Combined Injuries of the Secondary Stabilizer in Anterior Cruciate Ligament-Deficient Knees Increase Rotatory Instability: Quantitative Evaluation with Inertial Sensor

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INTRODUCTION:

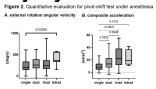
Medial meniscus ramp lesion (MMRL), lateral meniscus posterior root tear (LMPRT), and anterolateral complex injury (ALCI) are specific injuries to anterior cruciate ligament (ACL) injury and each injury is regarded as secondary stabilizer of ACL. However, the influence of their combination to knee stability was unknown. The purpose of this case-control study was to investigate the effect of the number of concomitant secondary stabilizer injuries on knee instability in patients undergoing ACL reconstruction.

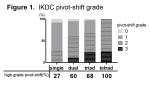
METHODS: Of 552 ACL reconstruction surgeries performed within 1 year of injury between January 2017 and April 2023, 321 patients who underwent quantitative assessment of knee instability under anesthesia were included. Patients with other ligament injury, knee joint laxity, history of contralateral knee injury, and meniscus injuries other than MMRL and LMPRT were excluded. MMRL and LMPRT were diagnosed with arthroscopy, and ALCI that defined as anterolateral ligament injury and/or Kaplan fiber injury, were diagnosed with magnetic resonance imaging. Patients were divided into four groups according to the number of concomitant injuries (single: isolated ACL injury, dual: one concomitant injury with ACL injury, triad: two concomitant injuries with ACL injury, tetrad: three concomitant injuries with ACL injury). Comparisons between each group were made for subjective pivot-shift grade (0-3), quantitative evaluations of pivot-shift test using the inertial sensor [side to side difference of tibial external rotation angular velocity (AVER; deg/s) and composite acceleration (CA; mm/s^2)], and anterior tibial translation (ATT; mm). Statistical analysis was performed using the Kruskal-Wallis test for continuous variables and Fisher's exact test for categorical variables, with a significance level of p=0.05. Multiple logistic regression analysis was performed to examine the odds ratio among three secondary stabilizers for high grade pivot-shift, and independent risk factors for increasing concomitant injuries.

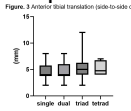
RESULTS: Finally, 142 patients were included in this study (mean age: 25.6 years old, male 55%). MMRLs were found in 52 knees (36.6%), LMPRTs in 22 knees (15.5%), and ALCIs in 81 knees (57.0%). Isolated ACL injury was 37 patients (26.1%), dual was 63 patients (44.4%), 34 triad knees (23.9%), and 8 tetrad knees (5.6%) (Table 1). The percentage of High-grade pivot-shift increased as the number of complicating injuries increased (Figure1). Quantitative evaluations with the inertial sensor, AVER had a significant difference between single and tetrad (single 201.4[95% CI: 192.0-269.5], dual 361.7[95% CI:278.9-528.1], p=0.033), and CA was significantly lower in the isolated ACL injury than in all other groups (Figure 2). There was no significant difference in the amount of anterior tibial translation between the groups (Figure 2). After multiple logistic regression analysis, ALCI and MMRL were independent risk factor for high grade pivot-shift (ALCI: odds ratio 3.3, 95% CI 1.6-7.1, *p* value=0.0015. MMRL: odds ratio 5.4, 95% CI 2.3-12.3, *p* value<0.001) (table 2). The risk factor for more than two secondary stabilizer injuries (triad or tetrad injury) was just only high-grade pivot-shift (odds ratio:2.5, 95% CI 1-6.3, p=0.049) (Table 3b).

DISCUSSION AND CONCLUSION:

As the number of the secondary stabilizer injuries increase, rotatory instability in ACL-deficient knee was increased. To put it another way, Patients with high-grade pivot-shift had an increased probability of concomitant secondary stabilizer injury. Patients with severe preoperative rotational instability should be treated for possible complicating injuries.







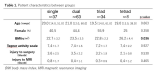


Table 2. Risk factor for high-grade pivot-shift

	odds ratio	95% CI lower limit	95% CI higher limit	p value
(Intercept)	0.39	0.21	0.73	0.0033
ALCI	3.34	1.58	7.07	0.0015
LMPRT	0.64	0.22	1.83	0.403
MMRL	5.38	2.34	12.3	<0.001

Table 3a. Multiple logistic regression analysis for more than **one** secondary stabilizer injuries.

	odds ratio	95% CI low	95% CI high	p value
BMI	1.1	0.961	1.26	0.16
Tegner scale	0.947	0.724	1.24	0.69
LPTS	1.09	0.916	1.3	0.32
MPTS	0.969	0.814	1.15	0.72
ATT	0.852	0.638	1.14	0.28
high-grade pivot-shift	6.3	2.31	17.2	<0.001

BMI body mass index, LPTS lateral posterior tibial slope, MPTS medial posterior tibial slope, ATT anterior tibial translation

Table 3b. Multiple logistic regression analysis for more than **two** secondary stabilizer injuries.

	odds ratio	95% CI low	95% CI high	p value
BMI	1.02	0.909	1.14	0.75
Tegner scale	0.936	0.746	1.17	0.56
LPTS	0.94	0.795	1.11	0.46
MPTS	1.1	0.941	1.29	0.23
ATT	1.07	0.821	1.4	0.61
high-grade pivot-shift	2.51	1	6.25	0.049

BMI body mass index, LPTS lateral posterior tibial slope, MPTS medial posterior tibial slope, ATT anterior tibial translation