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The ACL Graft Inclination Angle Effects in In Situ Force

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Summary:
Anatomic ACL reconstructions have lower graft inclination angle and higher in situ forces than non-anatomic reconstruction, which could contribute to early graft failure if individuals participate in strenuous activities that load the ACL. Because of this, specific rehabilitation protocols are needed to minimize the risk of early graft failure.

Abstract:
Introduction:
The purpose of this study was to determine the relationship between inclination angle of the ACL graft, as measured by MRI and in situ graft force following ACL reconstruction.
Methods:
MRI and CT images were obtained from twelve intact cadaveric knees. The cadaveric knees were then subjected to loading in a robotic system. Loading was performed with the native ACL intact and after section of the ACL. Loading conditions were as follows: 1) A 89N anterior tibial load at 0°, 15°, 30°, 45°, 60° and 90° of flexion and 2) a combined rotatory load of 5N/m internal tibial torque and 7N/m valgus torque at 0°, 15° and 30° of flexion. ACL reconstruction was then performed with an anatomically located tibial tunnel with three different locations of the femoral tunnel:: 1) center of the femoral insertion site (MID); 2) “high” femoral tunnel (S1) and 3) “higher” femoral tunnel (S2). The order of the femoral tunnel location was randomized. After each reconstruction, the knee was tested using the same loading protocol described above. In situ graft forces were calculated. After each reconstruction, the MRI was repeated to document the graft inclination angle and a 3D CT scan was obtained to verify tunnel position after all tests.
Results:
Only MID reconstruction (51.58° ± 4.05°) restored the ACL inclination angle to normal (51.67° ± 4.96). S1 (58,75° ± 5.39) and S2 (64.67° ± 6.52) had mean inclination angles that were increasingly higher than native ACL.
From 0° to 30° of knee flexion, the MID reconstructions had higher in situ graft forces than S1 and S2 and were closer to the native ACL for all torques applied and without statistical difference at 15° (p=0.761) and 30° (p=0.195) for simulated pivot shift and at 0° (p=0.830) for ATT loads. For S1 and S2 under ATT loads at knee flexion angles greater than or equal to 45°, in situ forces were increasingly higher and closer to native ACL condition. S2 reconstructions showed no statistical difference compared to intact ACL at 90° (p=0.393). A negative correlation was found between inclination angle and in situ force for all degrees of knee flexion under pivot shift loads and at 0° and 15° of flexion under ATT torque.
Discussion and conclusion:
Anatomic ACL reconstruction exposes the graft to higher loads at lower degrees of knee flexion (the majority of knee movements in sports) than non-anatomic ACL reconstruction, which could increase the risk of failure in the early rehabilitation phase when the healing process is still not complete.
Specific rehabilitation protocol accounting for the higher in situ forces in anatomic ACL reconstruction should be

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developed to avoid early graft failures.