Cost Analyses of Nonoperative Treatment of Sports-Medicine Conditions Are Lacking

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Funding The authors received no financial support for the research, authorship, or publication of this article.

Conflict of Interest The authors report no conflicts of interest.

ABSTRACT

The purpose of this study was to qualitatively review existing studies that examined cost data within sports medicine. A literature search was conducted for all economic studies related to sports-medicine conditions from 2000 to 2017 within the United States. Area of analysis, data source utilized, and the type of collected cost data was identified. There were 29 studies that met criteria, with the majority of studies (60%) focused on rotator cuff repair and anterior cruciate ligament reconstruction. Substantial variability in data source, practice setting, data metrics, and reported measures makes interpretation of existing reports challenging. Greater diversity in topics and more standardized methodology are necessary to better understand value and quality in sports medicine.

Keywords: Cost, Cost Analysis, Sports Medicine

INTRODUCTION

Providing high-value healthcare is a growing priority in the face of an increasing economic burden associated with healthcare.[1-3] Value is commonly understood to be the ratio of outcome to cost.[4] Although there are many outcome studies in sports medicine, there are few cost studies. Such economic studies are challenging to perform, and there is significant inter-study variation in region, methodology, and data source. Existing studies commonly report reimbursement or charges.[5] However, such figures are known to be disparate from actual cost. Conversion of these data sources to cost is unreliable as global cost-charge ratios lack adequate granularity.

Cost data that are more reliable and accurate is necessary. When combined with clinical outcome data, value and cost effectiveness can be determined.[5] Understanding the costs associated with various interventions is important for patient counseling, institutional resource allocation, reimbursement, and practice management. The purpose of this study was to determine the amount and variety of cost-identification studies within sports-medicine literature.

METHODS

A literature search was conducted using PubMed, Embase, Web of Science, and Scopus. Published economic articles that involved sports-medicine procedures, diagnostic tests, or treatment options between January 1, 2000 and December 31, 2017 were included in the initial search. The search included both economic and specific terms. The economic terms were "economic," "cost," and "cost analysis." The specific terms were "anterior cruciate ligament," "ACL," "posterior cruciate ligament," "PCL," "cartilage," "meniscus," "meniscal," "arthroscopy," "microfracture," "femoroacetabular impingement," "FAI," "labrum," "rotator cuff," "instability," and "tendon." Articles that were not cost-identification studies were excluded from this study, along with any study not based in the United States. The currency and author affiliation were both used to determine if a study was a United States-based study. Foreign studies were excluded to decrease study heterogeneity while increasing generalizability to the United States population. Two of the authors independently determined study size, time, clinical area, comparisons, economic data, data source, practice setting, cost and charge subcategories, findings, and level of evidence.

RESULTS

Search Results

The search algorithm identified 1,895 studies. There were 157 studies (8.28%) related to sports medicine (Figure 1). Thoroughly assessing abstracts and articles resulted in a total of 42 cost and economic studies. When excluding studies that were not based in the United States, a total of 29 articles (1.53% of the original search) were to be included in this review (Table 1).

Article references were searched, and the "related citations" function on PubMed was used. No further articles were found. Twenty studies (70%) addressed costs associated with surgical care. Eight studies (30%) evaluated costs related to diagnostic modalities.

