Unicortical Quadriceps Tendon Repair With All-Suture Anchors Results In Less Gap Formation Than Traditional Hard-Body Suture Anchors

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INTRODUCTION: Current quadriceps tendon repair techniques following rupture include transosseous patellar bone tunnels (TO) and suture anchors (SA) to reduce the quadriceps to the superior patella and promote tendon-to-bone healing. Despite their ability to restore knee extensor function, documented failure rates range from 0-16% for both techniques.[1] Adjustable all-suture anchors (ASAs) have recently been introduced to extensor mechanism repair to better restore the tendon footprint and minimize tendon-bone gap formation. While biomechanical evidence has demonstrated marked improvements when using ASAs for TO techniques[2], no studies have examined their use for unicortical fixation. The authors hypothesized that unicortical ASA fixation would reduce gap formation and exhibit comparable stiffness, yield load, and ultimate load to the conventional unicortical hard-body suture anchor approach.

METHODS: Eight matched pairs of male cadaveric knees were dissected to isolate and release the quadriceps tendon insertion, similar to Wittstein et al.[2] Male specimens were selected to best represent the demographic most commonly associated with quadriceps tendon rupture. Paired knees were randomized to 2.6-mm ASA or hard-body suture anchor control repair groups, both with medial and lateral Krackow suturing using 1.3-mm suture tape. The ASA repair had two 2.6-mm tunnels into which the ASAs were inserted, and the Krackow sutures were converted through the ASAs. For the control repair, two hard-body anchors were loaded with the Krackow sutures and screwed into two tapped 4-mm tunnels. Knees were then mounted onto a material testing system and actuated from 5° to 90° of flexion via the quadriceps tendon for 10 native preconditioning cycles, followed by 250 post-repair cycles at 0.1 Hz with a peak force of 150 N per cycle. Repairs were loaded to failure at a rate of 50 mm/min. Outcomes included plastic gap formation (mm) during cyclic loading and stiffness (N/mm), 0.2% offset yield load (N), and ultimate load (N) during load-to-failure. Paired t-tests were used for statistical analyses ($p < 0.05$).

RESULTS: The ASA repair had significantly less gap formation at cycle 250 compared to the control repair (mean Δ=4.2 mm; 95% CI = 2.9 to 5.3 mm; P<0.001). The mean control displacement surpassed the defined critical threshold for gap formation (5.0 mm) within the first 50 cycles, whereas the mean ASA displacement approached this threshold at cycle 200. No significant differences in stiffness (mean Δ=1.7 N/mm; 95% CI = -7.8 to 11.2 N/mm; P=0.682) or ultimate load (mean Δ=52.8 N; 95% CI = -45.9 to 151.4 N; P=0.247) were found between the two repairs. However, the yield load was significantly higher in the control group than the ASA group (mean Δ=54.7 N; 95% CI = 27.1 to 82.2 N; P=0.002).

DISCUSSION: The primary finding of this time-zero biomechanical evaluation of unicortical quadriceps tendon fixation is that ASA repair significantly reduced gap formation by 43% compared to traditional hard-body anchors. Gap formation is a primary contributor to post-operative re-rupture, and the unicortical ASA repair technique may result in enhanced clinical outcomes. In addition to improved gap formation resistance, biomechanical efficacy for ASA repair was proven to be not significantly different from hard-body anchors with respect to stiffness and ultimate load. While the yield load was significantly lower for the ASA repair group, this may not result in clinical deficiencies when the post-operative healing is complete. Despite the limitations of the study, which include not accounting for healing or stabilization and potential variability in tendon quality, the results still provide robust data to biomechanically support the viability of ASA for a unicortical quadriceps tendon repair.

SIGNIFICANCE/CLINICAL RELEVANCE: All-suture anchors are a biomechanically viable alternative to the conventional hard-body suture anchors for a unicortical quadriceps tendon repair.

REFERENCES: [1]VanDerwerker NB, Winzenried AE, Mosiman SJ, Grogan BF, Baer GS, Cotter EJ. Transosseous Tunnel Suture Fixation Results in Similar Rerupture Rates and Patient-Reported Outcome Measures Compared to Suture Anchors for Primary Quadriceps Tendon Repair: A Systematic Review. Arthroscopy. May 27 2025;doi:10.1016/j.arthro.2025.04.059
[2]Wittstein JR, Tejada MD, Smith BL, et al. Transosseous Quadriceps Tendon Repair With Knotless All-Suture Anchors Is Biomechanically Superior to Traditional Transosseous Fixation. *Orthop J Sports Med*. 2025;13(8):23259671251356627. Published 2025 Aug 14.

IMAGES AND TABLES:

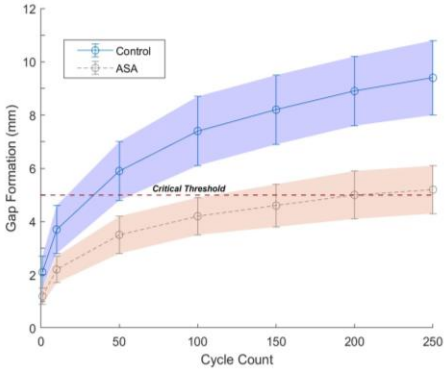

Fig 1. Gap formation at specified cycle intervals for unicortical tendon repair using control and all-suture anchor (ASA) techniques (5.0-mm critical threshold denoted). Values are shown as mean ± SD.

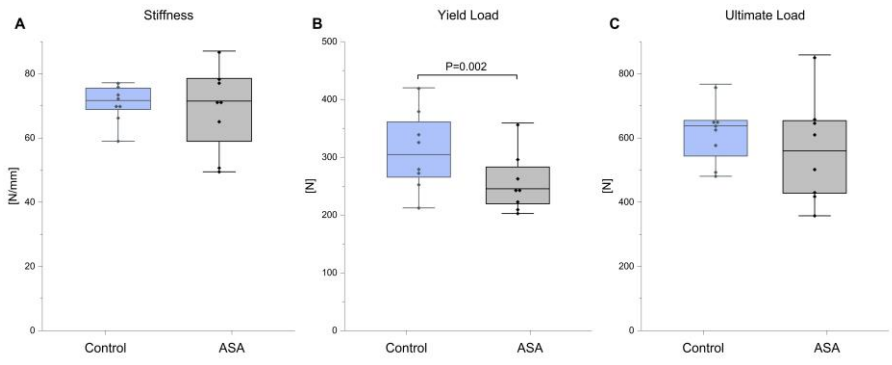

Fig 2. Unicortical quadriceps tendon repair (A) stiffness, (B) yield load (0.2% offset), and (C) ultimate load box plots for control and all-suture anchor (ASA) techniques.