Nanotechnology in Orthopaedics

IMPACT SERIES

As an orthopaedic surgeon specializing in shoulder/sports medicine, my priority has always been helping patients return to function with reliable, predictable healing. In 2018, I had the opportunity to co-author a paper exploring the potential of nanotechnology in orthopaedics—at the time, a forward-looking piece based solely on preclinical data and theoretical applications. In the article, we had just under one hundred peer reviewed references. Since then, there have been several thousand of publications focusing on nanotechnology in orthopaedics. The majority remain preclinical but show the promise that we recognized nearly a decade ago.

Clinically, the greatest real-world application has been in the spine domain. In 2019, Nanovis introduced their nanoVIS Ti™ nanotube surface into the spinal fusion space with consistently positive outcomes, including early and robust bone healing around implants. What's striking is how closely these outcomes align with the mechanisms we described in that original paper. While this technology is available, it has not yet been adopted in other areas of orthopaedics—despite clear parallels in biologic challenges such as osseointegration and healing. Like many emerging technologies, the science and early clinical outcomes provide a roadmap where implant technology will head in the future. There is growing anticipation for the day these innovations become accessible in shoulder, extremity, and sports medicine procedures, where I believe they could make a meaningful difference for our patients.

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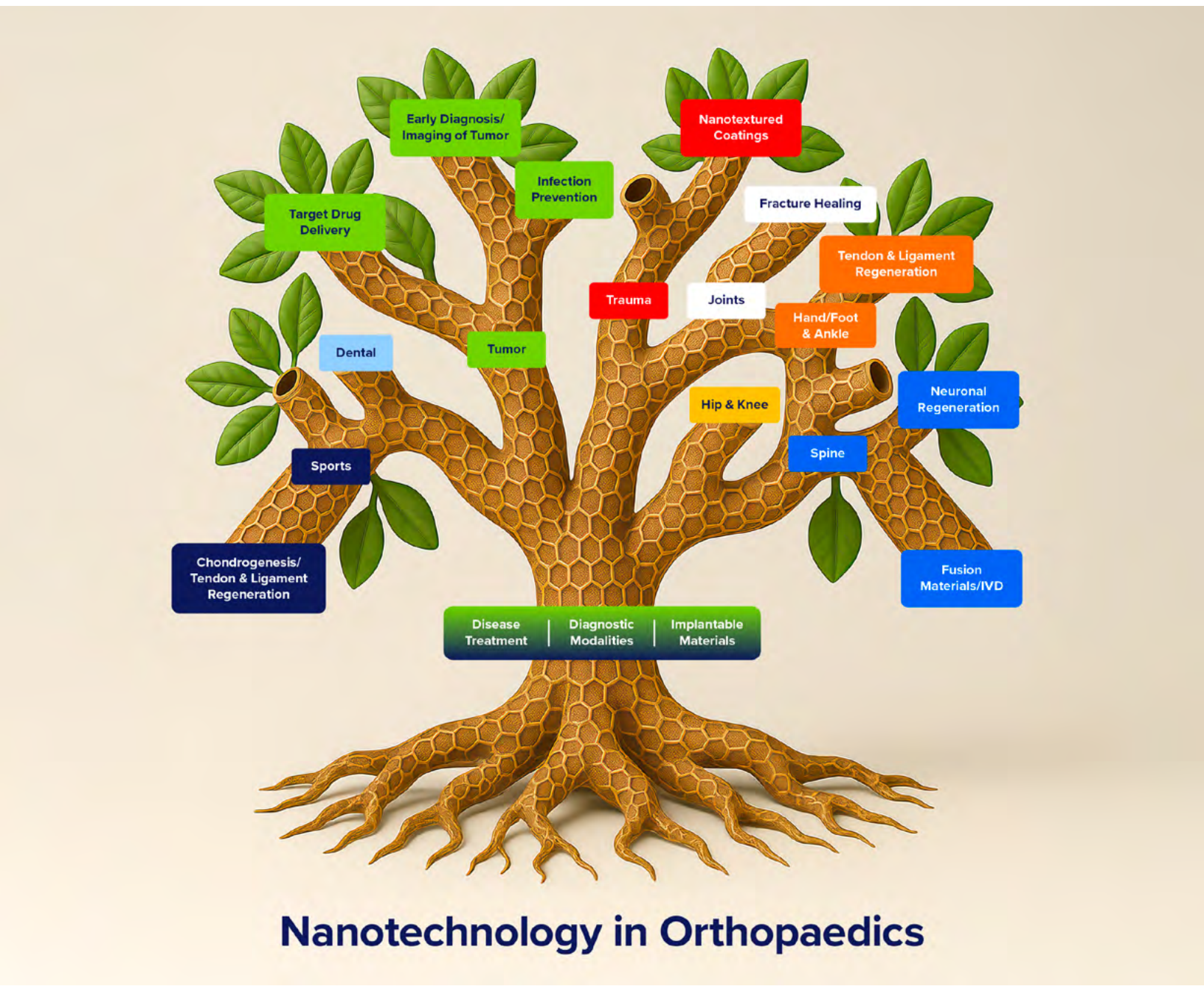
One of the greatest challenges in reading the clinical literature is understanding the widespread use of the term "nanotechnology". In other words, nanotechnology as a reference has become synonymous with random features at a nano metric scale which do not drive a defined biologic response. To satisfy the FDA's requirements for nanotechnology, implant features at the nano scale must be reproducible and engineered to drive a specific biological response. The nanoVIS Ti™ surface has shown to drive an accelerated calcification of extracellular matrix in vitro and this language is defined in each IFU (FDA Instructions for Use) referencing implants with Nanovis' surface.