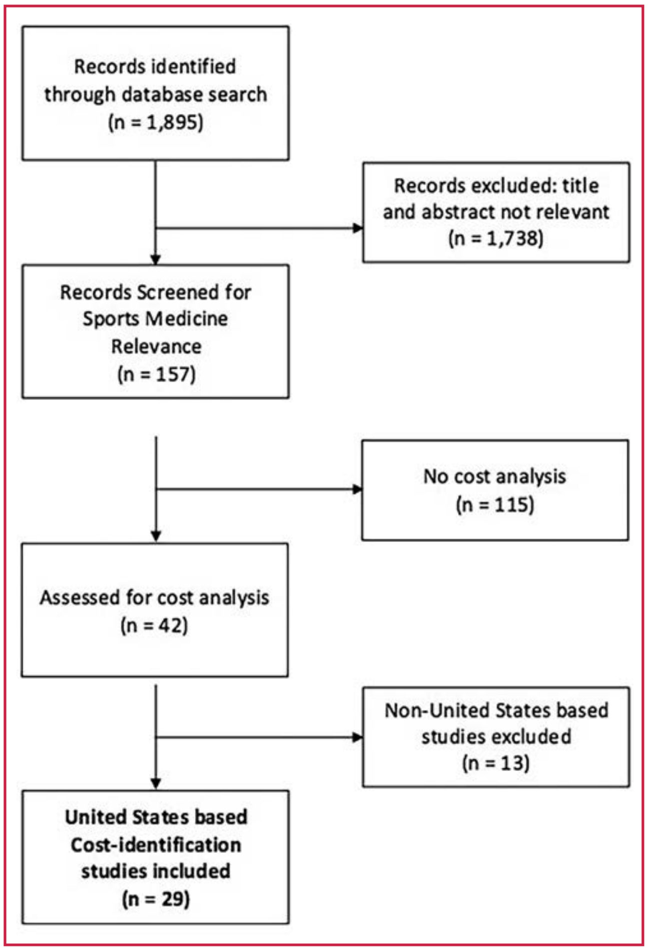

Figure 1. *Study Cohort Flowchart*

Only one study focused on the cost associated with nonoperative treatment for a specific condition. Eighteen studies (60%) focused on rotator cuff repairs (RCR) and anterior cruciate ligament reconstruction (ACLR). Other studies evaluated Achilles tendon ruptures, various treatments for cartilage lesions, and diagnostic and follow-up tests.

There was large variation in the cost metrics analyzed in the studies as well as the sources of collected data (Table 1). The cost data collected showed a wide variety between studies ranging from direct and indirect costs, charges, and reimbursement (Table 1).

Anterior Cruciate Ligament Reconstruction

ACLR was the most common clinical area studied. Of the 11 ACLR studies, there were 7 studies that presented cost subcategories (ie, facility, operating room, implant, graft, and supply fees) in addition to total costs.[6-12] One sole study presented therapy fees, and only three studies presented surgeon and professional fees.[6,10,11] Larson et al[6] was the only anterior cruciate ligament study to look at clinical outcome scores along with cost data.

Two studies examined costs beyond the immediate encounter for ACLR.[13,14] In 4 of 5 studies, allograft was significantly more expensive than autograft, even when factoring decreases in operating room time and supplies.[7,9-12] Archibald-Seiffer et al[8] reported inter-surgeon variation in suture, instrumentation, and allograft costs despite all surgeons being in the same hospital system (Table 1). These studies reported excellent direct cost data largely centered on time of surgery, with the exception of one study that evaluated 90-day direct costs for ACLR.[14]

Rotator Cuff Repair

RCR was also a common clinical area of study. Of the 8 RCR studies, there were 7 studies that presented cost subcategories in addition to total costs.[15-21] Operating room, implant, graft, and supply fees were the most common cost subcategories presented. Only one study included therapy-related costs after RCR (Table 1),[15] with the remainder looking a direct costs centered on time of surgery.

Similar to ACLR, RCR had high inter-surgeon variability in supply costs despite being in the same hospital system.[18] Reimbursement for both RCR and physical therapy afterwards was lower with Medicare payers than with non-Medicare payers despite similar costs for RCR.[15,17] A study by Bisson et al[19] compared single versus double-row RCR and found the latter cost to be as high as $5,407 more than the former, emphasizing the need for a proper cost-effectiveness analysis (CEA) to evaluate the two techniques. Two studies looked at the costs for transosseous RCR versus double-row transosseous equivalent (TOE) surgeries, and they found the mean implant cost for TOE repairs to be significantly more expensive than anchorless repairs, with no difference in operative time or short-term outcomes (Table 1).[16,21] Seidl et al[21] was the only group to associate clinical outcome measures with cost data among RCR studies. Both studies have good methodology but were also limited in their cost analysis. Black et el[16] also did not provide any clinical outcome analysis. These studies would benefit from having a clear economic model and outcome measure to be able to perform proper CEA in the future.

Chondral Defects

Only two studies examined treatment of articular chondral defects. Miller et al[22] did a cost analysis and found similar results between microfracture and osteochondral allograft transplantation (OAT), with microfracture being cheaper. However, the cost of OAT decreased postoperatively at the 10-year follow-up. Schrock et al[23] found microfracture to be more cost-effective than osteochondral allograft transplantation or first-generation autologous chondrocyte implantation, as measured by cost-per-point change in functional outcome scores (Table 1). Both of these studies incorporated clinical outcome measures with direct costs from surgery thorough an extended follow-up period.

