VOLUME 20, ISSUE 8 | APRIL 23, 2024

Orthopedics • This Week

WEEK IN REVIEW

4 Structure vs Chemistry in 3D Printed Spinal Implants >> Numerous factors can frustrate any surgeon's pursuit of osseointegration. But two basic factors can be every spine surgeon's ace in the hole—structure and chemistry. 3D-printed designs appear to be tipping the balance towards structure. Here are the details.

8 Representation and Editorial Boards, Does it Affect the Science? >> We've documented, as have numerous journals, the latest being *The Journal of Bone and Joint Surgery*, that editorial boards, surgeon society boards and, indeed, the membership of most orthopedic and surgeon societies do not match the gender, ethnic or racial characteristics of the patient populations they serve.

10 AAOS Best Paper Award Goes to NYU Langone Research Team >> The best paper in all of orthopedics for practice management and/or rehabilitation for 2024, according to the American Academy of Orthopaedic Surgeons (AAOS), came from a team of researchers at New York University's Langone Orthopedics hospital.

FOOTING THE BILL FOR HIGH CO-MORBIDITY PATIENTS

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Structure vs Chemistry in 3D Printed Spinal Implants

BY ROBIN YOUNG

The logical argument goes like this: if fusion is the goal—and many factors can frustrate a spine surgeon in pursuit of that goal, diabetes, smoking, age, comorbidities—then which of these two factors—structure or chemistry—is your osseointegration ace in the hole?

And how do such innovative designs as, for example, Camber Spine Technologies, LLC's Spira implants, which could never have been produced prior to additive manufacturing techniques, affect osseointegration, support and fusion?

Courtesy Camber Spine Technologies, LLC

Better Osseointegration (Fusion) Through Chemistry?

By definition, osseointegration is the connection between living bone and a load-bearing implant. Strong osseointegration means that the implant becomes so fused with the bone, it can't be separated without breaking. Osseointegration is one of the key definitions of stability and long-term spine fusion clinical success.

From experience, surgeons know osseointegration is complex. In the formative years of spine fusion (1990s) more than one early implant developed fibrous capsules, osteolysis or barely detectable traces of wear debris on or around interbody implants instead of integrating with the surrounding bone.

In addition to using osteoconductive or inductive bone void fills, the other early strategies were to coat or bind thin layers of various metals or osteoinductive ceramics such as hydroxyapatite, titanium, gold, titanium dioxide, diamond-like carbon, or even tert-butoxides to the implant's surface. And those strategies worked to a certain extent.

The most common of these bioactive coatings was hydroxyapatite—which is well known and well characterized.

The other strategy was to create a rough nanometer surface which, again, was able to demonstrate improved bony fusion. Titanium and gold coatings were also able to promote osteoblast adhesion on the implant.

But, as studies have demonstrated, these coatings have trade-offs—their modulus of elasticity, for example, can range from 10 GPa to 100 GPa (compared to 1.0–2.4 GPa in cortical bone), depending on the density of the coat.

Better Osseointegration (Fusion) Through Structure?

3D printing has unleashed a flood of creative implant design energy—struts, curves, arches—and opened the implant real estate for more bone graft material. As 3D printing changed the geometries of each implant, they also altered the implant's biomechanics. Change biomechanics, change osseointegration?

If you're a fan of chemistry over structure and your tools of the trade include, for example, hydroxyapatite, surface modification or other chemical interface, you may think all these new designs are fine, but they're just suspenders, while you still rely on chemistry to be your "belt" in this analogy.

In a 2022 review and analysis of spinal implant osseointegration and the role of 3D printing which was published in the *Journal of Bioengineering* by authors Kia, Antonacci, Wellington, Makanji, and Esmende wrote: "3D printed implants have come into the market, providing mechanical stability with increased surface design for bony ingrowth. While clinical outcomes studies are limited, early results have demonstrated more reliable and quicker fusion rates using 3D custom interbody devices."[i]

In a recent *Orthopedics This Week* Master Class, Bill Walsh, Ph.D., Professor at the University of New South Wales and head of one of the most active bioengineering and testing labs in the world, said: "The geometry of the implant dictates or drives the biomechanics" and biomechanics drives osseointegration and fusion.

Dr. Walsh has been doing osseointegration studies in his lab since the late 1990s and has looked at the osseointegration capabilities of more implants and materials than most surgeons see in their lifetime. Furthermore, Dr. Walsh's model for testing implants and materials has been validated repeatedly over the years.

