Introduction: Rotator cuff tears are often repaired surgically, but a significant percentage of large cuff tears fail after surgery. Rotator cuff repair outcomes are typically assessed with measures of muscle strength, range of motion, and pain, but these do not directly assess of tendon function. The purpose of this study was to evaluate a non-invasive imaging technique for quantifying in-vivo tendon excursion after tendon repair in a canine model. We hypothesized that tendon excursion would decrease over time in healing tendons, but not change over time in normal tendons.

Materials and Methods: The study used four adult dogs (25-30 kg). In two experimental dogs, the superior two-thirds of the left infraspinatus (INF) tendon was detached from the humerus and adjacent tendon strut, and then repaired to the humerus. Tantalum beads were implanted in the humeral head at the repair site and on the surface of the operated portion of the INF tendon. Beads were implanted in the same locations of two control dogs, but no tendon injury was created. Standard x-rays were obtained at surgery and two weeks post-surgery to determine if the tendon repair was intact.

Tendon function during treadmill trotting was assessed by measuring the position of the implanted beads from images acquired with a biplane x-ray system [1]. Tendon excursion, defined as the 3D distance between the tendon and humerus beads, was computed on each image frame. Data were collected at two-to-four week intervals starting at two weeks post-surgery.

Tendon function was quantified by changes in tendon excursion. We defined the standard deviation (SD) and mean of tendon excursion as measures of the amplitude and baseline position, respectively. We also calculated the coefficient of variation (CV) of tendon excursion (i.e., ratio of SD to mean). The CV is a normalized excursion parameter that is independent of the initial distance between beads (which can not be controlled). For each dog, regression analysis was used to determine if the mean, SD and CV of tendon excursion was significantly dependent on time.

Results: Standard x-rays at two weeks post-op indicated an intact tendon repair in one experimental dog and a failed tendon repair in the second experimental dog. The beads in the control dogs remained unchanged from their positions on the tendon and bone at the time of surgery.

In the intact repair, mean excursion decreased with time (p<0.01), suggesting that the tendon repair contracted approximately 19% over 28 weeks (Fig 1). The SD of tendon excursion decreased with time (p<0.01), suggesting that the tendon repair became less compliant (or 74% stiffer) over 28 weeks (Fig 2). The CV of tendon excursion also decreased with time (p<0.01, Fig 3). In contrast, significant changes in the mean, SD and CV of tendon excursion were not detected in the failed tendon repair (p>0.22, Figs 1-3). In the normal control dog, the SD and CV of tendon excursion did not change over time (p>0.62). There was a statistically significant (albeit small and not clinically significant) increase in mean tendon excursion over time (p=0.01, Fig 1).

Discussion: This study demonstrates the use of a non-invasive imaging technique for quantifying in-vivo tendon function. The data suggest that statistically and clinically significant decreases occur in the baseline (mean), amplitude (SD) and CV of tendon excursion in healing tendons following repair. In failed repairs, tendon excursion does not change over time suggesting that limited if any healing occurs following repair rupture. As expected, excursion data do not change over time in normal tendons. Ongoing work will correlate changes in in-vivo tendon excursion with measures of histology and biomechanics. Such data will allow us to interpret the changes in tendon excursion that occur during healing and further establish biplane x-ray analysis as a tool to quantifiy the timing and outcome of various strategies for treating rotator cuff tears.