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REVIEW ARTICLES

Decision making in treatment after a first-time anterior glenohumeral dislocation: A Delphi approach by the Neer Circle of the American Shoulder and Elbow Surgeons

John M. Tokish, MD[a,*], John E. Kuhn, MD, MS[b], Gregory D. Ayers, MS[c], Robert A. Arciero, MD[d], Robert T. Burks, MD[e], David M. Dines, MD[f], Xavier A. Duralde, MD[g], Neal S. ElAttrache, MD[h], Peter J. Millett, MD, MSc[i], Patrick St. Pierre, MD[j], Matthew T. Provencher, MD[i], James E. Tibone, MD[k], Jonathan B. Ticker, MD[l], Frank A. Cordasco, MD, MS[m]

[a]*Department of Orthopedic Surgery, Mayo Clinic Arizona, Scottsdale, AZ, USA*
[b]*Department of Orthopedic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA*
[c]*Department of Biostatistics, Vanderbilt University Medical Center, Nashville, TN, USA*
[d]*Department of Orthopedic Surgery, UCONN Health, Farmington, CT, USA*
[e]*Department of Orthopedic Surgery, University of Utah, Salt Lake City, UT, USA*
[f]*Weill Cornell Medical College, Hospital for Special Surgery, New York, NY, USA*
[g]*Peach Tree Orthopedics, Atlanta, GA, USA*
[h]*Kerlan Jobe Orthopedic Clinic/Cedars Saini, Los Angeles, CA, USA*
[i]*The Steadman Clinic, Vail, CO, USA*
[j]*Eisenhower Health, Rancho Mirage, CA, USA*
[k]*Kerlan-Jobe Orthopedic Clinic, Keck USC School of Medicine, Los Angeles, CA, USA*
[l]*Orlin and Cohen Orthopedic Group, New Hyde Park, NY, USA*
[m]*Department of Orthopedic Surgery, Hospital for Special Surgery, New York, NY, USA*

Background: The treatment of patients who sustain a first-time anterior glenohumeral dislocation (FTAGD) is controversial. The purpose of this study was to find consensus among experts using a validated iterative process in the treatment of patients after an FTAGD.
Methods: The Neer Circle is an organization of shoulder experts recognized for their service to the American Shoulder and Elbow Surgeons. Consensus among 72 identified experts from this group was sought with a series of surveys using the Delphi process. The first survey used open-ended questions designed to identify patient-related features that influence treatment decisions after an FTAGD. The second survey used a Likert scale to rank each feature's impact on treatment decisions. The third survey used highly impactful features to construct 162 clinical scenarios. For each scenario, experts recommended surgery or not and reported how strongly they made their recommendation. These data were analyzed to find clinical scenarios that had >90% consensus for recommending treatment. These data

Institutional review board approval was not required for this survey study.

*Reprint requests: John M. Tokish, MD, Department of Orthopedic Surgery, Mayo Clinic College of Medicine, 5777 E Mayo Blvd, Ste C100, Scottsdale, AZ 85054, USA.

E-mail address: Tokish.John@mayo.edu (J.M. Tokish).

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were also used in univariate and multivariate mixed-effects models to identify odds ratios (ORs) for different features and to assess how combining these features influenced the probability of surgery for specific populations.
Results: Of the 162 scenarios, 8 (5%) achieved >90% consensus for recommending surgery. All of these scenarios treated athletes with meaningful bone loss at the end of their season. In particular, for contact athletes aged > 14 years who were at the end of the season and had apprehension and meaningful bone loss, there was >90% consensus for recommending surgery after an FTAGD, with surgeons feeling very strongly about this recommendation. Of the scenarios, 22 (14%) reached >90% consensus for recommending nonoperative treatment. All of these scenarios lacked meaningful bone loss. In particular, surgeons felt very strongly about recommending nonoperative treatment after an FTAGD for non-athletes lacking apprehension without meaningful bone loss. The presence of meaningful bone loss (OR, 6.85; 95% confidence interval, 6.24-7.52) and apprehension (OR, 5.60; 95% confidence interval, 5.03-6.25) were the strongest predictors of surgery. When these 2 features were combined, profound effects increasing the probability of surgery for different populations (active-duty military, non-athletes, noncontact athletes, and contact athletes) were noted, particularly non-athletes.
Conclusion: Consensus for recommending treatment of the FTAGD patient was not easily achieved. Certain combinations of patient-specific factors, such as the presence of meaningful bone loss and apprehension, increased the probability of surgery after an FTAGD in all populations. Over 90% of shoulder instability experts recommend surgery after an FTAGD for contact athletes aged > 14 years at the end of the season with both apprehension and meaningful bone loss. Over 90% of experts would not perform surgery after a first dislocation in patients who are not athletes and who lack apprehension without meaningful bone loss.
Level of evidence: Survey Study; Experts

