Improved Fixation with nanoVIS Ti™ Surface Technology in a Horse External Fixator Pin Micromotion Model

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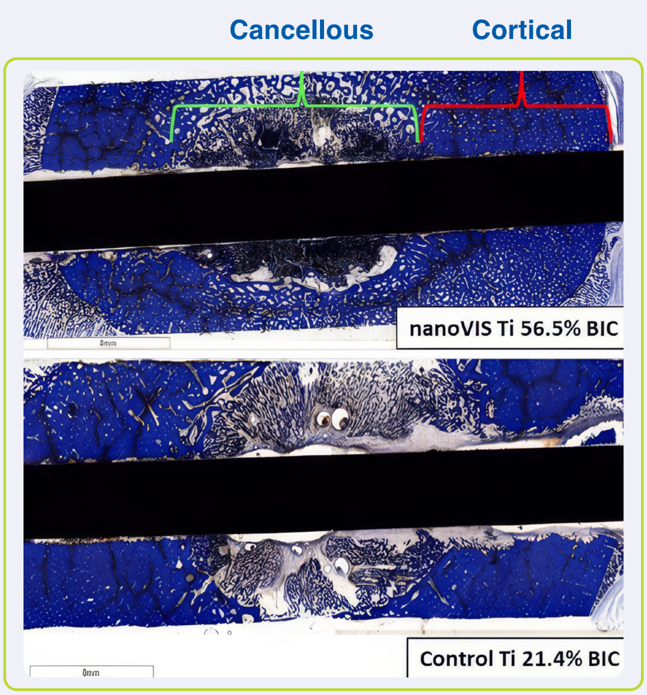
Introduction

Fracture fixation of the limbs can present substantial problems as micromotion can disrupt and delay the healing process, causing more pain and suffering for the patient. Micromotion and infection can damage bone adjacent to the implant, leading to loss of fixation. With an external fixator, increased micromotion increases the risk of infection and exacerbates patient pain. Nanosurfaces such as the nanoVIS Ti™ Surface Technology, as applied to an external fixator pin model, has shown an ability to reduce bacterial attachment *in vitro* and biofilm formation *in vivo* while supporting durable biologic fixation[1-3].

Commercially available surfaces focus on either improving fixation or creating an antimicrobial barrier. This is an either/or situation. Nanovis offers a commercially available surface that is engineered to improve implant integration and fixation while also reducing bacterial attachment and biofilm formation *in vivo*[1-3].



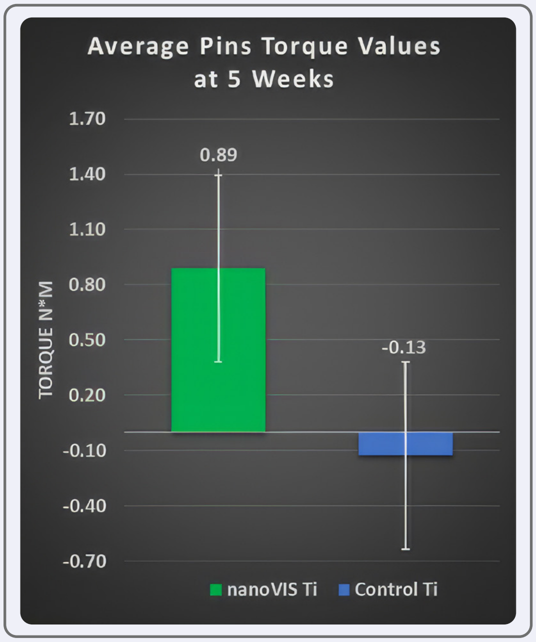


Figure 1 – Histology stained with Toluene Blue of transfixation pins in horse forelimb after 5 weeks in TPC. Cancellous bone is in the central canal and the denser cortical bone is on the outside. Bone-Implant Contact was measured for the pins. Relative torque measurements for each pin were also recorded.

Methods

Eight adult horses were utilized for this study. Titanium alloy Ti6Al4V ELI pins, 5.0 mm diameter, were shot peened to introduce micron level roughness. Control pins were compared to pins with nanoVIS Ti™ Surface Technology over 5-weeks of transfixation pin cast (TPC). Two pins of each type were placed in the right forelimb. The bone was pre-drilled in stages to avoid heat damage. Insertion torque of each pin was measured using a digital torque wrench. Pins remained under the cast without cleaning or supplemental antibiotics for the 5-week study allowing for an infection threat to be present. Six horses (24 pins) had pin extraction torque measurements recorded. Relative torque was calculated for each pin as the difference between extraction and insertion torque.

Two horses were used for histologic examination of the bone-pin interface comprising 8 bone-pin segments (4 per group) that underwent slide processing and Toluidine blue staining. Bone implant contact (BIC) was calculated as the length of bone in contact with the pin surface divided by the total length of the bone-pin interface.

Results

Overall, 8 of 12 (67%) nanoVIS Ti™ Surface Technology pins and control pins had measurable pin fixation. Of the pins that achieved fixation, 100% of the nanoVIS Ti™ surface pins had positive relative torque while only 50% of the Control Ti pins had positive relative torque. On histology, the mean (± SD) BIC for nanoVIS Ti™ Surface Technology pins were 50% ± 16%, whereas for control pins, the BIC was 23% ± 17%. From the histology slides, new bone formation was most evident within the cancellous regions of the bone. While all pins had similar levels of bacterial contamination on the surface, nanoVIS Ti™ Surface Technology pins had higher levels of fixation.

Discussion

Results of this study show that nanoVIS Ti™ Surface Technology pin encourages osseointegration and bone attachment to the surface of the pin over the course of 5 weeks within a horse TPC. Compared to humans, horses need to develop denser and more mineralized bone to handle the larger forces associated with their size (800-1200 pounds). This poses a challenge for implants dealing with the substantial forces generated by horses, resulting in micromotion that can disrupt osseointegration. A second challenge is the presence of skin bacteria at the open wound sites. These open wounds led to the presence of bacteria on all pins. In some cases, descending infections limited the ability of the pins to integrate and become biologically fixed over the course of 5 weeks.

Conclusion

Ensuring consistent osseointegration of pins under bacterial load and strong micromotion forces can reduce pin loosening as a complication. This improved stability of transcutaneous pins placed in bone may lead to reduced pain and faster healing of fractures treated with external fixation. The nanoVIS Ti™ Surface Technology is a surface that can perform and even excel in the most challenging environments like loaded fixation pins.

References

1. 1 David Detwiler, PhD; Thomas Webster, PhD *et al*. 2 (https://nanovistechnology.com/images/PDFS/NANWhite-Paper-Volume-2.pdf).

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3. David Detwiler, PhD; Sabrina Huang, PhD; James McCarthy, BSE; Alan Kraft, BSNE; Kreigh Williams, BS (https://nanovistechnology.com/images/PDFS/nanovis-ti-surface%20technology-increases-mineralization.pdf, 2024).