Rigid vs. Flexible Screwdriver for Femoral Interference Screw Placement: Comparison of Divergence and Fixation Strength

Mark E. Steiner¹, Kempland C. Walley², Aidin Masoudi³, Ohan S. Manoukian³, Miguel E. Perez-Viloria³, Stephen Okajima³, Jeffrey Spalazzi³, Araz Chiloyan³, Maria Drazek³, David W. Wing¹, Ara Nazarian².

¹New England Baptist Hospital, Boston, MA, USA, ²Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA, ³Stryker Corporation, Mahwah, NJ, USA.


Introduction: Acute rupture of the anterior cruciate ligament (ACL) accounts for over 100,000 injuries annually. Graft reconstruction is the preferred method of repair in the case of complete rupture, however current methods require improvement. Given that implanted grafts are mechanically stronger than native ACL, it is suggested that fixation and tunnel malposition are associated with substandard performance thus motivating the need for better methods to secure the ACL graft within the femoral tunnel. Anteromedial drilling is the preferred method to establish the femoral tunnel during ACL reconstruction as it allows a more anatomic placement of the graft and thus more closely approximates normal knee kinematics. A problem, however, is that it requires hyperflexion, which can be technically demanding. Thus, it has been suggested that ideal placement of an oblique tunnel via AM drilling would be preferable with flexible instrumentation and the knee held at 90° flexion. Increased angles of screw divergence within the femoral tunnel may result in improper graft fixation and compromise pullout strength. Therefore, parallel placement of the femoral interference screw to the axis of the graft is the preferred fixation orientation. A flexible screwdriver may prove to achieve parallel placement more successfully than rigid instruments, thus motivating this study.

We hypothesize that a flexible screwdriver will outperform a rigid screwdriver to place a femoral interference screw with less screw-tunnel divergence and with greater fixation strength. This study compares the placement of interference screws at 90° knee flexion using CT, plain radiography, and biomechanical testing.

Methods: ACL Reconstruction

Matched, human cadaveric tibiofemoral joint specimens were subject to anteromedial (AM) drilling to create the femoral tunnel using the VersiTomic Flexible Reaming System (Stryker Sports Medicine, Denver, CO). One knee from each pair was randomly assigned to either of two groups: Rigid Screwdriver (RIGID) (n= 10) or VersiTomic ISI Flexible Screwdriver (FLEX) (n=10). A 10mm patellar tendon graft with a 22 mm patella plug and 25mm tibial plug was sized to pass through a 10mm tunnel. For all specimens, ACL reconstructions were completed arthroscopically with the knee in 90° flexion. An anatomic tibial articular tunnel opening was created with a rigid 10 mm reamer starting just superior to the pes anserinus. The graft was pulled across the joint space in standard fashion. A 7x20 mm Titanium interference screw was placed over the guide nitinol wire and inserted through the AM portal to fixate the graft using the flexible screwdriver. For the grafts secured with the rigid screwdriver, a 1.1mm nitinol guide wire was placed manually anterior to the bone plug. An interference screw was placed over
the guide wire through the AM portal anterior to the graft. For all specimens, a strong tibial BTB graft fixation was achieved with a 9x25mm Titanium interference screw placed over a 1.1mm rigid guide pin, backed by synthetic sutures tied to a post.

Computed Tomography and Plain Radiography based Divergence Measurements

Following completion of each reconstruction, all specimens were scanned via computed tomography (CT) and processed using a 3D model software to determine divergence measurements. Traditionally, divergence measurements are obtained through radiographic analysis. As such, the following X-ray images were obtained: Anterior-Posterior (AP) projection with the knee in extension, an AP tunnel projection with the knee flexed at 60° and lateral projection with the knee in neutral position. For each radiograph, a line was drawn along the central longitudinal axis of the screw. A second line was drawn along the central longitudinal axis of the femoral tunnel/bone plug. The angle between these two lines was measured to provide divergence angles in the coronal and sagittal planes.

Biomechanical Testing

All knee joints were harvested intact by resecting all tissues except for the femur, BTB graft, and tibia. The distal femoral and proximal tibial ends of each specimen were potted and then mounted in a testing jig on an Instron 8511 with the knee in full extension. Cyclic loading was performed between 50 and 150 N at a frequency of 1 Hz and displacements were recorded continuously using the vertical component of the distance between visual markers on each specimen at a load of 50 N after cycles 50, 100, 150, 200, and 250 using a calibrated, high-resolution digital camera and custom MATLAB program. Load-to-failure tests were then performed at a rate of 1.0 mm•s⁻¹. Stiffness, yield load, ultimate load, failure load and the mode of failure (tibial bone plug pull, femoral bone plug pull, tibial bone plug fracture, and femoral bone plug fracture) was recorded for each specimen.

Statistical Analysis

Paired two-tailed, Student’s T-test (P ≤ 0.05) was used to compare yield load, ultimate load, failure load, stiffness, X-ray based and CT-based divergence angle between the groups. A repeated measures two-way analysis of variance (ANOVA) with cycles and groups as independent variables was used to assess the inter-group dissimilarities, and differences between cycles across the groups.

Results: No differences were observed in either the CT or radiography-based analysis of divergence angles between the groups (CT: {RIGID: 12.07 ± 4.04; FLEX: 10.68 ± 3.23, P = 0.35}, X-ray: {AP, lateral and tunnel projection across coronal and sagittal planes, P > 0.05 for all cases}). No significant differences in stiffness, yield load, ultimate load, and failure load (P = 0.99, 0.40, 0.32 and 0.20 respectively) were reported between the groups. No significant changes in displacement at 50, 100, 150 and 250 cycles were reported between the groups (P = 0.42, 0.93, 0.27, 0.47 and 0.91 respectively). No differences in failure modes were observed between the two groups either (RIGID: 6 tibial and 3 femoral plugs pulled; FLEX: 5 tibial and 4 femoral plugs pulled, P = 0.65).

Discussion: There were no differences between angles of divergence between fixation by flexible screwdriver and the rigid system as measured through X-ray. As a result of this finding, all biomechanical measurements quantifying the strength of the ACL reconstruction expectedly showed no significant differences between each fixation technique. Of note, it can be argued that the most important biomechanical outcome parameter clinically is the yield load rather than the ultimate load, or failure load, as the first significant slippage of an ACL graft inherently begins at the yield point. While it was hypothesized that a reduced angle of divergence would correlate to stronger graft fixation, our findings
yield inconclusive evidence needed to confirm or reject this hypothesis as a reduced angle of divergence was not observed BTB grafts were secured via flexible instruments. This is a time zero study, corresponding to a time point immediately after ACL reconstruction. While the graft is immediately strong following surgery, it has not had time to undergo a ligamentization process and heal biologically. Thus, while placing the interference screw with a flexible driver showed no improved fixation integrity at time zero, it is unclear if this would affect ACL reconstruction healing clinically.

Significance: These findings qualify the biomechanical outcome of interference screw fixation during ACL BTB graft reconstruction by a flexible screwdriver as equivalent to outcomes reached by rigid screwdrivers. Provided flexible screwdriver allows for reduced flexion of the knee during interference screw placement, its biomechanical performance observed in this study suggests it may be optimal for ACL graft fixation.

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