Nonoperative Management

Only one study included nonoperative management of Achilles tendon rupture versus surgical management.[24]

Table 1. Breakdown of Sports Medicine Cost Analysis Studies from 2000-2017 in the United States

Study	Clinical Area	Comparison	Study Size	Economic Data	Summary of Economic Data Presented	Findings
Herzog et al 2017[13]	ACLR	ACL with or without other knee injuries	229,446	Charges	Immediate Procedure Total, 9-month window total	Concomitant collateral ligament repair associated with higher costs. Subsequent procedures were more expensive than the index procedure.
Rosas et al 2017[14]	ACLR	N/A	10899	Reimburse-ments	Same-day, 90-day reimbursements	There is no significant difference in same-day or 90-day costs between age-matched males and females.
Schrock et al 2017[23]	Cartilage Defects	Microfracture vs OAT vs ACI	730	Charges	Procedural, diagnostic imaging, rehabilitation	Microfracture was found to be the most cost-effective option.
Truntzer et al 2017[24]	Achilles Rupture	Operative vs. Nonoperative Management	5,044	Charges	Surgeon, facility, office visits, physical therapy, supply, complication	Surgical management of Achilles rupture was significantly more costly than nonsurgical management.
Wester-mann et al 2017[28]	Shoulder MRI	Urban vs. Critical Access Hospital vs. Rural and Rural Referral Centers	94	Charges	MRI technical costs	Independent imaging centers have significantly lower charges to consumers for MRI compared to hospital-owned centers.
Black et al 2016[16]	RCR	Transosseous Rotator Cuff Repair vs Transosseous Equivalent Rotator Cuff Repair	344	Direct Costs	Implant Costs, OR Time	Costs associated with arthroscopic transosseous rotator cuff repair were lower than costs associated with transosseous equivalent repairs.
Narvy et al 2016[17]	RCR	Medicare vs. Non-Medicare Patients	184	Charges	Implant and Variable Charges	Reimbursement is lower in the Medicare group, but charges are similar.
Seidl et al 2016[21]	RCR	Transosseous Rotator Cuff Repair vs Transosseous Equivalent Rotator Cuff Repair	43	Implant Costs	Implant Costs, OR Time	Mean implant cost lower in the transosseous rotator cuff repair group than in the transosseous-equivalent rotator cuff repair group.
Terhune et al 2016[18]	RCR	Between Surgeon Differences	62	Cost	Suture anchors, suture-passing devices, suture, and disposable instruments and tools	There is significant variation across surgeon and case. Suture anchors were the most expensive and variable surgeon-directed cost.
Archibald-Seiffer et al 2015[8]	ACLR	Surgeon Variation in Costs for ACL Reconstruction	49	Limited Direct Costs	Fixation, Device, Implant, Supply Cost	Significant variation in cost of tibial or femoral fixation as well as in cost for sutures, instruments, and allografts.
Arshi et al 2015[15]	RCR	Medicare vs. United Healthcare Groups	365,891	Charges	Per-patient average charge, Utilization-weighted per-patient average charge	Utilization of physical therapy after rotator cuff repair is higher in privately insured than Medicare patients. Per-patient charges are similar between groups.
Bisson et al 2015[19]	RCR	Single Row vs. Double Row vs. Suture Bridge	N/A - Cost Modelling	Calculated Costs	Implant, Professional Fee, Anesthesia Fee, Opportunity Cost, Therapy Fee	Double row and suture bridge techniques are more expensive than the single row technique. Double row and suture bridge would need to have significantly lower revision rates than single row to justify their increased costs.
Miller et al 2015[22]	Cartilage Defects	Microfracture vs OAT for Distal Femoral Articular Cartilage Defects	N/A - Cost Modelling	Direct Costs	Anesthesia, OR fees, Surgeon Fees, Return Visits, MRI, Initial procedure cost, secondary procedure cost	Net direct costs and cost-effectiveness of microfracture and OAT are comparable for distal femur articular lesions.
Stucken et al 2015[39]	ACL Evalu-ation	N/A	340	Charges	Radiograph costs	Postoperative radiograph after ACL rarely resulted in changes in management and had significant costs.
Greene et al 2014[31]	Knee Arthroscopy	N/A	3797	Charges	Discordant diagnosis, discrepant diagnosis costs	Routine pathologic examination of knee arthroscopy specimens rarely altered management of patients

