It is challenging to reproduce both anatomical and functional aspects of anterolateral reconstruction. : Postoperative 3D-CT analysis of the femoral tunnel position

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INTRODUCTION: Based on exploratory cadaveric testing, many researchers agree that the ALL is an important stabilizer of internal tibial rotation. Previous studies have introduced ALL reconstruction with the formation of femoral tunnel and insertion of the ALL. Although there were inconsistencies in the femoral tunnel position, recent research has shown that the femoral tunnel position is located posterior and proximal to the lateral epicondyle (LE), with the length of the ALL varying from 30.41 to 59.0 mm in anatomical studies.

Some studies reported that proximal and posterior to the LE is the only position with a favorable isometry, being tight in extension and in internal rotation at 20°. The non-anatomical nature of ALL reconstruction has the potential risk of overconstraint and changes in knee biomechanics.

To our knowledge, no study has the investigated the consistency and accuracy of the femoral tunnel position after ALL reconstruction. This study aimed to evaluate the femoral tunnel position and the fiber length of the ALL compared with the ALL natural anatomy. Moreover, we evaluated whether the femoral tunnel position would affect the residual pivot shift.

METHODS: 59 patients who underwent ALL reconstruction between July 2019 and February 2020 during primary ACL reconstruction in the presence of a high-grade pivot shift [\geq International Knee Documentation Committee (IKDC) grade 2] or during revisional ACL reconstruction. The inclusion criteria were as follows: 1) age 18 - 60 years; 2) confirmed ACL injury with pivot shift of IKDC grade \geq 2; 3) revisional ACL reconstruction and 4) follow-up for at least 2 year after surgery. The exclusion criteria were as follows: 1) accompanied other ligament injury (n=3); and 2) follow-up period less than 2 year after surgery (n=1). Finally, 55 patients (55 knees) were enrolled in this study.

We determined the position of the femoral tunnel and the length of graft using a 3D-CT model after ALL reconstruction. We also measured graft excursion during surgery and examined pivot shift 2 year after surgery. We conducted a subgroup analysis of femoral tunnel position, fiber length, isometricity, and residual pivot-shift depending on whether the tunnel was anterior or posterior to the lateral epicondyle (LE). We also performed a subgroup analysis depending on whether the ACL reconstruction was primary or revisional.

To reduce the tibia's rotational force, tensile force is applied to the ALL graft during the range of 0~ 45° knee joint angle, and consequently, the length of the ALL graft is increased. When the knee is flexed more than 90°, an over-strain may be applied to the lateral compart if tension is applied to the ALL graft. The "excursion" is the increasing the length of ALL fiber during 90° flexion to extension of knee joint. We adjusted it several times to find the optimal position and recorded the adjustment number.

Considering the recent consensus on the femoral tunnel position, we performed subgroup analysis 1 following the femoral tunnel position (anterior or posterior to LE). We compared the fiber length, excursion, isometricity, residual pivot-shift, and clinical outcomes including Lysholm score, IKDC subjective score at 2-year follow-up.

We also performed subgroup analysis 2 with primary or revisional ACL. Revisional ACL requires technical considerations to determine the ideal femoral ALL tunnel position. We compared the femoral tunnel position, fiber length, excursion, and a number of adjustments (positioning error).

RESULTS: The mean femoral tunnel position of the ALL was 2.04mm (\pm 6.6mm) posterior, and 14.5mm (\pm 8.2mm) proximal from the center point of the LE. The femoral tunnel was positioned more proximal than the anatomical position. Although 20 cases (36.3%) involved the anterior positioning of the ALL relative to the center of the LE (average, 4.4 mm), these were mostly included in the LE boundary (Figure 2).

In subgroup analysis 1, there was no difference in residual pivot shift (rotational instability) at the 2-year follow-up regardless of the femoral anteroposterior tunnel position. (Table 1) However, there were significant differences in the femoral tunnel position (proximal-distal), and in the anterior and posterior fiber lengths. However, there was no difference in functional outcome, representing Lysholm and IKDC subjective score, at the 2-year follow-up.

In subgroup analysis 2, 35 knees underwent primary ACL reconstruction, and 20 knees underwent revisional ACL reconstruction. (Table 3) There was no significant difference between the two groups in the femoral tunnel position, anterior fiber excursion, posterior fiber excursion, or fiber length. However, the number of adjustments was higher in the revisional ACL group (p = 0.039).

DISCUSSION AND CONCLUSION: It is challenging to reproduce both anatomical and functional aspects of ALL reconstruction in both primary and revision ACL reconstruction. Especially for functional reconstruction, the femoral tunnel tended to be positioned more proximally than the anatomical position. However, the femoral tunnel position did not affect functional clinical outcomes at the 2-year follow-up.









Variables∺	Posterior position (n=35)년	Anterior position (n=20)+1	P value⊖
Sex (male/female), n+2	<u>29.;</u> 5+2	<u>15 ;</u> 6+3	0.183+2
Age, year⊷	25.8 ± 9.0 ^{µ2}	28.6 ± 10.4	0.313+2
Height, cm+2	172.4 ± 8.1↔	172.4 ± 8.2c	0.999+3
Weight, Kg≓	78.4 ± 13.1₽	77.2 ± 11.64	0.716
Body mass index=	26.3 ± 3.7+2	25.8 ± 2.94	0.595+2
Femur tunnel+	5.8 ± 5.2c ²	-4.4 ± 1.98+2	<0.001+3
(Antero-posterior)†, mm-1			
Femur tunnele	11.2 ± 6.342	20.5 ± 8.1+2	< 0.001+2
(Proxi-distal)≠, mm⊖			
Anterior fiber length, mm-	63.9 ± 6.94	71.4 ± 9.94	0.006
Posterior fiber length, mm	60.1 ± 6.44	69.4 ± 9.34	<0.001
Anterior fiber excursion, mm	3.0 ± 3.34	2.0 ± 2.34	0.153+2
Posterior fiber excursion, mm	7.5 ± 4.0 ⁻¹	6.0 ± 3.44	0.136+3
Anterior Fiber isometric, no	240	13⊷ੋ	0.507+3
Posterior Fiber isometric, nel	50	40	0.423
Both isometric, no	50	30	0.617
Number of adjustments, n=	1.8 ± 0.84	3.1 ± 1.14	<0.001+3
Pivot-shift (IKDC)+	41	41	**
at 2 Years, n⊬	4	÷	41
0 (equal)+	0+	0+	41
1 (glide)+	04	1 (5%)	1.0⊖
2 (clunk)+	1 (2.8%)	1 (5%)~	
3 (gross)+2	1 (2.8%)	0+2	
Lysholm score at 2 Year+3	85.8 ± 15.1¢	82.2 ± 15.04	0.76743
DC subjective score at 2 Year	83.1 ± 13.64	80.8 ± 16.84	0.374
data are presented as mean + :	00.1 ± 15.64	ou.o ± 16.8≓	0.374∺

* Positive value: proximal to the center of the lateral epicondyle# IKDC, International Knee Documentation Committee.#