Cost-Effectiveness Analysis of Primary Arthroscopic Stabilization Versus Nonoperative Treatment for First-Time Anterior Glenohumeral Dislocations

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Purpose: The purpose of this study was to compare the cost-effectiveness of initial observation versus surgery for first-time anterior shoulder dislocation. Methods: The clinical scenario of first-time anterior glenohumeral dislocation was simulated using a Markov model (where variables change over time depending on previous states). Nonoperative outcomes include success (no recurrence) and recurrence; surgical outcomes include success, recurrence, and complications of infection or stiffness. Probabilities for outcomes were determined from published literature. Costs were tabulated from Medicare Current Procedural Terminology data, as well as hospital and office billing records. We performed microsimulation and probabilistic sensitivity analysis running 6 models for 1,000 patients over a period of 15 years. The 6 models tested were male versus female patients aged 15 years versus 25 years versus 35 years. Results: Primary surgery was less costly and more effective for 15-year-old boys, 15-year-old girls, and 25-year-old men. For the remaining scenarios (25-year-old women and 35-year-old men and women), primary surgery was also more effective but was more costly. However, for these scenarios, primary surgery was still very cost-effective (cost per quality-adjusted life-year, <$25,000). After 1 recurrence, surgery was less costly and more effective for all scenarios. Conclusions: Primary arthroscopic stabilization is a clinically effective and cost-effective treatment for first-time anterior shoulder dislocations in the cohorts studied. By use of a willingness-to-pay threshold of $25,000 per quality-adjusted life-year, surgery was more cost-effective than nonoperative treatment for the majority of patients studied in the model. Level of Evidence: Level II, economic and decision analysis.

The optimal treatment for patients with first-time anterior glenohumeral dislocations is unknown. The traditionally accepted nonoperative treatment of temporary immobilization followed by careful resumption of activities results in high recurrence rates (57% to 90%), especially in young, active patients.1-4 To avoid recurrence, some authors have argued for treating this group with early open or arthroscopic stabilization, reporting good results.5-10 However, this strategy clearly exposes some patients to unnecessary surgery, because not all patients would have had recurrence. Conversely, waiting to operate until patients have recurrence may result in further damage to the glenohumeral joint with each recurrent dislocation.11,12 In addition, glenohumeral dislocations place a significant strain on patients and emergency departments (approximately 70,000 annually in the United States)13 that could be mitigated with early surgery. Therefore significant controversy and uncertainty exist in the
initial treatment for first-time glenohumeral joint dislocations.

To help address this uncertainty, Bishop et al.14 developed a decision analysis model based on patient preferences and published rates of potential outcomes after surgical and nonsurgical treatment. That model predicted that patients would prefer initial surgical treatment. Although it did compare operative versus nonoperative treatment, that model did not consider cost-effectiveness analysis (CEA). As health care resources become more limited, modern decision making increasingly will be driven by an intervention’s value, rather than by patient preferences alone. In the future, policymakers will likely be forced to direct their limited funds toward treatments with proven cost-effectiveness. We are not aware of any study analyzing the cost-effectiveness of operative versus nonoperative treatment for primary anterior shoulder instability.

CEA is a technique used to compare 2 or more treatment options in terms of their costs (either to patients, payers, or society at large) and their effectiveness (typically measured as quality of life over a period of time, termed quality-adjusted life-years [QALYs]). The federal government has proposed standardized techniques for CEA so that treatment methods can be compared consistently and accurately.15,16 The purpose of this study was to use accepted CEA methods to compare the cost-effectiveness of initial surgical treatment (arthroscopic stabilization) versus nonoperative treatment for patients with first-time anterior glenohumeral dislocations. The null hypothesis assumes that there is no difference between the cost-effectiveness of operative and nonoperative treatment. A secondary purpose of this study was to perform a subgroup analysis to determine cost-effectiveness of initial surgical treatment versus nonoperative treatment for patients with first-time anterior glenohumeral dislocations by age and by sex.

METHODS

Construction of Model

The clinical scenario of first-time anterior glenohumeral dislocation was simulated using a Markov model (where variables change over time depending on previous states) to describe how patients with this pathology might be treated over time (Fig 1) (TreeAge Pro 2011; TreeAge Software, Williamstown, MA). The upfront costs of a first-time dislocation, such as evaluation in the emergency department and closed reduction, were not incorporated into the model because these costs are incurred before the first decision node (i.e., before the treatment decision of operative vs nonoperative treatment). After the primary event, a decision between operative and nonoperative treatment is made. After operative treatment, 4 possible outcomes (chance nodes) were considered in the model: success (no recurrence), recurrence, infection, and stiffness. Other potential outcomes certainly exist (implant failure, nerve injury, and so on) but had such low probabilities (<0.9%) that they would have a negligible effect on the model. The 2 outcomes after nonoperative treatment that we considered were success and recurrence, because of similarly low probabilities of other outcomes after nonoperative treatment.

Estimate of Probabilities

To determine probabilities in the surgery branch (after operative treatment), a systematic review of the literature was performed by use of the MEDLINE database from 1950 to March 2009. The search terms were as follows: MeSH “shoulder dislocation” AND keywords “acute” OR “primary” for search 1 and keywords “anterior shoulder dislocation” AND “acute” OR “primary” for search 2. We excluded studies containing patients with recurrent instability,17 multidirectional instability,18 or exclusively bony Bankart lesions.19 Two studies were followed up with subsequent published reports on the same cohort.9,10 We included only the latter study in these situations.11,20 Weighted averages for successful surgery, recurrent dislocation or subluxation, infection, and postoperative stiffness were calculated by use of the remaining articles. Infection was defined as any reported wound complication, whether repeat surgery was required or not. Stiffness was defined differently in each study, but if a study reported a patient as “stiff,” we included that in our analysis. Generally, this meant postoperative external rotation of less than 15° or the need for postoperative manipulation or release for restricted range of motion. Recurrent instability was defined as a true dislocation or the subjective report of recurrent subluxation.

When probability data did not exist in the literature (i.e., for patients with >2 recurrences), simple formulas were used to estimate the future probability of recurrence. The formula

\[ P = P_{\text{initial}} \left( \frac{1}{1 + \# \text{Recurrences}} \right) \]
where P is the probability of recurrence, was used to estimate the increasing rate of recurrence with increasing number of recurrences. The probability returned from this formula approaches (but never reaches) 100% after many dislocations. A similar decay formula was used to gradually decrease a patient’s recurrence rate (but never reaching 0) if he or she survived for more than 2 years without a recurrence.

**Estimate of Cost**

Costs for each event in the model were considered from the payer perspective (commercial or government payer or other contracted payer). To ensure that all surgical costs were captured, itemized invoices from the previous 9 patients who had undergone arthroscopic Bankart repair at our hospital (Holy Cross Hospital, Taos, NM) were reviewed with identifying data removed. One patient had extra laboratory costs for hypothyroidism and was admitted overnight for observation; these extra charges were excluded. In addition, the costs for implants were subtracted from each account; these would be added back later to create our standard base case. The remaining costs were averaged and adjusted by the standard cost-to-charge ratio at our hospital. Costs for closed reduction were tabulated in the same fashion, from the last 9 patients undergoing this procedure in our emergency department. We assumed that patients could perform reduction of their own shoulder after 3 consecutive dislocations with no surgery (avoiding closed reduc-
tion in the emergency department). Costs for imaging and durable medical equipment were obtained from our billing department (Taos Orthopaedic Institute, Taos, NM) and from the hospital and were adjusted by the cost-to-charge ratio accordingly. Physicians’ fees were calculated from approved Medicare relative value unit–based payments by Current Procedural Terminology code for the New Mexico region (American Medical Association Current Procedural Terminology search).

