

Dermal Barriers to Prevent Infection of Percutaneous Implants

Dorthyann Isackson^{1,3}, Beau Bailey¹, Nicholas A. Brown Ph.D.¹, Kent N. Bachus Ph.D.^{1,2,3}

¹Orthopaedic Research Laboratory, University of Utah Orthopaedic Center, Salt Lake City, Utah

²Bone and Joint Research Laboratory, Department of Veterans Affairs, Salt Lake City, Utah

³Department of Bioengineering, University of Utah, Salt Lake City, Utah

Introduction:

Percutaneous implants are used in many clinical applications, such as bone-anchored hearing aids, catheters, left ventricular assist devices, and osseointegrated prostheses. Though widely used, these implants are prone to infection at the skin/implant interface (1). Success of these implants relies upon a strong, secure attachment of the skin and soft tissue to the implant thereby preventing infection. Several studies have shown that a porous implant surface increases soft tissue ingrowth and, subsequently, longevity of the implant (2,3). Further, incorporating a flange or disk into the percutaneous implant increases the surface area for tissue ingrowth thus decreasing stress at the skin/implant interface (2,3,4,5). The goal of this research is to utilize dermal barriers to inhibit infection of percutaneous implants. We hypothesize that porous surfaces will reduce the rate of infection.

Methods:

Implants: The percutaneous implants were fabricated from surgical grade titanium and consisted of two elements: (1) a subcutaneous disk (40 mm diameter, 10 mm height) with a centrally located threaded hole and (2) a percutaneous post (10 mm diameter, 15 mm height) that is threaded into the central hole in the subcutaneous disk. There were four combinations of implant surfaces: (1) smooth subcutaneous disk with a smooth percutaneous post, (2) smooth subcutaneous disk with a commercially pure porous titanium percutaneous post, (3) porous subcutaneous disk with a smooth percutaneous post, and (4) porous subcutaneous disk with a porous percutaneous post.

Animal model: Ten New Zealand White rabbits were used in this study. Four implants, one of each surface combination, were placed on the dorsum of each animal.

Surgical Procedure: Two 4-cm longitudinal incisions (cranial, caudal) along the midline were made through the skin. Lateral to the midline incisions, subcutaneous pockets were created by blunt dissection in which the subcutaneous disks were placed. Each disk was sutured to the supraspinous ligament to prevent the disk from migrating ventrally, and the midline incisions were sutured closed. A small, circular incision was made over the centrally located hole in the subcutaneous disk. The percutaneous post was then seated into the subcutaneous disk. After 10 weeks, animals were challenged once per week with a 10^8 concentration of *Staphylococcus aureus* solution. At sign of chronic inflammation, bacterial cultures and biopsies were taken from the tissue/implant interface, and the animal was then euthanized.

Histology: The implants with soft tissue were then fixed in formalin, embedded in methyl methacrylate, and stained with Giemsa. Using light microscopy, the

following parameters were examined: epidermal migration, cellular infiltration, capsule formation, and tissue infiltration into the porous surface.

Results: To date, we report on five of ten animals.

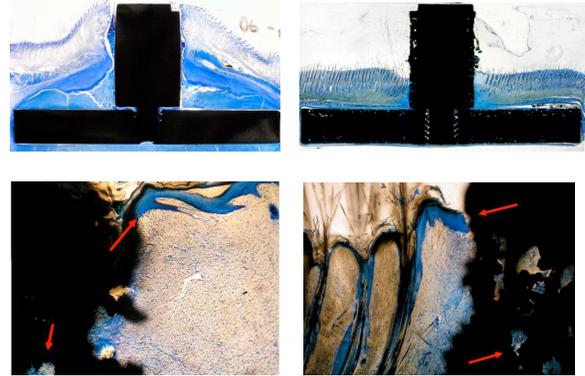


Figure: Top Left. Smooth post/disk with *S. aureus* infection. Top Right. Porous post/disk demonstrating no infection and tissue ingrowth. Bottom Left. Epithelial attachment and tissue infiltration into porous post/disk (10X). Bottom Right. Epithelial attachment and tissue infiltration into porous post/disk (4X).

Microbiology Results: Smooth surface implants had visible signs of infection after 5 treatments of weekly bacterial solution, while the porous surface implants had visible signs of infection after 9 weekly treatments of bacterial solution.

Macroscopic Results: The implants with a porous surface post did not have any visible epidermal downgrowth, but had an intimate contact with the skin. When applying motion to the porous/porous implants, they were very difficult to rotate. In contrast, the smooth surface posts had a gap between the skin and post, and moved very easily when the implant was rotated.

Microscopic Results: Cells and fibrous tissue were seen infiltrating the pores in the porous implants. Collagen fibers appeared aligned perpendicularly to the porous surface implants, but were aligned parallel with the smooth surface implants. Dramatic influx of inflammatory cells were seen around smooth surfaces in contrast to porous surfaces.

Discussion:

The results of this study showed that porous surfaces on the percutaneous implants greatly reduces the rate of infection seen at the tissue/implant interface. However, this implant treatment did not totally inhibit the infection, continued efforts toward this goal are planned.

References:

- (1) von Recum, 1984. *JBMR* (2) Gerritsen 2000. *JBMR*
- (3) Pendegrass 2006. *Biomaterials* (4) Gross-Siestrup 1984. *JBMR* (5) Boyd 1991. *Clin Mater*