Factors that Influence the Intra-Articular Rupture Pattern of the ACL Graft Following Single-Bundle Reconstruction

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Introduction

Anterior cruciate ligament surgery is one of the most frequently performed orthopaedic operations and revision cases are to be expected. Biomechanical studies have shown that variations in ACL reconstruction technique, i.e. difference in tunnel placement and graft type, result in variable postoperative knee kinematics and loads. Logically, this should result in variable forces placed upon the reconstructed ACL. We hypothesize that this would in turn, result in differing patterns of injury when the graft re-ruptures.

The aims of the current study were: 1. To determine the most common rupture pattern in ACL revision cases after previous single-bundle reconstruction. 2. To determine the relationship between rupture pattern and patient age, gender, time between the initial ACL reconstruction and re-injury, graft type, tunnel angle, and etiology of failure.

Methods

A level 3 cohort study design was chosen and Institutional Research Board approval was obtained. Between January 2005 and June 2009 all patients who underwent revision ACL surgery after a previous single-bundle reconstruction were included. Three sports-medicine fellowship trained orthopaedic surgeons independently reviewed the arthroscopic footage of the 60 enrolled subjects to determine the exact pattern of graft rupture. Rupture pattern was recorded using a classification system previously described by Zantop et al. [1] Since all included subjects had undergone previous single-bundle ACL surgery, only one bundle was available for evaluation. The injured single ACL-bundle was classified as either: 1) proximal rupture; 2) mid-substance rupture; 3) distal rupture; or 4) functionally insufficient due to elongation

Demographic and surgical data that were collected from the patient records included: patient age and gender, date of the initial ACL reconstruction, date of the re-injury and etiology of failure. The etiology of failure was classified as either traumatic or a-traumatic, based on the patient’s self report. Radiographs were reviewed for all patients using the hospital system’s commercially available radiographic imaging system (Stentor, Philips). The ACL tunnel angle was measured, which was defined as the angle between the tunnel and the long axis of the femur

Inter-observer agreement for the three observers was calculated using the Fleiss kappa coefficient for multiple ratings per subject. The Kruskal-Wallis one-way analysis of variance with post-hoc Mann-Whitney U was used to determine the relationship between the continuous variables and the graft rupture pattern. The Chi Square test was used to determine the relationship between the rupture pattern and nominal variables.

Results

Table 1 displays the frequency of each rupture pattern.

<table>
<thead>
<tr>
<th>Rupture Pattern</th>
<th>Frequency (%)</th>
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<tbody>
<tr>
<td>Proximal</td>
<td>21.7</td>
</tr>
<tr>
<td>Mid-substance</td>
<td>16.7</td>
</tr>
<tr>
<td>Distal</td>
<td>1.7</td>
</tr>
<tr>
<td>Elongated</td>
<td>58.3</td>
</tr>
</tbody>
</table>

The time between the initial ACL surgery and the re-injury was of influence on the rupture pattern of the graft. Specifically, elongation of the graft occurred more often when the reconstruction to re-injury time interval was greater, when compared to distal or mid-substance ruptures (p = 0.002). Rupture pattern was also related to graft type (Cramer V = .543, p < 0.001). Thirty-three percent of the proximal ruptures and 23% of the elongated grafts were allografts, while 91% of the mid-substance and distal ruptures were allografts. Patient age and gender, tunnel angle and etiology of failure did not influence the rupture pattern of the graft. The measured kappa value for multiple observers was 0.65.

Discussion

This study demonstrates that the most common graft re-rupture pattern in ACL revision cases following previous single-bundle reconstruction is elongation of the graft, accounting for 58% of all failures (Figure 1). This is different from the most frequent rupture pattern seen in the native ACL, as reported by Zantop et al.[1], which is proximal rupture of the anteromedial (AM) bundle with either proximal or mid-substance rupture of the posterolateral (PL) bundle.

The time between initial ACL reconstruction and the re-injury showed a significant relationship with the rupture pattern. Specifically a longer time frame between surgery and re-injury was consistent with a greater incidence of graft elongation. We hypothesize that this finding is a consequence of tunnel placement during the initial ACL reconstruction surgery. If the femoral tunnel was placed outside of the native ACL insertion site, the graft commonly assumes a more vertical orientation. This graft is subsequently exposed to forces that differ from a native ACL. As a result, these grafts may “heal” and the patient returns to full activity without difficulty. Since the graft is not subjected to the same forces as seen in the native ACL, frank retear of the graft does not occur. Rather, the graft is exposed to repetitive micro trauma that results in elongation over time. Later in the period of recovery, the patient may develop a sense of instability without distinct reinjury and in turn, present for re-evaluation.

The current study also demonstrated an influence of graft type on the rupture pattern. Autografts were more closely correlated with proximal re-ruptures, more similar to the pattern of injury seen in the native ACL. A possible explanation for this finding could be due to the fact that autografts generally take a shorter time to incorporate compared to allografts.

Limitations of the study include that the rupture pattern was established by retrospective review of arthroscopic videos taken at the time of the revision surgery. There was only one distal rupture noted. Statistical analysis of those data would have resulted in violation of the statistical assumptions. Therefore, distal and mid-substance ruptures we combined for statistical analysis.

Conclusion

In conclusion, this study showed that after single-bundle ACL reconstruction, the most common re-injury pattern seen at the time of revision surgery is elongation of the graft. This is different from the native ACL, which displays more proximal ruptures. Factors that influence the rupture pattern are months between ACL reconstruction and re-injury and graft type.

References: