J Shoulder Elbow Surg (2021) 30, e85–e102

ELSEVIER

Journal of Shoulder and Elbow Surgery

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ONLINE ARTICLES

Surgical treatment for recurrent shoulder instability: factors influencing surgeon decision making

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Background: The optimal surgical approach for recurrent anterior shoulder instability remains controversial, particularly in the face of glenoid and/or humeral bone loss. The purpose of this study was to use a contingent-behavior questionnaire (CBQ) to determine which factors drive surgeons to perform bony procedures over soft tissue procedures to address recurrent anterior shoulder instability.

Approval for this study was received from Duke Institutional Review Board (Protocol ID: Pro00101648).

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https://doi.org/10.1016/j.jse.2020.07.003

Methods: A CBQ survey presented each respondent with 32 clinical vignettes of recurrent shoulder instability that contained 8 patient factors. The factors included (1) age, (2) sex, (3) hand dominance, (4) number of previous dislocations, (5) activity level, (6) generalized laxity, (7) glenoid bone loss, and (8) glenoid track. The survey was distributed to fellowship-trained surgeons in shoulder/elbow or sports medicine. Respondents were asked to recommend either a soft tissue or bone-based procedure, then specifically recommend a type of procedure. Responses were analyzed using a multinomial-logit regression model that quantified the relative importance of the patient characteristics in choosing bony procedures.

Results: Seventy orthopedic surgeons completed the survey, 33 were shoulder/elbow fellowship trained and 37 were sports medicine fellowship trained; 52% were in clinical practice ≥10 years and 48% <10 years; and 95% reported that the shoulder surgery made up at least 25% of their practice. There were 53% from private practice, 33% from academic medicine, and 14% in government settings. Amount of glenoid bone loss was the single most important factor driving surgeons to perform bony procedures over soft tissue procedures, followed by the patient age (19-25 years) and the patient activity level. The number of prior dislocations and glenoid track status did not have a strong influence on respondents' decision making. Twenty-one percent glenoid bone loss was the threshold of bone loss that influenced decision toward a bony procedure. If surgeons performed 10 or more open procedures per year, they were more likely to perform a bony procedure.

Conclusion: The factors that drove surgeons to choose bony procedures were the amount of glenoid bone loss with the threshold at 21%, patient age, and their activity demands. Surprisingly, glenoid track status and the number of previous dislocations did not strongly influence surgical treatment decisions. Ten open shoulder procedures a year seems to provide a level of comfort to recommend bony treatment for shoulder instability.

Level of evidence: Survey Study; Experts

Keywords: shoulder instability; choice; conjoint analysis; contingent-behavior; bone loss

Shoulder instability remains one of the most common shoulder injuries and has a strong association with sports and a younger, active population.[11,27,28] The management of shoulder instability continues to evolve with controversy remaining on whether surgical stabilization or conservative management is appropriate for first-time dislocators.[5,40,51] Furthermore, once a decision has been made to proceed with surgery, the optimal surgical option remains elusive. And despite advances in surgical techniques, there continue to be high rates of postoperative recurrence in high-risk populations with reports as high as 22%-35%.[6,44] Although several studies have been performed to guide the decision between nonoperative and surgical treatment,[1,10,16,22,41,42] few studies have evaluated how surgeons make choices regarding their surgical strategy.

Bishop et al[2] used a retrospective review of prospective data in order to shed light on which risk factors affected a surgeon's surgical choice. They found in their cohort of 564 patients that 82% of patients were treated with arthroscopic labral repair, 6.7% with open capsulolabral repair, and 12.8% with a Latarjet procedure. They identified reasons for using an open technique, which included symptom duration (>1 year), number of dislocations (>5 dislocations), revision surgery, Hill-Sachs lesion size (11%-20% of humeral head), and glenoid bone loss (11%-30%).[2] Using a multivariate regression analysis, the authors identified number of dislocations, revision surgery, and glenoid bone loss as the best predictors of performing an open procedure over arthroscopic.[2] Although the study sought to answer an important question, as a retrospective assessment, it was unable to determine how each factor individually affected surgical treatment choice. The study design was also unable to separate out the interplay between factors (eg, younger age and higher-risk activity), differences between what a surgeon reports and what is actually driving their decision.

As a way to address the shortcomings of a retrospective cohort study, prospective evaluation of factors driving surgical decision making in patients with recurrent shoulder instability may be conducted using contingent-behavior questionnaires (CBQs).[4] This type of stated-preference instrument can be used in health care to study the relative importance of various factors or attributes as patients, physicians, and other stakeholders make choices between options.[4] This process allows for a systematic evaluation and quantification of the weights of various factors in a clinical decision-making context. CBQ is frequently used in marketing as a way to determine what drives consumers to make purchases. A car manufacturer, for example, may want to know how features (such as color, stereo-type, interior design, navigation, or cost) drive consumers to purchase a car. A CBQ will propose a hypothetical car with different combinations of these features and each subsequent proposed hypothetical car will help home in on which features of the car are driving consumer behavior. Similarly, as surgical decision making in shoulder instability continues to evolve, these methods are essential to determining the guiding forces behind surgical treatment recommendations within various patient populations.

The purpose of this study was to use a CBQ to determine which factors drive surgeons to perform bony procedures over soft tissue procedures to address recurrent anterior shoulder instability. The CBQ presented respondents with vignettes of hypothetical patients described in terms of 8 factors. A series of questions asked respondents to state which surgical procedure they would recommend for each patient. Patient characteristics were systematically varied according to an experimental design so treatment recommendations from respondents could be linked to the patient characteristics evaluated.

Methods

Survey instrument development

A review of the literature was conducted to identify predictors for failure of soft tissue repair and factors that may influence surgical technique choice. These attributes were then reviewed and refined by a small panel (n = 3) of orthopedic surgeons—2 attendings that are fellowship trained in sports medicine, and 1 orthopedic sports medicine fellow. The attributes were then presented to the American Shoulder and Elbow Surgeons (ASES) Instability Subcommittee for further refinement and evaluation of appropriateness. Additional experts (n = 2), each with more than 20 years of experience in consumer and health services research, assisted in questionnaire preparation, design, and analysis.

After the initial CBQ was developed, the questionnaire was evaluated by a set of orthopedic fellows and residents (n = 9) to ensure that its structure and design was appropriate and that responses provided relevant data. This was performed in a blinded fashion with all responses and concerns sent anonymously. Any scenarios that may have led to nonoperative management were identified. All combinations of factors that may have led to a nonoperative treatment plan were removed. Careful curation of the design patient profiles was performed to ensure that surgical management would be the only reasonable option. The objective in this portion of survey design was to create the simplest, cleanest design to reduce cognitive burden to maximize the quality of the answers; therefore, patient profiles that may lead to nonoperative treatment as the goal of this study was to evaluate operative choice by surgeons. Additionally, responses were reviewed in Sawtooth software to determine that code and data output were appropriate.

Contingent-behavior questionnaire

A CBQ was developed using Sawtooth Software Lighthouse Studio 9.6.1 (Sawtooth Software, Orem, UT, USA) and JMP Pro 14 following best practice guidelines.[4] The CBQ was designed to examine how orthopedic surgeons weigh different patient factors when choosing a surgical technique for recurrent anterior instability. The web-based instrument collected demographic information, provided background on patient factors, and guided respondents through the contingent-behavior exercises with various hypothetical patient profiles.

Demographic data collected on respondents included age, sex, years in practice (after training), state and city of practice, type of practice (ie, government, hospital-employed with academic affiliation, hospital employed without academic affiliation, or independent and group practice), subspecialty training (ie, general, shoulder/elbow, sports medicine, other), ASES Instability Subcommittee membership, percentage of total practice that is shoulder, percentage of total practice that is open shoulder, percentage of total practice that is shoulder arthroscopy, how many open shoulder procedures performed per year, how many shoulder arthroscopy procedures performed per year, how many shoulder instability patients treated per year, and how many operations for shoulder instability performed per year.

Vignettes in the CBQ were designed using a balanced incomplete block design. The questionnaire presented each respondent with 32 clinical vignettes of patients with recurrent shoulder instability that contained 8 factors, each with 2-4 levels per factor. The attributes included (1) age, (2) sex, (3) hand dominance, (4) number of previous dislocations, (5) activity level, (6) generalized laxity, (7) glenoid bone loss, and (8) glenoid track. See Table I for levels for each attribute. An example of the vignette display is provided in Fig. 1.

All descriptors emphasized that surgical management was already determined; each question asked respondents to choose only the preferred surgical technique for the hypothetical patient presented. It was also clearly stated that these were all primary surgeries and not revisions. Respondents were asked to broadly recommend either a soft tissue or bone based procedure, then specifically recommend arthroscopic labral repair, arthroscopic labral repair with Remplissage, open Bankart repair, coracoid transfer, or free bone-block augmentation.

Contingent behavior questionnaire distribution

The survey was distributed to shoulder/elbow and sports medicine trained attending surgeons through the ASES Instability Research group, Multicenter Orthopedic Outcome Network, and Duke Sports Medicine Fellowship Alumni Network.

Statistical analysis

The relative importance of individual factors and combinations of factors were summarized by means and standard errors. Responses were analyzed using a multinomial logit (MNL) regression model that quantified the relative importance of the patient characteristics in choosing a procedure.[29] Results from an MNL model represent the log of the odds (log-odds) that a specific intervention is recommended over a reference intervention based on changes in each studied patient characteristic. In the general surgical treatment, the reference intervention was soft tissue surgical treatment and the intervention was a bony surgical treatment. In the follow-up of more specific treatment, the reference intervention was coracoid transfer.

Latent class analysis (LCA) was used to address unexplained heterogeneity in the patterns of choices from respondents. LCA groups respondents into classes based on their patterns of choices. Respondents are assigned to a discrete number of classes probabilistically, leveraging similarities in their choices. The model jointly estimates relative attribute importance with a multinomial-logit regression and the probability that any given respondent is in each of the classes identified using an expectation-maximization algorithm.[47]

Although LCA identifies heterogeneity in the relative importance of the attributes evaluated, it does so without attributing any specific cause to such heterogeneity. Thus, we conducted subgroup analysis to evaluate the impact of specific respondent characteristics on response patterns. A subgroup analysis comparing years of training (<10 or ≥ 10 years), committee membership (ASES instability vs. non–committee members), and fellowship-training (shoulder/elbow vs. sports medicine) was conducted. A dummy-coded variable indicating subgroup

Table I Patient attributes and levels evaluated by surgeon respondents

Attributes	Level 1	Level 2	Level 3	Level 4
Age	Pre–high school (10-13 yr)	High School (14-18 yr)	Collegiate (19-25 yr)	Postcollegiate (26-40 yr)
Sex	Male	Female		
Hand dominance	Dominant arm	Nondominant arm		
Number of dislocations	2	3-5	>6	
Activities	Sedentary or below shoulder activities (eg, desk work, office job, cooking, or below shoulder activities such as cycling, running)	Overhead Activities (eg, painter, baseball, tennis, volleyball)	Manual Labor, Contact or High Risk Activities (eg, construction worker, farmer, mechanic, football, hockey, extreme sports, skydiving, BMX biking)	
Generalized laxity	Normal (Beighton score 0-3)	Laxity (Beighton score 4-6)	Hyperlaxity (Beighton score 7-9)	
Glenoid bone loss	<15%	15%-20%	21%-30%	>30%
Glenoid track	On-track	Off-track		

membership was interacted with each attribute, and the interaction was included as an explanatory variable for the recommendation of each intervention type. The interaction terms characterized the difference in the importance of attributes across subgroups. The interaction terms were jointly tested by intervention to determine whether relative importance varied across subgroups using a Wald chi-squared test. The number of yearly open surgeries that each respondent reported was also interacted with the attribute variables. This interaction adjusted the log-odds by intervention based on the number of open surgeries.

Results

Respondent characteristics

There were 70 orthopedic surgeons that completed the survey with an average age of 45 (range: 33-71). Of the respondents, 91% (n = 64) were male and 9% (n = 6) were female (see Table II). Thirty-three were shoulder/elbow fellowship trained and 37 were sports medicine fellowship trained. Overall, 52% were in clinical practice ≥10 years and 48% <10 years, and 95% reported that shoulder surgery made up at least 25% of their practice. There were 53% from private practice and 33% from academic medicine. The average number of shoulder instability treated including operative and nonoperative treatments was 87.7 per year (range 10-450). The average number of surgeries performed for shoulder instability was 40.2 per year (range 4-125).

Following administration of the survey, there were 9 procedures that were entered into the "Other" section. These were reclassified to a group, as appropriate. These procedures included (1) open Bankart and remplissage, which was reclassified to open repair; (2) distal tibial and remplissage, distal tibia/iliac crest and remplissage, bone augmentation of glenoid, and Hill-Sachs lesion, which reclassified as bony augmentation; and (3) coracoid transfer and remplissage, which was reclassified to coracoid transfer.

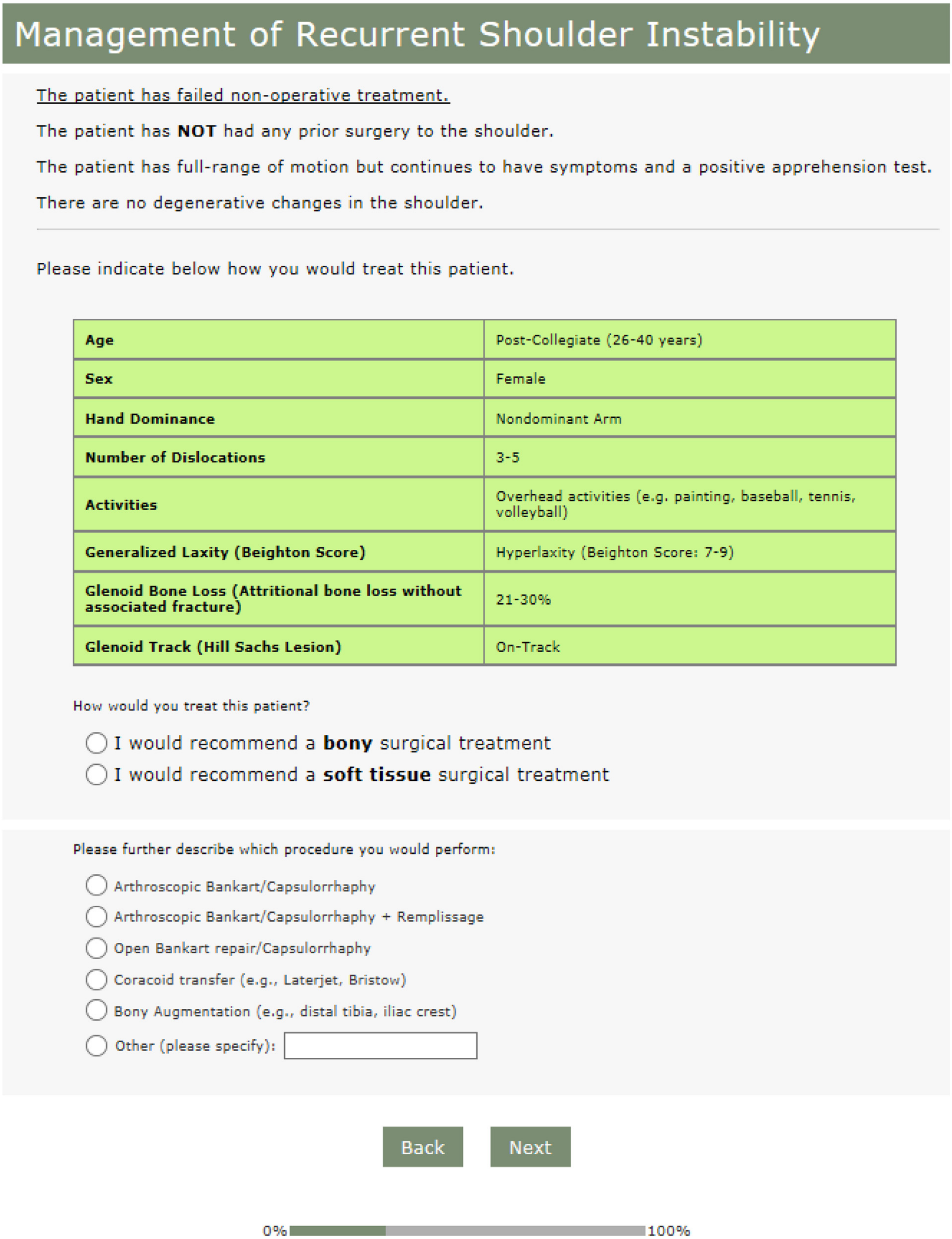
MNL regression model

Results of the MNL regression when the reference treatment was set to be soft tissue surgery are presented in Fig. 2. The results show the log-odds of choosing bony surgical treatment relative to choosing soft tissue surgery for the hypothetical patient vignettes in the CBQ. Log-odds higher than zero represent a higher chance of choosing bony surgical treatment when the patient is presented with a specific attribute level. Log-odds lower than zero indicate a greater chance that respondents choose a soft tissue surgical procedure. The figure also presents the 95% confidence interval indicating statistical significance relative to indifference between the 2 procedures (ie, zero log-odds) for a patient with specific attributes.

As expected, when bone loss increased, respondents were more likely to choose a bony surgical procedure. Off-track glenoid and being male were associated with preference for bony surgical procedures. Manual labor/contact/high-risk activity patients were more likely to undergo a bony procedure compared with overhead activity patients, which were similarly more likely to undergo a bony procedure than sedentary patients.

We also find that collegiate-aged subjects (19-25 years) had the highest likelihood to undergo a bony surgical procedure. Interestingly, high school–aged athletes (14-18 years) and pre–high school (10-13 years) had a lower likelihood of undergoing a bony procedure compared with older patients (aged 26-40 years).

Another way to interpret the MNL results is by looking at the relative importance of each patient attribute when choosing between bony and soft tissue surgical procedures



Management of Recurrent Shoulder Instability

The patient has failed non-operative treatment.

The patient has **NOT** had any prior surgery to the shoulder.

The patient has full-range of motion but continues to have symptoms and a positive apprehension test.

There are no degenerative changes in the shoulder.

Please indicate below how you would treat this patient.

Age	Post-Collegiate (26-40 years)
Sex	Female
Hand Dominance	Nondominant Arm
Number of Dislocations	3-5
Activities	Overhead activities (e.g. painting, baseball, tennis, volleyball)
Generalized Laxity (Beighton Score)	Hyperlaxity (Beighton Score: 7-9)
Glenoid Bone Loss (Attritional bone loss without associated fracture)	21-30%
Glenoid Track (Hill Sachs Lesion)	On-Track

How would you treat this patient?

- I would recommend a **bony** surgical treatment
- I would recommend a **soft tissue** surgical treatment

Please further describe which procedure you would perform:

- Arthroscopic Bankart/Capsulorrhaphy
- Arthroscopic Bankart/Capsulorrhaphy + Remplissage
- Open Bankart repair/Capsulorrhaphy
- Coracoid transfer (e.g., Laterjet, Bristow)
- Bony Augmentation (e.g., distal tibia, iliac crest)
- Other (please specify):

Back Next

0% 100%

Figure 1 Example of patient vignette.

Table II Surgeon demographic data

Demographic	
Age, yr	45.2 (8.5)
Gender, n (%)	
Male	64 (91.0)
Female	6 (9.0)
Percentage composition of shoulder practice	
Total practice is shoulder	70.6 (24.9)
Total practice is open shoulder	23.8 (17.8)
Total practice is shoulder arthroscopy	50.6 (23.0)
Frequency of annual procedures	
Open shoulder procedures	94.6 (92.5)
Shoulder arthroscopy procedures	175.2 (84.2)
Shoulder instability patients treated	87.7 (76.8)
Operations for shoulder instability	40.2 (25.5)

Values are mean (SD) unless otherwise noted.

(Fig. 3). Relative importance is defined as the change in respondents' preference for bony surgical procedures (relative to soft tissue surgery) when a specific patient characteristic changes, all else equal. The more preferences for a bony surgical procedure change with the levels considered in a patient attribute, the more important that attribute is. Results in Fig. 3 show normalized attribute importance, so the highest importance is set to have the value of 10 (or $r = 10.0$). The figure demonstrates that glenoid bone loss was most influential in selecting bony surgical procedure for a patient ($r = 10.0$, $P < .0001$). On average, age was the second most important factor ($r = 2.7$, $P < .0001$). Activity level had the third greatest influence ($r = 1.8$, $P < .0001$). Factors that did not influence the decision between bony or soft tissue surgery included number of prior dislocations ($r = 0.4$, $P = .19$), hand dominance ($r = 0.22$, $P = .37$), and generalized laxity ($r = 1.27$, $P = .26$).

Latent class analysis

With a recursive estimation approach (expectation-maximization algorithm[29]), the latent-class logit model estimates the log-odds for each class and the probability that each respondent is in each class. On convergence, the identified classes represent the most homogeneous sets of choices in the data given the number of assumed classes. Three classes were determined based on model fit (Akaike information criterion and Bayesian information criterion) as well as model parsimony.[14] We used several covariates to help explain the probability of class membership for respondents (see Table III). The coefficients in Table III represent changes in the relative likelihood (log-odds) that a respondent with specific characteristics would be in class 1 or class 2, relative to being in class 3. Respondents with characteristics that have a negative coefficient are more likely to be in class 3 than in class 1 or class 2. Respondents with characteristics that have a positive coefficient are more likely to be in class 1 or class 2. The rightmost column in Table III summarizes the class where each respondent group is more likely to be. Based on the characteristics that made membership to each class more likely, classes can be distinguished as follows: class 1, less experienced surgeons (<10 years in practice); class 2, experienced Surgeons (>10 years in practice) with limited open shoulder surgery per year; and class 3, experienced (>10 years in practice) high-volume open shoulder surgery per year.

The relative importance of patient attributes for class 1 and class 2 are summarized in Fig. 4. These importance weights were normalized following profile-based normalization for the most extreme levels in the attributes.[13] All 3 classes were heavily reliant on glenoid bone loss for surgical procedure decision making; however, class 3 showed less defined preferences as demonstrated by its wider standard error for treatments based on patient characteristics. Results for class 3, in fact, showed no discernible impact of attribute levels on treatment choice beyond glenoid bone loss, so this class was excluded from Fig. 4. Differences between class 1 and class 2 were statistically significant for the importance of glenoid bone loss ($P = .007$) and glenoid track ($P = .012$). Glenoid track was the second most influential factor for less experienced surgeons.

The average probability that respondents were in class 1 and class 2 were 43% and 39%, respectively. The average probability of being in class 3 was 18%.

Group analyses

Based on findings from the latent-class analysis, subgroup analysis was performed to determine if years of training (<10 years vs. ≥10 years), fellowship training (shoulder elbow vs. sports medicine), and number of open surgeries per year influence surgical treatment choice (see Table IV). Coracoid transfer was selected as the comparison group as this was the most commonly selected bony procedure. These findings will be explained further in the sections below. Results from these analyses are presented by comparing the relative importance that each attribute had in the treatment choice. The relative importance is presented as a percentage of the decision expected to be driven by each attribute.

Coracoid transfer vs. other treatment options

Treatment choice relative to coracoid transfer was also assessed (Fig. 5). These results represent log-odds relative to the probability of choosing a coracoid transfer for the average patient shown in the CBQ. Estimates higher than zero represent choice probabilities above the chance of choosing coracoid transfer, whereas estimates lower than zero represent choice probabilities below the chance of choosing coracoid transfer. The findings demonstrate that

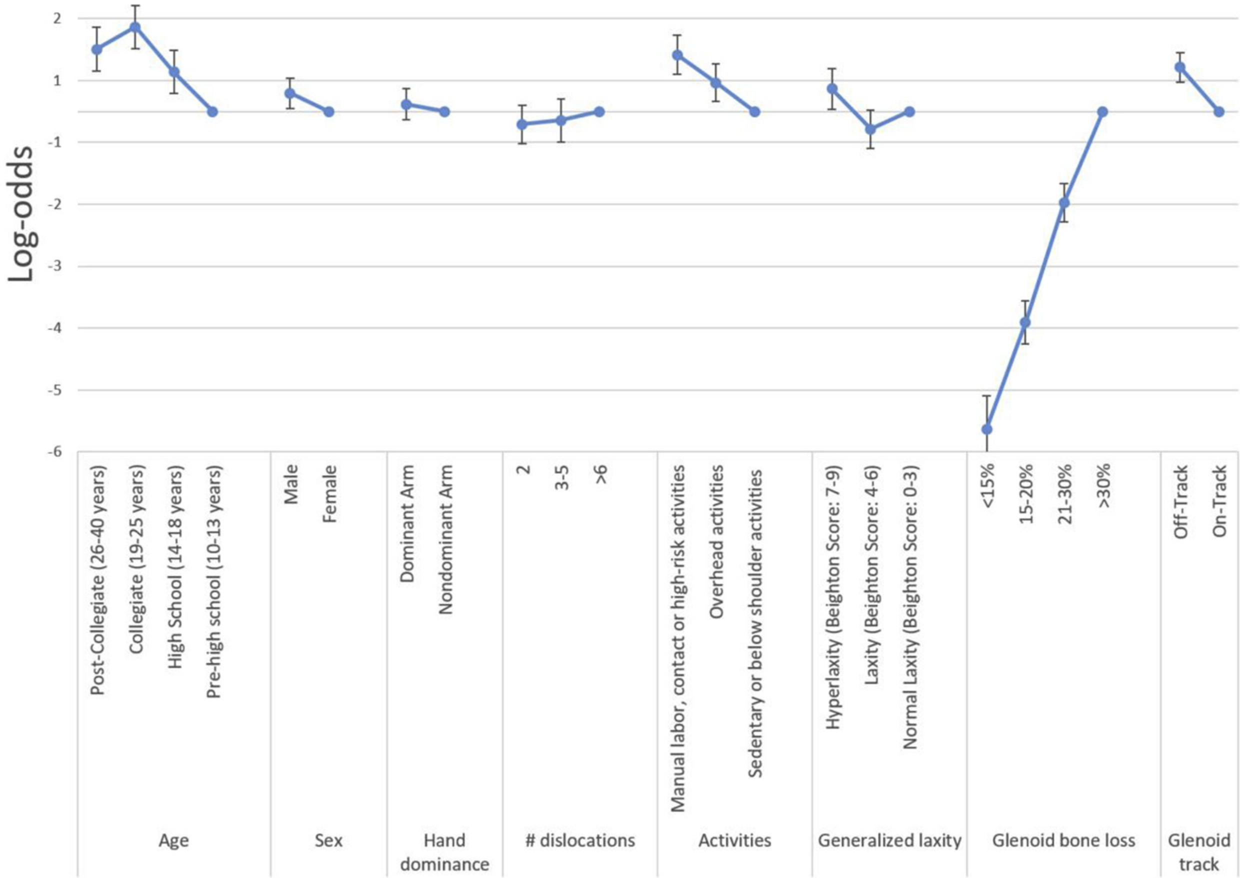


Figure 2 Log-odds of bony vs. soft tissue surgical treatment. For each attribute denoted in the X-axis, the larger the number on the Y-axis (higher on graph) above 0 then the more likely a bony procedure is chosen. Findings are in relation to the other levels within an individual attribute. Moreover, the steeper the curve the more influence the attribute had on decision making.

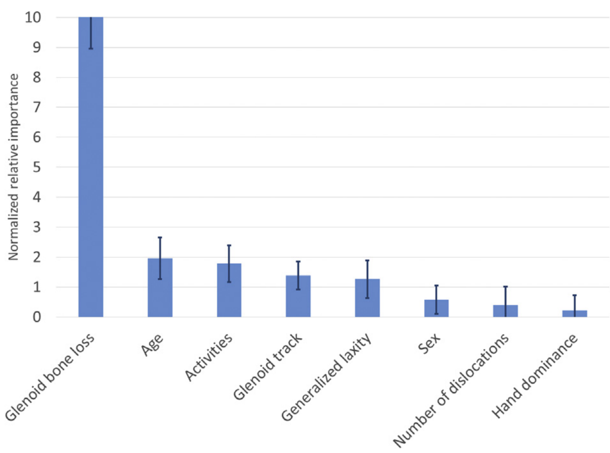


Figure 3 Attribute relative importance. Relative importance is defined as the change in respondents' preference for bony surgical procedures when a specific patient characteristic changes, all else equal. The more preferences for a bony surgical procedure change with the levels considered in an attribute, the more important that attribute is.

bony augmentation was a lot less likely to be selected as a treatment option than coracoid transfer ($P < .0001$). In fact, given most of the patient characteristics considered in the experiment, coracoid transfer was largely preferred over open Bankart and arthroscopic Bankart/capsulorrhaphy and remplissage. Only with younger patients (pre–high school) and patients with lower percentage of bone loss do we consistently find a systematic preference for interventions other than coracoid transfer.

Number of open procedures ($<$10 vs. $\geq$10 open procedures performed per year)

The optimal cutoff number of procedures per year that influenced treatment choice was determined to be 10, which would influence respondents to more likely choose an open repair or coracoid transfer (see Fig. 6). In other words, respondents who performed more than 10 open shoulder procedures a year were more likely to perform a coracoid transfer. Figure 7 demonstrates the percentage of influence of factors based on the number of open procedures.

Table III Class-membership results

	Class 1: less experienced surgeons		Class 2: experienced surgeons–limited open shoulder per year		More likely in which class?[*]
	Coeff.	SE	Coeff.	SE	
Class membership function (relative to class 3)					
Female	−0.277	1.853	0.847	1.890	
Age, yr	0.218[†]	0.102[†]	0.153	0.104	1, 2
Percentage of total practice dedicated to shoulder	−0.080[‡]	0.040[‡]	−0.101[‡]	0.042[‡]	3
Number of open shoulder surgeries	−0.003	0.006	−0.014[§]	0.007[§]	3
Number of shoulder arthroscopy procedures	0.032[†]	0.014[†]	0.038[§]	0.014[§]	1, 2
Number of patients with shoulder instability treated	−0.006	0.012	−0.004	0.012	
Number of operations performed for patients with shoulder instability	−0.097[‡]	0.041[‡]	−0.065[‡]	0.036[‡]	3
Type of practice (relative to private)					
Government	22.602	731.23	20.012	731.24	
Group academic	0.873	1.250	−0.594	1.356	
Group nonacademic	15.871	876.19	16.896	876.19	
Constant	−3.516	4.745	−1.420	4.776	

Coeff., coefficient; *SE*, standard error.
As the continuous variables increase, or the dichotomous variables assume a value of 1.
Negative coefficients imply that respondents with the characteristic represented by the variable are more likely to be in class 3 than in class 1 or class 2. Positive coefficients imply that being in class 1 or class 2 is more likely.
[*] Class 1: less experienced surgeons (<10 years in practice); class 2: experienced surgeons (>10 years in practice) with limited open shoulder surgery per year; class 3: experienced (>10 years in practice) high-volume open shoulder surgery per year. The assignment was made based on whether at least one class assignment results was statistically significant.
[†] Significant for class 1.
[‡] Significant for class 3.
[§] Significant for class 2.

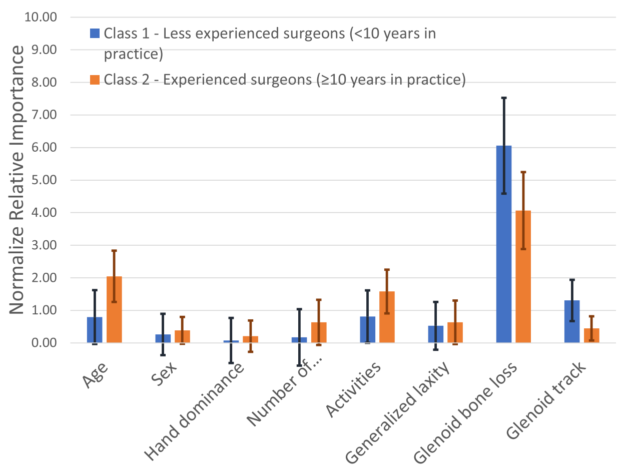


Figure 4 Attribute-normalized relative importance by latent class analysis.

Years of practice (< 10 years vs. ≥10 years)

The only surgical treatment choice that was influenced by experience was open Bankart/capsulorrhaphy ($P = .01$). The only attribute that influenced decision between open Bankart/capsulorrhaphy and coracoid transfer in the 2 groups was age of the patient, with less experienced surgeons more likely to perform a coracoid transfer over an open Bankart repair in older patients (age >19 years). More experienced surgeons were much more likely to choose open Bankart repair over a coracoid transfer compared with less experienced surgeons based on the age of the subjects ($P = .002$). Figure 8 demonstrates the percentage of influence of factors based on years of practice.

Shoulder/elbow vs. sports medicine fellowship training

Only changes in glenoid track had a statistically significant influence on the type of treatment choice between these shoulder/elbow vs. sports medicine trained surgeons. Sports medicine and shoulder/elbow surgeons chose similarly at lower degrees of bone loss (<15%, 15%-20%, or 21%-30%). At the high end of bone loss (>30% glenoid bone loss), shoulder/elbow-trained surgeons were more likely to choose more advanced procedures. When evaluating choice of open Bankart to coracoid transfer with >30% bone loss, shoulder/elbow surgeons were more likely to choose coracoid transfer over open Bankart than sports surgeons ($P = .0007$). Similarly, when evaluating choices between coracoid transfer or free bone

Table IV Subgroup analysis of treatment option compared to coracoid transfer

Procedure	Number of open surgeries (<10 or ≥10)	Years of training (<10 yr vs. ≥10 yr)	Training (shoulder elbow vs. sports medicine)
Arthroscopic Bankart/capsulorrhaphy	.11	.55	.41
Arthroscopic Bankart/Capsulorrhaphy + Remplissage	<.0001*	.17	.12
Open Bankart repair/capsulorrhaphy	.007*	.01*	.0007*
Bony augmentation	.11	.16	.0001*

* $P < .05$.

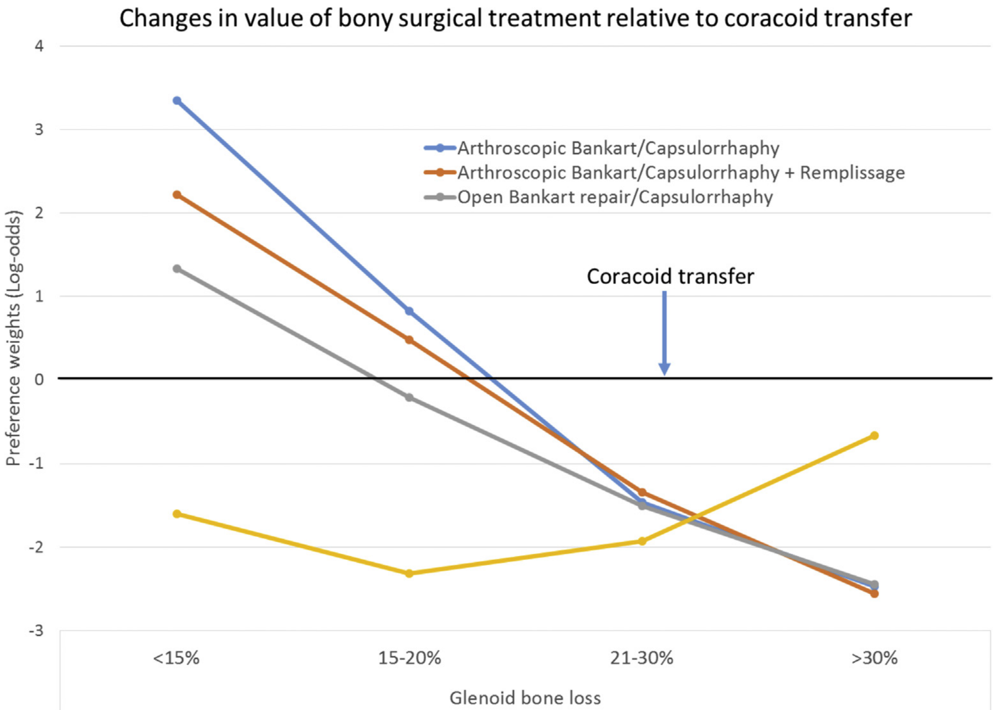


Figure 5 Surgical treatment choice relative to coracoid transfer. Data points below the solid line indicate greater likelihood of coracoid transfer. Points above the solid line indicate greater likelihood for represented procedure. Free bony augmentation (yellow line) was always less preferable than coracoid transfer in all levels of bone loss. In lower levels of glenoid bone loss, <20%, as data points are above the solid line, arthroscopic techniques were more preferable to surgeons. At 21% of glenoid bone loss, coracoid transfer was the clear preferred surgical option.

augmentation at 30% bone loss, shoulder/elbow surgeons were more likely to choose free bone augmentation than sports surgeons ($P = .0001$). In summary, in most scenarios except for extreme bone loss, shoulder/elbow and sports surgeons chose similarly when considering surgical treatment options.

Despite the general consistency in choices for treatment types, we found that the relative importance of patient characteristics varied systematically between these groups when choosing specific treatments. In the choice for arthroscopic Bankart/capsulorrhaphy + Remplissage or open Bankart over coracoid transfer, age of the patients was considered very differently by these 2 groups, with it being more than twice as important for shoulder/elbow surgeons than it was for sports medicine–trained surgeons (see Fig. 9). However, only for the choice for arthroscopic Bankart/capsulorrhaphy + Remplissage was this difference statistically significant ($P = .002$). This pattern was reversed when choosing bony augmentation and coracoid transfer where age of the patient was more important for sports medicine–trained surgeons, but the difference was not statistically significant at the 95% confidence level ($P = .897$).

Discussion

The current study employed a new, prospective, contingent-behavior model to identify factors that influenced surgeons' choice of operative procedure to manage recurrent anterior

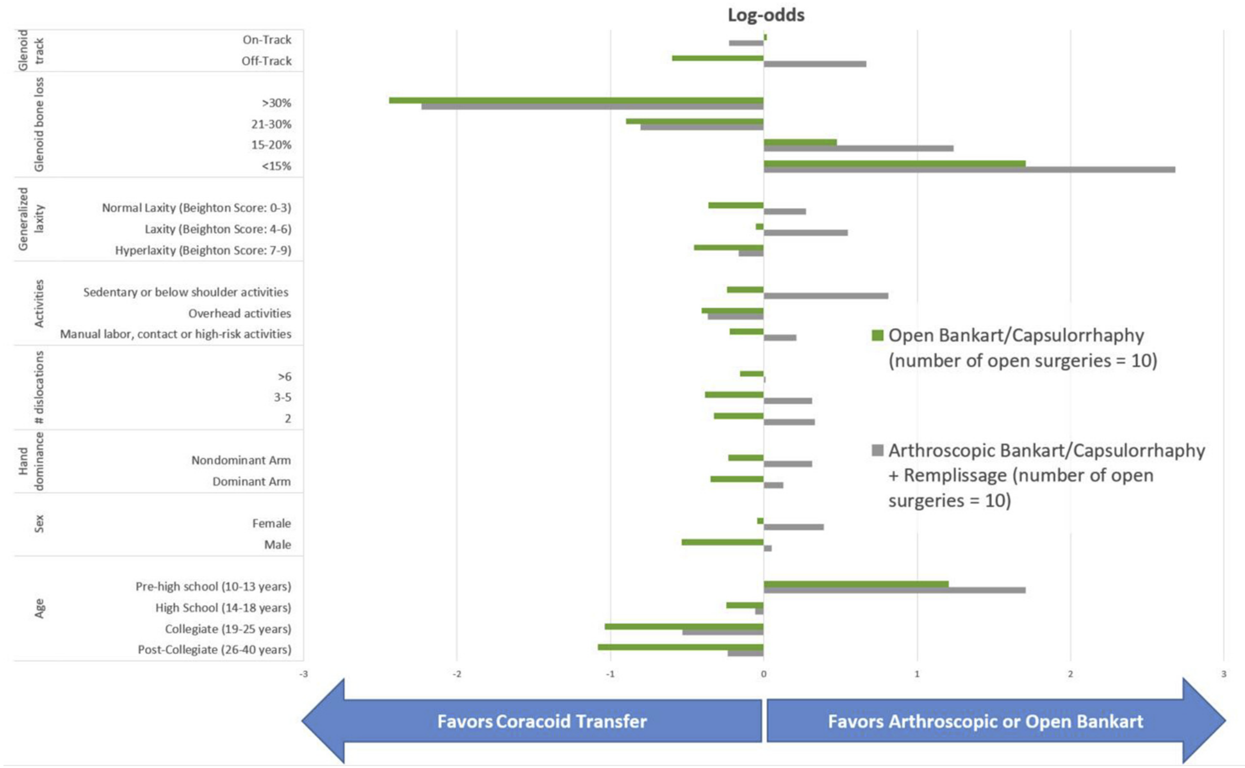


Figure 6 Differences in log-odds based on number of open procedures and effect on treatment choice. Negative numbers indicate a greater likelihood for coracoid transfer. Positive numbers indicate a greater likelihood for the represented procedure.

shoulder instability. Many potential factors are interrelated and can affect decision making. For example, younger age and high-risk activity level may be associated, and glenoid bone loss is part of the calculation of glenoid track. The use of CBQ analysis, however, allows for these variables to be evaluated individually and elicit the main drivers in surgeons' decision making. An important distinction to note is that the factors identified in this study are regarding surgical procedure choice and is different than factors that influence surgeons whether to operate or not. The main findings in this study are that glenoid bone loss (>21%) is the dominant factor influencing recommendation of a bony procedure over a soft tissue procedure. Less influential but statistically significant factors are collegiate age (19-25 years old) and at-risk activity level. In patients younger than 19 or older than 25 years, surgeons favored arthroscopic procedure over bony procedures. Interestingly, glenoid track, gender, higher numbers of prior dislocations, and history of generalized laxity did not influence choice of operative procedure.

A recent study by Bishop et al[2] also sought to understand which factors influence a surgeon's choice of procedure for anterior shoulder instability. The analysis was a retrospective analysis of prospectively collected cohort data on anterior shoulder instability subjects. The study identified symptom duration >1 year, number of dislocations, Hill-Sachs size (between 11%-20% of humeral head), and glenoid bone loss (11%-30% loss) as predictors of bony procedures. The strengths of the study are that it was a multicenter study with 564 patients. It was limited in that factors were not able to undergo individual assessment for their effects on surgeon treatment choice, radiographic measurements were not standardized, and the study did not seek to determine whether surgeon factors such as surgeon experience or training exposure influenced decision making.

The findings in this study add to prior research in offering a prospective contingent-behavior analysis that allows specific assessment of the influence of individual factors on surgical treatment choice. Moreover, by asking in a prospective manner with patient scenarios, recall bias is eliminated and a better picture of respondents' decision making is able to be made. Additionally, measurements such as bone loss, glenoid track, and generalized laxity were provided as an objective number in this research, thereby eliminating potential measurement errors.

Glenoid bone loss is the only factor to overlap within both studies as a key driver to lead surgeons toward bony procedures. Bishop et al did not specify a threshold but provided a wide range from 11%-30% bone loss. The current study identified the threshold at 21% bone loss that led to a bony procedure. The current findings are consistent with initial recommendations for a bony procedure with 20%-25% glenoid bone loss as supported by biomechanical

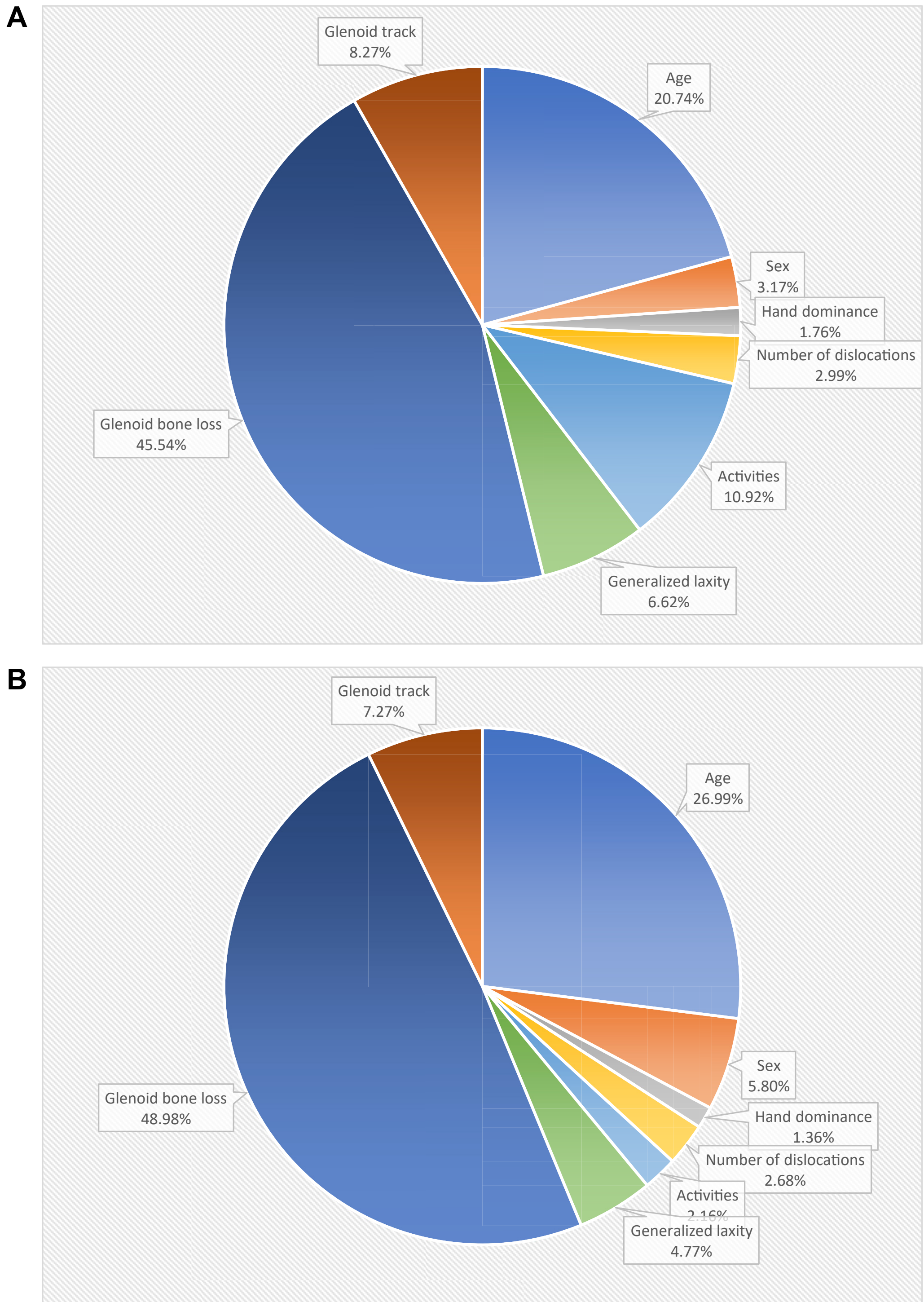


Figure 7 Percentage of influence of attributes based on the number of open procedures performed per year: (**A**) fewer than 10 open procedures; (**B**) 10 or more open procedures per year.

and clinical studies.[9,17,32,50] However, more recent literature suggests that glenoid bone as low as 13.5% may affect outcomes and benefit from a bony procedure.[8,18,25,38] These findings may suggest a delay between published literature and changes in surgeon behavior, or skepticism among surgeons about those findings, or unwillingness to accept higher complication risk at lower bone loss levels.

Although glenoid bone loss was most influential in leading surgeons to perform a bony procedure, the glenoid track had little influence. The glenoid track, off-track and

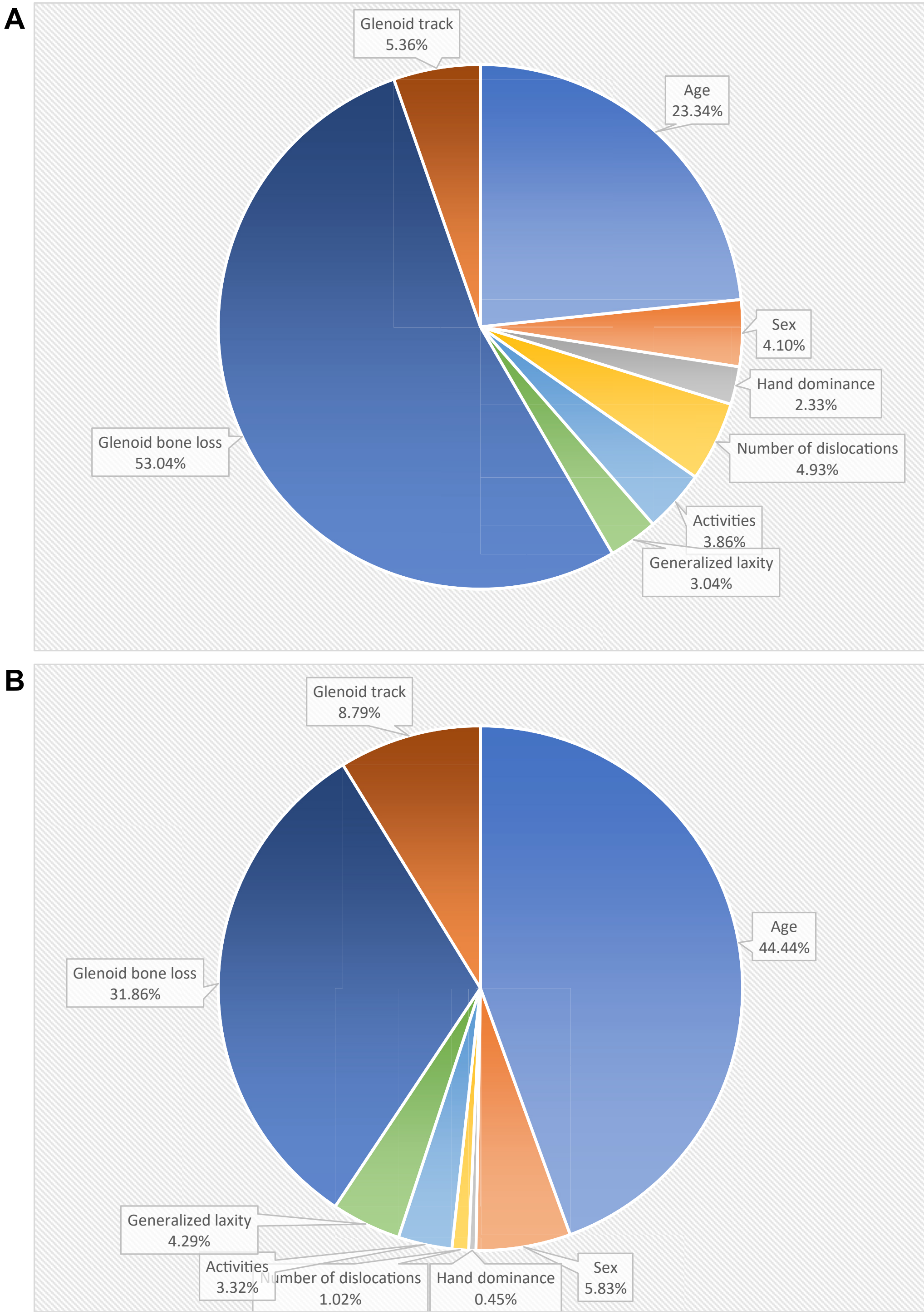


Figure 8 Percentage of influence by each attribute for those in practice (**A**) fewer than 10 years, (**B**) 10 or more years.

on-track, concept was developed by Yamamoto et al[50] as a way to measure the interaction between Hill-Sachs defects and glenoid bone loss. The concept has gained increasing popularity, with numerous studies suggesting treatment algorithms be based on the off-track or on-track classification.[23,31,49] Additionally, it has been reported that patients with off-track lesions fail treatment more often than those with on-track lesions (75% for off-track lesions vs. 8% for on-track lesions).[39] Despite the evidence and increasing recent literature on glenoid track, there was

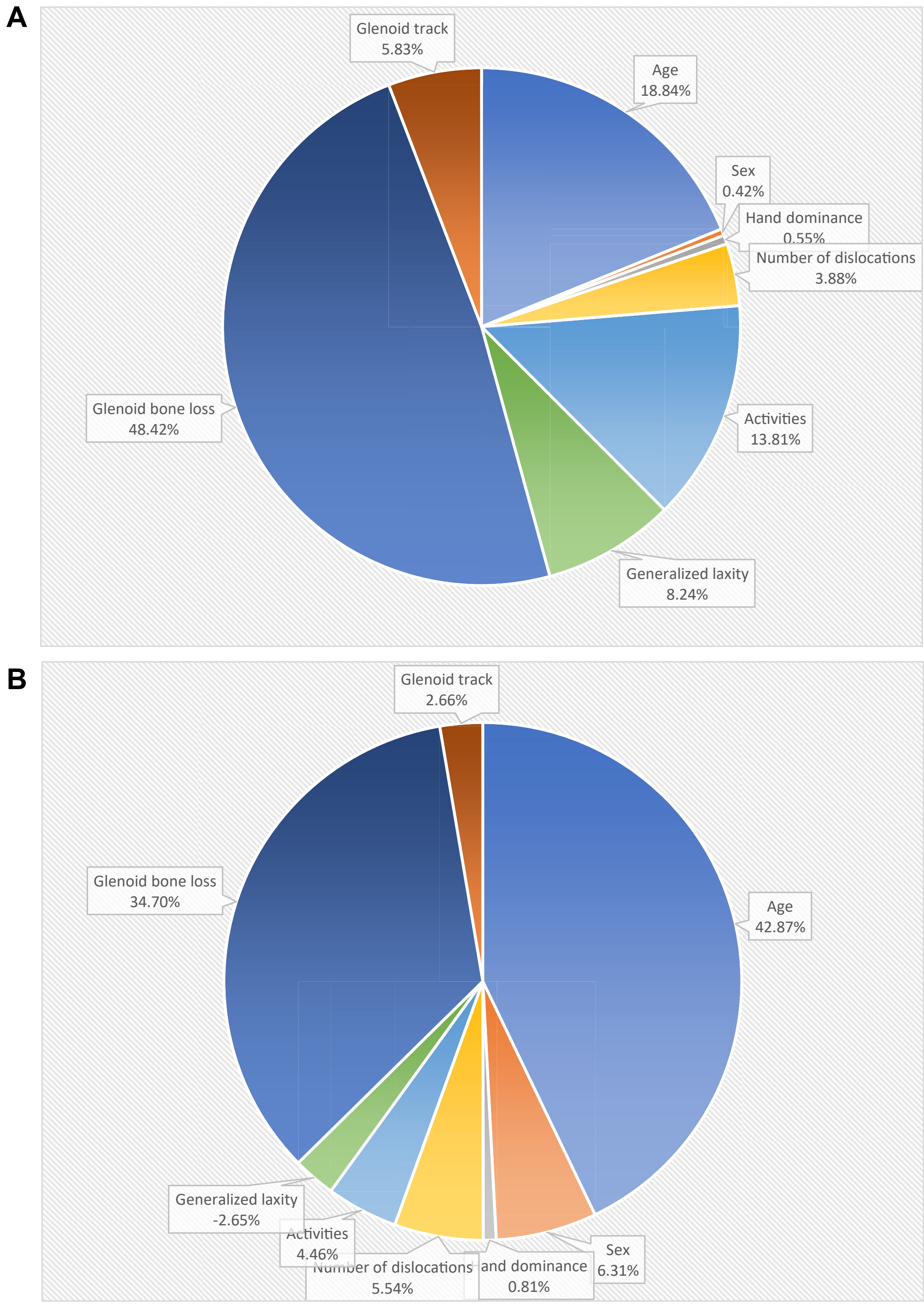


Figure 9 Percentage of influence by each attribute for sports medicine (**A**) compared to (**B**) shoulder/elbow-trained surgeons in deciding arthroscopic Bankart + Remplissage. Age is more than twice as important to shoulder/elbow-trained surgeons than sports medicine–trained; $P = .002$.

limited influence of this factor on surgeon decision making toward a bony procedure. As with glenoid bone loss thresholds, these may represent a delay between published literature and its application in practice, skepticism toward new research, or unwillingness to accept higher complication risks with bony procedures as an initial treatment.

Other commonly known risk factors for recurrence of shoulder instability, including younger age, higher risk activities in sport, occupation, male gender, and number of prior dislocations were also evaluated in the current study.[7,13,15,19,20,24,34,36,43,46,48]

Age of <20 years is a commonly identified to have a higher risk of recurrences.[46] The reasons for this finding are likely multifactorial. First, younger individuals have more years than older patients in which they could have a recurrence. Additionally, individuals younger than 20 years also tend to engage in higher-risk activities and participate in competitive sports. For the younger population, there remains controversy on management of first-time dislocators; however, there has been a recent increase in surgical management for this.[3,5,40,51,52] In the current study, when choosing which surgical procedure to perform, surgeons were most likely to choose a bony procedure in subjects between 19-25 years old. Interestingly, however, surgeons were also more likely to choose a bony procedure in older subjects between 26-40 years over those aged 10-18 years. A possible reason is that bony procedures such as coracoid transfers have higher rates of complications and morbidity, and surgeons may choose a soft tissue procedure to decrease these surgical risks in younger patients and reserve bony procedures as a secondary step if patients fail their primary surgery.

Higher-risk activities such as overhead activities, collision sports/activities, and manual labor are a known risk factor for higher rates of recurrent shoulder instability and failure of surgical treatment.[27,36,45] Patients who perform overhead activities have been shown to have a 5.76 times greater risk of recurrence.[36,45] Participation in contact sports including football, wrestling, and ice hockey leads to the greatest risk for shoulder instability.[27] Participants in the current study were significantly influenced by activity level for their choice of surgical procedure.

Several studies have identified male gender to be a risk factor for recurrent shoulder instability with an odds ratio of 3.18 compared with female.[21,26,35,37] Similar to age, it has been postulated that boys and men may participate in higher-risk activities and sports, which places them at higher risk of injury rather than male gender alone. This may explain the findings in this study, which was able to isolate male gender alone as not influential in leading surgeons toward a bony procedure, whereas activity level did. This is supported by studies that have shown similar incidence rates for glenohumeral joint instability when matched for sport.[27,30]

The number of prior shoulder dislocations has also been found to be a risk factor for recurrent shoulder instability after arthroscopic stabilization[2,12,21,42] Gasparini et al[12] found that patients treated with arthroscopic labral repair after multiple dislocations had a 3.8 times greater risk of recurrent instability than if these patients experienced only 1 episode of dislocation prior to surgery. Lee et al[21] found a 6.41 times greater risk in those with 2-5 prior dislocations and an 8.77 times greater risk for those with more than 5 prior dislocations. Bishop et al[2] found that greater than 5 prior dislocations was a predictor for an open Bankart repair over arthroscopic repair. Interestingly, in the current study, number of dislocations was not a factor in surgeons' choice in surgical procedure. A possible reason may be that surgeons were using glenoid bone loss as a proxy for degree of injury after multiple dislocations. As such, surgeons were less concerned about the number of prior dislocations than the amount of glenoid bone loss resulting from prior dislocations. This finding may be highlighted as a result of a contingent-behavior model that allows isolated assessment of individual factors.

However, in light of some of the conflicting findings in this study with current literature, a recent study by Hutyra et al found that for anterior shoulder dislocations, surgeons were disseminating accurate evidence only 59% of the time, and only 29% of patients were likely receiving appropriate evidence-based information to make a treatment decision.[17] As such, the findings of the current study may indicate that surgeons' practices lag behind published literature, that surgeons are not informed about recent literature, or that surgeons do not believe in recent findings. If one of the latter 2 options are the source of discrepancy, it is important as a community that recent literature be widely disseminated. In particular, given the current evolution of patient care toward personalized, shared decision making, up-to-date information should be given to patients to allow them to make informed decisions.

This study also sought to identify surgeon factors that may influence choice of surgical procedure. More experienced surgeons were more likely to perform open Bankart repair than less experienced, ≥10 and <10 years in practice, respectively. This may be due to a trend toward arthroscopic stabilization over the last decade.[33] Eighty-seven percent of shoulder instability is treated with arthroscopic stabilization,[33] and this likely results in changes in medical training programs with limited exposure and experience in open approaches. Similarly, the current study found that if surgeons were to perform more than 10 open shoulder cases per year, then they were more likely to address shoulder instability with an open approach, reflecting greater comfort with open techniques. The current study also used latent class analysis and identified 3 distinct groups with distinct preferences: class 1, less experienced (<10 years of practice); class 2, experienced surgeons with limited open shoulder procedures per year; and class 3, experienced surgeons with high volume of open shoulder procedures per year. All classes were most influenced by glenoid bone loss in their surgical procedure choice. Interestingly, beyond glenoid bone loss, the experienced, high-volume surgeons who performed a high volume of open procedures per year were not influenced by the remaining attributes in the current study. In contrast, experienced surgeons with limited open shoulder surgery per year were next most influenced by age of the patient, and less experienced surgeons (<10 years of practice) were next most influenced by glenoid track. The class analysis suggests that experience in years and in open surgery influenced which attributes contributed to surgical decision making. For example, those that are more comfortable with open procedures were more comfortable going to a coracoid transfer as indicated by glenoid bone loss without influence of other factors, whereas other surgeons may be more familiar with the relatively new concept of glenoid track and used this in their decision making. Lastly, the study found that shoulder/elbow and sports medicine trained surgeons had similar approaches to surgical management of shoulder instability in the majority of scenarios, which possibly reflects similar training in open shoulder stabilization techniques and/or interpretation of respective literature. At extreme levels of bone loss (>30%), however, shoulder/elbow surgeons were more likely to choose advanced procedures such as coracoid transfer or free bone augmentation than sports surgeons, which may reflect greater comfort with these open techniques.

Surgical options for the humeral side were limited and did not include bony augmentation, and open repair with remplissage was not offered as an option. However, there were only 9 entries entered into the "Other" section in more than 2240 separate vignettes (32 vignettes for 70 respondents). The influence of these few entries were limited. Another limitation is that the survey and link were sent over several list servers and respondents encouraged to forward to any surgeons they felt would be appropriate. As such, it is not possible to accurately estimate the total number of surgeons that received the survey.

Conclusions

This study used a novel approach with a CBQ analysis to prospectively evaluate factors that drive surgical procedure choice in recurrent anterior shoulder instability. The factors that drove surgeons to choose bony procedures were the amount of glenoid bone loss, with the threshold at 21%, patient age, and their activity demands. Patients who were collegiate aged (19-25) were more likely to have a bony procedure than younger (<18) or older (>25 years old). Glenoid track status and the number of previous dislocations did not strongly influence surgical treatment decisions. Ten open shoulder procedures a year seems to provide a level of comfort to recommend bony treatment for shoulder instability. These findings may suggest a delay between published literature and changes in surgeon behavior, or skepticism among surgeons about those findings, or unwillingness to accept higher complication risk at lower bone loss levels.

Disclaimer

Brian C. Lau is a board or committee member of the American Orthopaedic Society for Sports Medicine (AOSSM) and Arthroscopy Association of North America (AANA) and receives research support from Arthrex, Inc., and Wright Medical Technology, Inc.

Richard C. Mather III is a board or committee member of AANA, North Carolina Orthopaedic Association (NCOA), and AOSSM; is a paid consultant for KNG Health Consulting and Stryker; and receives research support from Reflexion Health and Zimmer.

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Sameer Nagda is a board or committee member of AAOS and ASES and receives research support from Wright Medical Technology, Inc.

Jonathan Braman is a board or committee member of AOA and is a paid consultant for and receives research support from Zimmer.

Alicia Harrison is a board or committee member of ACS and Minnesota Orthopaedic Society and is a paid presenter or speaker for Arthrex, Inc.

Peter MacDonald receives research support from Arthrex, Inc., Conmed Linvatec, and Ossur; is a board or committee member of the Canadian Orthopaedic Association (COA); and is on the editorial or governing board of *JSES* and the *Clinical Journal of Sports Medicine*.

Jonathan Riboh receives research support from Sparta Biopharma and is a paid consultant for Stryker.

The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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