INTRODUCTION: Substantial disability can result from malunions of the distal radius following fracture. Restoration of accurate anatomical congruity and stable fixation is paramount to obtaining excellent clinical function of articular fractures. Internal fixation is widely accepted as the treatment of choice in achieving this goal. The dorsal radial plate (DRP) pi plate (Synthes USA) was designed for dorsal applications in complex intraarticular and extraarticular fractures of the distal radius allowing multiple points of fixation, smaller implants, bone conforming profile, and periarticular placement to enhance fragment and articular support in highly comminuted fractures. Although the DRP appears to be an optimal implant for the distal radius and good results have been reported, complications such as tendon irritation, adhesions, tenosynovitis, and even spontaneous tendon rupture, have raised issues of concern with surgeons for use of the DRP. In this study, we evaluated the relationship of extensor tendon function and DRP using 2 metal types and 2 plate designs in a canine distal radial model.

METHODS: The study was composed of 14 dogs weighing 35 kgs studied for 9 mos. under an IACUC protocol. Bilateral distal radial plates were implanted with placement in identical periarticular positions on the dorsal bone surface without fracture. In one group of 7 dogs a standard titanium pi plate (Ti) was placed on one radius and an identical stainless steel plate (SS) on the other, randomized by side. In the other group of 7 dogs the standard titanium pi plate (Ti) was implanted on the right and a titanium pi plate (Ti) with a ramped profile (Ti ramped) on the left radius. A dorsal approach was used to identify the extensor carpi radialis (ECR) and common digital extensor (CDE) tendons which were elevated and retracted to expose the distal one-quarter of the radius. The primary tendon sheaths of the ECR and CDE tendons were opened along the length of the plate and proximal joint to allow direct contact of the tendons to the plate surfaces. Range of motion measurements (ROM) and orthoradial radiographs were obtained and then the lower forearm was placed in coaptation bandages for 2 wks. ROM and radiographs were obtained postoperatively and at 3, 6, 9 mos. and of the explanted bones.

Mechanical testing was performed on explanted forelimbs obtained from the plate treated radii pairs and non-plated control radii pairs from an additional 5 dogs. Each forearm was placed in neutral position from which the flexion and extension range of motion (FROM and EROM) were measured. FROM and EROM were determined as the angle between the neutral position to the fully flexed and fully extended, respectively. Flexion and extension motions of the carpus were applied manually to the maximum limits and measured. The ECR and CDE tendons were identified and only exposed distal to the radial articular surface. Tissues over the forelimb were left undisturbed. The excursion limits of ECR and CDE were identified with either metal type. However, they were not specific to any one design or metal type but seemed to occur with similar frequency in all three plated limb types.

Mean pullout forces of ECR and CDE for all tested groups showed that pull-out forces were significantly larger compared to the control group (p < 0.05) but were similar among treated groups. This increase in pull out force was greater in ECR than in CDE. FROM showed a significant relationship with displacement at force pick up (R² = 0.4 for ECR and R² = 0.13 for CDE), but not with pull-out force for both ECR and CDE. It was also found that the excursion and displacement at force pick up was significantly correlated (R² = 0.53 for ECR and R² = 0.26 for CDE). In all correlation analyses, ECR had better correlations than CDE.

DISCUSSION: This canine distal radial plate model replicated the anatomical positioning and tendon-plate relationship encountered in human clinical orthopedics. Mechanically, all plated specimens consistently had a tendon pull-out force greater than the non-plated control specimens regardless of the type or material of plate. Tendon movement may be significantly impaired by the radiating plate irrespective of the material (SS steel vs. Ti) and design (ramped vs pi). However, lack of a correlation between FROM and excursion implies that restriction of the tendon may be caused not by the direct contact of tendon to the implant, but through scar tissue formation. Histologically, tenosynovitis occurred to varying extents in all plated limbs implying that this is not specific to SS or Ti nor is it related to subtle design features of these different DRP plates. Occupation by metal in the space under extensor tendons even with the reduced thickness pi plate can alter the mecano-cellular interactions and strain within the tendon leading to a tendon tissue response. Internal fixation with bone plate provides excellent anatomic support of distal radial fractures and is important for restoration of joint function and superior to other fixation methods. Thus, other plating concepts incorporating tendon protection need investigation.

Acknowledgement: AO Institute and Synthes USA.