Biomechanical Comparison of Suture Anchor vs. Transosseous Tunnel Repair for Acute Quadriceps Tendon Rupture

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Introduction:
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Acute quadriceps tendon rupture is a relatively infrequent injury with serious consequences. The current gold standard for management of an acute quadriceps tendon rupture is surgical repair with suture through transosseous patellar bone tunnels. This repair has been successful, but can be a relatively time-consuming and labor intensive procedure, with potential complications including early or delayed patella fracture. Suture anchors have been used with excellent success for tendon repair in other joints. Despite the higher associated initial cost, this technique offers the potential benefit of decreased surgical exposure and soft tissue disruption, reduced operative time, and the potential for improved repair strength and decreased risk of patella fracture. The purpose of this study is to evaluate the biomechanical fixation strength of suture anchor versus “gold standard” transosseous tunnel quadriceps tendon repair.

Methods:
Materials and Methods
After a power analysis to determine a difference with p<0.05 being considered significant, a total of twelve human cadaveric specimens were utilized, consisting of whole quadriceps tendon - patella - patellar tendon. Prior to randomization into groups, DEXA measurement was performed to ensure equal bone quality amongst groups. Specimens were then randomly assigned to the following groups:
Suture anchor repair of quad tendon and patella tendon (n=6)
Transosseous tunnel repair of quadriceps tendon (n=6)

For all specimens, the quadriceps tendon insertion was sharply divided from the whole patella specimen with a scalpel. For the suture anchor group, three double loaded 4.5mm Arthrex Corkscrew anchors were placed in central, medial, and lateral aspects of the quadriceps footprint on the proximal patella. For the transosseous repair, three parallel tracks were drilled with a 2.5mm drill in a longitudinal fashion from the proximal patella to the distal pole, using identical starting points as the suture anchor group. For both groups, the same type and number of sutures (# 2 Fiberwire) were utilized for repair. Repair consisted of 3 krackow stitches placed along the medial, central, and lateral aspect of the tendon, and 3 horizontal mattress stitches placed 5 mm from the distal tendon edge in the medial, central, and lateral aspects, respectively. The only variable between groups was that the suture anchor group was tied down to the anchor sites, while the transosseous group was tied over a distal patella bone bridge, per standard technique. Each patella was mounted into a gripping fixture which is designed to hold each patella without disruption of tendon repair site. The fixture was rigidly attached to the table of an Instron 8821s servo-hydraulic load frame. The quadriceps tendon was gripped in a compression gripper attached to the Instron ram. Tensile load was applied at a rate of 0.1mm/s up to 100N after which cyclic loading was applied at a rate of 1Hz between magnitudes of 50N and 150N for 10 cycles. Next, cyclic loading between 50N and 200N was applied at a rate of 1Hz. Next, cyclic loading between 50N and 250N was applied at a rate of 1Hz. Finally, tensile load was applied at a rate of 0.1mm/s until failure. Failure was defined as a sharp deviation in the linear load vs. displacement curve. Displacement at the bone tendon junction was monitored using 3D optical tacking (NDI Certus) in which one LED target was placed on the patella and one was attached to the tendon using a soft tissue tack. Outcome measures include load to failure, displacement at 1st 100N load, as well as displacement after each 10th cycle of loading. Data was analyzed for statistical significance using the student’s t-test with p<0.05.

Results:
Results
Measured displacements across the tendon-patella junction are shown in figure 1. The method of failure for all suture anchors except for one sample was a mid-substance failure of the quadriceps tendon. One suture anchor repaired specimen pulled the anchor from the patella. The failure method of all bone tunnel repairs except for one specimen was pulling the repair knot through the tunnel. One sample in the bone tunnel group failed the tendon mid-substance. In our study, there was no significant difference (p=0.40) in ultimate load to failure between the 2 repair techniques (SA=285.16±86.30N, BT=250.49±41.97N), however there was significant difference (p<0.05) in gapping distance at the 1st 100N (SA=2.74±0.62mm, BT=4.68±1.29mm), after 10 cycles between 50N and 150N (SA=5.10±0.34mm, BT=7.43±2.40mm), between 50N and 200N (SA=6.39±0.56mm, BT=9.10±1.82mm), and between 50N and 250N (SA=7.74±0.79mm, BT=10.70±1.35mm) (fig 1).

Discussion:
Our study compares the biomechanical properties of suture anchor versus transosseous tunnels for quadriceps tendon repair. We demonstrated a significant difference in cyclic load favoring the suture anchor group at all time points(p<.05), and no statistically significant difference in ultimate load to failure between the groups (p=0.40). Suture anchors failed mostly through the tendon, while transosseous tunnel constructs failed mostly by suture pulling through bone. While previous studies have been performed looking at quadriceps tendon repair, this study is the first to control for bone density and to standardize repair construct between the two groups.

Significance:
Overall, our data supports the use of suture anchors as a viable alternative for quadriceps tendon repair. Future clinical research is needed to confirm these biomechanical results.

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Figure 1. Displacement across the tendon-patella junction following cyclic loading; where * indicates significance vs. suture anchor sample with significance set at p<0.05.

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