Single-Stage Revision Anterior Cruciate Ligament Reconstruction Requires Significantly Longer Operative Time Than Primary Reconstruction, Despite Comparable Reimbursement: A Single-Center Study

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Objectives: To evaluate labor and time investment for revision ACL-R procedures, assess billing versus reimbursement disparities, and compare value returned, controlling for time and relative value units (RVUs), between revision and primary ACL-R procedures.

Design: Retrospective cohort study

Setting: Academic Private Practice

Patients/Participants: Patients who underwent primary ACL-R and single-stage revision ACL-R at a single academic institution from 2010 to 2021.

Intervention: Primary ACL-R and single-stage revision ACL-R

Main Outcome Measures: Patient demographics, operative variables, CPT codes, RVUs, billed charges, and final reimbursements were collected and compared between groups.

Results: Of 57 patients, 42 (73.7%) underwent primary ACL-R and 15 (26.3%) underwent revision ACL-R. Revision procedures had significantly longer operative times (159.7±62.4 vs 111.6±32.2 minutes, $p<0.001$). Revision procedures generated numerically higher RVUs (49.5±13.3 vs 44.1±12.7, $p=0.14$) and similar RVU efficiency per minute (0.4±0.2 vs 0.4±0.1, $p=0.192$). Reimbursement per operative minute was numerically lower for revision procedures ($18.5±$10.1 vs $24.9±$16.2), but the difference was not statistically significant ($p=0.143$). Total reimbursement was comparable between groups ($2,671.4 vs $2,689.1, $p=0.972$).

Conclusion: Single-stage revision ACL-R required approximately 43% longer operative time than primary procedures ($p<0.001$) yet generated comparable total reimbursement. Although reimbursement per operative minute was numerically lower for revision procedures, this difference did not reach statistical significance in this small revision cohort (n=15). These findings suggest that a shared CPT code may not fully capture the added time and complexity of revision procedures.

Key Terms: relative value units, RVU, revision anterior cruciate ligament reconstruction, revision ACL-R, operative time, CPT, ACL reconstruction, revision, reimbursement, healthcare economics

INTRODUCTION

Anterior cruciate ligament (ACL) tears are one of the most common sports-related injuries,[1] with ACL reconstruction (ACL-R) being the gold standard for patients to return to their preinjury sport level.[2–4] However, there is a 5.2-34.2% graft failure rate,[5,6] and failure rates of 3.5-33% for revision ACL-R.[7] Revision ACL-R outcomes are not as successful as primary ACL-R regarding functional scores, patient satisfaction, and risk of developing knee osteoarthritis.[8,9] Additionally, ACL revision procedures are known to be technically challenging, with longer operation times relative to primary procedures,[8,10,11] yet the Current Procedural Terminology (CPT) code for billing remains the same for both primary and revision ACL-R.

There is a lack of literature investigating the valuation and reimbursement of revision ACL procedures. The current financial reimbursement system in the United States, relative value units (RVUs), is a fee-for-service model generated by the Centers for

Medicare and Medicaid Services (CMS). Each procedure has a preassigned CPT code and a predetermined quantity of assigned RVUs, and this RVU-based compensation has been the subject of critique in the setting of known discrepancies for cognitive and procedural services.[12] Several studies have demonstrated that revision orthopedic procedures have poor reimbursement relative to their primary counterparts.[13–18]

A NSQIP database study by Marx et al. found that total RVUs and reimbursement for revision ACL-R were significantly higher than those for primary ACL-R.[11] However, when accounting for operative time, RVU/minute and reimbursement/minute were similar between the two groups. This study was unable to account for operative data, including graft type, implant type, staged procedures, and bone grafting, which significantly affect the cost and length of the procedure.[10]

The purpose of this study is to (1) retrospectively evaluate labor, characterized by CPT codes billed, and time investment, defined as operation time, for each specific graft ACL-R revision at a single academic institution, (2) assess the extent of the disparity between the procedural value billed to insurance and what was ultimately reimbursed to the institution, and (3) compare the value returned, controlling for time and RVUs of revision procedures, to primary procedures.

METHODS

Study Design

A retrospective cohort study assessed discrepancies in billing, reimbursements, and RVUs between primary and revision ACL-R.

After obtaining approval from the institutional review board, we queried the administrative database at a single academic institution from 2010 to 2021 using the Current Procedural Terminology code 29888 (ACL reconstruction). Operative reports were then reviewed to distinguish between primary or revision ACL-R patients. Patients 14 years of age and older at the time of primary ACL-R were identified for study inclusion.

