Supplemental Fixation of Inner Graft Bands in Quadrupled Single Tendon (QST) Anterior Cruciate Ligament (ACL) Reconstruction Graft Construct for All-Inside Technique Yields Improved Biomechanical Properties

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INTRODUCTION: Quadrupled single-tendon graft preparation has been popularized in ACL reconstruction as a means to increase graft diameter. Biomechanical studies have shown optimal graft strength is achieved by applying symmetric loads to graft bands at the time of fixation, with decreased load to failure in asymmetrically tensioned grafts.[1] The purpose of our study was to evaluate the load-sharing characteristics of the usual QST construct for all-inside ACL reconstruction (UST) and to compare with a supplemented QST construct (SST).

HYPOTHESIS: Our hypotheses were that the bands of a QST construct are not symmetrically tensioned and do not carry an even distribution of strain.. We also hypothesized that supplementing the fixation of the inner bands, SST, in the QST preparation described by Lubowitz[2] would help to facilitate this equalization of the bands during preconditioning and that there may be a critical precondition load that will even the strain distribution between bands.

METHODS: Two graft preparations were compared for differences in band strain distributions and final biomechanical properties between a described UST graft preparation technique and a supplemented, SST, technique which secures the inner bandss of the graft to the tibial suspensory fixation. Right-left matched pairs of peroneus longus tendons from 8 cadavers were prepared according to the technique described by Lubowitz with one side UST and the contralateral side SST. The constructs were tensioned on an Instron E3000 while strain was monitored with DVRT's on the inner and outer bands during step load levels easily obtained during intra-operative preconditioning, 20 N, 40 N, 60 N and 80 N. Following the preconditioning cycles, the constructs were loaded in tension to failure. Measures were compared using paired Student's t test.

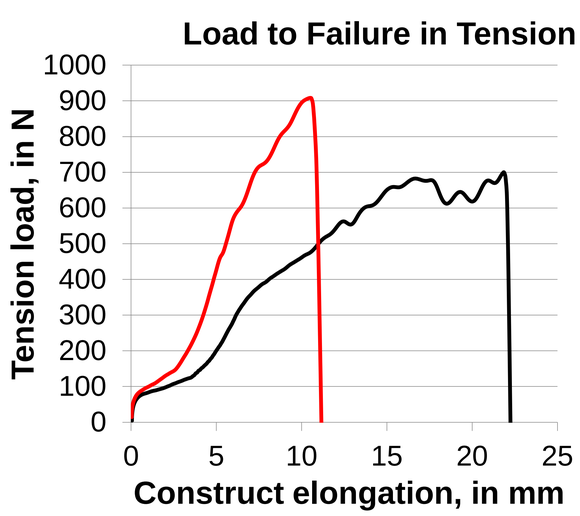

Figure 1: Tension test of the constructs, left. Right, 1 matched pair showing the effect of inner band slippage in black UST v red SST.

RESULTS: There was no load level that created a statistically significant improvement of even strain between the 4 bands of the QST preparations. The strain levels in the outer bands of all QST preparations were significantly greater than the inner bands and there was a trend for the SST preps to have greater strain in the inner bands compared to the UST. Less graft elongation at failure was observed for the SST, 3.1 ± 1.5 mm versus UST, 21.0 ± 21.2 mm , P=0.052. The number of grafts undergoing a 5 mm or greater change in length at failure was 1 of 8 in the SST versus 5 of 8 in the UST, P=0.038. Ultimate load to failure was significantly higher in the SSTs, 797.5 N ± 49.6 N versus UST, 719.6 ± 69.6 N, P=0.0442. Failures of these preparations occurred in the sutures, not in the graft itself.

DISCUSSION: The loading and measurements in this study only attempted to simulate things under the control of the surgeon during graft preparations in an attempt to create more even load sharing in the bands of the construct. No attempt was made to evaluate the biomechanical function of the graft after implantation.

CLINICAL SIGNIFICANCE: The weak point of a single tendon quadrupled ACL graft construct is the tendon to tendon suturing to secure the inner bands of the graft. Adding supplemental fixation by incorporating the sutures from the inner band to the tibial fixation leads to a higher load to failure and decreases graft elongation at load levels expected during graft preparation and preconditioning.

REFERENCES1.Hamner DL, Brown CH, Jr., Steiner ME, Hecker AT, Hayes WC. Hamstring tendon grafts for reconstruction of the anterior cruciate ligament: biomechanical evaluation of the use of multiple strands and tensioning techniques. *J Bone Joint Surg Am.* 1999;81(4):549-557. 2. Lubowitz JH. All-inside anterior cruciate ligament graft link: graft preparation technique. *Arthrosc Tech.* 2012;1(2):e165-168.

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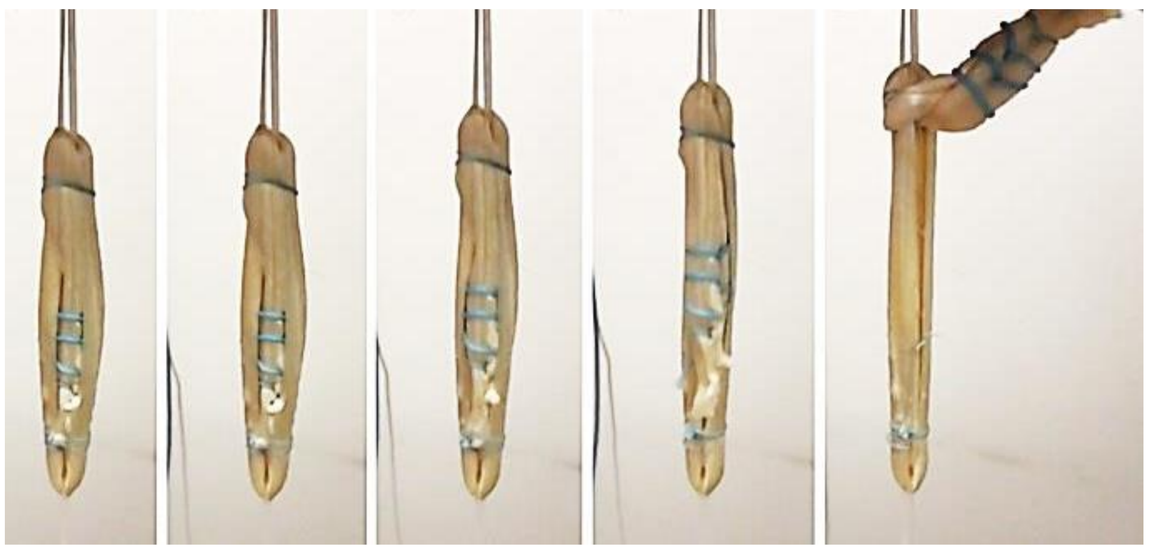

Figures2a-e: Construct failure from start of load (a), slippage of the inner bands (b-d), and failure (e) in a UST specimen