Keywords: First-time anterior glenohumeral dislocation; Delphi process; consensus; Neer Circle; shoulder instability; dislocation

The Inaugural Neer Circle Consensus Manuscript

I am honored to provide an introduction to this manuscript, entitled "Decision Making in Treatment after a First-Time Anterior Glenohumeral Dislocation: A Delphi Approach by the Neer Circle of the American Shoulder and Elbow Surgeons," which is meant to provide perspective, context, and history in the development of the Neer Circle and the production of this manuscript.

The American Shoulder and Elbow Surgeons (ASES) has grown substantially during the past several years with the establishment of the Candidate and Fellow membership categories. This has represented an important pivot in ASES membership policy, as it has provided for the admission of young surgeons who now may contribute to our society at an earlier stage in their careers. Currently, there are more than 1125 members of ASES. For perspective, I was honored and humbled to be admitted to ASES in 1996, joining a total membership of 110. I have been truly privileged to participate in the evolution of our society during the past 3 decades.

Equally important is the engagement of mid-career ASES members, who represent an integral component of global education and leadership. The mission of ASES, "serving patients, members, and society by advancing shoulder and elbow care," is predicated on the active engagement of ASES thought leaders who are well recognized internationally as experts in shoulder and elbow care.

The development of the ASES Neer Circle began in 2016 and was formulated in discussion with over 100 individuals representing all membership categories. The outcome was that we created the concept of a service-recognition group honoring Active and Corresponding Members who have met the criteria for service and leadership as a result of their career trajectories. The service-recognition criteria are updated each year, and included among the categories are those members who have served on the ASES Presidential Line, ASES Executive Committee, *Journal of Shoulder and Elbow Surgery* Board, *Journal of Shoulder and Elbow Surgery* Associate and Basic Science Editorial Boards, and ASES Foundation Board; as chair of the International Board of Shoulder and Elbow Surgery; and as chairs of specific ASES committees and education programs. At the October 2017 ASES Annual Meeting in New Orleans, the board formally established the Neer Circle. It is important to recognize that any Active or Corresponding Member of ASES may become a Neer Circle member by simply meeting the service-recognition criteria. Initially, 112 ASES members met these criteria to become Neer Circle members.

In March 2018, we formed the 12-member Neer Circle Taskforce at the ASES Specialty Day Meeting in New Orleans. Subsequently, in June 2019, it became a standing committee. The structure of the committee grew organically from 7 members, comprising the ASES 2019 Annual Meeting Co-chairs, Bob Arciero and Xavier Duralde; the ASES 2019 Annual Meeting Guest Nation (Japan Shoulder Society) Liaison, Jon Ticker; and the 4 members selected as the directors of the inaugural 2019 Neer Circle meeting, Jed Kuhn, JT Tokish, Pat St. Pierre, and Peter Millett. The group of 12 committee members was completed by adding 5 other individuals who were selected through a call for volunteers from the Neer Circle: Dave Dines, Jim Tibone, Bob Burks, Neal ElAttrache, and Matt Provencher. Notably, JT Tokish and Jed Kuhn were the inaugural co-chairs of the Neer Circle Committee; without their perseverance, leadership, and commitment, this manuscript would not have been possible. The Committee defined the Neer Circle Mission Statement as follows: "The Mission of the ASES

Neer Circle is to recognize service and leadership, strategically support our society and advance the practice of shoulder and elbow surgery through consensus.''

Among this impressive group of 12 thought leaders are 2 past presidents of ASES; 2 past presidents of the American Orthopaedic Society for Sports Medicine; 1 past president of the Association of Bone and Joint Surgeons; 1 past chairman of approximately 20 annual Metcalf Meetings; 1 past chair of the ASES Foundation; and multiple past chairs of various ASES, American Orthopaedic Society for Sports Medicine, and Arthroscopy Association of North America boards, committees, and educational events. In addition, the 4 branches of the US military are well represented in this group, which includes 3 colonels (US Army/Air Force), 1 captain (US Navy), and 1 major (US Air Force). Throughout this process, I served as the ASES Board Liaison.

The Neer Circle Committee held monthly conference calls for nearly 18 months. During this time, we established the iteration of the Delphi process described in the manuscript, which will serve as the model for subsequent Neer Circle consensus questions. We assembled the panel of 72 experts from the Neer Circle membership and developed the first through third rounds of surveys. Item reduction was performed to create 162 meaningful clinical scenarios, a Likert score rating was established, and the results were evaluated using univariate and multivariate modeling.

The results of this study were presented to, voted on, and accepted by the members of the Neer Circle at the inaugural Neer Circle meeting in New York City on Wednesday, October 16, 2019. Perhaps most important, through this process, we have learned how to best improve future Delphi initiatives. This knowledge and experience will be passed on through the Neer Circle Committee.

It was my pleasure to be along for the ride!

Frank A. Cordasco, MD, MS

35th President, American Shoulder and Elbow Surgeons

Controversy exists in the management of the patient who sustains a first-time anterior glenohumeral dislocation (FTAGD). Multiple instability events are associated with higher rates of failure after surgery[15,27] and the development of glenohumeral osteoarthritis.[3,13,17] Pioneering work from West Point has demonstrated that stabilization of the acute initial anterior shoulder dislocation leads to low recurrence, excellent return to activity, and a favorable altering of the natural history of this condition.[1,7,21] Yet, not every patient with an initial dislocation will have a recurrence, and in fact, the literature suggests that fewer than half of the patients who have had an initial dislocation will have another event.[19,28] Furthermore, many patients ''tolerate'' an initial dislocation event, returning to athletic events successfully.[4,8,12] It would be beneficial to know which patients are at risk of recurrence or disability after an initial dislocation event, yet these data are not clear.

Two meta-analyses of the literature have identified features associated with recurrence as well as features that reduce the risk of recurrence after a first dislocation.[19,28] Features that may predict higher rates of recurrence include age between 15 and 20 years,[28] male sex,[19,28] and the presence of hyperlaxity.[19] Features that reduce the risk of recurrence include an axillary nerve injury[19] and the presence of a greater tuberosity fracture.[19]

Olds et al[20] used a prospective cohort to develop a model for predicting recurrence after an FTAGD. Their data identified age, the presence of a bony Bankart lesion, higher levels of shoulder activity, higher levels of pain and disability, and no immobilization of the limb after the initial dislocation as predictors of recurrence. Unfortunately, they followed up patients for only 12 months, and only 60% of instability recurrence events occur by 12 months. In fact, recurrent instability events do not seem to plateau until 5 years after the initial dislocation.[23] In addition, the report by Olds et al[20] conflicts with reports of other prospective cohorts with respect to the effect of sex,[23] the presence of a bony Bankart lesion,[24] and the effect of post-reduction immobilization [16,22] on recurrence. As a result, the literature only provides some limited information on recurrence and is not particularly helpful for physicians who must make recommendations for treating the patient with an FTAGD.

The purpose of this study was to identify areas of consensus regarding the treatment of the patient with an FTAGD by use of the Delphi process[5,6,10] among a collection of experts from the Neer Circle of the American Shoulder and Elbow Surgeons (ASES).

Methods

The Delphi process (named after the ancient Greek oracle) was developed by the RAND Corporation (Santa Monica, CA, USA) as a method of obtaining consensus for international affairs.[5] It is characterized by anonymity and multiple rounds of surveys until consensus is reached. In general, questions in the first round are open ended, designed to solicit general information and areas of focus about the topic of controversy. These responses are then categorized into meaningful groups by the research team. The second round is designed to assess the importance of these items. Multiple rounds of surveys are conducted to find agreement.[11]

Assembling panel of experts

The Neer Circle is a subset of the membership of ASES that has been selected based on service to the organization. A survey sent was sent to all Neer Circle members (N = 81) to assess their experience in treating shoulder instability by asking each member of the group whether he or she wanted to participate and his or her age, years in practice, and self-rated level of expertise (''On a scale of 1-10, how would you rate your experience in treating glenohumeral instability?'' [with 10 representing the highest level of expertise]; Supplementary Appendix S1).

First round of survey

The group was surveyed using open-ended questions asking them to identify the features they considered important in determining the decision for surgery for a patient who sustains an FTAGD (Supplementary Appendix S1). This survey yielded 69 individual characteristics that were designated as important. The influential features identified from the first survey (Supplementary Appendix S2) were used to design the second survey.

