Graft-Tunnel Incorporation Following ACL Reconstruction: A Prospective Longitudinal MRI Study

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INTRODUCTION:
Function of an anterior cruciate ligament (ACL) reconstruction requires secure healing of a tendon graft transplanted into bone tunnels. Graft incorporation and healing is a slow and incompletely understood process. A clinical concern that has emerged is bone tunnel widening following ACL reconstruction. Despite its recognition, there is a paucity of knowledge regarding the etiology and natural history of bone tunnel widening. Graft-tunnel widening may be caused by a number of factors including osteoclastic bone resorption. Pre-operative bone mineral density (BMD) could be an important tunnel widening predictor.

The purpose of this prospective study was to use immediate post-operative magnetic resonance images (MRI) and subsequent longitudinal MRI data to investigate graft-tunnel incorporation and the rate of tunnel widening and to correlate pre-operative BMD with these measurements.

METHODS:
A prospective series of 19 knees in 18 patients (12 male/6 female; mean 35 years, range 19 to 47 years) underwent ACL reconstruction using bio-absorbable interference screw fixation on both the femoral and tibial sides. All ACL reconstructions were performed by the same surgeon, using the same surgical technique and subjected to the same rehabilitation regimen.

Pre-operative evaluations included regional (tibial plateau and femoral condyle) and standard BMD measurements. Post-operative evaluations included an MRI immediately following surgery and at 6, 12, 24, 52, and 104 weeks. Tunnel diameter was measured on two MRI planes at three distinct locations along the long-axis of the tibial and femoral tunnels: tunnel aperture, mid-tunnel, and tunnel exit (Figure 1).

Following the initial analysis, bivariate correlation analyses were performed to determine if there were relationships between the subjective (IKDC and Lysholm) or the objective (KT-1000) outcome measures and the change in tunnel dimensions at the tibial and femoral tunnel apertures. Statistical significance for all testing was defined as p<0.05.

RESULTS:
Significant tunnel expansion was present at the tibial and femoral apertures (p<0.05). The highest magnitude and rate of tunnel expansion occurred in the first 24 weeks post-operatively at both apertures (p<0.05). There was no significant mid-tunnel expansion on either the tibial or femoral sides. Significant tunnel closure was seen at both tunnel exits (p<0.01).

The results of the bivariate correlation analysis suggest that there is no correlation between either regional or standard BMD measures and the magnitude or rate of tunnel expansion at any time point. Side-to-side KT-1000 differences at final follow-up were 1.0mm. The mean IKDC and Lysholm scores increased from 54.1 and 62.2 to 86.2 and 85.8 respectively. All patients returned to their pre-operative activity level except for one patient who had a graft rupture.

There was no significant association between Lysholm or IKDC score and the magnitude of tunnel widening at either aperture. Likewise, increased side-to-side differences in stability as measured by KT-1000 did not correlate with increased tunnel expansion at either aperture.

CONCLUSION:
Significant tunnel widening following ACL reconstruction was limited to the tibial and femoral tunnel apertures, while tunnel diameter decreased at the tunnel exits. Of note, graft-tunnel motion is maximal at the tunnel aperture and minimal at the tunnel exits, suggesting that mechanical load plays a role in tunnel remodeling [1]. We found that the rate of tunnel aperture expansion was greatest in the early post-operative period, which may have implications for post-operative rehabilitation protocols. Pre-operative BMD does not seem to be a predisposing factor for post-operative tunnel widening. The patients’ perception of a successful reconstruction (IKDC and Lysholm scores) and the objective measure of stability (KT-1000) do not correlate with tunnel aperture expansion. Future analysis of the parameters affecting tunnel closure at both the tibial and femoral tunnel exits may elucidate key factors related to graft-to-bone healing.

References:
[1]: Rodeo et al., AJSM 2006; 34 (11): 1790-800

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