# THE USE OF A LOCKING VS. NON-LOCKING PLATE IN A DISTAL RADIUS ENDOPROSTHESIS FOR CANINE LIMB SPARING

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**Introduction**
Osteosarcoma is the most commonly occurring bone tumor in the canine population with 10% of newly diagnosed cases being in the distal radius. Limb-sparing surgeries involving massive cortical bone allografts have become the favored treatment option over limb amputation among clinicians and patients. However, massive bone allografts are encumbered by issues such as infection, construct failure and local tumor recurrence. Recently, metal endoprostheses have been proposed as a viable alternative to massive cortical bone allografts. However, these endoprostheses have been plagued by high failure rates (40%). A computational (finite element) modeling approach was undertaken to determine the exact mechanical and structural causes for failure of these implants. In addition, we investigated the effect using a locking plate in place of the current non-locking plate.

**Materials & Methods**
In order to investigate the mechanical underpinning of these failures, a finite element model of the canine forelimb was developed (Fig. 1(A)). The model included all 13 bones of the canine antebrachium. CT scans of a canine forelimb were used to generate a complete volumetric representation of the antebrachial region using linear hexahedral elements. Cartilage was extruded from the underlying mesh on all articulating surfaces and contact was established between the appropriate articulating surfaces, resulting in a total of 23 finite sliding contact pairs. In order to establish model validation, a total of four intact canine forelimbs were tested in a materials testing machine (MTS, Eden Prairie, MN) under a load of 110% BW. Strain data was collected at 3 locations on the radius and at the mid-diaphysis of the ulna, and a motion analysis system was used to capture relative interosseous motion from reflective marker data. Post-validation, the current generation endoprosthesis was implanted in the model (Fig. 1(B)). Five screws were inserted in both the proximal radius and the third metacarpal. For both plate conditions, contact was established between the radius and cortical screws with a coefficient of friction of 0.99 to simulate complete bonding. The locking mechanism between the plate and screw head was simulated using tie constraints. For the non-locking plate contact was established between the radial screws and plate with a coefficient of friction of 0.25. The model was loaded to 110% BW (400N) in compression at the proximal ends of the radius and ulna for all simulations.

**Results:** The intact model strain predictions were within one standard deviation of experimental strain predictions at all of the four locations. The implanted non-locking plate model yielded high von Mises stresses (519 MPa) at the bone-screw interface and high bending stresses (336 MPa) within the radial screws. The locking plate model predicted similar stresses at these two locations. Greater dissipation of stress was observed in the radius for the locking plate construct as compared to the non-locking plate construct (Fig. 2A, 2B).

**Discussion/Conclusion:** The common causes of failure observed clinically for the 1st generation endoprosthesis have been reported to be screw pullout and screw failure due to shear. Our model predictions are congruous with these findings. The use of a locking plate did not provide any significant mechanical improvements to the current construct design other than greater stress dissipation around the radial screw holes. However, this predicted reduction in stress would not be great enough to mitigate the very high stresses seen in these components. The overall conclusion of this study is that a complete redesign of the endoprosthesis is warranted.

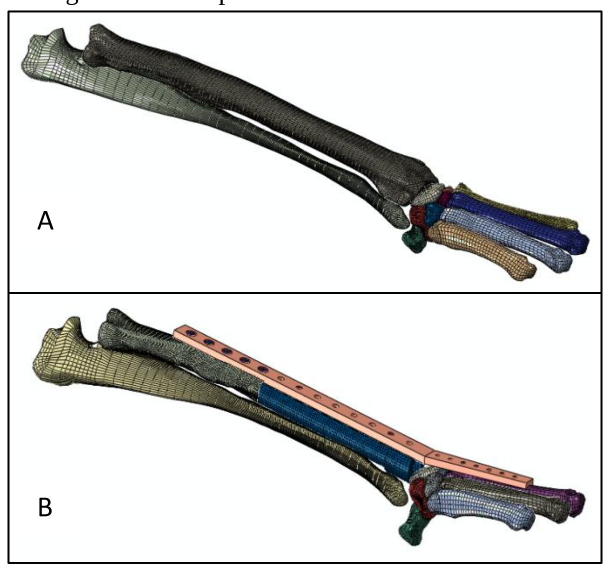


Figure 1: Intact (A) and implanted (B) finite element models of the canine antebrachium

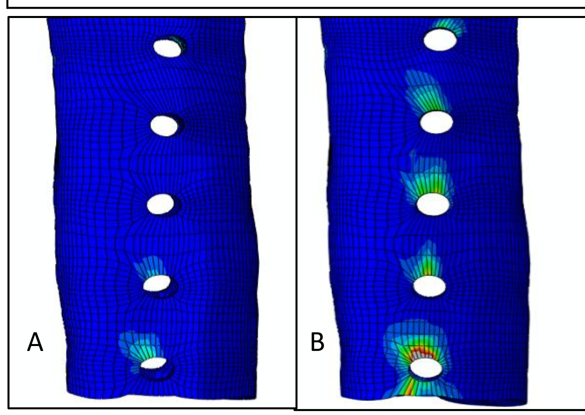


Figure 2: Greater stress dissipation can be observed in the radius for the locking plate model (A) as compared to the non-locking plate model (B).