CLINICAL STUDY

Cost Analysis of Failed Shoulder Stabilization

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ABSTRACT

Background: Shoulder instability is a common problem, especially in the young, active population. Revision stabilization has a high rate of recurrent instability, low rates of return to play, and low clinical outcome scores. The challenge for surgeons is identifying the best surgery for each patient. To our knowledge, no studies have been published examining the cost of failed shoulder stabilization.

Hypothesis: The high cost of index and revision stabilization procedures in a cohort of patients with recurrent shoulder instability can be reduced through judicious preoperative planning and the use of more aggressive surgical techniques during the index operation.

Methods: We retrospectively reviewed the medical records and billing information of 18 consecutive patients treated at our institution for failed shoulder instability repairs during a 36-month period. Using the billing records for each case, a cost analysis was conducted from a societal perspective.

Results: The actual costs of index stabilization and revision stabilization procedures for our cohort of 18 patients amounted to $1,447,690. The costs of revision surgeries conducted for this cohort by a single surgeon at our institution amounted to $673,248. The hypothetical costs of primary arthroscopic stabilization and open stabilization for a cohort of 18 patients leading to permanent repair was $395,415 and $585,639 respectively. The incremental difference between actual costs and hypothetical costs of primary osteoarticular (OA) allograft stabilization for patients with bony defects is $278,394. For patients with significant bone defects, an open repair with failure rate of 44.9%, or an arthroscopic repair with failure rate of 62.8%, is cost neutral to a primary open repair with OA allograft. In addition, an open repair with failure rate of 13.0%, or an arthroscopic repair with failure rate of 41.3%, is cost neutral to a primary definitive repair.

Conclusion: Failed shoulder stabilization bears high costs to society, even without considering the psychological costs to patients. We must identify and refine diagnostic and prognostic factors to better determine the appropriate treatment modality for patients with primary shoulder instability.

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INTRODUCTION

Recurrent shoulder instability is a significantly dissabling condition. The shoulder is the most commonly dislocated major joint with a reported incidence of 1.7% in the general population.[9] In addition, the incidence of shoulder instability in the US military population (1.69 per 1000 person-years) is considerably higher than that in the general US population (0.08 per 1000 person-years).[17] Shoulder instability is also more prevalent in athletes participating in contact sports. One study showed that 20% of elite collegiate football players suffered from anterior shoulder instability, while an additional 4% suffered from posterior shoulder instability.[11]

Studies dating back to the early 1950s investigated the incidence of primary and recurrent anterior shoulder instability. These studies noted a recurrence rate of 66 to 94% in patients younger than 20, and a recurrence rate of 40 to 74% in patients between 20 and 40.[7,15,20,26,35] More recently, Burkhart and DeBeer noted a 67% recurrence rate in patients with significant bone defects compared to a 4% recurrence rate in patients with nonsignificant bone defects.[6] Boileau et al reported a 15.3% recurrent instability rate following arthroscopic Bankart repair.[5] The authors noted a statistically significant relationship between bone defects and increased risk of recurrent instability. Specifically, glenoid bone loss greater than 25% ($p = 0.01$) and Hill-Sachs lesions ($p = 0.05$) were correlated with increased recurrence of instability, thereby reaffirming the conclusion reached by Burkhart and DeBeer.[5] Inferior ($p = 0.03$) and anterior ($p = 0.01$) hyperlaxity on clinical exam also demonstrated significantly increased risk of recurrent instability.[5] Taken together, glenoid bone loss greater than 25% and clinical hyperlaxity led to 75% recurrence rates ($p < 0.001$).[5] Finally, the number of suture anchors placed intraoperatively is statistically significantly related to recurrent shoulder instability. Patients with three or fewer suture anchors were at a higher risk for recurrent instability ($p = 0.03$).[5]

Balg and Boileau developed an instability severity index score to classify the aforementioned risk factors.[2] In their scoring system, two points are given for the following: age equal to or less than 20 years, participation in competitive sports, Hill-Sachs lesion visible in external rotation on AP radiograph, glenoid bone loss on AP radiograph.[2] One point is given for participation in a contact sport and hyperlaxity on physical exam.[2] Patients with a total score greater than six have a recurrent instability risk of approximately 70%.[2] Recurrent instability limits range of movement of the joint, requires multiple hospital and ER admissions for treatment and often calls for surgical procedures to prevent further dislocation.[7,12,19,21,30]

