LOCAL MECHANICAL PROPERTIES OF HUMAN HAMSTRING TENDONS FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTIONS: IS THERE A 'WEAK LINK'?

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After anterior cruciate ligament (ACL) rupture, reconstruction is often required to restore knee stability, with the hamstring tendon autograft as most widely used strategy. Dependent on the required graft length and diameter, either a semitendinosus tendon alone or combined with a gracilis tendon is folded into a multiple-strand structure, and positioned at the original anatomic insertions of the ruptured ACL. Despite overall good results, ACL graft rupture occurs in up to 10% of patients. Besides that, excessive joint laxity, due to e.g., plastic graft deformation, can lead to joint instability. These issues imply the mechanical properties of one or more strands in the graft to be insufficient for its new function. Regional differences in viscoelastic mechanical properties within one tendon and between the semitendinosus- and gracilis tendon have been described before, but it remains unknown whether these variations make specific regions potential weak spots in an ACL graft. Therefore, this research aimed to determine local mechanical properties of human semitendinosus and gracilis tendons, in order to identify potential mechanically inferior tissue regions. Such regions contribute to graft diameter, but could attenuate graft mechanical performance, and should be avoided if possible when selecting a graft configuration.

In total twelve full-length human semitendinosus- and gracilis tendons, remnant tissue from ACL reconstructions, were obtained. In addition, full-length semitendinosus- and gracilis tendons from six cadaveric specimens were obtained to compare both tendons from the same leg. In order to assess the viscoelastic properties, all tendons were subjected to a stress relaxation test, i.e. a ramp to 6% strain at 100% strain/min, followed by 20 min stress relaxation. Global force data as well as local displacements and strains were calculated, using a speckle pattern tracking, and compared between full-length tendons and tendon regions (representing graft strands).

The largest local displacements and strains were observed at the myotendinous junction side and could predominantly be ascribed to (plastic) tendon fascicle sliding. No other major differences in local strains between full-length tendons and regions within one tendon were observed. The ratio of peak force to force decay and the time constant of force decay were similar for the semitendinosus- and gracilis tendons from the same cadaveric leg, although absolute forces – and therefore stiffnesses – in semitendinosus tendons were 2-3 times higher. In all investigated tendons, the myotendinous junction displayed the largest (plastic) deformation, potentially making this region the most susceptible to excessive graft- or strand laxity. The obtained results will be used to compare the mechanical properties of various common ACL graft configurations. The gracilis tendon is currently used to reinforce a semitendinosus tendon graft to achieve sufficient graft length and diameter, and displayed similar general mechanical behavior as the semitendinosus tendon. Therefore, it might be mechanically favorable to include a gracilis tendon proper over a semitendinosus myotendinous junction to prevent plastic deformation, but this needs to be determined.