Although not explicitly outlined as such in my article, Nanovis has identified four foundational Pillars of Healing that are shown to create a more favorable environment for healing compared to traditional implant surfaces.



PILLAR ONE

Improves Inflammatory Response

Nanovis' nanotechnology increases protein attachment for a lower immune response. It also decreases inflammatory cell attachment and activation while encouraging pro-healing macrophages.

Supporting Evidence from the Paper:

"Injection therapy with poly (γ-glutamic acid) nanocomplexes... demonstrated anti-inflammatory properties in ex vivo models."
(Section: Spine - Tissue Regeneration)

"Studies have found that the addition of nanostructured additives to PMMA demonstrated increased osseointegration and osteoblast activity, despite PMMA's known immunologic response."
(Section: Arthroplasty - Cements)

PILLAR THREE

Increases Vascularization

Our nanotubes speed up growth on the implant, supporting new bone growth and accelerates healing.

3rd Party Supporting Evidence:

"Nanotopographical cues can enhance endothelial cell adhesion and proliferation, leading to increased angiogenic activity in vitro and in vivo."
McMurray et al.
Biomaterials, 2011. PMID: 21345642

"Nanoscale features influence angiogenesis via integrin-mediated signaling pathways, promoting endothelial sprouting and capillary formation."
Park et al.
Small, 2012. DOI: 10.1002/smll.201200221

"Disordered nanoscale topographies can stimulate both osteogenesis and angiogenesis by mimicking the native extracellular matrix."
Dalby et al.
Nature Materials, 2007. DOI: 10.1038/nmat1931

"Titanium dioxide nanotube arrays enhance VEGF-mediated angiogenesis by promoting endothelial cell function."
Zhao et al.
Biomaterials, 2013. DOI: 10.1016/j.biomaterials.2012.11.043

PILLAR TWO

Reduces Bacterial Colonization

Our surface technology reduces bacterial colonization and biofilm formation and spread.

Supporting Evidence from the Paper:

"Kose et al. developed a silver nanopowder coating that led to a decrease in bacterial colonization on coated titanium implants compared with uncoated."
(Section: Orthopaedic Infections)

"Nanophase silver... proven to be more effective at infection prevention and healing than conventional dressings."
(Section: Orthopaedic Infections)

"Novel anti-biofilm implants equipped with nanoparticles..."
(Section: Orthopaedic Infections)

"Titanium pedicle screw coated with silver nanoparticles... inhibited biofilm formation on the implanted screws in rabbits."

While these examples refer to silver-based nanostructures, the underlying principle is the antimicrobial effect of nanoscale surface features. The Nanovis TiO2 Nanotube surface has also been shown to reduce bacterial adhesion and colonization in pre-clinical evaluation.

PILLAR FOUR

Accelerates Osseointegration

Osseointegration is the marker of successful implantation. The sooner bone firmly attaches to the implant, the better the outcome.

Supporting Evidence from the Paper:

"Nanostructured implants may better mimic the environment of native bone and stimulate implant osseointegration and surrounding osteogenesis to a greater degree than conventional implants."
(Section: Arthroplasty - Implant Material, Fig. 4 Caption)

"Surface modifications to titanium spinal implants through the addition of nanoparticles such as titanium oxide... have shown promise in promoting increased bone formation and decreased resorption compared to conventional smooth implants."
(Section: Spine - Spinal Implants)

Chen, X., Murphy, R. F., & Chaudhary, N. (2018). Nanotechnology in orthopaedics: A clinically oriented review.
BMC Musculoskeletal Disorders, 19(1), 128. https://doi.org/10.1186/s12891-018-2039-2

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