**Estimate of Utility**

To quantify the utility of various states in the model, we used the Western Ontario Shoulder Instability Index. This is a functional scale that has been validated and is specific for patients having shoulder instability.\(^{21}\) When no published data existed for an event in the model, we performed an estimation based on Level V evidence (expert opinion of senior authors [D.G., M.K., and J.H.L.]).

**Base Case**

For our base case, we considered a 25-year-old male patient, because 25-year-old men have both a high recurrence rate and large economic impact (through missed work and so on). Primary surgical patients were assumed to undergo a standard noncontrast magnetic resonance imaging study, followed by an arthroscopic Bankart repair with placement of 4 single-loaded 2.4-mm BioComposite SutureTak anchors (Arthrex, Naples, FL), with 2 hours’ total operating room time. Those patients who had a postoperative recurrence were defined to have a 50% chance of choosing surgery again, reflecting the published choices of active patients involved in collision sports or occupations with overhead-level activity.\(^ {22,23}\) For those choosing no surgery, their risk of recurrence was thereafter assumed to mirror the experience of patients in the nonsurgical group. Patients with a postoperative infection were defined to have a 20% chance of having a septic joint, needing surgical irrigation and debridement and 4 weeks of intravenous penicillin with Visiting Nurse Association care. The remaining 80% were assumed to be minor wound infections resolving with oral antibiotics alone. Likewise, patients with stiffness were defined to have a 20% chance of needing capsular release, with the remainder improving with extended physical therapy alone. These rates were estimated from expert opinion and the few reported cases in the literature.\(^ {7,10,24,25}\)

Primary nonsurgical patients were assumed to incur no costs unless they had recurrence.

For patients in either group who had more than 5 dislocations before opting for surgery, additional costs for a computed tomography scan, magnetic resonance arthrogram, and follow-up office evaluation were included to evaluate for bone loss that might affect the surgical plan. We assumed that all patients still underwent a Bankart repair regardless of the outcome of these studies, because the surgical fees and times were almost identical between Bankart repairs and coracoid transfer procedures in our region; in addition, management strategies for bone loss in shoulder instability vary widely among surgeons.\(^ {26}\)

**Statistical Methods**

**Markov Analysis and Microsimulation:** Given the complex nature of the model and the requirement for “memory” from one cycle to the next (a patient’s probability of recurrence depended on what happened in previous cycles), microsimulation was used to “roll back” the model, where hypothetical patients repeatedly traverse the model and accrue costs and utility rewards or penalties based on their experiences.

Cycle length was defined as 3 months, with all utilities and probabilities adjusted accordingly. One thousand trials were run over 60 cycles (15 years). A discount rate of 5% per year was applied to all costs and utilities.

**Probabilistic Sensitivity Analysis:** Probabilistic sensitivity analysis (PSA) was used to vary all cost, probability, and utility parameters in the model. This method is preferred over standard sensitivity analysis for microsimulation models because it is able to change all variables simultaneously, thereby better estimating uncertainty in the model.\(^ {27-29}\) We obtained 100 (second-order) samples over 1,000 (first-order) cycles. Costs parameters were assigned gamma distributions based on their means.\(^ {30}\) Probability parameters were assigned beta distributions based on their means. Standard deviations were assumed to be 20% of the mean. PSA was repeated to consider different hypothetical cohorts by sex and age, specifically male and female patients aged 15, 25, and 35 years.

**Approval and Source of Funding**

This project was approved by the Holy Cross Hospital Medical Executive Committee, Taos, New Mexico. This hospital does not have an internal institutional review board, and no institutional review board approval was indicated, because this study evaluated hypothetical (computer-simulated) pa-
RESULTS

Literature Search and Estimate of Probabilities, Utilities, and Costs

References from the retrieved articles did not produce any extra citations that were initially missed. The minimum follow-up was 17 months (mean, 49 months). Probabilities for events in the model were based on 11 studies for a total of 329 patients (Table 1). For short-term probability inputs, the 2-year study by Robinson et al. was used. The exponential formula used to estimate dislocation probability after multiple recurrences was set to closely match the published rates after 1 and 2 recurrences in the 25-year follow-up study by Hovelius et al. The decay function was likewise set to reflect the cohort in their study in whom healing occurred over time.