Given the burden of disease and societal costs, there is a need for more information to guide resource allocation decisions within these areas of orthopaedics.[1,3,14,18,33,34] In our healthcare system, the use and allocation of resources has come under tremendous scrutiny. Newly passed healthcare reform calls for increased comparative and cost-effectiveness research. Combined, these forces have led to increased focus on cost-effectiveness in healthcare.[14,18] Because the open and arthroscopic repair of anterior shoulder dislocation yield different reoperation rates, the relative costs of the two operations call for attention. To better define the costs associated with surgical intervention and possible reoperation, for shoulder dislocations, we retrospectively examined a cohort of 18 revision shoulder instability repairs at a single teaching hospital. The purpose of this study is to determine the cost of failed shoulder stabilization procedures and subsequent surgery needed to definitively stabilize these patients. We hypothesize that failed shoulder stabilization bears high costs to society.

METHODS

We retrospectively reviewed the medical records and billing information of consecutive patients seen and treated by the principal investigator during a 36-month period (February 2007-January 2010). Inclusion criteria included recurrent shoulder instability with one or more failed prior stabilization procedures. Exclusion criteria included patients with volitional instability, which we defined as voluntary dislocators with or without psychiatric or secondary gain issues documented in the medical record upon evaluation at our institution. Our cohort of 18 patients includes patients who underwent a range of prior operative interventions (i.e. arthroscopic Bankart, open Bankart, open Bristow) as well as a variety of stabilization procedures by the principal investigator (i.e. open Bankart, Latarjet, humeral head and glenoid osteochondral allograft), to provide details concerning

the cost of failed stabilization procedures performed at other institutions prior to being referred to the principal investigator for recurrent instability. We did not include recurrent dislocators who had undergone initial surgical stabilization by the senior author, as we wanted to analyze this cohort separately. The patient cohort demographics are summarized in Table 1. The mean age for patients in our study cohort is 30.7 ± 10.3 years (17-47 years). Six of the patients are competitive high school athletes, one patient is a military cadet, one is a recreational athlete, and the remaining 10 do not participate regularly in athletic activity. The total number of shoulder dislocations per patient between the primary stabilization procedure and operative intervention by the principal investigator ranged from one to greater than 10. The time interval between primary dislocation and index stabilization surgery ranged from 7 days to 12 years.

Prior to intervention by the principal investigator, this cohort had a total of 13 arthroscopic and 13 open repairs. The index operation consisted of an arthroscopic Bankart repair in 12 patients, while six patients had undergone an open Bankart repair. Five patients had a second stabilization procedure prior to visiting our institution, including two open capsular shifts, an open Bristow repair, an open pectoralis major transfer and an arthroscopic Bankart repair. Three of these patients went on to require a third stabilization procedure, including two open capsular shifts and an open revision Bristow repair. Upon referral to the principal investigator, nine patients were diagnosed with anterior instability, seven were diagnosed with multidirectional instability (MDI), and two were diagnosed with posterior instability. Instability was defined as dislocation, subluxation, or pain with evidence of instability on exam. Clinical hyperlaxity was present in six of the patients. Hyperlaxity was determined by the presence of two major criteria, one

Table 1: Patient demographics

Variable	N	%
Sex		
Male	10	55
Female	8	44
Age (years)		
Dominant extremity	7	39
Clinical hyperlaxity		
Yes	6	33
No	9	50
Indeterminate	3	17
Definitive repair type		
Arthroscopic	14	70
Open Bankart	1	5
Open Latarjet	1	5
Open OA allograft	4	20

major and two minor criteria or four minor criteria, as defined by the Beighton hypermobility scoring criteria.[4] Four patients were noted to have significant bony defects based on radiographs and computed tomography scans done at our institution. Due to lack of historical imaging studies, we were unable to ascertain whether the bony defects were present at the time of index stabilization or if the bony defects had developed between index operation and presentation at our institution.