Patients who underwent additional ligamentous procedures, had incomplete billing or clinical records, or underwent a two-stage ACL-R revision were excluded from the study. At this academic center, billing and operative times were available only for queries at private surgical centers. Surgeries performed in the hospital setting were thus excluded due to medicolegal system limitations. This accounted for the large number of patients excluded for incomplete billing records (Figure 1). Patients with primary ACL-R were identified and matched to those with single-stage ACL-R revision by sex, age, and BMI (Figure 1). The final cohort groups were unequal after the inclusion and exclusion criteria were applied; thus, the final analysis was not matched.

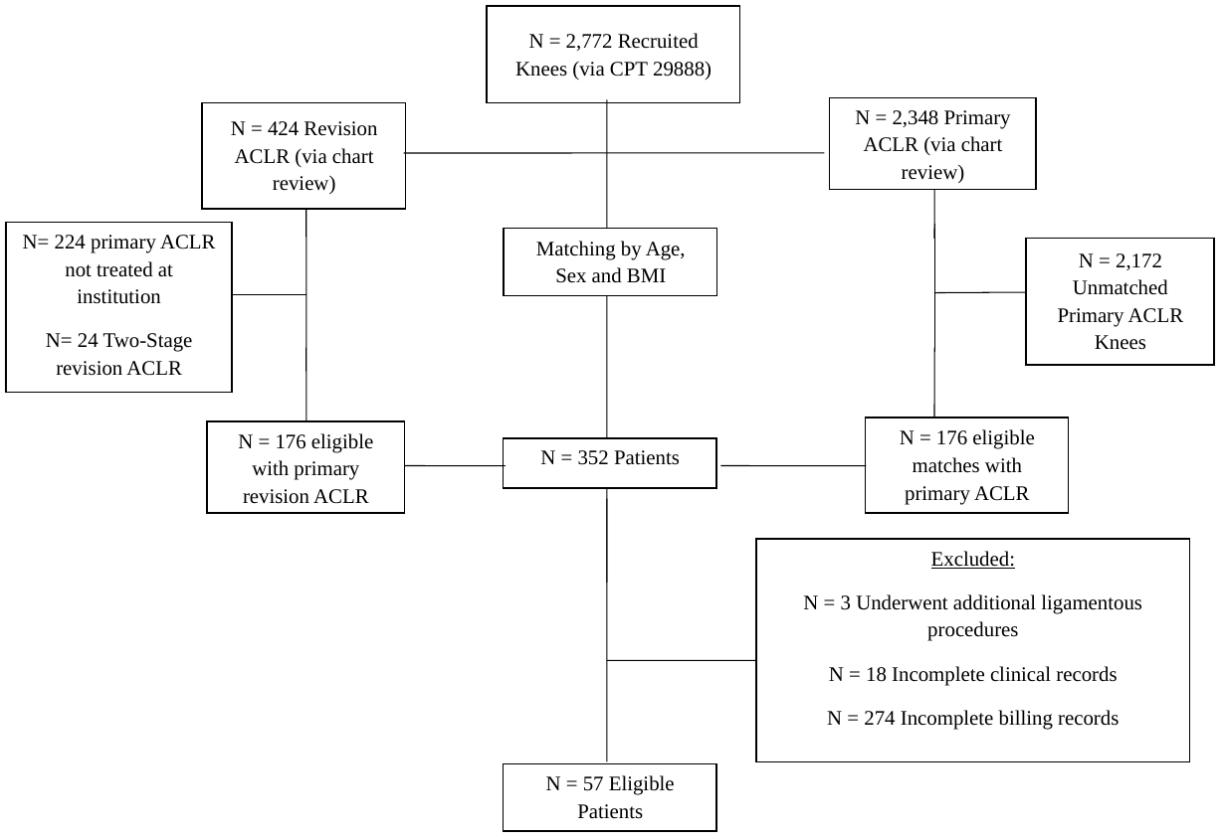
Data Collection

Clinical and operative notes of all eligible patients were reviewed, and demographic, operative, and postoperative data were obtained. Surgical variables included graft type, tunnel drilling method, and graft fixation type. All data were extracted from postoperative clinic notes as documented by the treating surgeon. Concomitant injuries and procedures for each reconstruction were collected. Study data were collected and managed using Research Electronic Data Capture System (Vanderbilt University), a secure web-based software platform hosted at our institution.[19]

Surgical Technique

All patients were treated by fellowship-trained sports medicine orthopedic surgeons (8 in total) at our single academic institution. Overall patient health, including vascular status and ability to adhere to postoperative rehabilitation protocols, was assessed individually and used to determine surgical appropriateness. Surgical approaches were not standardized for

Figure 1: Flow diagram (STROBE format) of patient identification, matching, and exclusions for primary versus single-stage revision ACL reconstruction.



this study, but operative data were collected to control for this in the analysis.

Reimbursement Collection

Operative reports from private surgical centers were reviewed to determine operative time. CPT codes for each surgery were obtained from billing records. The billing department reported total RVUs per case, total billed charges, and final collection reimbursement for each included surgery.

Total RVUs were the sum of all RVUs assigned to CPT codes billed for each surgical case, including the primary ACL reconstruction (CPT 29888). RVUs per minute were calculated as total RVUs generated divided by operative time in minutes. Reimbursement per minute was calculated as total reimbursement divided by operative time in minutes.

Statistical Analysis

Descriptive statistics and conventional univariable comparisons appropriate to the data type were used. Statistical significance was set at $P < 0.05$.

RESULTS

Patient Demographics and Baseline Characteristics

A total of 57 patients met the inclusion criteria. Of these, 42 underwent primary ACL-R only, while 15 (26.3%) subsequently required revision ACL-R. All surgeries were performed at our institution. The study population was predominantly male (66.7%), with a higher proportion of males in the revision group (80% vs 61.9%). Patient demographics and baseline characteristics are summarized in Table 1.

Concomitant Procedures

The most common concomitant procedures during primary ACL-R were meniscus repair (33.3% overall) and meniscectomy (24.6% unilateral, 8.8% bilateral).

Table 1: Comparison of Revision Surgery vs Primary Surgery Groups

Characteristic	Revision Surgery Group (n=15)	Primary Surgery Group (n=42)	P-value
Demographics			
Male	12 (80%)	26 (61.9%)	-
Female	3 (20%)	16 (38.1%)	-
RVUs generated	49.5 [13.3]	44.1 [12.7]	0.14
Efficiency Metrics			
Operative time (minutes)	159.7	111.6	P<0.001
RVUs per operative minute	0.4 [0.2]	0.4 [0.1]	0.192
Reimbursement per minute ($)	18.5 [10.1]	24.9 [16.2]	0.143
Financial Outcomes			
Billed charges ($)	4,914.3 [1,111.1]	6,228.6 [7,664.9]	0.504
Final reimbursement ($)	2,671.4 [1,096.6]	2,689.1 [1,915.9]	0.972
Reimbursement rate	0.5	0.5	0.605

Values are mean ± SD or n (%). SD, standard deviation; RVU, relative value unit.

The distribution of additional procedures was similar between groups at the time of primary and revision surgery (Table 2). In the primary ACL group, 17 patients underwent an isolated ACL reconstruction, with an average RVU per operative minute of 0.3. In the revision group, 2 patients underwent an isolated ACL reconstruction, with an average RVU per operative minute of 0.2.

Revision Surgery Characteristics

Among the 15 patients who underwent revision ACL-R, the mean age at revision was 27.0±9.6 years. Revision ACL-R procedures had substantially longer operative times than primary procedures, requiring 159.7±62.4 minutes compared with 111.6±32.2 minutes for primary procedures in the same patient population (p<0.001) (Table 1).

Financial Analysis and RVU Comparison

Revision procedures required significantly longer operative time (159.7 vs 111.6 minutes, p<0.001), representing a 43.1% increase and an additional 48.1 minutes per case.

Revision procedures generated higher RVUs (49.5 vs 44.1), though this difference was not statistically significant (p=0.140). RVU efficiency per minute was similar between groups (0.4±0.2 vs 0.4±0.1 RVUs per minute, p=0.192). Revision procedures had 25.7% lower reimbursement per operative minute ($18.5 vs $24.9), although this difference did not reach statistical significance (p=0.143). Total reimbursement was similar between groups ($2,671.4 vs $2,689.1, p=0.972).

DISCUSSION

This study reveals important disparities in operative complexity, time investment, and reimbursement patterns between primary and revision ACL-R procedures. The key finding that revision procedures require 43.1% longer operative time while generating proportionally similar RVUs indicates a misalignment between procedural complexity and compensation within the current healthcare reimbursement framework.

The significantly longer operative time for revision ACL-R (159.7 vs 111.6 minutes for primary procedures) aligns with existing literature documenting the increased technical demands of revision procedures.[8,10,11] Revision ACL-R often requires additional steps, including graft removal, tunnel assessment and potential bone grafting to avoid or attempt reusability, hardware avoidance or removal from prior surgery, and tunnel revision, all of which contribute to increased operative complexity. The 43.1% increase in operative time demonstrates the substantial additional resources required for revision procedures,

Table 2: Concomitant Procedures During Primary and Revision Surgery

Concomitant Procedure	Revision Surgery Group (n=15)	Primary Surgery Group (n=42)	P-value
Meniscectomy (medial or lateral)	6 (40%)	11 (26.2%)	0.2499
Meniscectomy (medial and lateral)	2 (13.3%)	4 (9.5%)	0.5
Meniscus repair (medial or lateral)	8 (53.3%)	15 (35.7%)	0.1874
Meniscus repair (medial and lateral)	0 (0%)	5 (11.9%)	N/A

Values are n (%).

yet the current CPT coding system assigns identical codes (29888) for both primary and revision procedures.

