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nanoVIS Ti™ Surface Technology Decreases Biofilm Formation In Vivo

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Introduction

Bacterial infections on implants can cause serious problems for patients and those involved in their care. What was intended to improve quality of life can sometimes lead to permanent disability or mortality due to infection. Unfortunately, antibiotics are becoming less effective against antibiotic-resistant bacteria. Surgeons take many precautions to prevent infections, such as patient preparation, gloves, sterile gowns, and antiseptic washes. However, on the implant side, there is still much to learn about preventing infections using surface technologies.

While there are academic solutions, few commercially available options exist due to the high levels of regulatory burden and associated clinical trial costs. However, there is one promising FDA approved surface solution: nanoVIS Ti™ Surface Technology. This technology has demonstrated the ability to resist or hinder bacterial colonization both in vitro and in vivo without the use of antimicrobial agents. Additionally, Nanovis has made it commercially available through a 510(k) pathway, making it a potential tool in the fight against implant-related infections.

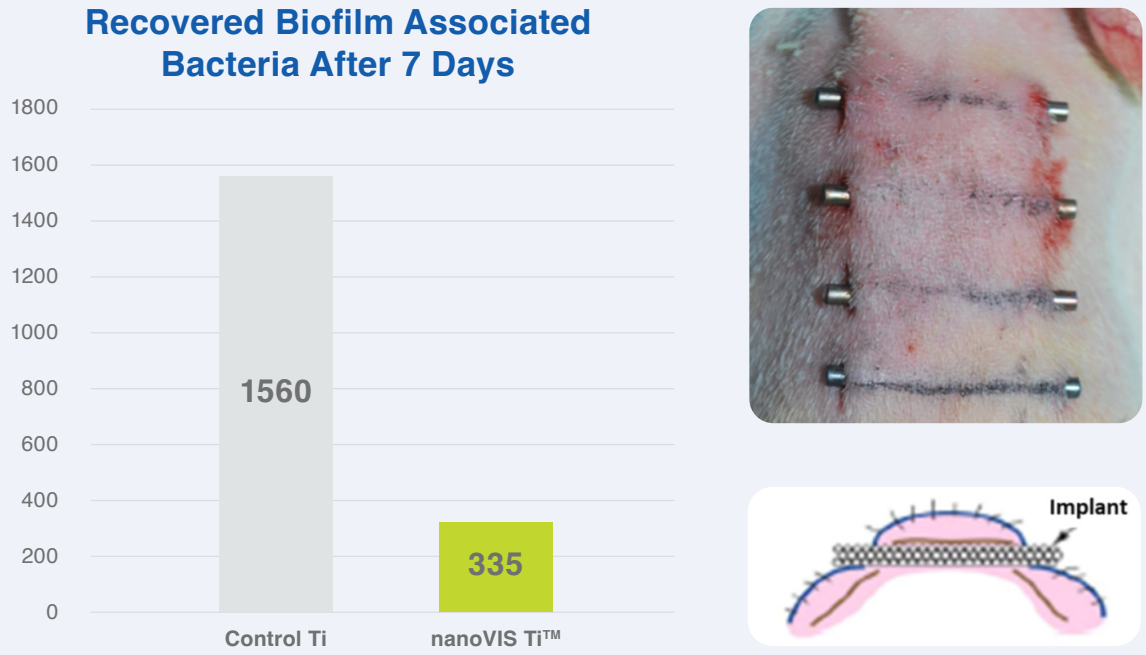

Figure 1 - Recovery of biofilm associated bacteria after 7 days in vivo. Titanium pins implanted through the skin of the Guinea pig and inoculated with 10^6 CFU of Staphylococcus aureus.

Because the bacterial wall is rigid, bacteria prefer a flat micron-rough surface relative to their size to adhere to a surface[1]. Nanosurfaces provide a roughness that is smaller than the scale of the bacteria, 100 nm or less compared to 500 nm for bacteria cell size. If the nanofeatures are closely spaced together, the bacteria can only interact with the very tips of the nanofeatures[1]. This effectively reduces the surface area for attachment by the bacteria. Nanofeature sizes below 20 nm that are within the same 20 nm distance between features can bind sufficient protein to negate the nanosurface effect, making the surface effectively smooth again[1]. The nanoVIS Ti™ Surface Technology is rough on a nanoscale, less than 100 nm. In vivo, a well-designed nanosurface means that fewer bacteria can attach to the surface, leaving the non-adhered bacteria in a more dangerous situation out in open tissue rather than in the relatively protected shelter of an implant. The purpose of this paper is to demonstrate the effectiveness of nanoVIS Ti™ Surface Technology in reducing bacterial adhesion in vivo within 7 days.

Methods

Guinea pigs were implanted with titanium rods placed through the skin in a bilateral transcutaneous setup on the back of the animals[2]. The rods were unfinished extruded titanium alloy or treated with the nanoVIS TI™ Surface Technology. The rods were sutured in place and inoculated with 1x10^6 colony forming units (CFU) of *Staphylococcus* aureus (ATCC 29213) at the wound sites. The implants remained in place for 7 days before extraction. Extracted implants were rinsed in PBS to remove loosely adherent bacteria and then subjected to sonication at 50 Hz for 7 minutes to recover biofilm associated bacteria. Results were reported as colony forming units per square centimeter (CFU/cm^2).

Results

Bacteria were able to proliferate across the pins and set up biofilms within 7 days. Plain titanium pins had an average of 1560 CFU/cm^2. Pins treated with the nanoVIS Ti™ Surface Technology had a significantly reduced average bacteria count of 335 CFU/cm^2.

Discussion

This model was intended to create infections on the implants. The average wound in the operating room is estimated to have between 10^3 to 10^4 bacteria. This model had 10^6 bacteria, which was a hundred to a thousand times more bacteria inoculated into the wound than occurs in a typical surgical site. With that insurmountable level of bacteria, the wounds all became infected. The question asked whether the surface could resist or impede colonization and subsequent biofilm formation on the implant. The nanoVIS Ti™ Surface Technology had 78.5% fewer biofilm associated colonies after 7 days in vivo.

Conclusion

By limiting or delaying the colonization of the implant surface by *Staphylococcus* aureus with the use of nanoVIS Ti™ Surface Technology, there was a 78.5% reduction in biofilm associated bacteria on the implants. The nanoVIS Ti™ Surface Technology may not stop or prevent infections, but it may help tip the scales in reducing implant infections when combined with other standard prevention techniques.

References

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