TWISTING AND BRAIDING REDUCES STRENGTH AND STIFFNESS OF HAMSTRINGS GRAFTS USED FOR ACL RECONSTRUCTION

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Introduction
Anterior cruciate ligament (ACL) injuries are among the most prevalent knee conditions requiring surgical repair. In widely-used repair techniques, the ACL is reconstructed with a doubled gracilis-semitendinosus tendon (DGST) graft. Many surgeons braid or twist the tendon strands in an apparent effort to improve graft strength and stiffness.

Studies of animal tendons have not yielded clear conclusions about how graft configuration affects stiffness and strength. A recent study of sheep tendons [1] showed that two different braiding techniques reduced failure load by 47% and 57%, respectively, from the parallel strand configuration. Braiding reduced stiffness by 82% and 85%. In a study of calves’ tendons [2], braiding and twisting did not affect failure load significantly. Braiding reduced stiffness by about 30%, while twisting had no effect on stiffness.

The effect of braiding and twisting on graft strength and stiffness has not been assessed using human tendons. Our objective was to determine whether twisting and braiding the strands of human hamstring tendons decreases graft strength and stiffness with respect to the parallel configuration.

Methods
We harvested gracilis and semitendinosus tendons in an open fashion from 24 pairs of unembalmed cadaver knees that had been stored frozen until one day prior to testing. The cross sectional area of each thawed tendon was measured at two separate locations along its length with an area micrometer. Prior to testing, the temperature of the graft midsubstance dropped below 13°C. After preconditioning, the 75 N load was reapplied. The tendons were then tested to failure at a strain rate of 100% elongation per second when the temperature of the graft midsubstance dropped below 13°C. The site and mode of failure were recorded. Failure load and stiffness were determined from load-elongation curves using custom data acquisition software.

We compared failure load and stiffness between paired parallel strand grafts and braided grafts. In twelve of the knee pairs, we tested the graft made from the tendons of one of the knees in a braided configuration, while a graft made from the tendons of the contralateral knee was tested in a parallel strand configuration. We tested whether failure load and stiffness were significantly different between parallel strand and braided grafts with the Student’s t test.

We also compared failure load and stiffness between parallel strand grafts and twisted grafts. In twelve of the knee pairs, we twisted the strands of the graft made from the tendons of one of the knees by rotating one of the clamps by one half turn (180°) about the axis of the graft, while a graft made from the tendons of the contralateral knee was tested in a parallel strand configuration. We tested whether failure load and stiffness were significantly different between parallel strand and twisted grafts with the Student’s t test.

Results
Braiding tendons decreased the mean failure load by 46% (p<0.01) and the mean graft stiffness by 54% (p<0.01) (Figure 2). Twisting tendons decreased the mean failure load by 26% (p<0.01) and the mean graft stiffness by 43% (p<0.01) (Figure 2). Tendon cross-sectional areas were not significantly different between testing groups.

Discussion
Braiding or twisting four-strand human hamstring tendon grafts significantly reduces initial graft strength and stiffness. This supports and adds to previous work that used animal tissue [1,2]. The advantages of the current study are that 1) we have tested human hamstring tendons, 2) we have taken care to pretension the grafts to ensure rupture at the midsubstance, and 3) we have simulated the geometry of the femoral and tibial bone tunnels in our test grips. A limitation of all tensile testing to failure is that it does not simulate the changing graft geometry and strand load distribution as the knee flexes.

We recommend against braiding or twisting hamstring tendon grafts for ACL reconstruction because they significantly reduce graft strength and stiffness.

References
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