Each procedure performed by the principal investigator resulted in stabilization, as defined by a lack of recurrent instability diagnosed by negative apprehension, relocation, and load and shift signs on physical examination by the principal investigator at last follow-up (minimum 24 months). The operative treatments performed by the principal investigator include 13 arthroscopic and six open stabilization procedures on this patient cohort. One patient underwent an arthroscopic Bankart repair and an open Bristow-Latarjet. The open surgeries include one Bristow-Latarjet procedure, one Bankart repair, and four osteoarticular (OA) allograft transplantations. Patients included in the study were followed postoperatively for a minimum of 24 months.

A cost analysis of each procedure was performed from the Medicare reimbursement rates and from the cost of various hospital consumables obtained from the hospital finance department. These costs are summarized in Table 2. Total direct medical costs were calculated by adding all cost data. Indirect lost labor costs were calculated by taking the average wage salary for Americans in this age group. The average yearly wage rate was then multiplied by the average time off of work for the patients in this cohort. A societal perspective was taken, meaning that the costs of all services associated with providing patient care, regardless of who bears the costs, were included.[25] Discounting was not used because the procedures were performed during the same period. Quality-adjusted life years (QALYs) were not used because we did not have preoperative or postoperative scores for the Medical Outcomes Study Short Form 36-Item Health Survey (SF-36) or the EuroQol instrument. Institutional review board approval was obtained from the host institution.

RESULTS

Based on 2009 data from the Centers for Medicare and Medicaid Services (CMS), the cost of arthroscopic soft-tissue repair and shoulder stabilization, including surgeon fees and diagnosis-related group reimbursement fees, was set at $6,820. Similarly, the cost of open soft-tissue repair and shoulder stabilization was set at $10,281. The average cost of OR time and consumables for an arthroscopic stabilization equated to $11,625, while those for an open repair equated to $18,732. In addition, OR time and consumables for a Bristow-Latarjet procedure averaged $24,295. Finally, the average cost of OR time and consumables, including the graft, for a stabilization procedure with a single osteoarticular allograft totaled $29,165, while that for stabilization with a double osteoarticular allograft equaled $45,254. The average annual wages for this cohort, based on data from the US Bureau of Labor Statistics, was set at $42,270. The average time away from work or sport was 1 month.

Given the above average figures, the actual costs of index stabilization and revision stabilization procedures for our cohort of 18 patients amounted to $1,447,690 (average, $80,427 per patient). The total cost prior to definitive stabilization by the principal investigator was $774,442 (average, $43,024 per patient). The total cost of definitive stabilization by the principal investigator amounted to $673,248 (average, $37,402 per patient). The average cost by procedure type is outlined in Table 2. The hypothetical cost of primary arthroscopic stabilization for a cohort of 18 patients leading to permanent repair equals $395,415. The hypothetical cost of primary open stabilization for a cohort of 18 patients leading to permanent repair equals $585,639. The hypothetical cost of primary open stabilization with osteoarticular allograft—for a cohort of 18 patients with bone defects—leading to permanent repair equals $918,234. The hypothetical cost of primary open stabilization with Latarjet—for a cohort of 18 patients with bone defects identified on radiographs—leading to permanent repair equals $685,773.

Assessing our entire patient cohort, we then compared the sole cost of a one-time definitive treatment to the total costs incurred by primary open or arthroscopic soft-tissue repair and the subsequent definitive treatment

Table 2: Average costs for procedures used in analysis

Parameters	Arthroscopic	Open	Latarjet	OA allograft
Diagnosis related group and surgeon fees	$6,820	$10,281	$10,281	$10,281
OR time and consumables	$11,625	$18,732	$24,295	Single = $29,165 Double = $45,254
Total	$18,445	$29,013	$34,576	Single = $39,446 Double = $55,535

needed at a later point in time due to recurrent instability. As mentioned above, the definitive treatment for this cohort was patient-specific and included 13 arthroscopic procedures, one open Latarjet procedure, one open Bankart repair, and four open OA allograft reconstructions. Based on our analysis, providing a one-time definitive treatment costs the same as treating patients with repeated primary open or arthroscopic soft-tissue repair under the following set of assumptions:

- 13.0% of patients treated with open repair would have to fail and end up needing definitive repair at a later point in time.
- 41.3% of patients treated with arthroscopic repair would have to fail and end up needing definitive repair at a later point in time.

