oxidized surface affected by peri-implantitis, which was subsequently removed and analyzed using SEM. The patient had previously undergone conservative treatment with plastic hand scalers and local antibiotic therapy without success.

Mechanical debridement using both hand scalers and ultrasonic instrumentation has been proposed as the initial treatment of choice, followed by adjunctive local and systemic antibiotic therapies. Chemical decontaminations, photodynamic therapy, and laser applications have been used with some success. However, there is no reliable evidence suggesting a single effective and predictable intervention for peri-implantitis treatment.

The clinical community considers use of implants with a moderately rough surface to be advantageous for patients compromised by class IV bone, medications, and various bone augmentations. The pores created by the oxidation process, once thought to house bone and connective tissue fibers, actually contain significant bacterial population. The findings of the present case reports are related to a specific implant surface characterized not only by roughness but also by extended porosity. Other moderately rough surfaces could demonstrate different biofilm characteristics. However, these findings are in accordance with previous studies demonstrating that early plaque formation starts from pits and grooves on the...
surface of the supporting substances and increased plaque growth on rough surfaces could be due to increased surface area and embedding of microorganisms in surface irregularities. 13–15

The small size of these pores precludes conservative clinical activities short of removing the oxidized surface that must be cleaned to accept regenerative therapeutics. Decontamination of a failing dental implant surface is complicated due to a shift from the use of turned surface implants to use of moderately rough-surface implants. The use of Er:YAG lasers has been demonstrated to decontaminate an infected dental implant surface by removing the oxidized layer. 16 This prepared the surface to accommodate reestablishment of bone-to-implant contact.

The complete removal of the treads and the rough surface with open-flap implantoplasty and resective bone has been proposed as an alternative treatment, but limited data are available in the literature.17–19 However, this technique may expose implants to the risk of fracture by reducing the thickness of the implant body.

The manufacturing community has made advances aimed to reduce inflammation of the soft tissues following microgap investigations.

**Fig 3** (left) Low-magnification (×52) SEM image of the coronal portion of the implant with abutment.

**Fig 4** (center) High-magnification (×500) image of the implant-abutment interface (white arrows). The smooth-surface titanium abutment shows little plaque accumulation and large areas free of bacteria, whereas the adjacent rough oxidized implant surface is deeply colonized by bacteria, as shown at higher magnification in Figs 5 and 7.

**Fig 5** (right) High-magnification (×10,000) image of the supragingival portion of the rough oxidized implant surface. Polymorphous aggregates of bacteria are visible immediately under the abutment-implant interface, filling the porosity of the oxidized surface. Cocci, rods, and filamentous bacteria are organized in a biofilm.

**Fig 6** (a) Low-magnification (×52) image of the middle (subgingival) portion of the implant. Large aggregates of subgingival contaminants are visible. (b) High-magnification (×1,000) image of the subgingival biofilm at the middle portion of the implant. A complex microbiota composed mainly of rods and filamentous bacteria is visible. (c) Higher magnification (×10,000) image of the same area.

**Fig 7** (left) Apical portion of the implant (×52). Bone remnants are attached to the implant surface.

**Fig 8** (right) High-magnification (×1,000) image of the residual bone attached to the implant surface. No bacteria can be found on the surface.
in the 1990s. Platform switching has been demonstrated to reduce crestal bone remodeling by moving the inflammatory cell infiltrations in a horizontal direction. More recently, lasers have been used to provide microgrooves to the coronal portion of the abutment and the apical portion of the implant, resulting in physical attachment of connective tissue to prevent apical migration of the epithelium. Surgical techniques must be optimal in placing the implants, and the patient’s oral hygiene compliance is essential.

Conclusions

It is necessary to select an appropriate implant surface as part of the treatment plan. Periodontal disease should be eliminated prior to implant placement, surgical diligence should be exercised, and the patient must be enrolled in a well-defined maintenance program. This will reduce potential risk of inflammation. Further long-term studies are necessary to determine whether other techniques, such as lasers, acid agents, air powder abrasion, or combinations of these, could decontaminate these areas or implantoplasty is the only option.

Acknowledgments

The authors reported no conflict of interest related to this study.

References