Research Shows Silicon Nitride (Si₃N₄) Exhibits Antibacterial Properties, Superior Bone Growth and More Effective Bone Attachment Compared to Other Biomaterials, and May Lead to Faster Fusion

Infection after spine surgery with instrumentation is becoming a common pathology, with reported infection rates ranging from 0.7% to 11.9%, depending on the diagnosis and complexity of the procedure. Treatment of implant-related infections in spine fusion surgery may require repeat surgery, implant removal and antibiotic therapy, with the result that patients may suffer bone loss, poor bone healing and disability, as well as added costs.

While no strategy has proven effective in completely eliminating the risk of infections related to implant surgery, recent studies have shown certain orthopedic implant materials better resist bacterial colonization and provide superior osteointegration properties than others.

Recent Studies Show Superiority of Silicon Nitride (Si₃N₄) as Compared to Poly-ether-ether-ketone (PEEK) and Titanium (Ti)

Three biomaterials that are used in spinal fusion implants – poly-ether-ether-ketone (PEEK), titanium (Ti) and Silicon Nitride (Si₃N₄) – were recently tested to ascertain their respective susceptibility to bacterial infection with Staphylococcus epidermidis, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli and Enterococcus. Under in-vitro incubation for up to 72 hours, decreased biofilm formation and bacterial colonization were confirmed on both as-fired and polished Si₃N₄ in comparison with PEEK or Ti. Si₃N₄ resisted bacterial proliferation despite the absence of antibiotic pharmaceutical agents.

The proprietary Silicon Nitride, a synthetic non-oxide bioceramic, is supplied by Amedica Corporation (Salt Lake City, UT).

Because protein adsorption on material surfaces affects bacterial adhesion, the adsorption of fibronectin, vitronectin, and laminin on PEEK, Ti, and Si₃N₄ have also been examined. Surface protein adsorption is relevant because previous studies have correlated increased vitronectin and fibronectin adsorption to decreased bacterial activity. Results show significantly greater amounts of these proteins adhered to Si₃N₄ surfaces than to PEEK or Ti.

How Neurosurgeons Are Using Si₃N₄

Grant Skidmore, MD, a neurosurgeon with Neurosurgical Specialists, Inc. in Norfolk, Va., has used Si₃N₄ for the past two years and reports: “The Silicon Nitride biomaterial appears to be superior
to Ti or PEEK in antibacterial properties and osseous fixation. In my experience, patients are healing faster, feeling less pain and progressing to physical activity faster with Si$_3$N$_4$ implants.”

Dr. Skidmore’s practice specializes in neurosurgical procedures utilizing state-of-the-art technology.

Chad E. Hartley, MD, a neurosurgeon whose specialties include brain and spinal cord tumors, pituitary tumors, complex spine disorders and neurotrauma, has used Si$_3$N$_4$ for three years and states: “Spine surgery is where I use the Silicon Nitride material the most. I use it as an interbody fusion device in spinal fusion surgeries, specifically anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF).”

With regard to fusion, Dr Skidmore reports: “Clinically we are seeing evidence of earlier rates of fusion with Si$_3$N$_4$. I perform many spinal nerve decompression surgeries and use Si$_3$N$_4$ to rebuild the area with a stabilizing procedure and to support the disk material. We like the rougher surface, which helps prevent movement.”

“I’ve definitely noticed post-op x-ray differences,” Dr. Hartley explains. “We do a CT scan at about three months for any type of fusion operation, and with the Silicon Nitride, the area looks almost completely fused at three months.”

Si$_3$N$_4$ serves as an excellent scaffold for osteocostruction and osteointegration. Push-out strength testing has demonstrated statistically superior bone growth onto Si$_3$N$_4$ as compared with PEEK and Ti. Si$_3$N$_4$ implants were stable due to sufficient juxtaposed tissue growth and showed reasonable osteointegration even at three and seven day time periods. In one study, three months after surgery, the amounts of new bone at the implant interface and within the surgical defect were 5%, 9% and 23%, and 21%, 26% and 41%, for PEEK, Ti and Si$_3$N$_4$, respectively. (4)

“In more than four years and a great many patients, I’ve seen bone growth and attachment onto the Si$_3$N$_4$ devices that I have not seen with titanium or PEEK,” reports Alpesh A. Patel, MD, FACS, a spine specialist and surgeon in Chicago, Illinois at Loyola University Medical Center. “From a technical standpoint, the Si$_3$N$_4$ systems are easy implants for the surgeon to use, and there is a quick learning curve. The benefits the material has for bone formation and fusion formation include the fact that it doesn’t cause the same kind of scatter or artifact that titanium or other metals cause, so if you do need to get a CAT scan or MRI scan on a patient afterwards, it makes for very clean and easy-to-interpret images.”

Dr. Patel discloses that he serves as a consultant to Amedica and receives royalties from one of its products, but that his use of the Si$_3$N$_4$ material began prior to his relationship with the company.

Dr. Hartley agrees with Dr. Patel: “Si$_3$N$_4$ is easy to use. It’s easy to see the entire Silicon Nitride fusion device on x-ray as compared to a PEEK spacer, where you only see two little lines. It makes post-operative care much easier. The material is easy to work with, and I’ve never had one break on me. I like the space in the middle of these devices for bone graft or amnion stem cell graft. The Si$_3$N$_4$ cages are far superior to the PEEK and Ti spacers. (5)

For more information about Amedica’s flagship material Silicon Nitride (Si$_3$N$_4$), and complete product line for spine surgeons, please call (855) 839-3500, or visit our website at www.amedica.com.

References: