

# EFFECT OF TWISTING HAMSTRING TENDON GRAFTS ON FAILURE LOAD AND JOINT LAXITY THROUGH THE RANGE OF KNEE MOVEMENT

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**Introduction:** Anterior cruciate ligament (ACL) injury is often treated by reconstructing the ligament with multi-strand hamstring tendon grafts. Some surgeons advocate twisting or braiding the tendon strands together rather than using the standard parallel strand configuration. Although braided and twisted configurations were initially believed to be stronger and stiffer than parallel configurations, mechanical tests in animal tendons have shown that parallel tendon grafts are strongest and stiffest [1,2]. To ensure repeatable results, these mechanical tests have been performed with the load shared equally between the tendon strands. However, load sharing in the different fascicles of the intact ACL depends on knee flexion angle [3], and it is reasonable to assume that load sharing in multi-strand grafts will also depend on knee position. Because they require equal strand tension, the tensile tests do not simulate physiological load conditions through the range of knee movement and the results of these tests may not be an accurate representation of graft behaviour in the loaded knee.

The aim of this study was to determine whether twisting a hamstring tendon graft increases the joint laxity and the maximum force at failure under physiological loading conditions.

**Materials and Methods:** We used a mathematical models to predict the laxity of twisted and parallel hamstring tendon grafts produced by simulated anterior loads on the tibia through the range of knee flexion. The models (developed using Matlab version 5.3 software) are based on Zavatsky's model of passive and loaded behaviour of the intact ACL [3].

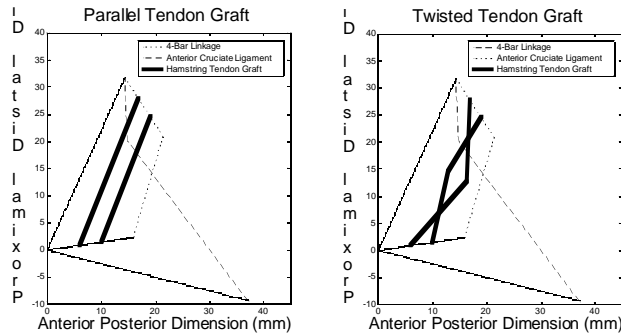


Figure 1. Geometric models of parallel and twisted tendon grafts.

Each graft was modeled in the sagittal plane using two tendons. Line elements were used to represent the centerline and extents of each tendon. The twisted graft was modeled using a single twist and a force balance was used to calculate the position of the intersection of the two strands.

To predict tendon lengths at a given flexion angle, the position of the tibia relative to the femur in passive (unloaded) flexion was determined using the four-bar linkage made up of the tibia, femur and the isometric fascicles within the ACL and the PCL [3]. Displacement of the tibia from this position under anterior load was then simulated by displacing the femoral insertion of each graft posteriorly with respect to the tibia. Tendon lengths were determined for 1mm increments of displacement up to 10mm.

The strain in each tendon was calculated using a nonlinear relationship that compares the deformed length of the tendon to its reference length. A nonlinear constitutive relationship was then used to calculate the stress in each tendon.

A drawer test was simulated to determine the joint laxity under a 100 N anterior load. In this test the horizontal components of tension in the tendons were summed to determine the anterior loading profile as the tibia was displaced. Laxity was then defined as the anterior displacement required for the graft to balance the external anterior load. These physiological loading conditions were studied for twisted and parallel strand grafts between 0° and 100° of flexion.

**Results:** From 0-40° of flexion, laxity values were more or less independent of the tendon configuration and the flexion angle at which the load was applied (Figure 2). Above 40° the laxity for both graft configurations increased to a maximum and then decreased slightly. The twisted tendon graft produced higher joint laxity than the parallel tendon graft at high flexion angles. The difference in laxity between the two configurations was a maximum of 26% at 85° of flexion.

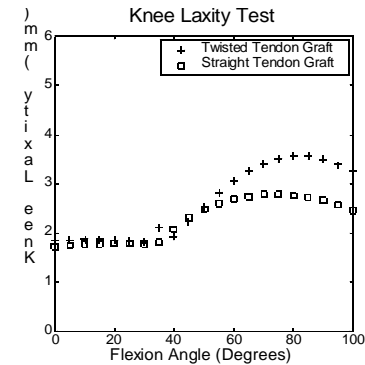


Figure 2. Anterior Laxity vs. Flexion Angle

The parallel tendon graft was able to support was more anterior load than the twisted tendon graft between 40-80° of flexion (Figure 3). The maximum difference between the failure loads was 28% at 65° flexion. Outside of this range the maximum anterior load increased with flexion angle and was comparable for the two graft orientations.

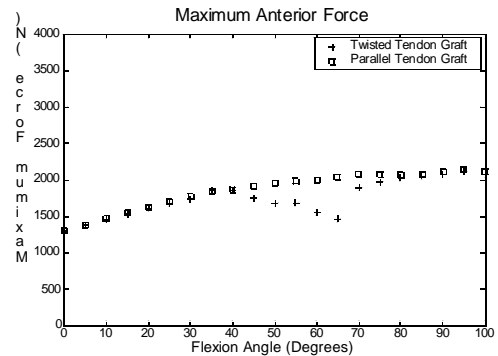


Figure 3. Maximum Anterior Load vs. Flexion Angle

**Discussion:** Twisting the strands of a hamstring tendon graft reduces the maximum failure load and increases the joint laxity under physiological loading conditions. This supports previous studies using human and animal tissue which recommend against braiding or twisting hamstring tendon grafts [1,2]. Some advantages of the current study are that the physiological loading of the joint is simulated in finding the maximum failure load, and joint laxity is calculated, which allows for comparison with clinical measures of joint stability. The primary limitation of this study is that it models three dimensional joint motion of a three dimensional structure in only two dimensions.

These results suggest that twisting or braiding graft strands may have a detrimental effect *in vivo* that is not evident in tensile test.

- References:**
1. Nicklin *et al* ORS 2000 p. 296.
  2. Kim *et al* ORS 2002.
  3. Zavatsky *et al*: *J MechE Part H*: 125-145, 1992.

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