Although revision procedures generated higher total RVUs (49.5 vs 44.1), the increase was not proportional to the operative time investment, resulting in similar RVU efficiency per operative minute. Despite this, revision procedures generated 25.7% less reimbursement per minute of operative time ($18.5 vs $24.9), although this difference did not reach statistical significance (p=0.143). This pattern suggests a disconnect between RVU generation and actual compensation and raises concern that the current reimbursement system may not adequately compensate surgeons for the increased complexity, planning, and technical expertise required for revision procedures.

The analysis shows that revision procedures yield reimbursement comparable to that of primary procedures ($2,671.4 vs $2,689.1, p=0.972) yet require 43.1% longer operative time. This substantially reduces financial efficiency, as revision procedures generate 25.7% less reimbursement per minute of operative time, although this difference was not statistically significant. Despite significantly greater complexity and time investment, total reimbursement remains similar, suggesting that current billing and RVU assignment practices may not capture the true resource utilization and technical demands of revision procedures. This disparity has important implications for surgeon compensation and may influence willingness to perform these complex cases. Our findings corroborate and extend the work of Marx et al.,[11] who found similar RVU and reimbursement patterns between primary and revision ACL-R. However, our study provides additional context by controlling for additional procedures and enabling detailed data analysis.

Studies in other orthopedic subspecialties have likewise shown inadequate compensation for revision procedures. Patel et al. found that revision total knee arthroplasty required 32% longer operative time yet generated only 15% higher RVUs,[15] while Sodhi et al. reported similar disparities in revision total hip arthroplasty.[17] Our findings suggest that this pattern of inadequate compensation for revision complexity extends to sports medicine procedures.

The current study highlights several important healthcare policy considerations. First, the substantial gap between operative complexity and RVU assignment suggests a need for revision-specific CPT codes that better reflect the increased technical demands and time required for these procedures. Second, inadequate compensation for revision procedures may discourage surgeons from performing these complex cases, potentially limiting patient access to necessary revision surgery. Finally, the financial disincentive for revision procedures may influence surgical decision-making and affect the quality of care for patients requiring complex revision surgery.

Future research should examine larger, multi-institutional cohorts to validate these findings across diverse healthcare systems. Studies investigating how specific technical factors (graft type, tunnel revision complexity, bone grafting requirements) relate to operative time and RVU generation would provide valuable insights to inform CPT code refinement.

Health economic analyses that assess the total cost of care for revision ACL-R, including indirect costs and long-term outcomes, would provide a more comprehensive understanding of the value proposition of these procedures. Additionally, studies examining the impact of reimbursement disparities on surgeon behavior and patient access to revision procedures would inform healthcare policy decisions.

Limitations

Several limitations should be acknowledged. First, this is a single-institution study, which may limit generalizability to other healthcare systems or geographic regions. However, this academic center specializes in revision surgeries; the discrepancy in operative time between primary and revision ACL-R may be even greater among community surgeons than at this center. Additionally, multiple surgeons were included, which can introduce variability in operative time based on experience. Second, the relatively small sample size of revision cases (n=15) may limit statistical power for some comparisons. The smaller sample size was partly due to the retrospective nature of retrieving billing and operative times, which were available only for queries at private surgical centers, resulting in many patients being excluded for incomplete billing records. Third, we were unable to analyze specific technical factors, such as graft type, bone grafting requirements, or tunnel revision complexity, that may influence operative time and complexity.

Additionally, we did not account for indirect costs, such as increased preoperative planning time, specialized instrumentation requirements, or longer postoperative care, that may be associated with revision procedures. The study also did not examine long-term outcomes or the cost-effectiveness of revision procedures from a healthcare system perspective.

CONCLUSION

This single-center study demonstrates that single-stage revision ACL-R requires significantly longer operative time than primary reconstruction ($p<0.001$) yet yields comparable total reimbursement. Although this translates to lower reimbursement per operative minute, the difference did not reach statistical significance in this limited revision cohort. Taken together, these findings suggest that a shared CPT code may not fully capture the additional time and technical demands of revision procedures, a question that warrants confirmation in larger, adequately powered, multi-institutional studies.

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