Iyengar et al 2014[20]	RCR	N/A	NR	Estimated Costs from Hospital Charges	Total Hospital Charges	Charges associated with inpatient rotator cuff repair increased in Nationwide Inpatient Sample over time. Increase in healthy patients undergoing rotator cuff repair in outpatient surgery centers
Kahlenberg et al 2014[27]	Hip Evaluation	N/A	78	Charges	Healthcare provider visits, diagnostic imaging, conservative management	There are significant costs associated with delay to diagnosis of femoracetabular impingement and labral tears
Voigt et al 2014[25]	Shoulder and Knee Evaluation	Diagnostic Office Arthroscopy vs MRI	705000	Calculated Costs	Treatment, Complication Costs	Suggests that Diagnostic Office Arthroscopy is significantly more cost-effective than MRI
Keeney et al 2013[29]	Hip Evaluation	Impact vs nonimpact Hip MRI	218	Procedural Cost Utility	Cost Utility of MRI	MRI of the hip rarely impacts clinical decision making independent of hip x-ray.
Yeranosian et al 2013[30]	Rotator Cuff Evaluation	N/A	92688	Charges during 90-day period prior to Rotator Cuff Repair	Diagnostic Imaging, Injections, Outpatient Visits, Physical Therapy, Laboratory/Preoperative Studies, Miscellaneous, Unknown	Majority of preoperative costs comes from MRI related costs.
Greis et al 2012[7]	ACLR	Allograft vs Autograft for ACL Reconstruction	96	Charges, Direct Costs, Reimbursement	OR costs, intraoperative supplies, anesthesia, pharmacy, recovery, total	Allograft cost was not offset by decrease in OR time. However, could be cost-effective in an outpatient setting
Barrera et al 2011[10]	ACLR	Allograft vs Autograft for ACL Reconstruction	164	Cost and Calculated Costs from Case Details	Supply, Labor, and Facility Costs	Allograft ACL reconstruction cost significantly higher than autograft ACL reconstruction cost
Churchill and Ghorai 2010[41]	RCR	Mini-open vs. All-arthroscopic	5,224	Charges	Total Charges	Mini-open is cheaper than all-arthroscopic. Low and intermediate volume centers were cheaper than high volume centers.
Cooper and Kaeding 2010[9]	ACLR	Allograft vs Autograft for ACL Reconstruction	98	Direct Costs	Anesthesia, Pharmacy, Medical Supply, Operating Room, and Recovery Room Costs	Allograft cost was not offset by decrease in OR and recovery room time.
Brophy et al 2009[32]	ACLR	Double Bundle vs Single Bundle ACL Reconstruction	N/A - Cost Modelling	Direct Costs	Total estimated hospital costs	Model predicted that double bundle technique significantly increased cost of ACL reconstruction.
Nagda et al 2009[12]	ACLR	Allograft vs Autograft for ACL Reconstruction	155	Cost and Calculated Costs from Case Details	Graft, implant, operating room, recovery room, anesthesia, supplies costs	Allograft ACL reconstruction is costlier than autograft ACL reconstruction in the outpatient setting
Cole et al 2005[11]	ACLR	Allograft vs Autograft for ACL Reconstruction	123	Charges	Hospital, Surgical Center, Pharmacy, Anesthesia, Anesthesia Supplies, Radiology, OR supplies, PACU, Laboratory, Central supplies, Respiratory Care, Cast Room, Other Charges	Allograft ACL reconstruction cost significantly lower than autograft ACL reconstruction. Autograft has likely increased hospital stay
Larson et al 2004[6]	ACLR	Single vs Two Encounters for Bilateral ACL Reconstruction	57	Charges	Total charges, OR costs, ancillary fees, anesthesiologist, surgeon, allograft, equipment, rehabilitation	Bilateral ACL reconstruction over one encounter was associated with significant cost savings versus a two episodes of unilateral ACL reconstruction
Jari et al 2002[40]	ACLR	Bilateral Simultaneous vs. Unilateral Reconstruction	56	Charges	Hospital	Unilateral ACL reconstruction was cheaper than bilateral simultaneous ACL reconstruction, however they not did report statistical significance.

