Anteromedial and Posterolateral Graft Kinematics of a Double Bundle ACL Reconstruction: a 3D Computer Simulation Analysis

Xudong Liu, MD,1,2, Jing-Sheng Li, PT, MS,1, Ali Hosseini, PhD,1, Thomas J. Gill, MD,1, Guoan Li, Ph.D1.
1Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA, 2Shanghai Sixth People’s Hospital Affiliated to Shanghai JiaoTong University, Shanghai, China.

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Introduction: The grafts of a double bundle ACL reconstruction were reported to prone to rupture at the femoral and mid-substance sides [1, 2]. The intrinsic biomechanical mechanisms of the anteromedial (AM) and posterolateral (PL) graft failure is still unclear. In this study, we investigated the biomechanical function of the AM and PL grafts of an anatomical double bundle reconstruction during a functional stair ascending activity.

Methods: Twenty healthy knees from 20 subjects (age, 35.0±10.4 years; gender, 12 males and 8 females; body height, 175.0±9.3cm; body weight, 80.5±15.5kg, BMI, 26.1±3.2) were recruited and the 3D knee joint models were constructed using magnetic resonance (MR) images. The anatomical DB ACLR was simulated on each 3D knee model using the anteromedial portal (AMP) technique [3]. All subjects performed a stair ascending activity while imaged by a dual-fluoroscopic imaging system (DFIS). The relative tunnel positions were then determined along the normal stair ascending motion path. The interaction between the graft and the femoral and tibial tunnels were presented as the graft-tunnel contact angle (GT angle, Fig 1) to simulate the “killer turn” effect and the graft-tunnel edge contact range (GTECR, Fig 2) to simulate the “windshield wiper” effects during the stair ascending. The data of the two graft bundles was analyzed using an ANOVA and significant difference level was set as p<0.05.

Fig. 1. Schematic drawing showing the graft-tunnel angle (GT angle) and the intra-articular graft length.
Results: The femoral GT angles of the AM and PL grafts were 97.6±7.5° and 100.7±7.7°, respectively at full extension of the knee (p < 0.05), while the tibial GT angles of the two grafts were 158.8±6.5° and 146.5±8.9°, respectively. The ranges of the GTEC angles were 23.2±5.3° and 28.1±7.6°, respectively in the AM and PL femoral tunnel edges during the stair ascending activity, and they were 27.3±2.2° and 34.5±2.1° in the tibial tunnel edges of the two graft bundles (Fig. 3).

Discussion: These biomechanical data demonstrated that there is a “killer turn” effect on the femoral tunnel aperture, implying an important factor to influence the grafts after the double bundle ACL reconstruction. “Windshield wiper” effect was also a factor causing the grafts ruptured on both femoral and tibial side. Our results implied that the grafts would experience a non-optimal kinematic condition after the anatomical ACL reconstruction that might dispose the graft to failure on the femoral side due to the combination of “killer turn” and “windshield wiper” effects.

Significance: Contemporary double ACL reconstruction may provide a non-optimal biomechanical environment to the grafts at
the femoral tunnels. Future research should consider the improvement of the ACL reconstruction to minimize the “killer turn” and “windshield wiper” effects on the grafts so that to increase the longevity of the ACL reconstruction.

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**References:**