STRENGTH OF DIFFERENT KRACKOW STITCH CONFIGURATIONS USING HIGH STRENGTH SUTURE

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ABSTRACT

There are many suture methods to repair the Achilles tendon. The current study was performed in Dokuz Eylul University, Department of Biomechanics. Purpose of the present study is to find using high strength sutures, if increasing the number of locking loops with different sized sutures or decreasing the suture size with increased suture strands have any influence on the strength of achilles tendon repair. Thirty-two fresh bovine Achilles specimens were randomly assigned into 4 groups. For 3 of the groups, 1 suture was used (No. 2 or No:5 FiberWire; Arthrex, Naples, FL with 2, or 4 Krackow locking loops). For the last group 2 sutures (No:2-0 FiberWire) with 2 locking loops was used. Following repair, the study groups were subjected to the cyclic loading (0-200N, 200 cycles) and then tensioned to failure in a testing machine (AG-I 10 kN, Shimadzu, Japan). Cyclic elongation (mm), peak to peak displacement (mm), ultimate load (N), stiffness (N/mm), and failure mode were recorded for each specimen. Tendon width and thickness were measured in all specimens. Mean width, thickness, cycle displacement (mm), load to failure (N), pull-out stiffness were not different among the groups. Cyclic peak to peak displacement (0.01±.01mm) were smallest at the No:5 suture with 4 locking loops group ($p<0.05$) with no failure during cyclic loading unlike other groups. 6 of No:2-0 group with 4 strands, 2 locking loops failed during cyclic loading. Number of locking loops may have an influence on the strength of Krackow suture configuration using the larger diameter high strength sutures while decreasing the suture diameter with simultaneous increase of the number of strands failed to improve the initial strength of the repair.

1. INTRODUCTION

Despite much interest in the management of acute tears of the Achilles tendon, there is still considerable debate regarding the best treatment of this debilitating injury. Operative intervention is associated with a lower incidence of rerupture, ranging from 1.4%5 to 2.8%,17 and facilitates earlier functional treatment (1). The Krackow locking loop technique has come into favor in open repairs since 1995 when a cadaver study showed this locking loop repair method to be superior to two other commonly used open techniques, the modified Kessler and the standard Bunnell (2). A recent biomechanical study reported that strength of Krackow configuration increased by increasing the number of strands instead of increasing the number of locking loops. However conventional braided polyester sutures were tested with failure mode of suture rupture (3). High-strength sutures composed either partially or totally of ultrahigh-molecular-weight polyethylene (UHMWPE) show improved biomechanical properties over those of nonabsorbable braided polyester suture (Ethibond; Ethicon, Somerville, NJ) or absorbable monofilament polydioxanone used traditionally in arthroscopic repairs (4,5).

Purpose of the present study was to compare initial biomechanical strength of different configurations of Krackow suture technique using different sized high strength sutures (FiberWire; Arthrex, Naples, FL). Hypothesis was that a No: 5 suture with 2 strands, 4 locking loops will be stronger than No2: suture with 2 strands , 2 locking loops and No

2 suture with 2 strands , 4 locking loops. Additionally No: 2-0 suture with 4 strands and 2 locking loops would be no different than No:2 suture configurations.

2. MATERIALS AND METHODS

Thirty-two fresh bovine Achilles specimens were obtained from a local abattoir. Specimens were frozen and thawed overnight before testing. Sharp dissection was used to remove all muscle tissue and accessory tendon insertions, leaving approximately 15 cm of Achilles tendon and the calcaneal attachment. A tenotomy was made 5 cm above the bony insertion, and the proximal and distal limbs of the simulated rupture were each sutured with running, locking stitches as described by Krackow (6). All specimen preparation and repairs were done in a standard manner by one investigator. Suturing started 0.5cm from the tendon edge and constant 5mm space was kept between the loops. No:2-0, No:2, No:5 polyblend sutures (Fiberwire™, Arthrex, Naples, FL) were used. There were 4 groups as follows: No:2 suture, 2strands, 2 locking loops (2/2S2L), No:2 suture 2 strands 4 locking loops (2/2S4L), No: 5 suture , 2 strands, 4 locking loops (5/2S4L), No:2-0 suture, 4 strands, 2 locking loops (2-0/4S2L). The construct was mounted securely in the jaws of a materials testing system (AG-I 10 kN, Shimadzu, Japanese) around a knot leaving 10 cm of suture from the jaws to the first locking loop (Figure 1).