For utility inputs, our literature search revealed 5 studies that reported Western Ontario Shoulder Instability Index data for patients in various states in our model (Table 1). Cost inputs were tabulated for each event in the model and were adjusted by the cost-to-charge ratio at our hospital when appropriate (48.5%) (Table 2).

Validation of Base Case

We validated our model by comparing our base case against published external sources not used as inputs in the model. For short-term analysis, we compared our incidence of recurrence with that in the studies of Kirkley et al. and Bottoni et al., which followed up patients with similar demographics to our base case. In our base case, 574 of 1,000 patients (57%) had recurrence within 3 years,
close to the rates reported by Kirkley et al. and Bottoni et al.: 47% at 33 months and 75% at 37 months, respectively. Published recurrence rates in other studies have varied dramatically from 25%32 to over 80%, 3, 6, 33 leaving our results well within these published ranges.

For long-term validation, we reran our model for a period of 10 years and compared the results with the 23- to 29-year-old cohort in the 10-year natural history study of Hovelius et al.34 For this analysis, we adjusted the rate of choosing surgery in our model to match that in the cohort of Hovelius et al. (31%), to ensure that the remaining assumptions and parameters in our model were valid. In their cohort 58% of patients had recurrent dislocations, compared with 49.8% in our nonoperative arm. Of the patients in their model, 22.7% “healed over time” (had ≥2 recurrences in the first 5 years, followed by no further recurrences in the last 5 years). That rate was 21.7% in our model. In their cohort, 6.7% of patients were still symptomatic at the time of final follow-up (had a recurrence within the last 5 years) versus 11% in our model. In sum, our results are validated as similar to published data.

**Cost-Effectiveness**

For our base case of a 25-year-old man, the PSA showed surgery to be the dominant preferred strategy (less costly and more effective), resulting in average cost savings of $2,894 and an increase of 0.95 QALYs per patient (Table 3). Surgery was also the dominant strategy for 15-year-old male and female patients. For the remaining demographics (25-year-old women and all 35-year-old patients), initial observation was the preferred strategy, being less costly but also less effective. We calculated how much a payer would have to be willing to spend to “purchase” the additional benefit of surgery for these demographics. This concept is referred to as willingness to pay (WTP). For the scenario of a 35-year-old man, for surgery and nonoperative treatment to be equally cost-effective, WTP would have to be set at $13,359/QALY (Fig 2). If the WTP was increased to $25,000/QALY, surgery became the preferred strategy in 88% of cases. The WTP acceptability curves for the remaining demographics looked identical, except that the threshold WTP value for surgery to become the preferred strategy increased with decreasing probability of recurrence with nonoperative treatment, and vice versa.

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**Table 2. Cost Input Data in 2010 US Dollars**

<table>
<thead>
<tr>
<th>Source</th>
<th>Antimicrobials</th>
<th>CT scan</th>
<th>Capsular release*</th>
<th>Closed reduction</th>
<th>Irrigation and debridement†</th>
<th>MRI</th>
<th>MR arthrogram</th>
<th>Surgery‡</th>
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<tr>
<td>AWP—2010 Pharmacy Red Book</td>
<td>$55</td>
<td>$812</td>
<td>$234</td>
<td>$667</td>
<td>$1,600</td>
<td>$1,166</td>
<td>$7,023</td>
<td></td>
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<tr>
<td>CPT 73200</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Hospital records, CPT 23650 and 73030 × 2</td>
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<td>CPT 73222 and 23350</td>
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</table>

Abbreviations: Anes MD, anesthesia fees, calculated from CPT 01630 (procedures of the shoulder and axilla) (5 base units plus conversion factor of $21 per 15-minute block); AWP, average wholesale price; CPT, Current Procedural Terminology; CT, computed tomography; DME, durable medical equipment (abduction sling); E&M, office visit (evaluation and management) fee; MR, magnetic resonance; MRI, magnetic resonance imaging; PT/VNA, physical therapy/Visiting Nurse Association; Surg MD, surgeon’s fee for CPT 23020 (capsular release), 23650 (closed treatment of shoulder dislocation with manipulation, no anesthesia), 29823 (shoulder arthroscopy, extensive debridement), and 29806 (shoulder arthroscopy, capsulorrhaphy); X-ray MD, radiologist fee for CPT 73030 (radiologic examination, shoulder; complete, minimum of 2 views), 73200 (computed tomography, upper extremity; without contrast material), 73221 (MRI, any joint of upper extremity; without contrast materials), 73222 (same as 73221 but with contrast), and 23350 (injection for arthrogram).  
*Used baseline arthroscopic stabilization cost except excluded implants and assumed 60-minute operating room time.  
†Same as * except added laboratory costs, VNA at 2 visits per week, and intravenous penicillin (approximately 12 million units/day at $7.99 per 5 million unit vial).  
‡Four SutureTaks (Arthrex) at $603.34/unit and 120-minute operating room time.
To standardize the analysis, all remaining scenarios were then compared with WTP set at $25,000/QALY, a price generally agreed on as the threshold between highly and moderately cost-effective interventions. At this WTP, the model predicted that initial surgical treatment would be more cost-effective for all demographics. However, the confidence of the model decreased for older and female patients (Table 4). In other words, for patients with a low probability of recurrence with nonoperative treatment, the model’s preferred strategy was less likely to be correct for all patients. The incremental cost-effectiveness ratio (ICER) scatterplot for the scenario of a 35-year-old man illustrates this concept (Fig 3).

The model was rerun for patients already having had 1 recurrence. After the initial dislocation and 1 additional recurrence, surgery became the dominant strategy (more cost-effective at all WTP values) for all demographics studied.

### Sensitivity Analysis

All parameters in the model were varied across their reasonable clinical ranges to assess their effect on the model. This was performed by repeating the PSA with varied inputs, because traditional sensitivity analysis would yield inaccurate results for this type of micro-simulation model. Rates, costs, and utilities for post-

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**Table 3. Results of PSA for Different Clinical Scenarios**

<table>
<thead>
<tr>
<th>Age</th>
<th>Input P-NOTrecurrence (Robinson et al., 2006)</th>
<th>Output P-NOTrecurrence at 15 yr (From Model)</th>
<th>Average Incremental Cost of NOT (2010 US Dollars)</th>
<th>Average Incremental Effectiveness of NOT (QALY)</th>
<th>Preferred Strategy (ICER in $/QALY)</th>
<th>Recurrences Needed for Surgery to Dominate</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 yr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.86</td>
<td>0.81</td>
<td>$17,824</td>
<td>−1.15</td>
<td>Surg (dom)</td>
<td>—</td>
</tr>
<tr>
<td>Female</td>
<td>0.54</td>
<td>0.53</td>
<td>$1,441</td>
<td>−0.90</td>
<td>Surg (dom)</td>
<td>—</td>
</tr>
<tr>
<td>25 yr</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.56</td>
<td>0.52</td>
<td>$2,894</td>
<td>−0.95</td>
<td>Surg (dom)</td>
<td>—</td>
</tr>
<tr>
<td>Female</td>
<td>0.28</td>
<td>0.29</td>
<td>−$9,900</td>
<td>−0.69</td>
<td>NOT (14,394)</td>
<td>1</td>
</tr>
<tr>
<td>35 yr</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Male</td>
<td>0.29</td>
<td>0.27</td>
<td>−$9,521</td>
<td>−0.71</td>
<td>NOT (13,359)</td>
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<tr>
<td>Female</td>
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<td>0.13</td>
<td>−$13,508</td>
<td>−0.61</td>
<td>NOT (22,101)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Abbreviations:** dom, dominant strategy (less costly and more effective); ICER, incremental cost-effectiveness ratio, or WTP value needed to switch strategies; NOT, nonoperative treatment; P-NOTrecurrence, probability of recurrence with nonoperative treatment; Surg, primary surgical treatment.

