Effectiveness of Combined Anterolateral and Anterior Cruciate Ligament Reconstruction for Grade 3 Pivot Shift: A Quantitative Evaluation Under Anesthesia

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INTRODUCTION: Residual knee laxity after anterior cruciate ligament (ACL) reconstruction remains a challenge, particularly in patients presenting with high-grade pivot shift. Preoperative knee laxity has been associated with persistent postoperative instability, and patients with a Grade 3 pivot shift are at increased risk for graft failure and revision surgery. Additionally, such patients frequently present with complex injury patterns involving meniscal, posterior root, ramp, and anterolateral complex, which may further compromise knee stability if not adequately addressed. Recent biomechanical and clinical studies suggest that combining anterolateral ligament (ALL) reconstruction with ACL reconstruction may enhance rotational stability. This study aimed to evaluate the intraoperative stabilizing effect of adding ALL reconstruction to ACL reconstruction (ACL+ALLR) in patients with Grade 3 pivot shift using quantitative laxity assessments under anesthesia. Furthermore, the study investigated the relationship between severe knee laxity and the presence of combined injuries.

METHODS:

A retrospective cohort analysis was conducted on patients who underwent primary ACL+ALLR between 2016 and 2024. Exclusion criteria included concomitant multi-ligament injuries, contralateral knee injuries, and absence of quantitative measurements. Patients were stratified into two groups based on the grade of preoperative pivot shift: the Grade 3 group and the Grade ≤2 group. Quantitative knee laxity was assessed under general anesthesia at three intraoperative stages: preoperatively, after isolated ACL reconstruction (ACLR), and after combined ACL+ALLR. Anterior tibial translation (ATT) was measured using a Rolimeter, and expressed as a side-to-side difference in millimeters (mm). Rotational laxity was assessed using inertial sensors that recorded tibial acceleration and external rotational angular velocity (ERAV) during the pivot-shift test, both calculated as side-to-side ratio. Combined injuries were assessed: meniscal injury, lateral meniscus posterior root tear (LMPRT), and ramp lesion were identified through arthroscopic examination; ALL injury and Kaplan fiber injury were diagnosed using preoperative MRI. Statistical analysis included Mann-Whitney U test, with significance set at $p < 0.05$.

RESULTS: Eighty-two knees were included (Grade 3 group: n = 46; Grade ≤2 group: n = 36). The Grade 3 group showed significantly greater ATT, acceleration, and ERAV before surgery (all $p < 0.001$). After isolated ACL reconstruction, rotational laxity improved in both groups. However, ERAV remained significantly higher in the Grade 3 group ($p = 0.046$). After combined ACL+ALL reconstruction, no significant differences remained between groups in ATT ($p = 0.539$), acceleration ($p = 0.638$), or ERAV ($p = 0.533$). The change in ERAV from ACLR to ACL+ALLR (representing the effect of ALLR) was significantly greater in the Grade 3 group (0.4 vs. 0.2, $p = 0.044$). The incidence of combined injuries was also significantly higher in the Grade 3 group, including meniscal injury (89.1% vs. 66.7%, $p = 0.026$) and Kaplan fiber injury (20.0% vs. 0.0%, $p = 0.017$).

DISCUSSION AND CONCLUSION:

Patients with high-grade pivot shift demonstrated more severe preoperative knee laxity and a higher incidence of combined injuries, including meniscal, anterolateral complex. While isolated ACL reconstruction reduced knee laxity to some extent, rotational instability—particularly in ERAV—persisted in Grade 3 cases. The addition of ALL reconstruction significantly improved rotational laxity and eliminated group differences in intraoperative laxity parameters. MRI-based identification of ALL and Kaplan fiber injuries, along with careful assessment for ALC injuries, may aid in preoperative planning and surgical decision-making. Given the high prevalence of complex combined injuries in this population, consideration of additional procedures—such as ALL reconstruction—may be essential for achieving comprehensive knee stability and optimizing long-term clinical outcomes.

Figure. Quantitative Assessment of Knee Laxity under General Anesthesia

Table 2. Quantitative data on knee laxity under anesthesia *

	Grade ≤2 n = 36	Grade 3 n = 46	*P* value
ATT side-to-side distance, mm			
Pre-op	4.8 (4.0–6.0)	7.0 (6.0–8.0)	**<.001**
ACLR	−1.0 (−1.0–−1.0)	−1.0 (−2.0–−1.0)	.252
ACLR+ALLR	−1.5 (−2.0–−1.0)	−2.0 (−2.1–−1.0)	.539
Acceleration side-to-side ratio			
Pre-op	2.2 (1.9–3.1)	4.9 (3.5–8.0)	**<.001**
ACLR	1.2 (0.9–1.5)	1.4 (1.1–1.5)	.098
ACLR+ALLR	1.1 (0.9–1.3)	1.1 (0.9–1.3)	.638
ERAV side-to-side ratio			
Pre-op	2.9 (2.1–3.5)	3.4 (2.5–5.0)	**.014**
ACLR	1.1 (0.8–1.7)	1.4 (1.0–1.8)	**.046**
ACLR+ALLR	0.9 (0.6–1.3)	0.9 (0.7–1.3)	.533

* Data are presented as median (interquartile range) unless otherwise indicated. Boldfaced P-values indicate significant differences between groups ($P < .05$). ATT, anterior tibial translation; ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction; ERAV, external rotational angular velocity

Table 1. Patient Demographics and Combined Injury Characteristics *

	Grade ≤2 n = 36	Grade 3 n = 46	*P* value
Age, yr	19.0 (17.0–21.3)	20.0 (16.0–28.8)	.536
Sex: male/female, n	20 / 16	28 / 20	.374
BMI	22.6 (20.9–24.9)	22.5 (20.8–24.4)	.698
Tegner activity score	8.0 (7.8–9.0)	7.0 (6.8–9.0)	.060
Injury to surgery, mo	3.0 (2.0–6.0)	6.3 (3.3–22.5)	**.002**
Meniscal injury, n (%)	24 (66.7)	41 (89.1)	**.026**
LMPRT, n (%)	3 (8.3)	9 (19.6)	.213
Ramp lesion, n (%)	14 (38.9)	19 (41.3)	1.00
ALL injury, n (%)	20 (55.6)	30 (66.7)	.301
Kaplan fiber injury, n (%)	0 (0.0)	7 (20.0)	**.017**

* Data are presented as median (interquartile range) unless otherwise indicated. Boldfaced P-values indicate significant differences between groups ($P < .05$). BMI, body mass index; LMPRT, lateral meniscus posterior root tear; ALL, anterolateral ligament