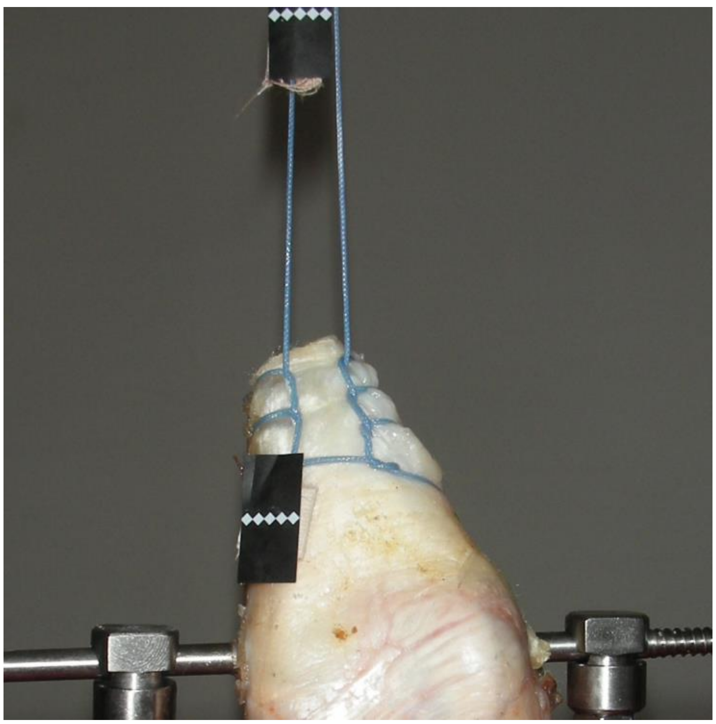

Figure 1: Test set-up.

Each tendon was preloaded to 50 N. Security of the suture fixation was measured by elongation of the suture loop under a 200-N cyclic loading for 200 cycles (8,9). Marking dots were placed on the sutures outside the tendon and on the tendon without any stitch (8,9). Elongation and peak to peak displacement were determined during cyclic testing using video extensiometer (dve-101-201,Shimadzu, Japan). Elongation was the difference in y-displacement between the first cyclic peak and the two hundreth cyclic peak. The average of the displacement of the 198th, 199th, and 200th cycles was defined as peak to peak displacement. After cyclic loading for 200 cycles, each sample was loaded to failure in the displacement control. The extensile rate was set to 200 mm/min. Load (in Newtons) versus displacement (in millimeters) was recorded until failure. Ultimate tensile load was considered to be the peak force. Stiffness was calculated by determining the slope of the load-elongation curve with use of a best-fit line on the load versus displacement curve. Cyclic elongation (mm), peak to peak displacement (mm), ultimate load (N), stiffness (N/mm), and failure mode were recorded for each specimen.
Statistical methods

Kruskal-wallis test was used to detect a difference for variables among groups. When a differecnce was deteceted for a given variable, mann-whitney test was used to compare groups to detect the source of the difference. Statistical significance was set at a p value <0.05.

3. RESULTS

Table 1: Groups: (No:2 suture, 2 strands, 2 locking loops (2/2S2L), No:2 suture 2 strands 4 locking loops (2/2S4L), No: 5 suture 2 strands 4locking loops (5/2S4L), No:2-0 suture 4 strands, 2 locking loops (2-0/4S2L)).

Groups	Width (mm)	Thickness (mm)	Cyclic displacement (mm)	Peak to peak displacement (mm)	Load to failure (N)	Stiffness (N/mm)
2/2S2L	15±0.9	9±0.7	2.7±1	0.07±.08	305±73	47±21
2/2S4L	16±0.7	10±1.1	5.2±2	0.2±0.6	319±23	42±6
5/2S4L	16±0.9	9±0.9	5±2	0.01±.01	382±85	37±15
2-0/4S2L	16±1.1	9±0.7	1.9±2	0.3±0.4	254±103	69±32

There were 8 specimens tested at the each group. Mean width and thickness were not different among the groups (p>0.05). Cyclc displacement (mm), load to failure (N), pull-out stiffness were not different between groups (p>0.05). Cyclic peaek to peak displacement (0.01±.01mm) were smallest at the 5/2S4L group compared to other groups (p<0.05). Failure mode was suture rupture at the knot at all of the specimens. 4 specimens at 2/2S2L, three specimens at the 2/2S4L and six specimens at 2-0/4S2L group failed during cyclic loading.

4. DISCUSSION

Main findings of this study were No:5 fiberwire with 4 locking loops and 2 strands had lower peak to peak displacement than other groups and no failure during cyclic testing unlike other groups.

Krackow et al.(6) described a commonly used locking-loop technique and this configuration with no:2 or no:5 sutures is the conventional suture configuration used for large tendon repairs or ligament reconstructions around the knee (3,7). At a recent biomechanical study it was proven that increasing the number of locking loops did not have influence on the initial strength of achilles tendon repair with Krackow stitch however suture used at that study was no:5 ethibond suture which was reported to be weaker than Fiberwire suture at bovine achilles tendon repair model (3,8).

Depending on the cyclic elongation and peak to peak displacement values seem more important than the ultimate load and pull-out stiffness values of the single load to failure testing. At the present study although cyclic elongation was not different among the groups, 5/2S4L group had lower peak to peak displacement and no failure during cyclic testing.

There are some limitations to our study, including the use of bovine specimens, which may not reproduce the size and structure seen in human tendons. In addition, we used a surgical tenotomy in our model of tendon rupture, which allowed for well-standardized repairs but did not recreate the frayed appearance of most traumatic tears. The cyclic load magnitudes used in this study may not reflect the tension placed on tendon repairs in vivo. It has been shown that even with passive range of motion of the ankle, often performed within weeks of surgery; the forces across the Achilles tendon can approach 400 N (9). Increasing number of loops at Krackow stitch may be helpful at larger diameter high strength sutures while increasing the strand number with decrease of the suture diameter did not seem to increase the strength of the repair.

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