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**Figure 2.** Cost-effectiveness (CE) acceptability chart for the 35-year-old man scenario, from the PSA. (NOT, nonoperative treatment; USD, US dollars.)
operative complications were found to have minimal effect on the model, because only 2 of 1,000 patients had major complications (requiring surgery) in the base case. The financial cost and disutility of surgery, as well as the probability of surgical failure, also caused no change in the preferred strategy within their reasonable ranges. We hypothesize that this is because patients in both arms were affected similarly by these changes, because the average numbers of operations per patient were 1.29 and 1.19 in the operative and nonoperative arms, respectively. However, changing the probability of choosing surgery after a recurrent dislocation did change the preferred strategy. At values lower than 0.2, the ICER for choosing surgery over nonoperative treatment rose dramatically (Fig 4). However, for values within the published range (0.2 to 0.5), the ICER remained relatively constant, only ranging from −$3,046 to −$248 per QALY (where a negative ICER represents surgery as the dominant strategy).

**DISCUSSION**

When analyzed over a period of 15 years, primary surgery was less costly and more effective for 15-year-old boys, 15-year-old girls, and 25-year-old men. For the remaining scenarios (25-year-old women and 35-year-old men and women), primary surgery was also more effective but was more costly. Primary surgery was still very cost-effective for these scenarios, however (cost per QALY ranging from $14,394 to $22,101). As a comparison, knee arthroscopy and anterior cruciate ligament reconstruction were recently found to have costs of $5,783 and $10,326

| Table 4. Willingness to Pay Analysis |
|-------------------|-------------------|-------------------|
| Age | Sex | % of Cases Where Surgery Is Dominant Strategy | % of Cases Where Surgery Is Preferred Strategy | Total % of Certainty That Surgery Is Preferred Strategy |
| 15 yr | Male | 100 | — | 100 |
| | Female | 70 | 29.8 | 99.8 |
| 25 yr | Male | 83 | 16.9 | 99.9 |
| | Female | 0 | 85.4 | 85.4 |
| 35 yr | Male | 0 | 88.0 | 88.0 |
| | Female | 0 | 62.8 | 62.8 |

NOTE. The percent of cases in which surgery is more cost-effective with WTP set at $25,000/QALY is shown, from the PSA. Dominant indicates more effective and less costly. Preferred indicates more effective but also more costly.

**Figure 3.** Incremental cost-effectiveness scatterplot for the 35-year-old man scenario, from the PSA, shown with a 95% confidence ellipse. All points to the right of the diagonal WTP line represent the 88% of patients for whom the model correctly predicted surgery as the most cost-effective strategy at WTP of $25,000/QALY. (NOT, nonoperative treatment; USD, US dollars.)
After 1 recurrence, surgery was less costly and more effective for all scenarios. This disproves the null hypothesis that there is no difference between the cost-effectiveness of nonoperative and operative treatment.

We are aware of no other study analyzing the cost-effectiveness of surgical versus nonsurgical treatment for primary anterior shoulder instability. One other Markov model of shoulder instability was published recently; however, the authors intended it for prognostic use and not cost analysis. Although our 2 models have some differences, they have very similar predictions. For example, Mather et al. predicted a 39% recurrence rate after 1 year for the general population and 77% for an 18-year-old man; our prediction at 1 year was 31.5% for our base case and 72.9% for a 15-year-old boy. Their total recurrence rate after 10 years was 63%; our model predicted 51.5% for our base case. This close agreement between our models, as well as with the published literature, corroborates Markov modeling as an appropriate technique for shoulder instability and lends confidence to the validity of the findings of both models.