Second round of survey

Features identified as important by the experts in treatment decisions for the patient with an FTAGD were arranged into groups based on the patient's history, physical examination findings, and imaging findings. A literature review was conducted for each item to help guide the development of the third survey and to provide the expert panel with a succinct summary of the literature pertinent to that question. For example, regarding age, the literature review was used to determine how age might be subdivided into meaningful ranges. A second survey (Supplementary Appendix S3) was developed around these items in an attempt to ascertain the relative importance of each feature by applying a 5-point Likert scale as follows:

1. Strongly influences me to recommend nonoperative treatment
2. Influences me to recommend nonoperative treatment
3. No specific influence
4. Influences me to recommend operative treatment
5. Strongly influences me to recommend operative treatment

Features that scored <2 or >4 on the Likert scale were considered highly impactful drivers in decision making. The results of the second survey (Supplementary Appendix S4) were used to construct the third survey (Supplementary Appendix S5).

Third round of survey

The purpose of the third survey was to develop clinically meaningful scenarios using highly impactful features and to survey the group using these scenarios regarding whether surgery would be recommended, as well as the strength of that recommendation. The resultant features from the second survey (Supplementary Appendix S4) were compiled into domains that reflected the history (age, sport and/or position played, sport intensity, timing in season, timing in career, circumstances of injury, and other historical features), physical examination findings, and imaging findings (Table I). The first 2 surveys identified 69 potential variables; however, many of these variables were related or duplicates. To reduce the number of clinical scenarios, item reduction was carried out based on the strength of response of the items, with similar categories combined and reduced.

Item reduction

To create meaningful clinical scenarios, the multiple variables identified as important underwent item reduction. Duplications were eliminated. Some features were not independent variables and could be combined (eg, age and school level). Other features were mutually exclusive (eg, active-duty military and age < 14 years). We approached item reduction as described in the following sections.

Age

Age and level of sports participation were combined as follows: age < 14 years (child); age of 14-18 years (high school age); age of 18-22 years (college age); age of 23-30 years (including professional athletes); and age > 30 years.

Sport

Although some specific sports were identified as helpful in making treatment decisions, the number of individual sports would create too many clinical scenarios to be reasonable for a survey. Therefore, we combined sporting activity into 4 distinct categories: non-athletes, noncontact athletes, contact athletes, and active-duty military.

Season timing

Results from the first 2 surveys regarding timing revealed that the in-season athlete would be recommended to undergo a different treatment than the athlete at the end of the season. Therefore, we divided a sporting season into the following categories: (1) early in the season or at midseason and (2) end of the season. The activities of non-athletes and active-duty military are not seasonal.

Physical examination findings

Results from the first 2 surveys revealed that the presence or absence of apprehension and presence or absence of generalized ligamentous laxity on physical examination were important features in determining operative vs. nonoperative treatment for the FTAGD patient, and these factors were included in the third survey.

Bone loss

The presence of glenoid bone loss was identified as a critical factor in recommending surgical intervention in the first-time dislocator. Meaningful glenoid bone loss was defined as >13.5%, which has been correlated with worse Western Ontario Shoulder Instability scores and a higher recurrence rate.[25] There was some disagreement among the authors on whether significant bone loss occurs in the first-time dislocator; however, a recent study by Dickens et al[9] documented that 17% of patients with an FTAGD had glenoid bone loss ≥ 13.5%. After discussion, the committee decided to include bone loss as a category in the final survey as the presence or absence of "meaningful bone loss (>13.5%)."

Other factors

The committee elected not to include a concomitant rotator cuff tear and the presence of a greater tuberosity fracture in the final multifactor survey, despite these being listed as important to the Neer Circle in the first 2 surveys, because these findings would be exceedingly rare in clinical scenarios in which the age is <40 years.

After item reduction, the remaining features were evaluated for their impact on treatment decision making. Individual features rated with Likert scale scores < 2 or > 4 were considered highly impactful in affecting treatment decisions for patients with an FTAGD and were included in the clinical scenarios. The following features were then used to construct 162 unique clinical scenarios for the third survey: history (age, athletic status, and timing in season), physical

Table I Results of second survey: features that influence decision making for surgery after FTAGD sorted into domains and ranked

