Difference Of Graft Tension Pattern Between The Intra- And Extra-articular Graft Portion In Anatomic Anterior Cruciate Ligament Reconstruction

Kanto Nagai, M.D., Ryosuke Kuroda, M.D., Ph.D., Yuichi Hoshino, M.D., Ph.D., Yuichiro Nishizawa, M.D., Ph.D., Daisuke Araki, M.D., Ph.D., Shinya Oka, M.D., Ph.D., Naoki Nakano, M.D., Takehiko Matsushita, M.D., Ph.D., Tomoyuki Matsumoto, M.D., Ph.D., Koji Takayama, M.D., Ph.D., Kouki Nagamune, Ph.D., Masahiro Kurosaka, M.D., Ph.D.

1Kobe University Graduate School of Medicine, Kobe, Japan, 2Kobe Kaisei Hospital, Kobe, Japan, 3Graduate School of Engineering, University of Fukui, Fukui, Japan.


Introduction: In order to restore normal function of the anterior cruciate ligament (ACL) after the ACL reconstruction, proper tension should be applied to the ACL graft during fixation[1]. However, ideal tensioning strategy has not been established due to lack of knowledge about the actual intra-articular graft tension behavior. Most previous studies which investigated the graft tension pattern during knee joint motion assessed the graft tension outside of the knee joint[2,3]. Since the graft tension reduction due to the friction between the graft and the bone tunnel is highly expected, it is important to directly evaluate the intra-articular graft tension. The objective of this study was thus to evaluate the intra- and extra-articular graft tension simultaneously during the knee extension to flexion motion after anatomic single bundle ACL reconstruction using hamstring tendon. The hypothesis was that the tension pattern of the ACL graft was different between intra- and extra-articular portion of the graft.

Methods: A total of 9 fresh-frozen human cadaveric knees (81.9 ± 9.6 y.o., 4 male / 5 female) with skin and soft tissues preserved were examined. Each specimen was examined to ensure that there was no evidence of osteoarthritis, ligament insufficiency, or torn menisci by manual and arthroscopic evaluation. After removing the native ACL, anatomical single bundle ACL reconstruction was performed. Both femoral and tibial tunnels were created at the center of the original ACL footprint with a diameter of 6.5 mm for femoral side and 7.0 mm for tibial side. The hamstring tendon graft was made with an originally developed micro force sensor inserted in the middle. The micro force sensor consists of an aluminum plate and two types of strain gauges (Figure 1A).

The graft was placed so that a micro force sensor was placed in the articular portion (Figure 1B). The graft was fixed on the lateral femoral cortex by using a suspensory button, and then fixed to a graft tensor with the suture connected with the graft. The graft tensor can fix the graft with an arbitrary tension and measure the extra-articular tension applied at the graft fixation by load cell as we previously reported[4] (Figure 1C). The load-relaxation of the graft was achieved by removing the creep of the construct by pulling the graft sutures for 5 minutes at 20 ° of knee flexion. A total of 20 N of the initial graft tension was applied using the graft tensor from the outside of the joint, and then the intra- and extra-articular graft tensions were simultaneously measured during the passive knee motion from full extension to 90 °. The knee flexion angles were confirmed using an electromagnetic measurement system[6]. Paired t-test were used to compare the each value of the intra- and extra-articular graft
tensions at each flexion angle during passive knee motion. A P-value < 0.05 was considered statistically significant.

**Results:** During passive knee motion with 20 N of initial tension, the intra- and extra-articular graft tensions were gradually increased less than 20° of knee flexion. The highest value of the intra- and extra-articular graft tensions were 75.7 ± 14.6 N and 65.8 ± 14.7 N respectively at full extension. The intra-articular graft tensions were significantly smaller than the extra-articular graft tensions at each flexion angle from 20° to 70° of knee flexion (all, P < 0.05, Figure 2). Additionally, the increase of the intra-articular graft tension from 20° to full extension was significantly larger than that of the extra-articular graft tension (64.8 ± 12.6 N and 44.7 ± 14.7 N, P = 0.0068, Table 1).

**Discussion:** The main findings of the present study were that both intra- and extra-articular graft tension were highest at the passive full knee extension in anatomic single bundle ACL reconstruction. The previous study[3] indicated that the graft tension was highest at 0° of knee flexion in anatomic double bundle ACL reconstruction, supporting the present findings. Furthermore, the increase of the intra-articular graft tension from 20° of flexion to full extension was significantly larger than that of the extra-articular graft tension, although the intra-articular graft tension was significantly smaller than the extra-articular tension at 20° to 70° of flexion. These results indicated that the tension applied to the graft from extra-articular portion was not fully transmitted to the intra-articular portion of the graft supposedly due to the friction between the graft and bone tunnels. However, once the graft was tensioned at a flexed knee position, the intra-articular graft tension was substantially increased toward extension compared with the previously known tension pattern which was measured outside of the joint. These findings suggest that care should be taken for us not to apply the initial graft tension too much especially when the graft is fixed at a flexed knee position.

**Significance:** The intra-articular graft tension pattern was quantitatively measured using an originally developed micro force sensor, and both the intra- and extra-articular graft tension were highest at passive full knee extension. Furthermore, the increase of the graft tension was significantly larger in the intra-articular portion than that in the extra-articular portion.
The increase of graft tension from initial tension at 20° of flexion to passive full extension.
<table>
<thead>
<tr>
<th></th>
<th>The increase of graft tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-articular graft tension (N)</td>
<td>64.8±12.6</td>
</tr>
<tr>
<td>Extra-articular graft tension (N)</td>
<td>44.7±14.7</td>
</tr>
</tbody>
</table>

ORS 2015 Annual Meeting
Poster No: 0790