Bony Versus Soft Tissue Reconstruction for Anterior Shoulder Instability

An Expected Value Decision Analysis

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Background: One complication of anteroinferior glenohumeral shoulder dislocation is a critical bone defect that requires surgical repair to prevent recurrent instability. However, controversy exists regarding the surgical management because both open and arthroscopic surgeries have respective advantages and disadvantages. Moreover, it is difficult to determine the patient's preferred treatment, as factors that influence treatment choice include recurrence rates, morbidity of the procedures, and patient preferences.

Hypothesis: Patients who have a higher probability of recurrent instability after arthroscopic surgery will select open surgery whereas patients with a lower probability of recurrent instability after arthroscopic surgery will favor arthroscopy.

Study Design: Economic and decision analysis; Level of evidence, 2.

Methods: A decision tree was constructed to model each hypothetical outcome after open or arthroscopic surgery for glenohumeral instability in patients with bone defects. A literature review was performed to determine the probability of occurrence for each node while utility values for each outcome were obtained via patient-administered surveys given to 50 patients without prior history of shoulder injury or dislocation. Fold-back analysis was then performed to show the optimal treatment strategy. Finally, sensitivity analysis established the thresholds at which open treatment becomes the optimal treatment.

Results: The ultimate expected value—the objective evaluation of all potential outcomes after choosing either open or arthroscopic surgery—was found to be greater for arthroscopic surgery than for open surgery (87.17 vs 81.64), indicating it to be the preferred treatment. Results of sensitivity analysis indicated that open surgery becomes the preferred treatment when probability of recurrence after arthroscopic treatment is ≥23.8%, although varying the utility, defined as an aggregate patient preference for a particular outcome, has no effect on the model. When the rate of no complication after open surgery is 97.6%, open surgery becomes the patient's preferred treatment.

Conclusion: Arthroscopic surgery is an acceptable treatment if recurrent instability occurs consistently at ≤23.8%. This has important implications given the technical difficulty of successfully performing arthroscopic fixation to resolve recurrent anteroinferior glenohumeral dislocations associated with critical osseous defects. However, due to a lack of clinical outcomes studies, more research is needed to better predict the optimal operative treatment.

Keywords: shoulder instability; shoulder dislocation; Latarjet; arthroscopic; decision analysis; glenoid

The proper management of first-time traumatic anterior glenohumeral dislocation is a subject of much debate. Traditional treatment has included nonoperative immobilization of the joint, although studies have shown that there is a high rate of recurrence in these patients, especially in young athletes.[23] As a result, both open and arthroscopic surgical techniques that repair the capsule and labrum are commonly used as a primary operative procedure.[18]

A large volume of previous research has compared the effectiveness of different surgical treatments to repair the labrum, including various open and arthroscopic techniques[2,34,36]; however, one of the major factors that

contributes to the failure of these soft tissue repairs is the presence of bone damage in the glenohumeral joint. Acute fracture of the anteroinferior glenoid can occur, as well as chronic attrition of the anterior glenoid with multiple dislocations. A Hill-Sachs lesion, an impaction of the humeral head where it contacts the glenoid during dislocation, can also occur.[17] These bone defects increase in size with recurrent dislocations. Larger bone defects are associated with higher recurrence rates after soft tissue reconstruction,[15,25] so some surgeons have recommended surgery to address bone injury at the time of the initial operation.

There is significant controversy regarding this management decision because most clinicians and investigators agree that open procedures to address bone loss have greater morbidity than arthroscopic procedures, but arthroscopic procedures in the presence of bone loss have greater postoperative treatment failures (recurrent instability) than open procedures.[3] Even though it is an arthroscopic procedure, remplissage is still aimed at addressing humeral bone loss by suturing the infraspinatus muscle into the Hill-Sachs lesion, and it still may have additional morbidity compared with standard arthroscopic labrum repair. For example, this procedure has been associated with postoperative loss of motion and infraspinatus strength deficits.[9] Therefore, making a decision about what type of surgery is best for the patient is difficult.

The application of expected value decision analysis to medical decision making is a borrowed approach from economic analysis that involves the construction and subsequent analysis of a decision tree to guide optimal decision making when faced with uncertainty. In this technique, given outcomes, each with distinct utility values and probabilities of occurrence, are created for a primary situation in which there is uncertainty. Following construction of a model, a technique known as "fold-back analysis" can be performed, which evaluates the model and elucidates the optimal decision. Afterward, sensitivity analysis allows for relative manipulation of both probabilities and utility values in the decision tree, allowing the investigator to highlight the effect of varying probabilities and utilities on optimal decision strategy.

The intent of this study was to use the technique of expected value decision analysis to determine whether arthroscopic or open treatment is the optimal surgical treatment choice for primary anterior glenohumeral shoulder instability with a "critical bone defect." In addition, a secondary goal was to identify which patient utility values and potential terminal nodes are most influential on optimal decision making. It was hypothesized that patients who preoperatively have a high probability of recurrent instability after arthroscopic surgery would, in fact, be more likely to select open surgery, while patients with a low probability of recurrent instability after arthroscopic surgery would choose arthroscopic treatment.