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; RCR, rotator cuff repair; MRI, magnetic resonance imaging

These authors used a database to compare billing codes with the assumption that outcomes were similar between operative and nonoperative groups based on prior literature.[24]

Diagnosis

Several studies looked at the diagnostic costs of different sports-medicine conditions. Two studies evaluated in-office diagnostic arthroscopy for knee and shoulder intra-articular injuries. These studies suggested that diagnostic arthroscopy resulted in cost savings; however, these studies had no clinical outcome data using prior studies and used Medicare billing information for cost data.[25,26] Magnetic resonance imaging (MRI) evaluation and other workup for joint pain was assessed in four studies.[27-30] These studies reported in their cohorts that the use of MRI as a screening tool for hip pain is not cost effective, that MRI accounts for a significant portion of preoperative costs before RCR, and that independent facility shoulder MRIs are cheaper than large institutional facility MRIs.[28-30] These studies provided no clinical outcome data and used cost information ranging from Medicare billing information to direct charges from hospitals and imaging centers. Greene et al[31] reported that routine pathology specimens following knee arthroscopy was not cost effective (Table 1).

There has been an increasing amount of cost analysis studies through the timeline of this study. The data used for cost analysis is still widely variable over the years, and quality of data analysis also varies from study to study. The majority of studies in this review lacked direct future costs and indirect costs to patients, which needs to be taken into the total cost equation.

DISCUSSION

In the past 18 years, there have only been 29 sports-medicine economic studies within the United States. Over the course of this review, there has been a trend of increased studies published per year. Economic studies in sports medicine have mostly focused on RCR and ACLR. This was also the case for CEA in sports medicine in a review from 2014.[2] There is a large need for economic studies that evaluate other areas within sports medicine. Although the studies presented here provide valuable information, variation in source data and type of cost data limits the generalizability of their conclusions.

In many of the included studies, reimbursement or charges were used in lieu of cost data. However, charges can be as much as twice or triple the amount of the actual cost.[14] The use of reimbursement is also limited as the contribution margin (revenue-direct cost) is highly variable. Furthermore, there are significant indirect and societal costs that should be accounted for, including lost wages and productivity, family burden costs, and other non-medical costs that are deficient in these studies.[5] Direct costs certainly underestimate the total cost of an illness or treatment. Cost remains the most complex component in value calculation, and the most complete model should include direct and indirect costs.[5]

The variety of settings in these studies also limits their generalizability to larger populations. Most studies focused on patients within a single institute or small region. There were six studies that used large and privately insured financial databases, which are more useful when comparing to an entire healthcare system. However, these databases do have their limitations such as only accounting for the insured population. Other studies in this review gathered financial data from multiple sources such as implant companies and surgical centers without using any patient information, whereas one study prospectively questioned patients about their diagnostic workups and reviewed their medical records to fully capture all financial information.[19,25,27] Other studies were economic models rather than observational studies.[19,22,32] Regardless of the design, it should be noted that findings from all economic studies are difficult to generalize across different populations. For this reason, the amount and diversity of economic literature within sports medicine needs to continue to increase.

Despite the variability and limitations discussed above, there are some preliminary conclusions that providers and policy makers can draw to help reduce their expenditure. Two studies, although from the same institution, reported significant inter-surgeon differences in supply costs.[8,18] It is unclear whether this is a widespread practice; however, our institutional experience suggests that this variability may be common. Furthermore, similar trends have been reported in other fields.[33-37] Some of this variability can be mitigated by surgeons choosing less expensive surgical equipment if they feel it will not negatively impact patient outcomes. However, most of the cost information presented here should be used to further evaluate the cost-effectiveness of their various interventions. Even though Bisson et al[19] found single-row RCR to be less costly than double-row RCRs, a CEA will help determine if the decreased revision rates associated with double-row repairs justifies the increased cost, as other reports have done with mixed results.[38]

CONCLUSION

More economic studies that focus on all possible cost information are needed to further understand the economic impact of sports medicine. Future studies should explore different treatments and diagnostic options and should try to reproduce previous findings with different populations. Calculation of indirect and societal costs of nonoperative treatment for sports-medicine conditions would also be a useful direction for future research.

In a healthcare economy with limited resources, it is important to provide the greatest health benefit at the lowest possible cost. With a trend toward more economic studies over the last several years, sports medicine is moving toward that goal. The biggest limitation to CEA remains obtaining accurate cost data, which allows for greater generalizability across different populations. These existing studies provide a foundation for future researchers to utilize their results alongside patient outcome measures to conduct CEA.

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