FOOT & ANKLE INTERNATIONAL

Tendon Transfer Fixation: Comparing a Tendon to Tendon Technique vs. Bioabsorbable interference-Fit Screw Fixation

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ABSTRACT

Tendon transfer techniques in the foot and ankle are used for tendon ruptures, deformities, and instabilities. This fresh cadaver study compares the tendon fixation strength in 10 paired specimens by performing a tendon to tendon fixation technique or using 7x20-25 mm bioabsorbable interference-fit screw tendon fixation technique. Load at failure of the tendon to tendon fixation method averaged 279N (Standard Deviation 81N) and the bioabsorbable screw 148N (Standard Deviation 72N) [p=0.0008]. Bioabsorbable interference-fit screws in these specimens show decreased fixation strength relative to the traditional fixation technique. However, the mean bioabsorbable screw fixation strength of 148N provides physiologic strength at the tendon-bone interface.

INTRODUCTION

The use of specific tendon transfers is important in the foot and ankle to correct congenital and acquired deficiencies and deformities. The fixation of the tendon to bone can be time consuming and may require lengthening of the tendon. Fixation may also leave hardware that may become prominent and symptomatic. This hardware can also interfere with future diagnostic studies.

The results of this study demonstrate that the use of a bioabsorbable interference screw to anchor transferred tendons in the foot and ankle is a reproducible technique of tendon fixation. The goal is to provide stable fixation that maintains the tendon in the operatively placed position in a manner that is time efficient and minimizes the placement of nonabsorbable foreign bodies in the foot and ankle.

There is a wealth of data on the use of bioabsorbable interference screws in knee reconstructive surgery.[5,6,7] Tendon transfer in the foot and ankle has been continually developed in treating various ankle instabilities and insufficiencies. Other forms of fixation include passing the tendon through an osseous tunnel with suturing of the tendon to itself or to a button on the outside of the tunnel. Recent advances in arthroscopic technique of the knee have led to the development of an interference screw for fixation of anterior cruciate ligament reconstructions, specifically concerning the femoral tunnel to graft interface. Initially, titanium interference screws (7x25 mm, Linvatec) were developed with subsequent complications of graft laceration,[5] difficulty with revision surgery, and interference with further MRI studies.[7] Further research introduced biodegradable interference screws (7x25 mm poly-l-lactide acid, self-tapping, Linvatec) with recent improvement to second-generation biodegradable screws requiring less torque on insertion.[6] It has been shown that the Instrument Makar PLGA bioabsorbable screw is completely eliminated in six months with MRI.[3]

The purpose of this study was to compare the load at failure and method of failure of a tendon to tendon fixation technique vs. bioabsorbable interference-fit tendon fixation technique. It is hypothesized that a similar load to failure will be noted independent of the method of failure between the tendon to tendon and the bioabsorbable screw to tendon fixation techniques.

MATERIALS AND METHODS

Ten pairs of fresh cadaver foot and ankles were used after thorough initial anatomic evaluation for scars and gross anatomic deformity. All lower extremity specimens had bone densitometry performed using a Hologic QDR 4000 DEXA Scanner prior to manipulation to document variations in bone quality between specimens.

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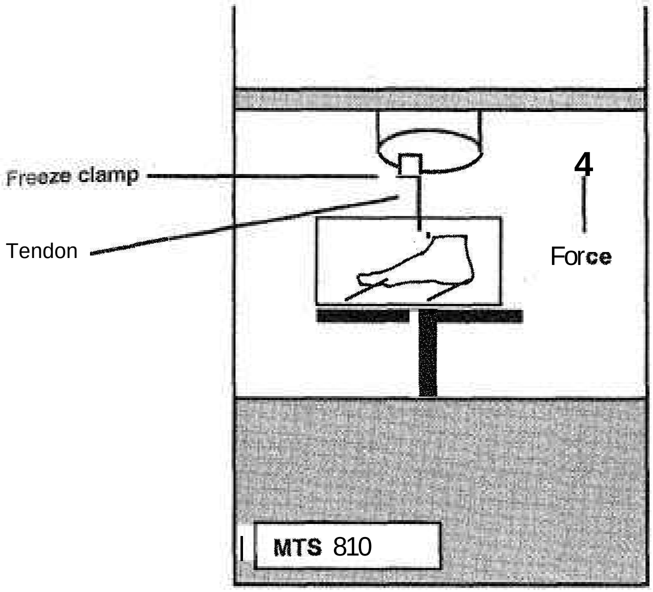

Fig. 1: The tendon is attached to the testing ram of the material testing system though a freeze clamp. The cadaver specimen is anchored to the system base through smooth wires placed in the calcaneus and first metatarsal.

Tendon to Tendon Technique

Out of each pair of specimens, one had a tendon to tendon transfer intervention by transferring the Flexor Digitorum Longus (FDL) tendon to the tarsal navicular. This was performed by drilling a 6.4 mm bone tunnel through the tarsal navicular and passing the tendon through to the medial side where the end distal to the tunnel was sutured to tendon proximal to the tunnel using figure of eight stitches with 1 PDS-II (Ethicon, Somerville, NJ). The tendon was also sutured to the surrounding periosteum in similar fashion. The tendon was then exposed proximally and transected at the myotendineous junction.

Bioabsorbable Technique

The contralateral specimen had the FDL tendon transferred into a 6.4 mm x 25 mm (minimum) bone tunnel in the navicular. The bone tunnel was created using a 6.4 mm drill (Arthrotek, Warsaw, IN). The distal tendon end was placed into the bone tunnel to a depth of 25 mm, pre-marked in ink on the tendon. A 1.5 mm Nitinol guide wire (Arthrotek, Warsaw, IN) was then placed beside the tendon in the bone tunnel. A 7x25 mm bioabsorbable interference-fit screw (Arthrotek, Warsaw, IN) was placed in five specimens and a 7x20 mm bioabsorbable interference-fit screw (Arthrotek, Warsaw, IN) was placed in the remaining five specimens. Each cannulated screw was placed over the guide wire and advanced using a screwdriver (Arthrotek, Warsaw, IN) until the head was buried. The screwdriver and guide wire were then removed. The tendon was exposed proximally and transected at the myotendineous junction.

The bioabsorbable interference-fit screws are a copolymer composed of 82% L-lactic acid and 18% glycolic acid. The screw is amorphous with complete resorption by 17 months.[1]

Testing

The foot and ankle specimens were fixed with smooth wires through the calcaneus and the first metatarsal to a machine jig (Fig. 1). Together, the specimen and jig were placed in the loading ram of the MTS Machine Testing System 810. The free proximal end of the FDL tendon was attached to the load cell using a freeze clamp. Tensile testing of each specimen using the computer controlled, servo-hydraulic materials tester was performed at a uniform rate of 1 mm/sec until failure of fixation or tendon rupture occurred. A paired two-tailed student's t-test was used to evaluate the data.

RESULTS

Bone Mineral Density

Average Bone Mineral Density for the traditional tendon fixation technique specimens was 0.32 g/cm^2, while for the bioabsorbable interference-fit screw technique it was 0.34 g/cm^2. A repeatability study was performed on the cadaver DEXA scanning technique which showed a coefficient of variation = 2%. Student's t-test showed no statistical significance between cadaver specimen matched pair results ($p=0.29$).

Mode of Failure

The mode of failure for the traditional tendon fixation group was 4/10 bone tunnel fracture, 4/10 tendon suture interface, 2/10 tendon mid-substance.

The mode of failure for the bioabsorbable interference-fit screw group was at the tendon-screw interface for all specimens.

Pullout Strength

The average pullout strength of the tendon to tendon fixation technique was 279N (Standard Deviation 81N) (Fig. 2) and for the bioabsorbable group 148N (Standard Deviation 72N) (Fig. 3) [$p=0.0008$]. One specimen was removed from the study due to technical errors.

The average pullout strength for the 7x20 mm bioabsorbable screw was 161N (Standard Deviation 65.2N) and for the 7x25 mm bioabsorbable screw 130N (Standard Deviation 85.6N) [$p=0.56$].

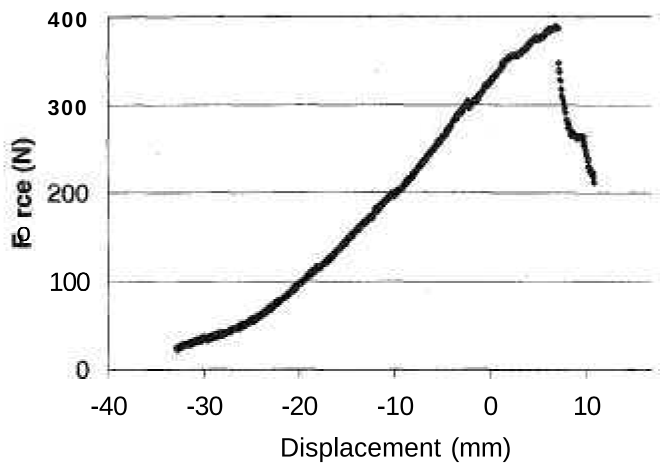

Fig. 2: Load displacement curve for tendon to tendon fixation.

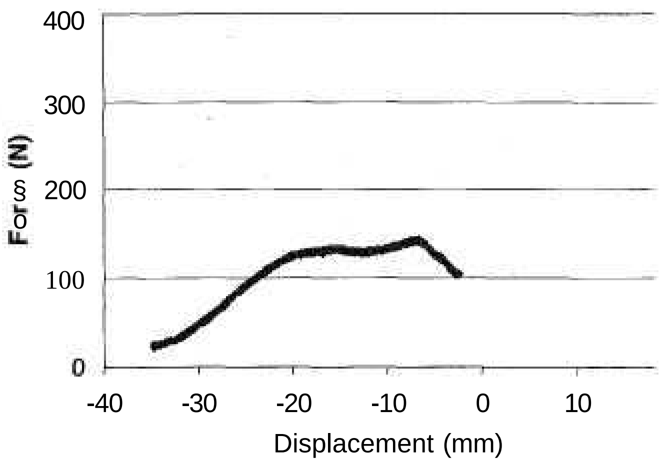

Fig. 3: Load displacement curve for bioabsorbable screw fixation.

DISCUSSION

The pullout strength of the tendon to tendon fixation technique is significantly greater than the pullout strength of the bioabsorbable interference-fit screw fixation technique in this cadaver study. The minimum required pull out strength for *in vivo* tendon to bone healing correlating with this cadaver model has not been determined and may be satisfied with bioabsorbable interference screw fixation. All fixation failures for the bioabsorbable interference-fit screw group occurred at the tendon screw interface. In vivo results may be different secondary to reactive edema and hemorrhage into the tendon and surrounding bone resulting in a closer initial interference fit. The resulting changes in the mechanical and bioabsorption properties of the fixation are not known.

The benefits of using a bioabsorbable screw can include decreased operative dissection, a completely resorbed implant,[8] and no interference with follow up studies. The goal would be to achieve stable fixation for six weeks at which time type III collagen fiber interconnections between tendon and bone should be established.[4]

There were several confounding variables experienced during testing. The innate tendon strength between specimens may affect pullout strength. It is presumed that using matched pairs reduced the inter-cadaver variability. The angle of pull on the tendon by the material testing system may not be similar to physiologic forces. However, this variable remained constant throughout specimen testing. To minimize screw variability, all screws originated from the same manufacturer and the same production lot. Bone mineral density did not significantly affect pullout strength between matched pair results, although this may be an important variable in larger studies.

CONCLUSION

Bioabsorbable interference-fit screws in these cadaver specimens show statistically decreased fixation strength relative to the tendon to tendon fixation technique. The technique of screw insertion is quickly mastered and can be repeatedly reproduced.

Further biomechanical testing and the initiation of prospective, randomized clinical studies using bioabsorbable interference-fit screws are forthcoming.

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