Surgical Delay and Tissue Quality are Independent Predictors of Outcomes Following Anterior Cruciate Ligament Primary Repair

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INTRODUCTION:
Studies evaluating ACL repair techniques often describe a surgical delay of maximum 1 to 28 days after injury as in inclusion criterion for primary repair of the ACL, though clear evidence for this approach has not been presented yet. Additionally, tissue quality of the ACL remnant in relation to the delay of surgery as a potential cofounder has not been investigated yet.

Purpose of this study was to evaluate the impact of surgical delay on tissue quality, failure rates, clinical outcomes, and PROMs at a minimum two-year follow-up following selective arthroscopic ACLPR. It was hypothesized that surgical delay and tissue quality are independent predictors of outcomes, and that timing alone does not adversely affect results.

METHODS:
This study retrospectively analyzed prospectively collected data from 298 patients with proximal, modified Sherman type I or II ACL tears, who underwent ACLPR between 2008 and 2021. Patients were categorized into three treatment groups based on surgical delay: acute (<21 days after injury), subacute (22 to 90 days after injury), and chronic (>90 days). Primary outcomes included tissue quality, assessed via synovial sheath integrity (Grade 1, completely intact; Grade 2, >50% intact; Grade 3, <50% intact) and rupture pattern (Grade 1: single-bundle, Grade 2: double-bundle, Grade 3: complex tear pattern), and repair failure. Secondary outcomes included re-operation rate, negative Pivot Shift test rate, anterior-tibial translational side-to-side difference (ATT SSD), and PROMs, including the International Knee Documentation Committee Subjective Knee Form (IKDC), Lysholm, Single Assessment Numeric Evaluation (SANE), Cincinnati Knee Rating System (Cincinnati), Forgotten Joint Score-12 (FJS-12), ACL Return to Sport after Injury Survey (ACL-RSI), and Tegner activity scale (Tegner).

RESULTS:
At minimum two-year follow-up (mean follow-up: 2.9±1.0 years, mean age: 39.7±10.7 years; 49% female) 68 acute, 152 subacute and 56 chronic ACLPR patients were included. A total of 22 patients (7.3%) were lost to follow-up. Repair failure occurred in 28 patients (10.1%), with no significant differences among groups (acute: 10.3%, subacute: 11.2%, chronic: 7.1%; p=0.76). While patient age was identified as a significant risk factor for failure (p=0.02), surgical delay was not significantly correlated with poorer tissue quality (Grade 2: p=0.79, Grade 3: p=0.06) or increased failure risk (p=0.57) (**Figure 1**). However, a positive correlation between ACL tear pattern and the grade of synovial sheath injury (Spearman Correlation 0.621, p<0.001) could be demonstrated, whereby less then 50% intact synovial sheath showed a significantly increased failure rate (p= 0.049) with an odds ratio of 3.3 when correcting for sex, age and BMI. Reoperation rates (p=0.62), Pivot shift test (negative rate, acute: 90.7%; subacute: 91.8%; chronic: 89.5%; p= 0.21), and ATT SSD (mean + SD, acute: 1.0 ± 1.5mm; subacute: 1.0 ± 1.1mm; chronic: 1.1 ± 1.4mm; p= 0.65), as well as all PROMs (**Table 1**) were comparable across all groups (IKDC, p=0.72; Lysholm, p=0.28; SANE, p=0.87; Cincinnati, p=0.79; FJS-12, p=0.79; and ACL-RSI, p=0.31).

DISCUSSION AND CONCLUSION:
In this cohort, delay of surgery did not have a significant influence on failure rate or clinical outcome after ACLPR at two years follow-up. Additionally, tissue quality did not correlate with delay of surgery, though <50% of remaining synovial sheath led to a significantly increased surgical failure rate. Since acute surgery is not always feasible, this study may encourage surgeons to consider ACLPR for selected patients with modified Sherman type I or II ACL tears and favourable tissue quality, characterized by preserved synovial sheath integrity and a simple rupture pattern, also in the subacute or chronic state after ACL injury.
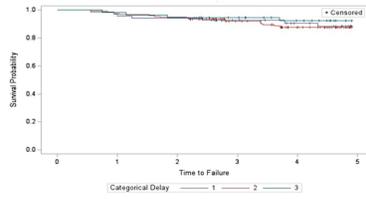
Figure 1: Censored survival analysis using cox regression in dependents of categorical delay of anterior cruciate ligament primary repair (ACLPR) (acute ACLPR: 1, subacute ACLPR: 2, and chronic ACLPR: 3). The graphic illustrates that there was no significant difference in survival among the three groups.

Table 1. Patient Reported Outcome Measurements

	Acute ACLPR n= 61	Subacute ACLPR n= 132	Chronic ACLPR n= 48	p-value
Subjective IKDC	89.0±10.9	87.5±13.4	88.8±11.0	0.72
Lysholm	92.6±10.4	92.5±9.7	89.5±17.3	0.28
Cincinnati	91.6±10.0	92.6±8.5	92.1±10.7	0.79
SANE	87.7±14.4	88.7±12.2	88.3±9.4	0.87
Tegner score post-op	5.9±1.5	6.0±1.6	6.0±1.7	0.80
Tegner score diff. (pre vs. post)	-0.5±1.3	-0.4±0.9	-0.3±1.1	0.58
FJS-12	83.4±21.0	85.5±17.3	84.8±19.8	0.80
ACL-RSI	76.0±24.5	69.8±25.2	72.2±22.0	0.31

ACLPR, anterior cruciate ligament primary repair; n, number of patients; IKDC, International Knee Documentation Committee; Lysholm, Lysholm score; SANE, Single Assessment Numeric Evaluation score; Cincinnati, Cincinnati Knee Rating System; FJS-12, Forgotten Joint Score–12, ACL-RSI, ACL - Return to Sport after Injury.