The New Geometries OVER Chemistry for Osseointegration

Dr. Walsh has looked at the chemistry and coatings of implants as well as the mechanical geometries of the implants. "We've looked at the mechanical properties, adding hydroxyapatite," explained Dr. Walsh, "different coating thicknesses, traditional manufactured implants, additive manufactured implants from different groups, different companies over those years and we tested them all with the exact same model."

"What we see is that the geometry of the implant dictates or drives the biomechanics."

It's the Macro Topography, Stupid.

"Bone will grow into the available geometry of the implant. I think it is important to realize that macro features can often achieve stability independent of the material. Geometry of the implant is a very, very important component. The porosity and macro topography almost makes the material irrelevant for osseointegration."

"Macro topography is an important component for osseointegration."

Dr. Walsh continued, "Once you achieve some level of biomechanical stability at the implant interface be it at the aperture or at the porous walls, the biomechanics of the whole environment changes. We're not just talking about how strong a cage is, we're talking about a motion segment that you want to stabilize and as soon as you start to fuse especially in the aperture, the stresses go off the implant and down the aperture."

"The cages companies are now designing have elegant features that will hopefully provide better ways for the body to integrate into and facilitate the clinical outcome. The opportunity to make complex shapes with titanium is there. Surface roughness or macro topography? I'll take macro topography any day."

Using Arches, Expanding the Space for Bone Graft and Changing the Macro, Micro and Nano topography

One spinal implant manufacturer that has won Orthopedics This Week's Best Technology in Spine award did so by creatively changing the design of interbody implants to drive improved biomechanics (along with other attributes).

The company, Camber Spine, has combined design, surface macro, micro and nano topography and more space for bone graft into a truly one-of-a-kind implant.

Here are its key features: *(See table on page 7.)*

For more information about Camber Spine's bone graft, here's a link: www.cambermedtech.com/spira-technology ♦

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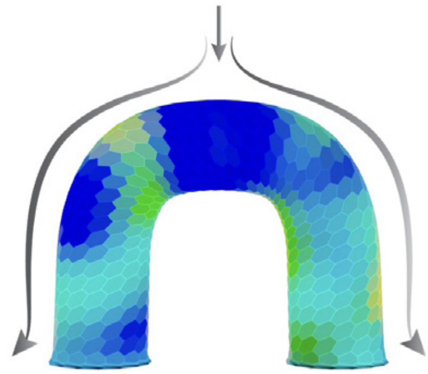
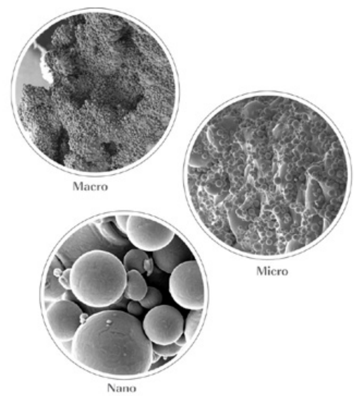
[1] *Spinal Implant Osseointegration and the Role of 3D Printing: An Analysis and Review of the Literature Cameron Kia 1,* , Christopher L. Antonacci 1 1 , Ian Wellington 1 , Heeren S. Makanji 2 and Sean M. Esmende 2*

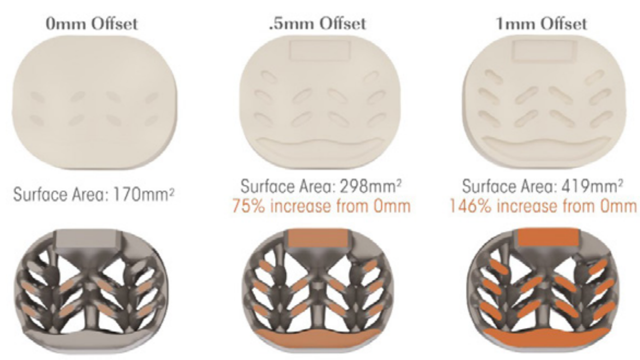
The Arch Design. Camber's Spira implants employ a series of arches which distribute loads and stresses throughout the implant itself—and, in the process, take advantage of Wollf's Law to help improve osseointegration.



Macro, Micro and Nano Surface Topography. Because of Camber's additive manufacturing approach, the implant's surface topography extends down three levels, macro, micro and nano, providing cells with multiple ways to attach and proliferate. The implant's surface design is trabecular bone-like with an average pore diameter of just 500µm.



Subsidence Resistance. It's called the "snowshoe effect." As you can see in the attached images, these designs distribute loads widely across the endplates. More surface area, decreases bone stress (load/area) and reduces subsidence risk.



More Bone Graft per Implant. Finally, because of the 3D printing process, Camber, like all companies using 3D printing, can create more space within each implant for bone graft.

Source: Camber Spine Technologies, LLC

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