



Pin Fixation with **Nanosurfaces** in a Multi-Pin Transfixation Cast System for Fracture **Healing**

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Background

Fractures of long bones are very often treated with screw and plating systems that are intended to stabilize the fracture and provide some amount of loading resistance to enable physical therapy. When the fracture site is loaded, the screws adjacent to the fracture receive the highest stress load and thus are subject to the most micromotion¹⁻³. Excessive micromotion will cause the adjacent bone to break down. This loss of bone around the screw compromises fixation initiating a cascade effect where adjacent screws progressively experience the same deterioration pattern¹⁻³. Stabilizing the implant earlier can slow the loss of bone keeping the construct more stable for a longer period of time. Nanosurfaces have been demonstrated to accelerate and increase the formation of bone around implants^{4,5}.

This study evaluated fixation of external transfixation pins with or without the nanoVIS Ti™ Surface Technology in a horse model over a five-week period, during which the pins were subjected to varying levels of mechanical loading depending on their implanted positions. Torque measurements were used to quantify pin fixation and compare fixation across different positions.

Methods

The transfixation construct consists of pins that pass through the skin and bone on both sides of the forelimb and are secured with a cast to treat fractures in racehorses¹. Titanium ex fix pins with or without the nanoVIS Ti™ Surface Technology were implanted into the forelimb of six horses. A total of 6 pins were implanted in each limb at positions 1 to 6, with position 1 being the most proximal and position 6 being the most distal. Pin stress was modeled with finite element analysis and predicted to be highest on the distal and proximal pins with the central pins being stress shielded¹. Pins were placed to ensure an equal number of pins for each surface at positions 1-6, with the control and nanoVIS Ti™ Surface Technology surfaces randomly assigned to the limbs. No single horse had only one surface type.

Pins were transcutaneous and secured in a weightbearing polymer cast that directed the weight of the horse through the pins and into the cast and then into the floor, bypassing fractures in the foot. The pins remained in place for 5 weeks with daily weightbearing activity. No supplemental antibiotics or cleaning of the pin-skin interface was done. After 5 weeks, animals were sacrificed and the cast removed to recover the forelimb with pins. Pins were removed with Snap-On torque wrenches to quantify the extraction torque. Torque was recorded at each pin position.

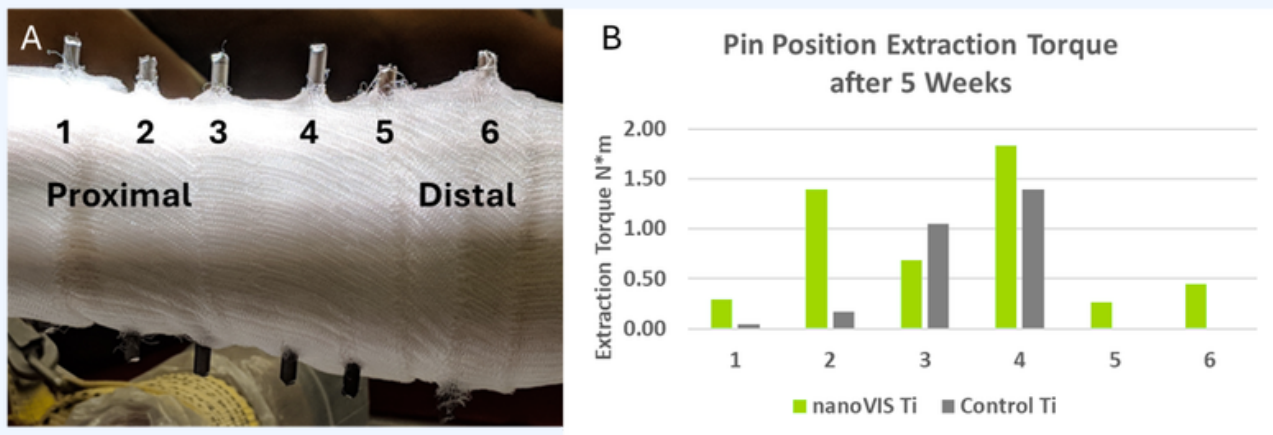


Figure 1: (A) Pins placed in the cannon bones of the horse. (B) Extraction torque of transcutaneous cast pins after 5 weeks of osteointegration. N = 2 at each pin position.

Results

Control titanium pins showed the highest fixation at positions 3 and 4 and very little fixation at positions 1 and 2. Furthermore, positions 5 and 6 were completely loose, and no torque values could be measured. Pins with the nanoVIS Ti™ Surface Technology demonstrated higher fixation at all positions except at position 3, which was considered the most stress-shielded location. At the proximal and distal positions, which were considered to experience the highest mechanical loading, higher fixation was seen for pins with nanoVIS Ti™ Surface Technology compared with the control titanium.

Discussion

Pin position generally correlated with the predicted fixation outcomes. Based on finite element analysis, positions 1 and 6 were predicted to have the lowest fixation due to higher pins stress, followed by positions 2 and 5, while positions 3 and 4 were predicted to experience the lowest pin stress¹. The results were consistent with the prediction that positions 1 and 6 would have the lowest fixation for both surfaces. Although positions 1 and 6 showed the lowest fixation, the nanoVIS Ti™ surface demonstrated higher fixation at positions 1, 2, 4, 5, and 6 compared with the control titanium surface. The low average torque observed at position 3 for the nanoVIS Ti™ surface was affected by one pin with minimal torque, with the small sample size further contributing the variability. Overall, the nanoVIS Ti™ surface outperformed the control surface.

Conclusion

This study evaluated pin fixation in a multi-pin transfixation cast system in horses over 5 weeks. The results showed that the proximal and distal positions had lower fixation than the central positions, consistent with finite element analysis predictions that these locations experienced higher pin stress and micromotion. Despite the increased mechanical loading and micromotion at these locations, pins with the nanoVIS Ti™ surface demonstrated better fixation than those with the control surface, indicating the nanoVIS Ti™ surface can enhance fixation under high-stress and micromotion conditions.

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