Two-Year Patient-Reported Outcomes and Graft Rupture Following Anterior Cruciate Ligament Reconstruction in Skeletally Immature Athletes: Results from the PLUTO (Pediatric ACL: Understanding Treatment Options) Prospective Cohort Study

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INTRODUCTION: The frequency of anterior cruciate ligament reconstruction (ACLR) is increasing at a faster rate in pediatric patients than in any other sub-population. There remains a dearth of prospective comparative studies designed to elucidate the optimal techniques for this active, high-risk sub-population. The purpose of this study was to compare patient-reported outcomes (PROs) and graft rupture in a multicenter prospective cohort study of skeletally immature patients who underwent ACLR using growth-preservation techniques. The hypothesis was that PROs across sub-cohorts would be similar, but ACL graft rupture rates would be higher in the early adolescent/pubescent group than in the pediatric/pre-pubescent group.

METHODS: Skeletally immature patients who underwent ACLR by one of 23 PLUTO surgeon-investigators at one of 10 participating academic medical centers across the United States over a five-year period (2016-2020) were included. Surgical techniques were categorized as one of three different pediatric/prepubescent physeal-sparing techniques (all-epiphyseal, AE; partial transphyseal, PTP; combined intra-articular/extra-articular, extraphyseal using ilitiobial band, ITB) or an early adolescent/pubescent transphyseal (TP) physeal-respecting technique, and by autograft type (hamstring, HS; soft tissue quadriceps, Q; iliotibial band, ITB). Demographics, surgical characteristics, pedi-IKDC scores, and ACL graft rupture (re-tear) rates were analyzed with comparative statistics.

RESULTS: 742 patients (mean age: 12.9 years (SD 1.9), 62% male) were included (Table 1). Two-year follow-up pedi-IKDC was available in 553 (74%) of patients at a median 24 (IQR, 24.0-26.7) months post-ACLR. The median pedi-IKDC score for the full cohort at two-year follow-up was 94.6 (range, 21.7 to 98.9). Median pedi-IKDC was not found to be different across surgical technique groups (p=0.22, Figure 1) or graft types (p=0.51) at two-year follow-up. Of 665 (665/742, 90%) patients with adequate two-year re-tear data, 48 (7%) experienced a re-tear at a median 16 months post-operatively (IQR, 10-22 months). Significant differences were detected in re-tear across surgical techniques (p=0.008), with pairwise comparisons revealing higher re-tear in TP (10%) than ITB (3%; p=0.02). No differences were otherwise detected in re-tear across graft types (p=0.12). The rates of re-tear were significantly higher in the pubescent group (10%) than in the prepubescent group (3%; p=0.001).

DISCUSSION AND CONCLUSION: Amongst skeletally immature patients undergoing ACLR, pre-pubescent children undergoing physeal-sparing techniques have superior two-year retear rates than pubescent adolescents undergoing transphyseal techniques. The physeal-sparing ITB technique has superior retear rates compared to the transphyseal technique, but similar outcomes to other pediatric physeal-sparing (PTP, AE) techniques.

Figure 1. Boxplot of pedi-IKDC scores by surgery technique.

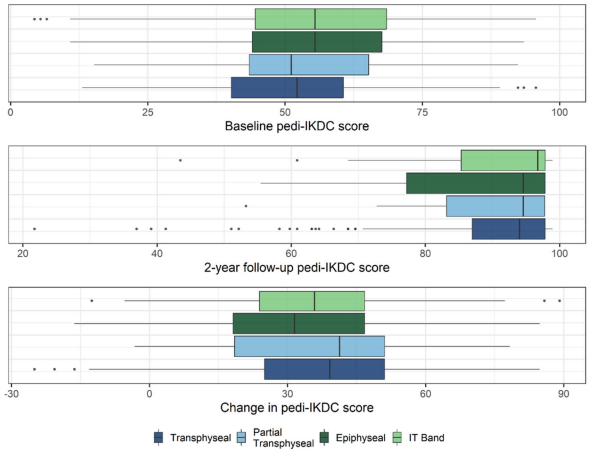

Table 1. Cohort summary (N=742).

Characteristic	Freq.	(%)
Age at injury (*years; mean (SD)*)	12.9	(1.9)
Bone age (*years; mean (SD); n=700*)*	13.0	(1.9)
Sex (*% male*)	461	(62%)
Puberty status (*n=700*)*		
Pre-pubescent	311	(42%)
Adolescent	389	(52%)
Height (*cm; mean (SD); n=735*)*	160.1	(13.3)
Weight (*kg; mean (SD); n=741*)*	54.3	(15.4)
BMI Percentile (*median (IQR); n=735*)*	75	(50-90)
Race		
White	587	(79%)
Black or African American	74	(10%)
Asian	26	(4%)
American Indian or Alaskan Native	1	(0%)
Native Hawaiian or Pacific Islander	2	(0%)
Other/Unknown	52	(7%)
Ethnicity		
Hispanic	62	(8%)
Not Hispanic	668	(90%)
Unknown	12	(2%)
Laterality (*% right*)	364	(49%)
Method of injury		
Contact	259	(35%)
Non-contact	456	(62%)
Uncertain/unknown	27	(4%)
Surgical technique		
Transphyseal	390	(53%)
Partial Transphyseal	52	(7%)
All Epiphyseal	98	(13%)
IT Band	202	(27%)
Graft Type		
Transphyseal - Hamstring	231	(31%)
Transphyseal - Quad tendon	159	(21%)
Partial Transphyseal - Hamstring	41	(6%)
Partial Transphyseal - Quad tendon	11	(2%)
All Epiphyseal - Hamstring	71	(10%)
All Epiphyseal - Quad tendon	27	(4%)
IT Band	202	(27%)