A subgroup cost analysis was performed on the four patients in our cohort who underwent osteoarticular allograft reconstruction for significant bone defects of the humeral head and/or glenoid. Three patients in our cohort had OA allograft reconstructions of both the humeral head and the glenoid, while one patient had a glenoid OA allograft transplant reconstruction. These techniques have been previously described, and the total actual costs of all failed stabilizations and definitive treatment for this group equaled $514,624.[8,10,23,27-29,31,32] The hypothetical cost of treating these patients with significant bone defects with OA allografts as a primary method of stabilization would have been equal to $236,230. This represents a potential cost savings of $278,394, a 54% decrease from the actual total amount.

Based on our analysis, providing definitive treatment to the subset of our cohort with significant bone defects in the form of OA allograft (s) costs the same as treating these patients with primary open or arthroscopic soft-tissue repair under the following set of assumptions:

- 44.9% of patients treated with open repair would have to fail and end up needing definitive repair with OA allograft (s) at a later point in time.
- 62.8% of patients treated with arthroscopic repair would have to fail and end up needing definitive repair with OA allograft(s) at a later point in time.

DISCUSSION

Failed shoulder stabilization bears high costs to society, even without considering the psychological costs to patients. With imminent healthcare reform and an increasing focus on value-based healthcare, providers and payers must be more aware of the costs of episodes of care. More transparent quality metrics for shoulder stabilization will press surgeons to identify and refine diagnostic and prognostic factors to better determine the appropriate treatment modality for patients with primary shoulder instability. This is especially true for those with a higher probability of recurrence, including patients with significant bone defects, patients under the age of 20, and patients who participate in contact sports.

There have been several important studies identifying parameters associated with a higher risk of recurring shoulder instability. Burkhart and DeBeer found that for the group of patients without significant bone defects (inverted pear or engaging Hill-Sachs lesions), there was a 4% recurrence rate of instability.[6] Meanwhile, there was a 67% recurrence rate of instability in patients with significant bone defects.[6] For contact athletes without significant bone defects, there was a 6.5% recurrence rate, whereas for contact athletes with significant bone defects, there was an 89% recurrence rate.[6]

Moreover, Balg and Boileau identified the following risk factors: patient age under 20 years at the time of surgery; involvement in competitive or contact sports or those involving forced overhead activity; shoulder hyperlaxity; a Hill-Sachs lesion visible in external rotation on AP radiograph of the shoulder and loss of the inferior glenoid contour.[2]

These factors were integrated into a 10-point preoperative instability severity index score, and patients with a score over six points had an unacceptable recurrence risk of 70% ($p < 0.001$).[2] On this basis, the authors believe that an arthroscopic Bankart repair is contraindicated in these patients, to whom they suggest a Bristow-Latarjet procedure instead. Similarly, Boileau et al found that the risk of postoperative recurrence was significantly related to the presence of a bone defect, either on the glenoid side or on the humeral side (a large Hill-Sachs lesion; $p = 0.05$).[5] Recurrence of instability was significantly higher in patients with inferior shoulder hyperlaxity ($p = 0.03$) and/or anterior shoulder hyperlaxity ($p = 0.01$).[5] Lastly, the number of suture-anchors was critical: patients who had three anchors or fewer were at higher risk for recurrent instability ($p = 0.03$).[5]

Biomechanical studies have also analyzed predictors for recurrent dislocations. Sekiya et al showed that the size and orientation of the humeral head defect have important contributions to glenohumeral joint function. Increasing defect size required less anterior translation before dislocation and decreased the stability ratio, thereby increasing the risk of recurrent instability.[23] At zero degree of external rotation, shoulders with 12.5 to 37.5% defects did not dislocate, and only two shoulders with a 50.0% defect dislocated.[23] At 60° of external rotation, a 25.0% defect and 37.5% defect had significantly less anterior translation before dislocation, as compared with the intact humeral head ($p < 0.05$), both of which became similar to the intact after repair ($p > 0.05$).[23] The stability

ratio at 60° of external rotation significantly decreased in the 25.0 and 37.5% defects, as compared with the intact (p < 0.05), representing a 25 and 40% decrease in stability ratio.[23] The stability ratio became similar to intact after repair (p > 0.05).[23]