METHODS

Outcome Probabilities

A critical component to modeling any decision tree with the technique of decision analysis requires one to determine the occurrence probabilities for each terminal node in the decision tree. For our project, to determine these probabilities, a literature review for recurrent anterior glenohumeral dislocation with "critical bone defects" was performed using the PubMed database from 1970 to January 2014. The search criterion used variations of *recurrent shoulder dislocation*, *critical bone defect*, *glenohumeral instability*, *Bristow-Latarjet*, *bony Bankart*, *arthroscopic Bankart repair*, *glenoid*, and *surgery*. Critical bone defects were loosely defined as a bony Bankart lesion comprising at least 25% of the glenoid rim, although 2 articles that were included in the review were less clear as to the definition of critical bone defect.[27,40] Numerous articles were discarded due to bone defect cohorts with less than 25% glenoid deficiency.§ Additional articles looking at both arthroscopic and open surgery were not included in the final literature review data as these articles did not independently report the final postoperative outcomes of the critical bone defect cohort subset.[5] Articles were discarded if they described a novel surgical approach to the glenoid, such as the 2B3 approach described by Boileau et al,[8] but were included if they described a novel bone graft technique (eg, iliac crest craft).[46] Most open and arthroscopic techniques described were variations of the coracoid transfer initially described independently by Bristow[22] and Latarjet.[30] Mean follow-up varied between studies, but was at minimum 5 months[24] with an overall mean follow-up among all 14 articles of 42.23 months.‖

To calculate the probabilities of occurrence for each terminal node in the decision tree, each study was reviewed for outcome data after either arthroscopic or open repair for critical osseous deficits with anterior glenohumeral instability. Probabilities for both open and arthroscopic repair were calculated independently by dividing the aggregate sum of occurrences for a given outcome by the total number of shoulders for the given operative course such that the sum of probabilities for all terminal nodes for both open and arthroscopic surgery equaled 1. For both arthroscopic and open repair, "no complications" was defined as no further episodes of subluxation or recurrent dislocation following surgical repair, while "recurrence" was defined as 1 or more episodes of subluxation or dislocation following surgery. "Infection" was noted per each individual study, and "stiffness" was broadly defined as any decrease in the range of motion postoperatively. For open repair, a fifth outcome—nerve damage—was added because of the inherent increased risk for damage to the musculocutaneous nerve during an open bone grafting procedure. Per the model, any given shoulder could only have 1 independent outcome (ie, infection could not also be recurrent instability).

Utilities

Utility refers to a value assigned to patient preferences given a specific outcome. In this study, following expedited

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§References 7, 20, 21, 29, 35, 38, 41, 43-45, 48.
‖References 4, 10, 15, 16, 19, 24, 26, 27, 33, 37, 40, 42, 46, 47.

institutional review board approval, utility values were obtained via direct survey of 50 ambulatory orthopaedic patients at a tertiary care orthopaedic sports clinic. Patients were aged 18 to 35 years so as to most closely represent the age groups with the highest prevalence of recurrent instability after arthroscopic surgery.[28,32] The survey was designed with a visual number line utility score, as that has been shown to be most effective as per Parkin and Devlin[39] (see the Appendix). Subjects who had a prior history of dislocation, subluxation, shoulder surgery, or other shoulder injury were excluded from participation to limit positive or negative bias in the subject's ability to assign utility values. In addition, the survey included the shoulder activity scale described by Brophy et al[14] to correlate utility values, with individual activity levels ranging from a minimum score of 5 to maximum of 20. The survey presented hypothetical scenarios after recurrent anterior glenohumeral instability that represented terminal end points in the decision tree. Participants were asked to identify their utility preferences by both vertical line and associated number. The scale was prefaced by a predetermined best outcome (arthroscopic surgery followed by no recurrent instability) and worst outcome (open surgery followed by recurrent instability) at 100 and 0, respectively. The parameter for best outcome was chosen because it combined the optimal surgical outcome (resolution of instability with no postoperative complications or recurrence) with the least morbid intervention technique (arthroscopy). This similar methodology was applied in selecting the worst possible outcome, as this option combined recurrent postoperative instability with the most morbid operative technique (open surgery). For survey responses that did not include a value associated with the number line, the primary reviewer assessed the utility value and then a second reviewer independently assessed the same survey. Discrepant measures were averaged if found. After data collection, the average response for each utility outcome was calculated and applied to the initial decision tree construction and subsequent fold-back analysis.

Decision Tree and Fold-Back Analysis

The decision tree was constructed with 1 decision node, 2 chance nodes, and 9 outcome nodes. Per convention, time was not modeled because the events are discrete and the decision occurs over an acute period. The standard way to display a decision tree involves the corresponding utility value to be placed to the right of its outcome node while the probability of that outcome be placed underneath the node.

Fold-back analysis was performed by multiplying the utility value for the given outcome by its probability of occurrence. This provided the "expected value" for the terminal node. To determine the optimal decision course, the expected values for each independent outcome node of both chance nodes (open vs arthroscopic surgery) were summated to create an "ultimate expected value." This value allowed for comparison of both potential choices, as the highest ultimate expected value is the optimal decision choice.

