



Improved Fixation with nanoVIS TiTM Surface Technology in a Horse 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 resulted from insufficient initial fixation, poor bone quality, and continuous excessive loading can damage the bone adjacent to the implant, leading to loss of fixation¹⁻². With an external fixator, enhanced micromotion increases the risk of infection and exacerbates patient pain. Nanovis offers a commercially available surface that is engineered to improve implant integration and fixation³. In this study, we demonstrated how nanoVIS™ Surface Technology could improve fixation using a horse external fixator pin micromotion model.

Methods

Eight adult horses were utilized for this study. Titanium alloy Ti6Al4V ELI pins with a diameter of 5.0 mm were shot peened to introduce micron level roughness. These micro-roughened pins, with and without nanoVIS Ti™ Surface Technology, were investigated over 5 weeks using a transfixation pin cast (TPC) to maintain stable fixation throughout the study. Two pins from each group 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. The pins remained under the cast without cleaning or supplemental antibiotics throughout the study.

Relative torque was calculated for each pin as the difference between extraction and insertion torque. Six horses (24 pins total across both groups) had pin extraction torque measurements recorded. 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 direct contact with the pin surface divided by the total length of the pin.

Results

Figure 1 shows representative histology images of the BIC for both groups, along with the average relative pin torque values at 5 weeks. Overall, 8 of 12 (67%) pins for both groups had measurable pin fixation. Among the pins that achieved fixation, 100% of the nanoVIS Ti™ surface pins had a positive average relative torque of 0.89 N·m, while only 50% of the control Ti pins had positive relative torque, resulting in a negative average relative torque of -0.13 N·m. On histology, the average BIC for nanoVIS Ti™ Surface Technology pins was $50\% \pm 16\%$, whereas for control pins, the average BIC was $23\% \pm 17\%$.

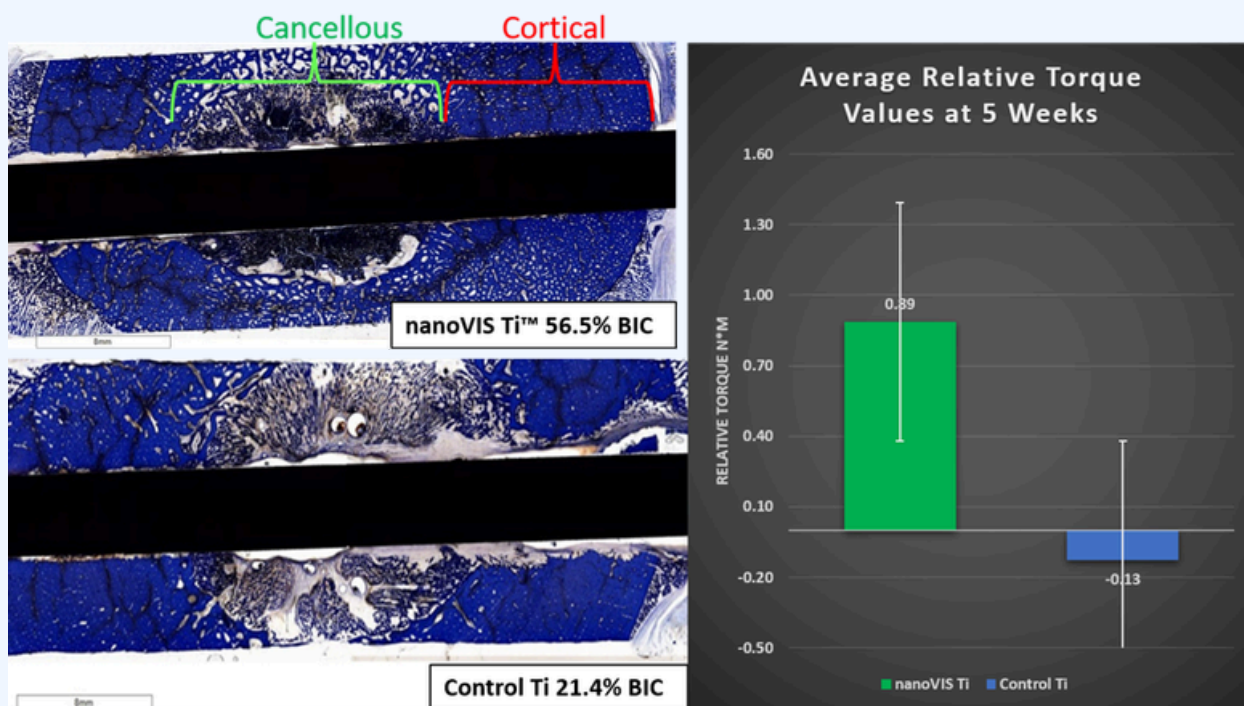


Figure 1: Left: histology of transfixation pins stained with Toluene blue after 5 weeks in a TPC in the horse forelimb. Cancellous bone is in the central canal, while the denser cortical bone is on the outside. Bone implant contact (BIC) was measured for these specific pins. Right: the average relative torque measurements for each group.

Discussion

Compared to humans, horses need to develop denser and more mineralized bones to handle the larger forces associated with their larger body size (800-1,200 pounds). This poses a challenge for implants dealing with the substantial forces generated by horses, resulting in micromotion that can disrupt osseointegration. In this study, the pins with nanoVIS Ti™ surface showed a positive average relative torque value, whereas the control surface showed a negative average relative torque value, indicating greater resistance to micromotion and stronger fixation with the nanoVIS Ti™ surface pins. From the histology slides, new bone formation was most evident around the nanoVIS Ti™ surface pins within the cancellous regions of the bone, indicating earlier bone formation and bone attachment. This finding is consistent with previous studies showing that nanotube surfaces can promote vascularization and enhance osseointegration⁴⁻⁵.

Conclusion

The nanoVIS Ti™ surface can enable consistent osseointegration of pins exposed to strong micromotion forces and 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 designed to perform in challenging environments such as cyclically loaded fixation pins. The results of this study show that nanoVIS Ti™ Surface Technology pins encouraged early osseointegration and achieved strong fixation over 5 weeks in a horse TPC model.

References

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