Despite the similar findings, there are several important theoretic differences between our 2 studies. Mather et al. assumed that the probability of recurrence after 5 recurrence-free years would drop to 0. Our model uses an exponential decay function that decreases the probability of recurrence for every recurrence-free cycle, but it never reaches 0. We believe that there is no patient with a 0 probability of recurrence. We also incorporated the concept of Hovelius et al. of “healing over time” in our model, reflecting the small group of patients (14%) in their study who had not had recurrence in over 10 years, despite having early recurrences and not having surgery. Although it probably did not alter our results significantly, we believe that including this subgroup more accurately reflects the longest natural history data available. In addition, our model includes potential complications of surgery (infection and stiffness), to consider the effect of the cost of these potential outcomes. However, our results show that the effect of these complications was of minimal significance with regard to our primary outcome measure (cost-effectiveness). Mather et al. thus seem justified in ignoring these outcomes (complications of surgery) because they are rare and because CEA was not performed.

In summary, CEA may assist clinicians, patients, policymakers, and payers in making decisions regarding the treatment of anterior shoulder instability. Our model is externally validated with available data in the literature, as well as with another recently published Markov model. Future amendments to the model could include the cost of osteoarthritis developing and other new data that become available.

The gold standard in clinical decision making is a shared decision-making model, in which surgeon and patient consider all medical, socioeconomic, and patient-specific factors to arrive at a treatment plan tailored to each patient. However, in an era of ever-increasing health care costs and limited resources to pay for them, knowledge of the value gained from different interventions is also important to consider. This study provides the first evidence that surgical care is a cost-effective treatment for anterior shoulder instability and should serve as a framework for future research.

There are inherent weaknesses in cost-effectiveness studies. First, the results of the model are no more accurate than the data used as inputs, mostly Level III studies in this case. To help counteract this, we used PSA to vary the inputs and determine the overall uncertainty of our results. Another weakness is that our model ignores the potential large cost of post-traumatic osteoarthritis developing from dislocation events. It has been proposed, and is intuitive based on articular physiology, that each dislocation damages cartilage and therefore increases the risk of future osteoarthritis. Hovelius and Saeboe showed an increase in the rate of arthropathy from 18% to 39%.

![Figure 4](image-url)
for patients with 1 versus no recurrence. However, it is unclear whether surgical treatment decreases this risk.\textsuperscript{38} In addition, utility data for glenohumeral arthritis are reported using different scales (e.g., Short Form 36 and Western Ontario Osteoarthritis of the Shoulder), and no validated instrument is available to combine utility for both arthritis and instability.\textsuperscript{11,37} Because of these issues, we chose to exclude arthritis from the model. In doing so, we have biased the results in favor of nonoperative treatment, because the average number of dislocations per patient in the nonoperative arm was much higher than in the operative arm (2.5 v 0.5) for our base case. Despite this bias, our results still favor primary surgery.

Another limitation is that we ignored indirect costs for patients, such as time off work, transportation costs, and so on. These costs are typically difficult to estimate accurately, and we believed that their inclusion would increase rather than decrease the uncertainty in the model. These costs are typically ignored by payers when making coverage decisions in any case, and our model was designed from the payer’s perspective. Another limitation is that other geographic locations could have different costs.

In addition, we considered sex and age but not activity for subgroup (cohort) analysis. Activity level certainly affects a patient’s risk of recurrence in the real world. However, sex and age naturally affect some element of activity (a 15-year-old boy is more likely to be involved in contact sports than a 35-year-old woman). Future research could consider other cohorts.

**CONCLUSIONS**

Primary arthroscopic stabilization is a clinically effective and cost-effective treatment for first-time anterior shoulder dislocation in the cohorts studied. By use of a WTP threshold of $25,000/QALY, surgery was more cost-effective than nonoperative treatment for the majority of patients studied in the model.

**REFERENCES**