Sensitivity Analysis

One-way sensitivity analysis was performed to determine the importance of each variable to the decision tree model and also to determine the effect of changing probability values on the optimal treatment outcome. Manipulating the probability of occurrence for arthroscopic surgery followed by recurrent dislocation was the primary focus during analysis to identify the precise probability of recurrent instability after arthroscopic surgery at which the optimal treatment outcome changes ("threshold value"). Furthermore, 1-way sensitivity analysis was performed on open surgery with no recurrence, open surgery with nerve damage, and arthroscopic surgery with no recurrence.

Two-way sensitivity analysis is a similar technique that is used to evaluate the effect of simultaneously changing 2 discrete variables on the overall outcome of the model. This analysis technique was employed primarily to determine the preferential treatment outcome while varying the probabilities of open surgery and no complication with arthroscopic surgery and recurrent instability. Throughout this analysis, utility values were largely held constant and not evaluated with 1-way and 2-way sensitivity analysis with the exception for the node defined as arthroscopic surgery followed by recurrent instability. This utility value was analyzed since the primary focus of the sensitivity analysis was to determine the threshold value between arthroscopic surgery with recurrence and open surgery without recurrence.

RESULTS

Probabilities

Following the search strategy outlined in the methods, 9 articles were found that pertained to open surgical treatment for glenoid osseous critical bone defects, while 5 articles were found that pertained to arthroscopic surgical treatment (Tables 1 and 2). In total, there were 240 shoulders that underwent open treatment, of which 91.3% had no recurrence or complication, 5.8% had recurrent instability, 0.8% had infection, 2.1% had stiffness, and 0% had nerve damage. In contrast, there were 186 shoulders that underwent arthroscopic treatment, of which 81.7% had no recurrence or complication, 16.1% had recurrent instability, 0% had infection, and 2.2% had stiffness.

Utilities

The mean age for the survey respondents was 25.38 years; 18 respondents were women while the remaining 32 were men. Mean Brophy shoulder activity score was 12.94. A complete listing of utility values including predetermined best and worst outcomes (arthroscopic surgery with no complication and open surgery with recurrent instability) with associated SDs can be found in Table 3. The population surveyed was similar in age and activity to populations previously analyzed for recurrent instability,[6] although there was a lower male:female ratio (16:9) than previously described. Many of the utilities obtained through the

TABLE 1
Probability Values for Arthroscopic Surgery and Associated Outcomes

Outcome	Burkhart and De Beer[15]	Boileau et al[10]	Lafosse and Boyle[27]	Mologne et al[33]	Porcellini et al[40]	Total Shoulders	Probabilities
No complications	7	3	65	18	59	152	.817
Recurrent instability	14	9	0	5	2	30	.161
Infection	0	0	0	0	0	0	.000
Stiffness	0	0	0	0	4	4	.022
Total	21	12	65	23	65	186	1.000

TABLE 2
Probability Values for Open Surgery and Associated Outcomes

Outcome	Auffarth et al[4]	Burkhart et al[16]	Warner et al[46]	Weng et al[47]	Khazzam et al[26]	Scheibel et al[42]	Pagnani[37]	Hovelius et al[24]	DiPaola et al[19]	Total Shoulders	Probabilities
No complications	42	97	9	7	10	10	4	36	4	219	.913
Recurrent instability	0	5	0	2	0	0	0	7	0	14	.058
Infection	2	0	0	0	0	0	0	0	0	2	.008
Stiffness	3	0	2	0	0	0	0	0	0	5	.021
Nerve damage	0	0	0	0	0	0	0	0	0	0	.000
Total	47	102	11	9	10	10	4	43	4	240	1.000

patient survey were found to have large SDs (Table 3). This was not considered to be a major concern for fold-back analysis given the relatively low probabilities of occurrence for these nodes, and thus, their relative lack of contribution to the ultimate expected value of the model.

Decision Analysis

Fold-back analysis on the initial decision tree revealed the ultimate expected value for arthroscopic surgery to be 87.17 and the ultimate expected value for open surgery to be 81.64 (Figure 1), indicating arthroscopic treatment to be preferred. One-way sensitivity analysis of arthroscopic surgery followed by recurrent instability indicated a probability threshold value of 0.238 (Figure 2A), demonstrating that when the probability of recurrent instability following arthroscopic surgery eclipses 23.8%, the desired course is no longer arthroscopic fixation but rather open treatment. Probability threshold values for open surgery without recurrence and arthroscopic surgery without recurrence were 0.976 (Figure 2B) and 0.762 (Figure 2C), respectively. These values indicate that when either the probability of open surgery without complication is 97.6% or the probability of arthroscopic surgery without complication is only 76.2%, the desired treatment choice changes from arthroscopic to open surgery. No probability threshold value for open surgery followed by nerve damage was obtained, indicating that arthroscopic stabilization is the patient's preferred treatment irrespective of the probability of occurrence of nerve damage after open stabilization. This lack of threshold value was primarily due to the

TABLE 3
Utility Values From Survey Responses

Utility	Response, mean ± SD
Arthroscopic + no complication[a]	100 ± 0
Open + recurrent instability[b]	0 ± 0
Arthroscopic + recurrent instability	28.08 ± 24.85
Arthroscopic + infection	52.9 ± 30.26
Arthroscopic + stiffness	43.02 ± 24.54
Open + no complication	88.34 ± 18.04
Open + nerve damage	18.26 ± 21.71
Open + infection	37.36 ± 30.71
Open + stiffness	32.72 ± 22.76

[a]Predetermined scenario with given maximum utility value (100).
[b]Predetermined scenario with given minimum utility value (0).

low utility value (18.26) that patients assigned to this scenario; given an understanding of expected value decision analysis, it becomes clear that a low utility value for a terminal node combined with a low probability of occurrence for that same node will have little, if any, effect on the overall model. One-way sensitivity analysis was also performed on the utility value for arthroscopic surgery with recurrent instability, but yielded no threshold value (Figure 2D). Two-way sensitivity analysis was performed to determine the effect on the model of changing 2 variables simultaneously. The probability values for open surgery without recurrence and arthroscopic surgery with recurrence were varied in accordance with 2-way sensitivity analysis (Figure 3A), while
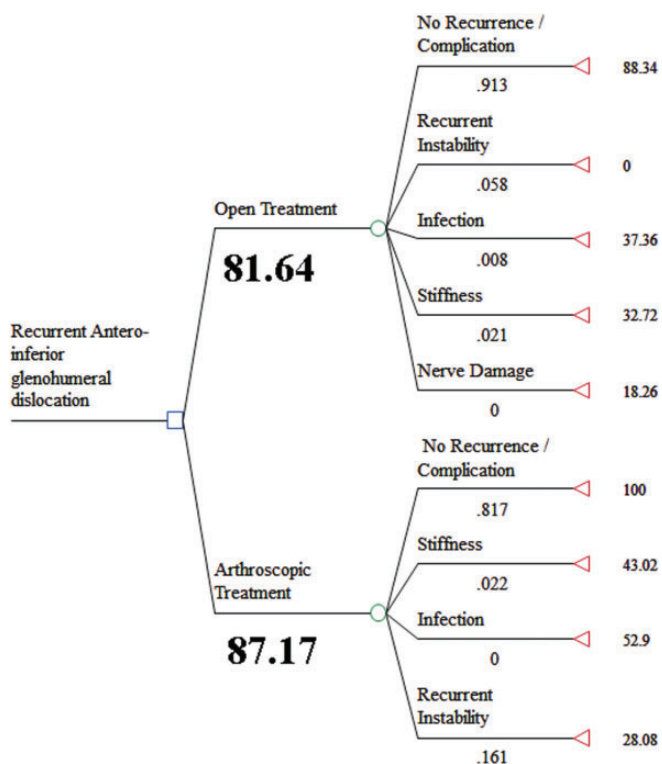
Figure 1. Initial decision tree surrounding optimal treatment following primary anteroinferior glenohumeral dislocation revealing 1 decision node (blue square), 2 chance nodes (green circles), and 9 terminal nodes (red triangles). The numbers listed to the right of the terminal nodes are the utility values for the corresponding terminal node, while the probability of occurrence for that node is located below the line segment. The numbers listed below the chance nodes indicate the ultimate expected value for the decision path, clearly indicating arthroscopic treatment as the optimal treatment.

both the probability of arthroscopic surgery with recurrent instability and the utility value for that event were also analyzed (Figure 3B). By comparing probability values for open surgery without recurrence to arthroscopic surgery with recurrence, there appears a general inverse relationship indicating that as open fixation becomes more successful (ie, less recurrence), the probability of arthroscopic surgery with recurrence must similarly decrease to remain the preferred surgical method. Likewise, there was a general positive correlation when comparing the probability of arthroscopic surgery with recurrent instability with the utility of arthroscopic surgery with recurrent instability, implying that as the recurrence after arthroscopic surgery increases, so too must the patient utility for that event if arthroscopic surgery is to remain the patient's preferred treatment.

DISCUSSION

The optimal management for anterior glenohumeral instability with a critical osseous defect remains controversial. While arthroscopic labrum repair allows for treatment with less morbidity, there is a considerably higher probability for recurrent instability. In contrast, open treatment has less risk of recurrent instability while having increased morbidity. Our study utilized decision analysis techniques to assess patient preferences for various treatment outcomes and to develop a decision tree model, and we concluded that arthroscopic treatment is preferred for the treatment of patients with critical bone defects as long as the risk of recurrent instability is less than 23.8%. Patients seem to be willing to accept the risk of recurrent surgery or failure if the success rate is approximately 75% or greater. This value is consistent with recent studies that have highlighted the need for open surgery as a primary treatment option with glenoid osseous defects due to the correlation with recurrent instability.[42,47] The problem is determining what a critical osseous defect is and how an isolated glenoid or humeral defect or a combination of the 2 affects the failure rate of surgery. Therefore, it is important to better define the relationship between bone defects and recurrent instability in future research so that patients can be better selected for either arthroscopic or open treatment and they can therefore make better informed decisions about their surgery.

We found that when the combined complication rates (including recurrence) after open surgery are less than 2.4% (corresponding to a probability threshold value of 0.976), then open surgery is preferable to arthroscopic surgery. While this represents a low complication and recurrence rate, this value is still feasible, as large cohorts have been previously described with similar success rates without complication.[13,15] This is a critical conclusion that similarly warrants continued research to create open fixation techniques that have both successful and reproducible outcomes.

While varying probability threshold values were important, so too was modeling threshold utility values because it seems plausible that some individuals may prefer open surgery to arthroscopic surgery, largely because of the lower chance of recurrent instability. However, modeling this scenario demonstrated no threshold utility value where the expected value for open surgery was greater than that for arthroscopic surgery (see Figure 2E). This surprising result is explained by the low rate of recurrent instability after arthroscopic surgery, as significant alterations to the model did not occur while utility values were manipulated because the low probability rate of this terminal node prevents it from having significant contributions to the overall model. Because of this result, 2-way sensitivity analysis was then performed in an attempt to model the relationship between the utility value and probability value for recurrent instability after arthroscopic surgery as both variables were simultaneously manipulated. This analysis yielded distinct combinations of both utilities and probabilities for which open surgery would be optimal (see Figure 3B), suggesting that higher values of instability after arthroscopic fixation are associated with lower utility values and, thus, allow for situations in which open treatment is the patient's preferred surgical procedure.

Musculocutaneous nerve damage has traditionally been a concern for surgeons and a well-documented adverse
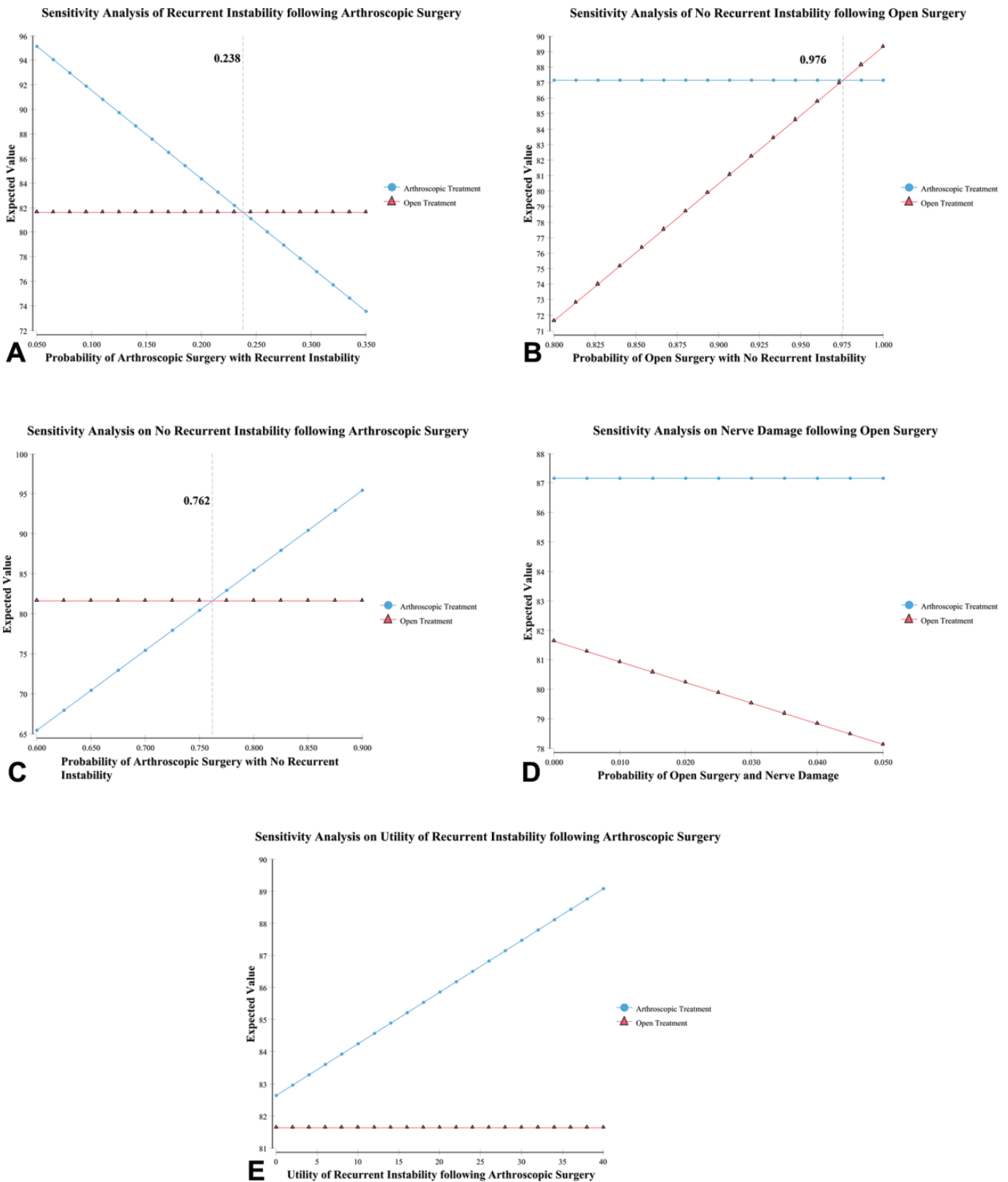
Figure 2. One-way sensitivity analysis showing threshold values for instability after (A) arthroscopic surgery and (B) open surgery without complication or instability. One-way sensitivity analysis showing threshold values for (C) arthroscopic surgery without instability or complication and (D) open surgery with nerve damage. (E) One-way sensitivity analysis showing no threshold value for the utility of recurrent instability after arthroscopic surgery.
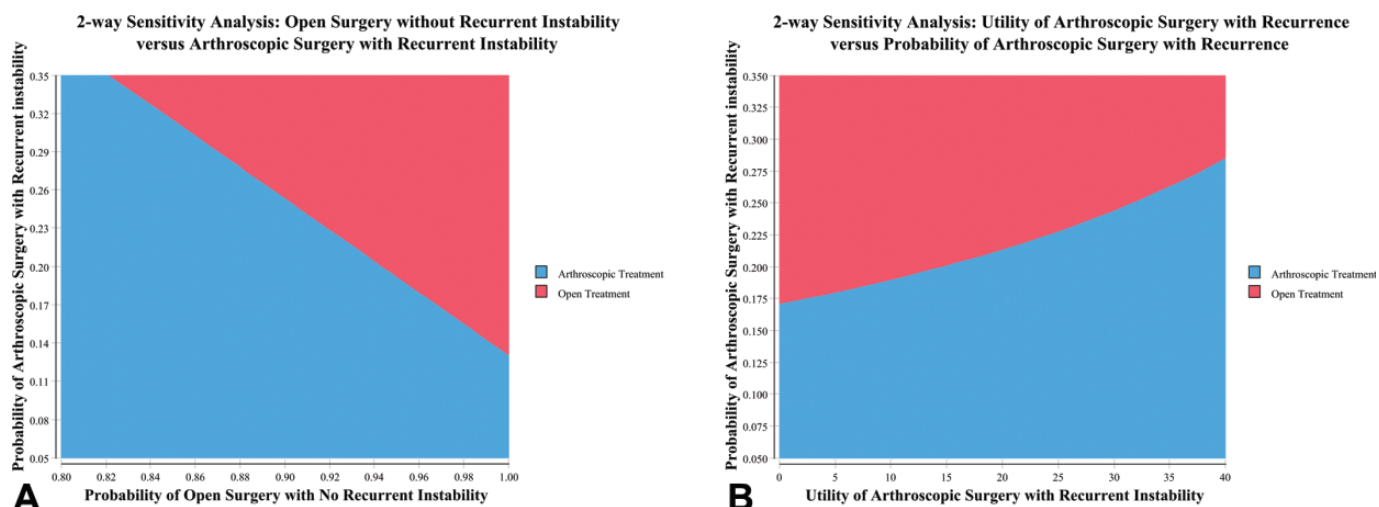
Figure 3. Two-way sensitivity analysis for (A) the probability of recurrent instability after arthroscopic surgery and open surgery without recurrent instability and (B) utility of recurrent instability after arthroscopic surgery and probabilities of recurrent instability after arthroscopic surgery.

effect of open shoulder surgery.[12] It is interesting to note the terminal node defined as open surgery followed by nerve damage contributed little to the overall decision analysis because of the low utility value and probability of occurrence. While the probability of occurrence for this node obtained through the literature review of papers employing Latarjet specifically for shoulders with critical bone defects was 0, this value is likely underrepresentative of the actual patient population following open surgical fixation. However, even with sensitivity analysis, it was clear that no feasible probability value would enable this node to influence optimal decision of technique; it had no bearing on final outcome. Thus, one can conclude that while nerve damage is a feared outcome of open surgical fixation, it should not prevent surgeons from choosing this treatment option when it is the optimal treatment.

The results from the initial fold-back analysis indicated that arthroscopic surgery was the patient's preferred management option for a patient with recurrent anteroinferior glenohumeral instability with a critical osseous defect. The data supporting this conclusion were obtained via the literature review and the patient-administered survey. This finding is surprising given the increasing number of research studies that advocate for open treatment for critical osseous deficits,[10,15,24,31] although concrete treatment protocols are lacking due to individualized patient preferences,[6] novel surgical techniques,[1,4,46] and improved understanding of glenoid reconstruction.[1,31] However, it is important to note that age and activity level were not directly modeled in this study. Age was indirectly involved in the utility scores by controlling the population to which the survey was administered and was also represented in the probability values through the studies used in the literature review. Similarly, activity level was presumably an indirect component in the utility values, as more active individuals expressed less utility for recurrence. Most important, however, was the inability to determine the

direct effect of changes to the size of the critical bone defect to the model, as there is currently no research that allows for accurate prediction of recurrent instability associated with glenoid defects though correlation has been strongly suggested.[1,15,31] It is important to remember, however, that patient preferences outside of those assessed in this study exist in the community, and it is important for the surgeon to elicit these from the patient prior to deciding on a particular operative intervention.

Anterior shoulder instability has previously been analyzed through the use of a similar decision analysis technique. A prior study published by Bishop et al[6] focused on operative versus nonoperative care as the 2 initial decision nodes in the decision tree analysis. The authors concluded that the patient's preferred treatment for primary anterior glenohumeral dislocation was arthroscopy, but they did not evaluate the differences in recurrence related to critical osseous defects, nor did they evaluate open versus arthroscopic surgery. It is important to note that osseous defects are quite common with anterior shoulder dislocation, and a relationship between defect and recurrent instability has been demonstrated previously.[31]

There are published studies that have reviewed open versus arthroscopic treatment for anterior glenohumeral instability in the setting of critical bone defect while also providing guidelines for management.[1,11] Anakwenze et al[1] discussed the effectiveness of open surgical fixation for glenoid repair and arthroscopic treatment for moderately sized humeral head defects. Bollier and Arciero[11] advocated for open surgical fixation when glenoid loss eclipsed 20%, an engaging Hill-Sachs lesion was present, and the instability severity index score was greater than 6, and further advised either arthroscopic remplissage or open bone grafting for a Hill-Sachs lesion greater than 30%. These studies support our conclusion of open surgery as the patient's preferred treatment for glenohumeral surgical repair given a high arthroscopic surgical failure rate;

at the core of both studies was the effect of the critical bone defect on the treatment choice, indicating that arthroscopic surgery under these conditions produced a high recurrence rate. While both of these studies acknowledge the need for further research into the area of surgical fixation of critical bone defects, they do not address patient preferences or utility for a given treatment modality—something that has been considered in our analysis.

There were a few limitations that were encountered in this study. While the probability data were acquired through an exhaustive literature search, there were relatively few studies that discussed critical bone defects in the setting of anterior glenohumeral instability, and this paucity of literature has a potentially negative effect on both treatment modalities. Although studies have begun to address critical bone defects and even categorize glenoid osseous defects,[5] there is still a lack of consensus regarding what constitutes a "critical bone defect." Bigliani et al[5] proposed a 25% osseous glenoid deficiency to be the defect necessary to characterize a critical bone defect, but even more important, there has yet to be an established relationship between the size of defect and recurrence after arthroscopic surgery. This is an extremely important undefined variable given the effect of this relationship to our model. As such, further research is warranted to not only universally define a critical bone defect, but also to better establish its effect on recurrent instability. Last, it is important to note that the advent of arthroscopic surgery to address critical glenoid bony defects is a technically demanding procedure, and the outcomes used in this study came from experienced shoulder surgeons, many of whom are pioneers with these techniques. As a result, these procedures may not necessarily be reproduced with similar success rates by other surgeons in the community.

The data from this study may help us to better understand the optimal surgical treatment for recurrent glenohumeral instability in the setting of a critical osseous defect. To determine optimal treatment, both the probability of a certain outcome happening and the individual's utility for that outcome must be considered. Large defects have been associated with a higher probability of recurrent instability, and we conclude that the optimal treatment should be open surgery to address bone loss when the rate of arthroscopic recurrent instability eclipses 23.8%. Furthermore, it is important to have better outcome studies to predict the rate of recurrence with arthroscopic treatment based on patient osseous defects, as this would allow for accurate predictive modeling in the clinical setting. However, a strong patient-doctor relationship that emphasizes trust and collaboration will be crucial to achieving any successful outcome, as obtaining patient preferences can help elucidate the optimal surgical treatment.

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APPENDIX
Critical Bone Defect Patient Utility Survey

Demographic Information (please fill in the blanks)

Age: _____

Gender (Circle):   MALE   FEMALE

Reason for current visit: _____

Please indicate **with an "X"** how often you performed each activity in your healthiest and most active state **in the past year**.

	Never or less than once a month	Once a month	Once a week	More than once a week	Daily
Carrying objects 8 pounds or heavier by hand (such as a bag of groceries)					
Handling objects overhead					
Weight lifting or weight training with arms					
Swinging motion (as in hitting a tennis ball, golf ball, baseball, or similar object)					
Lifting objects 25 pounds or heavier (such as 3 gallons of water) NOT INCLUDING WEIGHT LIFTING					

For each of the following questions, please **circle the letter** that best describes your participation in that particular activity.

1) Do you participate in contact sports (such as, but not limited to, American football, rugby, soccer, basketball, wrestling, boxing, lacrosse, martial arts, etc)?

   A No
   B Yes, **without** organized officiating
   C Yes, **with** organized officiating
   D Yes, at a professional level (ie, paid to play)

2) Do you participate in sports that involve hard overhand throwing (such as baseball, cricked, or quarterback in American football), overhead serving (such as tennis or volleyball), or lap/distance swimming?

   A No
   B Yes, **without** organized officiating
   C Yes, **with** organized officiating
   D Yes, at a professional level (ie, paid to play)

This survey is meant to see how you rate potential situations if you happened to have a shoulder dislocation which needed to be treated with a surgical operation to prevent further dislocations. Shoulder dislocation occurs when the ball and socket of your shoulder joint come apart and you are in severe pain and cannot move your shoulder. This is treated by going to the emergency room immediately where you are sedated so that a doctor can pull on your arm to relocate your shoulder. After this, your shoulder is sore for a few weeks before you can return to sports. The first time you dislocate your shoulder it usually happens after a violent injury such as a fall or an injury during a contact sport, but the repeat dislocations can occur during daily activities or even sleep.

BEST AND WORST OUTCOMES

1. **BEST OUTCOME: Arthroscopic surgery and no complication.** You have a shoulder dislocation. You go to the Emergency Department and your arm is put back in place. However, arthroscopic shoulder surgery is needed to make sure that your shoulder stays in place. During this surgery, 2 or 3 cuts measuring ¼ inch (called "portals") are made around the shoulder.

Figure 1

Arthroscopy of the shoulder

A thin, pencil-sized camera and surgical instruments are put through the portals to perform the surgery. Stitches and small plastic "anchors" that measure about 1/8 inch are used to repair torn cartilage to the bone. You will be unconscious for the procedure, but no overnight stay in the hospital will be required. Your arm will be in a sling following the surgery and then you will need physical therapy. Your shoulder will return to normal following the 6 month recovery time and you will have no more shoulder trouble. **This scenario is the best possible outcome and has been assigned a value of 10.**

0 -- 10
Worst outcome   Best outcome

2. **WORST OUTCOME: Open surgery with further dislocations.** You have a shoulder dislocation. You go to the Emergency Department and your arm is put back in place. However, open shoulder surgery is needed to make sure that your shoulder stays in place. During this surgery, a vertical cut 2-3 inches in length is made in the shoulder and a small portion of the shoulder blade is moved to the shoulder. A saw is used to cut part of your shoulder blade and move it to make the shoulder socket more

stable, and the piece of bone is attached with two stainless steel screws. You will be unconscious for the surgery, but no overnight stay in the hospital will be required. Your arm is initially in a sling following the surgery and then you will need physical therapy. However, after the 6 month recovery time, you still get shoulder dislocations that keep you from normal activity and may require trips to the emergency room to have the shoulder put back in place. **This scenario has been deemed the worst possible outcome and has been assigned a value of 0.**

0 -- 10
Worst outcome   Best outcome

(continued)

START SURVEY HERE

3. **Arthroscopic surgery with further dislocations that require an open surgery.** You have a shoulder dislocation that needs arthroscopic surgery. After surgery, physical therapy, and 6 months of recovery, you continue to suffer from shoulder dislocations that keep you from normal activity. You need a second surgery and are treated with the open procedure which requires more physical therapy and another 6 months of recovery time.

0 --- 10
Worst outcome   Best outcome

4. **Arthroscopic surgery and infection.** You have a shoulder dislocation that needs arthroscopic surgery. Unfortunately, following the surgery, an infection develops that requires you to be hospitalized and receive treatment with IV antibiotics. The infection clears and your shoulder returns to normal after physical therapy and 6 months of recovery. You have no more shoulder trouble after this.

0 --- 10
Worst outcome   Best outcome

5. **Arthroscopic surgery and shoulder stiffness.** You have a shoulder dislocation that needs arthroscopic surgery. Following surgery, physical therapy, and a 6 month recovery time, your shoulder no longer dislocates although it is stiff. You are unable to regain your complete range of motion which may limit your ability to do things that require the full motion of your shoulder or make these activities painful.

0 --- 10
Worst outcome   Best outcome

6. **Open surgery and no complications.** You have a shoulder dislocation that requires open surgery. Following the surgery, physical therapy, and 6 month recovery time, your shoulder returns to normal and you have no more shoulder trouble.

0 --- 10
Worst outcome   Best outcome

7. **Open surgery and nerve damage.** You have a shoulder dislocation that needs opens surgery. The surgery is successful, although there is nerve damage during the procedure that prevents you from bending your elbow to lift.

0 --- 10
Worst outcome   Best outcome

8. **Open surgery and infection.** You have a shoulder dislocation that needs open surgery. The surgery is successful although, afterwards, an infection develops that requires you to be hospitalized for 3-5 days and receive treatment with surgery to wash out the infection. After leaving the hospital, a nurse has to give you antibiotics through an IV every day for 6 weeks. The infection clears and your shoulder returns to normal after the 6 month recovery period.

0 --- 10
Worst outcome   Best outcome

9. **Open surgery and stiffness.** You have a shoulder dislocation that needs open surgery. The surgery is successful and then you are treated with physical therapy and a 6 month recovery period. After treatment, your shoulder no longer dislocates although it is stiff. You are unable to regain your complete range of motion which may limit your ability to do things that require the full motion of your shoulder or make these activities painful.

0 --- 10
Worst outcome   Best outcome

Thank you for your participation