The Influence of Graft Type on Graft-Tunnel Motion During Gait After Hamstring or Bone-Patellar Tendon-Bone Autograft ACL Reconstruction

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Disclosures:

Introduction: Graft-tunnel healing following ACLR is a complex process that is influenced by multiple surgical variables, including graft type, tunnel placement, fixation method and relative graft/tunnel size. Although in vivo clinical outcomes between hamstring and bone-patellar tendon-bone (BTB) grafts are similar, animal studies suggest that the rate and characteristics of the healing process may differ between bone plug and soft tissue grafts. Moreover, little is known about the relationship between graft-tunnel motion and healing process in vivo in humans. Therefore, the purpose of this study was to compare within-tunnel graft motion between BTB and hamstrings autografts in patients 6 weeks (and eventually 1 year, to be reported after long-term follow-up is completed) following reconstruction. We hypothesized that motion between the grafts and the bone tunnels would be greater with hamstrings grafts than with BTB grafts, due to slower healing between soft-tissue and bone.

Methods: Following IRB approval, 16 subjects (8 hamstrings, 8 BTB grafts) were recruited from our sports medicine clinic. All subjects underwent anatomic single-bundle ACL reconstruction by the same surgeon, using uniform tunnel placement techniques and fixation (endobutton for femur, screw/washer for tibia). At time of surgery, six 0.8 mm tantalum beads were implanted in the ACL graft using a custom bead injector. Two beads were placed in proximal and distal ends of the graft (within-tunnel), and two were placed mid-substance (approximately 1 cm from each tunnel aperture) as shown in Figure 1. Six weeks following surgery, computed tomography (CT) scans of the operative limbs were obtained. Dynamic stereo x-ray (DSX) images were collected at 100 frames/s while subjects walked on an instrumented treadmill at 1 m/s. 3D femur and tibial bone models were generated from the CT images, and graft tunnel directions were determined by fitting cylinders to the 3D bone tunnels. Tibiofemoral kinematics from footstrike through loading response were recorded by combining CT scan based 3D models with DSX data, using previously validated methods (precision ±0.1mm [4]). Graft-tunnel motion was determined by measuring the maximum displacement of the implanted beads relative to the surrounding bone along the direction of the bone tunnel during early to mid-stance phase of gait (0-20% of the gait cycle). Graft strain was estimated from the maximum percent increase in 3D distance between the two mid-substance beads, relative to the bead-to-bead distance immediately prior to heelstrike. Hamstrings and BTB graft-tunnel motion (tibia and femur) and mid-substance strain were compared using t-tests, with a significance level of p < 0.05.

Results: Data are currently available for 6 BTB and 5 hamstring grafts (one hamstring group patient was excluded due to insufficient DSX data for processing and one BTB group patient is missing strain data due to a malpositioned mid-substance bead). For the femoral tunnel, the BTB group (n=6) had 1.66 ± 0.85 mm (mean ± s.d.) of graft-tunnel motion and the hamstring group (n=5) had 0.99 ± 0.18 mm of motion (n.s.; p=0.12). For the tibial tunnel, the BTB group had 1.05 ± 0.33 mm, as compared to 1.28 ± 0.53 mm in the hamstring group (n.s.; p=0.42). The maximum mid-substance strain was 1.40 ± 1.68% for the BTB group and 1.92 ± 2.35% for the hamstring group (p=0.70).

Discussion: Six weeks following ACLR, there was no significant difference between tibial or femoral tunnel motion or mid-substance strain between the two graft types. Considerable variability in both tunnel motion and strain were observed across subjects. While the source of this variability is unknown, it could be related to differences in initial graft tensioning or protective neuromuscular adaptations that might shield the ACL graft from high loading during this early time point. EMG and lower-limb kinematics data (collected as part of the study) will be analyzed to investigate this latter possibility. Limitations include a relatively small sample size and an activity (gait) that may not have adequately loaded the ACL to detect meaningful graft motion and strain. Additional 6-week data collected during a higher-load activity (stair ascent) has yet to be analyzed, and may yield more significant results. Subjects will be retested at one year to quantify changes over time, with the expectation that tunnel motion should decrease due to graft-tunnel healing. The 1-year test will also include a higher-demand task (downhill running). Results could have important implications for graft selection, post-surgical rehabilitation and timing for return to sports.

Significance: This is the first study reporting both graft-tunnel motion and mid-substance graft strain in vivo in humans during a dynamic, functional activity. Though no differences between grafts were detected at this early time point (6 weeks after surgery), this method has promise for assessing graft healing, and effects of rehabilitation and timing of return to sports on dynamic graft function.
Six tantalum beads were implanted into the ACL grafts of subjects at time of surgery to quantify strain.

References:

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