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A comparison of lateral ankle ligament suture anchor strength

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ABSTRACT

Background: Lateral ankle ligament repairs increasingly use suture anchors instead of bone tunnels. Our purpose was to compare the biomechanical properties of a knotted and knotless suture anchor appropriate for a lateral ankle ligament reconstruction.
Methods: In porcine distal fibulae, 10 samples of 2 different PEEK anchors were inserted. The attached sutures were cyclically loaded between 10 N and 60 N for 200 cycles. A destructive pull was performed and failure loads, cyclic displacement, stiffness, and failure mode recorded.
Results: PushLock 2.5 anchors failed before 200 cycles. PushLock 100 cycle displacement was less than Morphix 2.5 displacement ($p < 0.001$). Ultimate failure load for anchors completing 200 cycles was 86.5 N (PushLock) and 252.1 N (Morphix) ($p < 0.05$). The failure mode was suture breaking for all PushLocks while the Morphix failed equally by anchor breaking and suture breakage.
Conclusions: The knotted Morphix demonstrated more displacement and greater failure strength than the knotless PushLock. The PushLock failed consistently with suture breaking. The Morphix anchor failed both by anchor breaking and by suture breaking.

1. Introduction

Lateral ankle ligament repairs increasingly use suture anchors instead of bone tunnels [1–4]. While interference screws have been used in the past [5], suture anchors have gained in popularity. Both conventional suture anchors which require knot tying and knotless anchors are appropriate. A difference may exist in clinical outcomes for repairs performed using a knotless anchor and a knotted anchor because of the prominence of a tied knot in the subcutaneous environment. While single pull load to failure strength testing provides one element of an anchor's properties, the anchors used in these ankle ligament repairs are actually subjected to multiple, sub maximal cyclic loads, especially during the postoperative rehabilitation phase. Biomechanical testing of suitable ankle anchors with sub maximal cyclic loads is needed to provide data to help the surgeon in deciding what construct to use clinically.

The introduction of ultra high molecular weight polyethylene (UHMWPE) containing suture has significantly changed tissue repair strength and performance. Not only are these sutures much stronger than conventional braided polyester suture but they demonstrate a greater tendency to slip at submaximal loads prior to outright failure [6,7]. This has implications on how to effectively fix the suture–anchor–tissue construct. An effective suture locking mechanism becomes important. Suture locking mechanisms can be internal (within the anchor), by compression of the suture between the side of the anchor and the adjacent bone, or external to the anchor such as a tied knot. A knotless anchor does not rely on a knot for security. Instead it relies on either internal locking or compression between the bone and the anchor for suture fixation.

The hypothesis of this study was that knotless anchors and knotted anchors would perform differently during cyclic loading in a lateral ankle reconstruction model. The purpose of this study was to compare the biomechanical properties of a knotted and knotless suture anchor appropriate for a lateral ankle ligament reconstruction.

2. Methods

Fresh adult porcine lower legs were obtained from a local abattoir. Porcine bones were used because of their availability and because several recent studies have been based in the porcine model [7–10]. The bones were stripped of soft tissue and prepared for anchor insertion at the site on the distal fibula where a Brostrom ankle reconstruction would be performed. Two different anchor types (one knotless and one knotted) were chosen for testing: Arthrex PEEK 2.5 PushLock knotless anchor threaded with No. 2-0 FiberWire suture (Arthrex Corp, Naples, FL) and the Morphix 2.5 PEEK threaded with No. 2 high strength suture which

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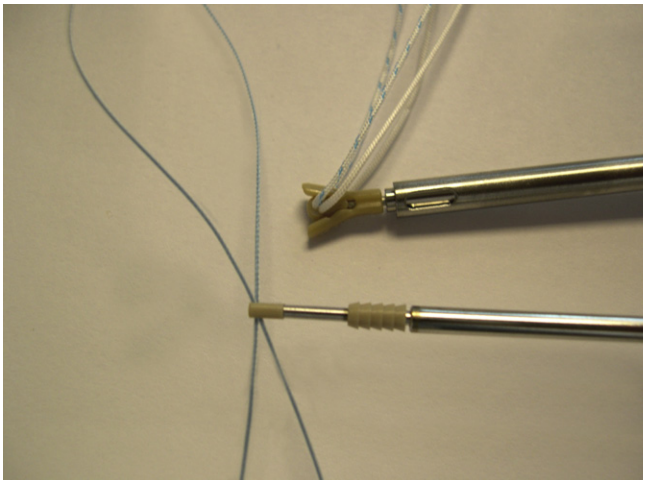

Fig. 1. One knotless and one knotted anchor were chosen for testing. The Morphix 2.5 PEEK anchor is shown on top and the Arthrex PEEK 2.5 PushLock knotless anchor is shown on the bottom.

required knots (MedShape, Atlanta, GA) (Fig. 1). Both anchors are made with polyetheretherketone (PEEK). 10 anchors of each type were used for testing. All anchors were threaded with the ultra high molecular weight polyethylene (UHMWPE) containing suture with accompanied them and which is normally provided by the manufacturer. Two insertion sites (one proximal and one distal) were identified on the distal fibula and both suture anchors were rotated between these two different insertion locations so that an equal distribution was achieved and to decrease the effect of variations in bone quality and density (Fig. 2). These two anchor insertion sites were consistent with those we customarily use for a Brostrom repair. It was also important to place the anchors in good bone and at least 1 cm apart to prevent crack propagation between anchor sites.