Similarly, Yamamoto et al found that the stability ratio significantly decreased after creating a 6 mm defect, which was equivalent to 20% of the glenoid length.[36] These results suggest that reconstruction of the glenoid concavity might be necessary in shoulders with an anterior glenoid defect of at least 20% of the glenoid length.[36] Kaar et al found that glenohumeral stability decreases at a 5/8 radius defect in external rotation and abduction.[10] At 7/8 radius, there was a further decrease in stability in the neutral position with external rotation.[10] Therefore, defects of 5/8 the humeral head radius may require treatment to decrease the failure rate of shoulder instability repair.[10]

While many clinical studies have described and linked these lesions to failed instability repairs, an actual definition of the critical size of glenoid and humeral head defects that risks surgical failure has not been determined. Sekiya et al developed a cadaveric model with 25% Hill-Sachs lesions.[22] While only small kinematic changes were seen, there were subtle yet significant bony contact force changes when the Hill-Sachs lesion was present.[22] While this may not be a risk factor for failure of a standard capsular repair, there certainly may be long-term consequences secondary to abnormal joint wear and potential arthritis from altered forces. For larger humeral head defects in this patient cohort, we employed an open allograft humeral head reconstruction.

Laboratory testing suggests that allograft humeral head reconstruction can restore shoulder stability in large Hill-Sachs defects (>25%).[10,22,23] Tjoumakaris et al have described combined glenoid and humeral head osteochondral allograft reconstruction in patients with bony Bankart and large Hill-Sachs lesions.[31,32] According to Miniaci et al, there were no episodes of recurrent instability at a mean of 50 months follow-up following allograft humeral head reconstruction.[16] Kropf and Sekiya describe a technique for this procedure using a miniopen posterior approach in conjunction with a capsulolabral repair.[13] Moreover, an all-arthroscopic technique for allograft humeral head reconstruction has also been described.[8]

The risk of shoulder stabilization failure is difficult to predict. Failure of primary shoulder stabilization procedures is often related to uncorrected anatomic pathology. Orthopaedic surgeons must recognize capsular laxity or large glenohumeral bone defects preoperatively to avoid recurrence of instability.[24] Given the biomechanical and clinical studies presented above as well as our cost analysis, it makes sense to be more judicious in the primary treatment method for patients with shoulder instability. When history, physical examination and radiographic evaluation are used in conjunction, patients at risk for failure can be identified. When treating patients in whom prior surgical intervention has failed, the success of revision procedures correlates to the surgeon's ability to identify the essential pathology and use lesion-specific treatment strategies. Not withstanding the significant emotional costs incurred by patients with shoulder instability, orthopaedic surgeons need to be aware of the financial costs of failed shoulder stabilization.

This study has a number of limitations. A lack of preoperative and postoperative health assessment questionnaires, which allow for the derivation of Quality-Adjusted Life Years (QALYs), prevents us from completing a cost-effectiveness analysis. In addition, the size of our patient cohort is limited, and the instability categories are heterogeneous. The differences in outcomes may be attributed to surgeon technical expertise rather than the procedure performed.

Moreover, we made an assumption of the average annual wage rate across the cohort based on US Bureau of Labor Statistics. Deviations from this assumed value in either direction affect the overall costs. In addition, two patients had possible redislocations but were completely stable at latest follow-up and very satisfied with their result.

CONCLUSION

Failure of primary shoulder stabilization procedures is often related to uncorrected anatomic pathology. Failed shoulder stabilization bears high costs to society, even without considering the psychological costs to patients. We must identify and refine diagnostic and prognostic factors to better determine the appropriate treatment modality for patients with both primary and recurrent shoulder instability in an attempt to avoid failures. More specifically, orthopaedic surgeons must recognize excessive capsular laxity or large glenohumeral bone defects preoperatively to avoid recurrence of instability. When treating patients in whom prior surgical intervention has failed, the success of revision procedures correlates to the surgeon's ability to identify the essential pathology and use lesion-specific treatment strategies. Revision procedures remain technically demanding. Keen preoperative and intraoperative judgment is required to avoid additional recurrence of instability after revision procedures, particularly because results deteriorate with each successive operation. Doing so will decrease not only the clinical but also the cost burden of failed shoulder stabilization.

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