	Mean score	SD
Age		
10 yr	1.404	0.849
13 yr	1.899	1.023
30 yr	2.315	1.164
15 yr	3.157	1.296
25 yr	3.213	1.143
17 yr	3.966	1.102
20 yr	3.989	1.082
Sport and/or position played		
Competitive soccer player—not goalie	3.247	1.014
Competitive swimmer	3.438	1.054
Competitive infielder	3.685	0.937
Competitive pitcher	3.697	1.283
Competitive football lineman	3.854	1.144
Competitive basketball player	3.888	1.027
Competitive hockey player	3.899	1.034
Competitive volleyball player	3.966	0.982
Competitive quarterback	4.045	1.043
Competitive football receiver	4.067	0.975
Competitive football defensive back	4.146	0.995
Competitive rugby player	4.247	1.014
Sport intensity		
Competitive noncontact athlete	3.742	0.911
Competitive high school athlete	4.011	0.898
Competitive collegiate athlete	4.191	0.824
Competitive professional athlete	4.236	0.853
Active-duty military	4.348	0.880
Contact or collision athlete	4.416	0.751
Competitive contact or collision athlete	4.528	0.755
Timing in season		
First third of season	2.416	1.106
Last third of season	3.056	1.274
End of season	4.258	0.911
Timing in career		
College senior athlete	2.707	1.150
High school senior athlete	2.933	1.259
Professional veteran athlete	3.685	1.072
High school freshman athlete	3.708	1.130
Professional rookie athlete	4.135	1.036
College freshman athlete	4.191	0.928
Circumstances of injury		
Instability event that was sustained atraumatically	2.022	0.965
Event that happened with arm at side	2.775	1.063
Dislocation that self-reduced	3.011	1.006
Event that happened in abduction and/or external rotation	3.629	0.774
Event that was complete dislocation requiring reduction	3.854	0.860
Instability event that was sustained traumatically	3.989	0.832
Other historical features		
History of collagen disorder	1.517	0.709
Pending litigation related to dislocation	2.438	0.865
Workers' compensation claim	2.663	0.811
Nondominant arm in LE athlete	2.798	0.855
Female sex	2.843	0.767
Nondominant arm in UE athlete	2.989	0.885
Dominant arm in LE athlete	3.112	0.982
Working as overhead manual laborer	3.394	0.848

(*continued on next page*)

Table I Results of second survey: features that influence decision making for surgery after FTAGD sorted into domains and ranked (*continued*)

	Mean score	SD
Male sex	3.663	0.811
Dominant arm in UE athlete	3.798	0.979
Physical examination findings		
Sulcus sign on examination	2.764	0.879
>4 on Beighton scale	2.843	0.999
Positive Gagey test finding on examination	3.045	0.952
Pain in apprehension position	3.337	0.904
Positive apprehension sign, negative relocation test finding	3.449	0.905
Negative apprehension sign, positive release and/or surprise test finding	3.483	0.867
Marked apprehension on examination	4.146	0.873
Imaging findings		
Nondisplaced greater tuberosity fracture	1.674	0.876
Acute partial-thickness rotator cuff tear	3.011	0.776
Hill-Sachs lesion	3.438	0.839
Bipolar bone loss on MRI—on track	3.551	1.000
Bony Bankart lesion comprising 10% of glenoid	3.708	0.979
ALPSA lesion on MRI	3.876	0.850
HAGL lesion on MRI	3.989	0.971
Bipolar bone loss on MRI—off track	4.236	0.754
Acute full-thickness rotator cuff tear	4.461	0.867
Bony Bankart lesion comprising 25% of glenoid	4.596	0.719
Bony Bankart lesion comprising >33% of glenoid	4.787	0.630

FTAGD, first-time anterior glenohumeral dislocation; *LE*, Lower Extremity; *SD*, standard deviation; *MRI*, magnetic resonance imaging; *ALPSA*, anterior periosteal sleeve avulsion; *HAGL*, humeral avulsion of glenohumeral ligament; *UE*, Upper Extremity.
Features are scored on a 5-point Likert scale from lowest (strongly influences nonoperative treatment) to highest (strongly influences operative treatment). Historical features are listed first, followed by physical examination findings and imaging findings. Features are ordered within groups by mean Likert scores.

examination findings (apprehension or generalized laxity), and imaging findings (presence or absence of meaningful glenoid bone loss) (Supplementary Appendix S5). For each scenario, each expert was asked to comment on whether he or she would recommend surgery and to rate the strength of this recommendation using a 5-point Likert scale (Supplementary Appendix S5).

