Labral Management Technique and Operating Surgeon Drive Costs for Hip Arthroscopy: A Time-Driven Activity-Based Costing Analysis

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INTRODUCTION: Despite growing interest in delivering high-value orthopaedic care, the costs associated with outpatient hip arthroscopy remain poorly understood. Previous studies assessing the gross cost and relative cost-effectiveness of hip arthroscopy have been limited by their derivation of costs from insurance reimbursements, hospital charges, or national averages – all of which have been criticized for limited accuracy and lack of granularity. Time-driven activity-based costing (TDABC) has been shown to outperform traditional hospital accounting systems and has recently emerged as the gold-standard accounting methodology in the field of orthopaedics. Thus, this study aimed to 1) quantify the cost of outpatient hip arthroscopy for symptomatic labral tears using TDABC; 2) explore the composition of total cost within an episode of care; and 3) identify factors that drive variability in cost.
METHODS: Institutional review board approval was obtained to retrospectively review all outpatient hip arthroscopy cases performed at multiple outpatient surgery centers associated with a single, large urban healthcare system between June 2015 and November 2022. Total costs were measured using TDABC methodology and subsequently multiplied by an undisclosed constant to normalize the study mean for total cost to 100. We defined the care cycle to include preoperative, intraoperative, and postoperative phases. Descriptive cost analyses per surgery and multivariable linear regression were used to identify patient characteristics (e.g., age, body mass index (BMI), gender, American Society of Anesthesiologists (ASA) classification, previous hip surgeries) and case-specific features (e.g., operating surgeon, surgery center, labral management technique, osteoplasties performed) underlying variation in costs.
RESULTS:
This study included 890 cases performed by five orthopaedic surgeons at four outpatient surgery centers (Table 1). The normalized total cost per patient of hip arthroscopy ranged from 43.4 to 203.7 (mean ± standard deviation: 100 ± 24.2), with 1.8-fold variation in total costs between patients in the 10^{th} and 90^{th} percentile. A wider cost variation between the 10^{th} and 90^{th} percentile was identified among supply costs (2.5-fold) versus labor costs (1.8-fold). The majority of total costs were incurred during the intraoperative phase (91.5%), followed by the preoperative (5.5%) and postoperative phases (3.0%) (Table 2). On average, supply costs accounted for 48.8% of total costs, while labor costs comprised the remaining 51.2%. Variation in total costs was most effectively explained by the method of labral management (partial R^2=0.338) and operating surgeon (partial R^2=0.329), followed by osteoplasty type (partial R^2=0.090) and surgery center (partial R^2=0.087; p<0.001 for all) (Table 3). Demographic features associated with increased costs included male gender (4.9-point increase, p<0.001) and younger age (0.08-point decrease per additional year, p<0.001). Interestingly, BMI, race, ethnicity, and ASA score were not independently associated with total costs (p>0.05 for all). The linear regression model incorporating these factors explained 74.8% of the observed variance in total costs. Finally, data trends over the study period revealed a shift toward labral preserving techniques over debridement (77.8% to 93.2%; P_{trend}=0.0039), with a strong correlation between operative year and increasing supply/labor costs and operative time (p<0.001 for all).
DISCUSSION AND CONCLUSION:
To our knowledge, this study is the first to use TDABC to characterize cost drivers of outpatient hip arthroscopy. We identified wide patient-to-patient variation in costs that was most effectively explained by the method of labral management, operating surgeon, osteoplasty type, and surgery center. These findings – coupled with the growing body of outcomes-based research supporting labral preserving techniques – call into question current reimbursement rates that do not differentially compensate labral repair versus debridement. Given the current trends in procedural coding, declining reimbursement, and rising healthcare costs, these findings may support physicians, hospitals, and other stakeholders in developing value improvement strategies that promote the delivery of equitable, evidence-based musculoskeletal care.