An equal number of each anchor was inserted at the two different insertion positions. The anchors were inserted perpendicular to the orientation of the lateral ankle ligaments. All anchors were inserted using the manufactures' instrumentation and recommended technique.

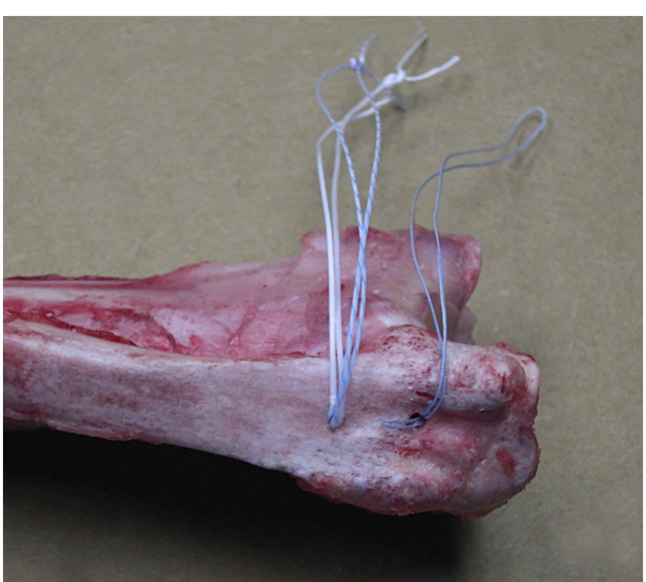

Fig. 2. Two insertion sites were selected to represent the superior and inferior suture anchor placement for a Broström repair.

After anchor insertion, the ankles were placed in a specially prepared open sided aluminum box that supported the bone and the sutures affixed to the actuator arm of a mechanical materials testing machine (model 3345, Instron Corp., Canton, MA). A 1 kN load cell was used in the Instron machine to allow adequate resolution of the data. The sutures from the anchors were secured to the actuator arm using a suture holding device and positioned with a standard suture gauge length. The sutures were secured so they were at a 45° angle to the line of anchor insertion to represent the loads exerted on the anchor during and after a Brostrom ankle repair. The sutures were secured in such a manner that the tied knots were not subjected to loading, only the suture material itself. Therefore any variability in knot tying did not influence the failure strength.

All constructs were pre-loaded to 10 N at 1 N/s. The pre-load was held for 5 s and then the constructs were cycled from 10 N to 60 N at 0.5 Hz for 200 cycles. Post cycling, a single cycle pull to failure (monotonic) was conducted at 33 mm/s.

Study endpoints included: (1) the failure load observed if failure occurred during cycling and the number of cycles the anchor withstood, (2) the displacement at 100 cycles (the displacement between the length after cycle 1 and after cycle 99) and 200 cycles (the displacement between cycle 100 and cycle 200), (3) the ultimate load at failure for those anchors successfully completing all 200 cycles, (4) construct stiffness, and (5) the mode of failure (i.e. anchor pull out, eyelet/suture cut out, or suture breakage).

2.1. Statistical analysis

The sample size of 10 anchors was based on a power analysis using standard deviations for glenoid and hip anchors from other publications [9,10]. This sample size is sufficient to show a significant difference of 50 N given a standard deviation of 30 N. A two way ANOVA was used to examine the affect of anchor type and the affect of anchor position.

3. Results

Only the PushLock 2.5 anchors failed prior to completing all 200 cycles. The failure load for those PushLock anchors which failed at less than 100 cycles was 48.8 N, for those that failed after 100 cycles but before 200 cycles was 91.4 N, and the single sample that completed all 200 cycles failed at 132.2 N.

The displacement at 100 cycles and 200 cycles was recorded. The greatest displacement recorded with the PushLock 2.5 anchors was 0.71 mm. This occurred in the single sample that reached 200 cycles. The mean displacement in the first 100 cycles was 0.42 mm (range, 0.25–0.52 mm). As mentioned, only one sample reached 200 cycles since suture breaking generally occurred between 100 and 200 cycles (6 of 9 tests). The data from one PushLock anchor was lost because of operator error during testing.

The mean displacement for the Morphix 2.5 anchor at 100 cycles was 3.76 mm (range, 2.8–5.37 mm). The mean displacement at 200 cycles was 5.46 mm (range, 4.54–6.82 mm). A comparison of the mean displacement for the PushLock and Morphix anchors demonstrated that the PushLock demonstrated statistically less displacement at 100 cycles than the Morphix anchor ($p < 0.001$).

The ultimate load at failure for those anchors successfully completing all 200 cycles was 86.5 N for the single PushLock 2.5 anchor and 252.1 N for the ten Morphix 2.5 anchors ($p < 0.05$).

The average stiffness for the PushLock anchor was 55.7 N/m and for the Morphix anchor was 74.9 N/m. This difference was not statistically significant.

The mode of failure was observed. The PushLock 2.5 anchor failed by suture breaking in 9 tests. The Morphix 2.5 anchor failed