Use of Cortical Button Augmentation for Flexor Digitorum Longus Tendon Transfer in Stage II Posterior Tibial Tendon Dysfunction: A Technique Guide and Cadaveric Biomechanical Study.

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Purpose

Stage II Posterior tibial tendon dysfunction with a reducible flat foot is a common clinical presentation that may progress to require surgical correction. Flexor digitorum longus (FDL) tendon transfers are an acceptable surgical treatment in conjunction with additional procedures. To date, there has been no objective biomechanical evaluation regarding the pullout strength of an FDL tendon transfer as well as in comparison to the addition of a cortical button. The FDL muscle belly has been shown to have the ability hypertrophy to carry an increased workload, but the pullout strength has not been evaluated to determine if the strength of the anchor can withstand the required newtons. The authors present a modified fixation technique and cadaveric biomechanical comparison. Nine fresh frozen paired cadaveric specimens were utilized to undergo FDL tendon transfer plus a cortical button in addition to a standard interference screw verse a single interference screw alone. The mean ultimate load increased with the addition of a cortical button from 190 ± 77 N, to 259 ± 66 N that was statistically significant (p= 0.029). Our results demonstrate that the addition of a cortical button to augment the construct appears to have a significant affect in the ultimate load to failure ($p<0.05$).

Methodology

Nine fresh frozen paired cadaveric navicular bones were harvested. Each specimen had a matching flexor digitorum longus (FDL) tendon with muscle belly. The navicular and associated tendon/muscle were adequately inspected for any prior damage during the harvesting process and ensured the matched specimens were paired. There were 9 navicular in the study group and 9 navicular in the control group who underwent an FDL tendon transfer. Group 1 consisted of 9 navicular which utilized a cortical button with a interference screw and group 2 was 9 control navicular which utilized an interference alone. Following implantation each sample was inspected for intra-articular violation as well as if there was any peri-articular overhang. Each sample underwent 100 cyclic loads and results were recorded for ultimate load(N), yield load(N), stiffness(N/mm), and plastic displacement(mm) as well as a load to failure.

Biomechanical testing

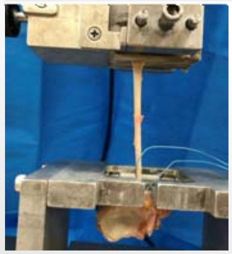
Image 1. Biomechanical testing of the tendon transfer

Nine matched pairs of cadaveric feet (average age = 50 ± 7, 3 male, 6 female) were dissected to isolate the navicular and the flexor digitorum longus tendon. Mechanical testing was performed using an Instron 8871 Servohydraulic Testing Machine (S/N: 8871P7974) with a 1kN load cell (S/N: 40361). A custom freeze clamp and dry ice was used to secure the proximal end of the tendon to the cross-head, and the navicular was held under a metal box fixture, allowing the direction of pull to be directly in-line with the socket.

Samples were loaded between 20 and 60N for 100 cycles at 1Hz. Cyclic loading was followed by a pull to failure conducted at 1.25mm/sec. Load and displacement data were recorded at 500Hz. The mode of failure was recorded at the time of testing. Matched pair t-tests were used to compare the ultimate load and cyclic displacement results for the two repair groups.

Results

There were 3 males and 6 females in each group and laterality was split 5 left and 4 right. The average age was 50 ± 7. Group 1 consisted of the interference screw plus cortical button. Group 2 was the control group with the s interference crew alone. The average ultimate load (N) in group 1 verse group 2 was 259N (171-339) to 190N (43-266) respectively. The average yield load (N) was 227N (126-336) and 172N (43-266) respectively. The average stiffness (N/mm) was 54.2N/mm(28.3- 73.5) and 47N/mm(14.2-71.3) respectively. The average plastic displacement prior (mm) to failure was 1.7mm (0.7-3.6) and 1.6mm (0.4-2.8) respectively. A paired t-test was performed and ultimate load (N) was found to be significant ($p<0.02$). Yield load ($p=0.07$), stiffness (N/mm) ($p=0.3$) and plastic displacement prior to failure (mm)($p=0.9$) were non-significant ($p>0.3$). In group 1 all tendons failed by tearing at the suture interface proximal to the tendon inserting at the bone. No hardware failure was encountered. In group 2, 6 samples failed at the suture interface with 4 displaying the tendon slipping past the bone anchor.

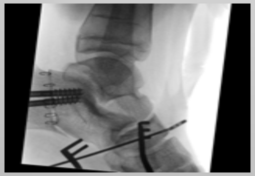
Image 2. intra-operative x-ray of tendon transferred to navicular


Image 3. intra-operative picture of tendon transferred to navicular


Image 4. Post-operative radiographs of proper button placement.

Literature Review

FDL tendon transfer in conjunction with a medial displacement calcaneal osteotomy has been shown to be an adequate stage II PPTD procedure [2, 6]. Rosenfeld demonstrated the ability of the FDL muscle belly to hypertrophy by 27% in cross sectional area on MRI following transfer[7]. Selby et al demonstrated that the size of the interference screw can play a significant role in pullout strength of the tendon being transferred. It was also noted that bone density, dilation, gap size, and screw placement can affect varying strength of the transfer[8]. Weiler et al found that screw length played a more critical role in the success of a tendon transfer opposed to increasing the diameter of the anchor and that this was due to the amount of tendon/bone/anchor interface to allow for incorporation[10]. The findings by Weiler plays a role in the utilization of a cortical button due to their findings regarding the tendon slipping past the anchor and the limited size of the navicular[10, 11].

Cortical button tendon fixation has been well reported in the repair of distal biceps tendon ruptures. In their biomechanical study, Greenberg et al compared the strength of Mitek anchor fixation, conventional bone bridge, and titanium endobutton fixation[15]. The button was 3 times stronger than the bone bridge and 2 times stronger than the Mitek anchor. Utilizing this technique inherently requires less dissection than traditional bone tunnel or interference screw methods. In addition, this technique does not require dorsal navicular visualization, limiting soft tissue stripping and unnecessary devascularization of the bone. Inherently this is presumed to lead to less postoperative pain, lower dehiscence rates, and a decreased risk to the saphenous nerve.


Image 5. intra-operative view of tendon harvested and prepared.

Analysis & Discussion

There is a significant difference noted with the ultimate load to failure in the FDL tendon transfer utilizing a cortical button ($p<0.02$). No anchor or cortical button was noted to be the failure location. At all failure sites the tendon was torn by the suture. There appears to be a statistically significant increase in the ultimate load force with the use of a cortical button as a secondary fixation point with FDL tendon transfers for stage II posterior tibial tendon dysfunction. This construct has the ability to undergo an increased load prior to failure. With the addition of a second point of fixation, if the anchor fails, there is a failsafe to prevent tendon retraction and hardware failure. In the author's opinion, the addition of a secondary point of fixation with a cortical button would assist in preventing the tendon from slipping past the anchor prior to healing and may give surgeons more confidence in the repair. The authors concluded the technique is safe, simple, reproducible and stronger than any currently available anchoring techniques and gives the surgeon a choice in bone preparation. We feel the use of cortical button fixation for FDL tendon provides a similar advantage. The technique, as we have described in this report, has been utilized in a number of cases without complication and the authors plan to report their success in future literature.