Table 1. Characteristics of the study population (n = 890)

Variable	Mean (SD) or No. (%)	Variable	Mean (SD) or No. (%)
Year of Surgery	2019.5 (1.9)	**Osteoplasty type**	
Age	37.1 (12.7)	Acetabuloplasty	162 (18.2)
Body mass index (kg/m^2)	26.6 (4.7)	Femoroplasty	224 (25.2)
Gender		Combined	407 (45.7)
Female	515 (57.9)	None	97 (10.9)
Male	375 (42.1)	**Labrum procedure**	
Race		Debridement	76 (8.5)
Asian	23 (2.6)	Repair	531 (59.7)
Black or African American	22 (2.5)	Augmentation	266 (29.9)
White	806 (90.6)	Reconstruction	17 (1.9)
Other	21 (2.4)	**Surgeon**	
Unavailable	18 (2.0)	Surgeon #1	297 (33.4)
Ethnicity		Surgeon #2	275 (30.9)
Hispanic or Latino	34 (3.8)	Surgeon #3	231 (26.0)
Not Hispanic or Latino	831 (93.4)	Surgeon #4	52 (5.8)
Unavailable	25 (2.8)	Surgeon #5	35 (3.9)
ASA Class		**Surgery center**	
1	380 (42.7)	Surgery center A	366 (41.1)
2	476 (53.5)	Surgery center B	254 (28.5)
3	34 (3.8)	Surgery center C	177 (19.9)
Anxiety	273 (30.7)	Surgery center D	93 (10.4)
Depression	178 (20.0)	**Insurance**	
Previous ipsilateral surgery	30 (3.4)	Government	93 (10.4)
Previous contralateral surgery	85 (9.6)	Private	763 (85.7)
		Workers Compensation/MVA Claims	34 (3.8)

Abbreviations: SD, standard deviation; kg, kilogram; m, meter; ASA, American Society of Anesthesiologists; MVA, motor vehicle accident.

Table 2. Normalized cost estimates of the hip arthroscopy care cycle

Variable	Mean (SD)
Total cost	100.0 (24.2)
Total supply cost	48.8 (16.1)
Implant and/or graft* costs	15.8 (9.2)
Other/disposables costs	33.0 (12.9)
Total labor cost	51.2 (12.3)
Fixed labor cost	8.5 (0.2)
Variable labor cost	42.7 (12.2)
Preoperative cost	5.5 (0.1)
Intraoperative cost	91.5 (24.2)
Postoperative cost	3.0 (0.2)

*Includes allografts or autografts

Abbreviations: SD, standard deviation.

Table 3. Multivariable linear regression evaluating characteristics underlying variation in costs

Variable	Mean difference	95% CI		Partial R^2*	P value
		Lower	Upper		
Patient characteristics					
Age, per 1-year increase	-0.08	-0.16	-0.01	0.005	**0.033**
BMI, per 1-unit increase	-0.02	-0.21	0.16	<0.001	0.820
Male gender	4.93	3.09	6.77	0.031	**<0.001**
Asian race†	-2.83	-8.05	2.38		0.287
Black or African American race†	4.21	-1.15	9.56	0.008	0.123
Other race†	-5.27	-11.43	0.90		0.094
Unavailable race†	2.23	-4.07	8.54		0.487
Hispanic or Latino ethnicity‡	4.37	-0.52	9.27	0.004	0.080
Unavailable ethnicity‡	0.26	-5.11	5.63		0.925
ASA 2§	-0.10	-1.96	1.76	<0.001	0.919
ASA 3§	0.92	-3.82	5.66		0.702
Case-specific factors					
Year, per 1-year increase	1.01	0.48	1.54	0.016	**<0.001**
Acetabuloplasty¶	5.06	1.23	8.90		**0.010**
Femoroplasty¶	8.39	5.00	11.77	0.090	**<0.001**
Femoral acetabuloplasty¶	14.82	11.03	18.60		**<0.001**
Labral repair#	23.46	19.86	27.07		**<0.001**
Labral augmentation#	23.23	17.77	28.69	0.338	**<0.001**
Labral reconstruction#	72.61	65.72	79.50		**<0.001**

*Multiple R^2 = 0.748. †Reference: White race. ‡Reference: Not Hispanic or Latino. §Reference: ASA 1. ¶Reference: no osteoplasty. #Reference: labral debridement. This model also controlled for surgeon and surgery center. Surgeon partial R^2 = 0.329; surgery center partial R^2 = 0.087. Boldface denotes statistical significance.
Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists.