Determinants of Cost Variation in Pediatric Anterior Cruciate Ligament Reconstruction and Associated Procedures

Emily Moya, BA[1], Kenny Ling, MD[2], Kelly McFarlane, MD, MBA[3], Kali Tileston, MD[3], Kathryn Harbacheck, ATC[3], James Gamble, MD, PhD[4], Molly Meadows[4], Charles Chan, MD[4], Kevin Shea, MD[4]
[1]Stanford University School of Medicine, Palo Alto, CA, [2]Renaissance School of Medicine, Stony Brook, NY, [3]Stanford University Department of Orthopedic Surgery, Palo Alto, CA, [4]Stanford Medicine Children's Research Informatics, Palo Alto, CA
Email: enmoya@stanford.edu

Disclosures: No disclosures to report.

INTRODUCTION: Surgical procedures, especially high-volume ones like Anterior Cruciate ligament Reconstruction (ACLR), contribute significantly to healthcare costs. As ACLR surgeries increase in pediatric populations, understanding the cost drivers of these procedures is crucial for informed decision-making and resource optimization. This study aimed to identify and analyze the determinants of cost variation in ACLR surgeries in a pediatric setting.

METHODS: Using cost data obtained from Epic ®, a cost review analysis was performed for all ACLR procedures with and without meniscus repair performed by four surgeons at one institution from January 2019 to July 2023. The procedures were identified using Current Procedural Terminology (CPT) for ACLR (code 29888). Costs were categorized into total procedure, supply, and implant costs. Various factors, including graft type/source, surgical side, presence of meniscal injuries, and femoral and tibial fixation were examined. Statistical analysis involved a one-way analysis of variance (ANOVA) to evaluate cost differences across categories. All data was deidentified and therefore exempt from approval by our University's Institutional Review Board.

RESULTS SECTION: Graft source significantly affected supply (p=0.002) and implant costs (p=0.003) in ACLR procedures. Autografts led to higher supply costs (mean=$2,388.14) and allografts had increased implant costs (mean=$3,136.50). Graft type influenced procedure (p=0.038), supply (p=0.005), and implant costs (p=0.017), with quadriceps tendon being the costliest (mean=$4,489.61). Meniscus tears impacted total procedure (p<0.001) and supply costs (p<0.001); absence of tears was the cheapest (mean=$2,754.08 for the total procedure; mean=$1,046.38 for supply cost), and medial tears the highest (mean=$5,547.49 for the total procedure; mean=$3,450.88 for supply cost). Meniscus repair mechanism also affected total procedure (p<0.001) and supply (p<0.001) cost, with the inside-out repair method being the priciest for one-sided tears (mean=$6,468.31 for total procedure cost; mean=$3,275.68 for supply cost). Finally, femoral fixation played a role in total procedure cost (p=0.009), with fixed loop fixation being the most expensive (mean=$4,555.78).

DISCUSSION: While our data is validated, it's important to acknowledge the limitations of this study. The new surgical receipts tool in Epic® may have biases or errors due to staff inputs. We also didn't account for patient comorbidities affecting costs or evaluate clinical outcomes. Thus, while a particular graft source or type may present as cost-effective, it should not be inferred as the optimal clinical decision for patient care. Despite these limitations, this study provides a detailed insight into the cost variability associated with isolated ACLR procedures in a pediatric population. By identifying individual cost components linked to surgical attributes, meniscal repair, and fixation techniques, we present a roadmap for potential cost optimization strategies. However, further research should be conducted to determine if any of these cost-saving variables compromise patient outcomes.

SIGNIFICANCE/CLINICAL RELEVANCE: This comprehensive cost analysis of ACLR procedures with and without meniscus repair procedures reveals the significant impact of graft source/type, meniscal injuries, and fixation methods on costs. It offers actionable insights for hospitals and care organizations aiming for cost-effective surgical interventions.

Table 1: One-way analysis of variance (ANOVA) of costs in ACLR and ACLR with meniscus repairs by surgical characteristics (N=78). Data presented in USD with total number of patients, mean, and standard deviation reported. Bold p-values indicate statistical significance with $p < 0.05$.

		Total procedure cost			**Total supply cost**			**Total implant cost**		
	N	**Mean**	**Std. Dev**	**p-value**	**Mean**	**Std. Dev**	**p-value**	**Mean**	**Std. Dev**	**p-value**
Side				0.753			0.856			0.422
Right	34	4,079.69	1,862.29		2,297.43	1,679.14		1,782.26	886.61	
Left	44	4,205.07	1,644.10		2,240.62	1,067.64		1,964.44	1,058.51	
Graft source				0.474			**0.002**			**0.003**
Autograft	73	4,187.45	1,779.51		2,388.14	1,314.57		1,799.31	958.80	
Allograft	5	3,609.71	595.54		473.21	366.64		3,136.50	230.32	
Graft type				**0.038**			**0.005**			**0.017**
Quad Tendon	57	4,489.61	1,779.88		2,590.11	1,361.25		1,899.50	932.83	
BTB Patellar Tendon	8	3,538.63	1,051.40		898.32	778.06		2,640.31	880.75	
IT Band	4	2,470.43	1,289.06		1,815.18	1,235.19		655.25	441.73	
Quad Tendon + Gracilis	1	4,148.21	--		2,928.21	--		1,220.00	--	
Quad Tendon + Semitendinosus	1	5,477.01	--		2,579.01	--		2,898.00	--	
Semitendinosus/Gracilis	7	2,858.36	1,045.01		1,301.33	346.56		1,557.04	1,093.65	
Meniscus Tear				**<0.001**			**<0.001**			0.394
None	27	2,754.08	788.84		1,046.38	452.82		1,707.70	919.18	
Medial	22	5,547.49	1,752.25		3,450.88	1,232.96		2,096.60	1,017.05	
Lateral	29	4,390.60	1,376.69		2,500.98	1,072.62		1,889.62	1,021.98	
Meniscus Repair				**<0.001**			**<0.001**			0.172
None	27	2,754.08	788.84		1,046.38	452.82		1,707.70	919.18	
All-inside suture repair (one-side)	43	4,672.38	1,532.65		2,828.63	1,260.97		1,843.74	958.27	
Inside Out (one-side)	2	6,468.31	174.82		3,275.68	33.60		3,192.63	208.42	
Luggage tag sutures	1	3,195.65	--		1,272.65	--		1,923.00	--	
All-inside (both sides)	4	6,449.65	2,105.04		3,725.40	672.12		2,724.25	1,497.10	
Combination (both sides)	1	6,529.09	--		4,091.09	--		2,438.00	--	
Femoral fixation				**0.009**			0.130			**0.013**
Suture alone	4	2,470.43	1,289.06		1,815.18	1,235.19		655.25	441.73	
Fixed loop	50	4,555.78	1,764.84		2,497.67	1,543.40		2,058.11	976.75	
Adjustable loop	24	3,585.90	1,417.63		1,856.50	760.43		1,729.41	916.19	
Tibial fixation				0.532			0.112			0.056
Hybrid	61	4,110.74	1,595.59		2,363.30	1,332.59		1,747.44	767.57	
Interference	9	3,870.46	1,451.58		1,383.18	1,445.33		2,487.28	905.42	
Suspensory	8	4,767.88	2,866.48		2,511.26	1,241.33		2,256.63	1,976.14	