Statistical analysis

For the first round of the survey, the mean age, years of experience, and level of expertise of the respondents were calculated. For the second round of the survey, the mean Likert score (and standard deviation) for each of the 69 features was calculated, and the features were placed in rank order according to their mean values. Correlations, redundancy analysis, and cluster analysis were used to assist in feature reduction for the development of clinical feature combinations to be evaluated in round 3 of the survey. For the third round of the survey, the percentage of yes responses (surgical recommendation) was calculated for each scenario. Those scenarios that achieved 90% agreement (percentage of yes responses either ≥90% or ≤10%) were considered to have achieved consensus. The strength of each recommendation was also averaged for each scenario both for yes responses for surgery and for "no" responses for surgery. We considered recommendations that achieved a mean Likert score of 0-1.49 as ambivalent about the recommendation; 1.5-2.49, somewhat strong; 2.5-3.49, moderately strong; 3.5-4.49, very strong; and >4.5, emphatic.

Modeling probability of recommending surgery

Univariate and multivariate associations between features and the probability that a surgeon would select surgery for a given feature (or features) were estimated as odds ratios (ORs) with 95% confidence intervals (CIs) by use of generalized linear mixed models with a logit link to account for within-reviewer repeated scoring of each clinical scenario.[2] Reference feature sets were noted, and 95% CIs for the ORs and model-predicted probabilities were constructed separately for active-duty military, non-athlete, noncontact athlete, and contact athlete patient groups. A global interaction test was used to assess 2- and 3-way interactions between and among age groups, apprehension, and bone loss. All statistical analyses were conducted using R (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria; https://www.R-project.org/).

Results

Round 1: expertise of panel and identification of features important in treatment decisions

Of the 81 members of the Neer Circle, 64 (79%) responded to the first survey. The average age of the expert panel was 58.6 years (range, 43-81 years); all members had >10 years in practice, and 49 had >20 years in practice. The average self-

Table II Clinical scenarios that reached 90% operative consensus

Age, yr	Sport and/or position played	If athlete, timing in season	Physical examination findings	Imaging findings	% Recommending surgery	Strength of recommendation when recommending surgery	Strength of recommendation when recommending nonoperative treatment
23-30	Contact athlete	End of season	Positive apprehension sign	Meaningful bone loss	98.6	3.97 ± 1.04	3.87 ± 1.04
18-22	Contact athlete	End of season	Positive apprehension sign	Meaningful bone loss	97.2	4.19 ± 0.90	3.00 ± NA
14-18	Contact athlete	End of season	Positive apprehension sign	Meaningful bone loss	95.8	4.06 ± 1.01	2.50 ± 0.77
>30	Contact athlete	End of season	Positive apprehension sign	Meaningful bone loss	91.5	3.92 ± 0.87	3.00 ± 1.41
23-30	Contact athlete	End of season	Generalized laxity	Meaningful bone loss	91.5	3.63 ± 1.17	3.00 ± 0.71
23-30	Noncontact athlete	End of season	Positive apprehension sign	Meaningful bone loss	91.5	3.77 ± 0.96	2.80 ± 1.10
14-18	Noncontact athlete	End of season	Positive apprehension sign	Meaningful bone loss	90.1	3.77 ± 1.00	2.33 ± 1.21
18-22	Noncontact athlete	End of season	Positive apprehension sign	Meaningful bone loss	90.1	3.97 ± 0.91	2.83 ± 0.98

NA, Not Applicable.
The strength of recommendation should be interpreted as follows: score of 0-1.49, ambivalent about the recommendation; 1.5-2.49, somewhat strong; 2.5-3.49, moderately strong; 3.5-4.49, very strong; and >4.5, emphatic.

reported level of expertise was 8.89 (range, 6-10). Open-ended questions designed to identify features designated as important in deciding treatment after an FTAGD produced a variety of features (N = 69), which could be divided into several domains (history, physical examination findings, imaging findings, and so on) (Supplementary Appendix S2).

Round 2: ranking of importance of identified features

Experts from the Neer Circle completed the second survey and rated the 69 features regarding their importance (Supplementary Appendix S4). The individual features were then placed in their domains to construct clinical scenarios (Table I).

Round 3: clinical scenarios

The results of the third survey are included in Supplementary Appendix S6.

Consensus for clinical scenarios

Of the 162 scenarios, 8 (5%) achieved >90% consensus by the group for an operative recommendation (Table II). It is important to note that for all patients aged > 14 years who were contact athletes at the end of the season and had apprehension and meaningful glenoid bone loss, there was >90% agreement by the experts that surgery should be performed after the first dislocation, with very strong feelings toward that recommendation.

Of the scenarios, 22 (14%) achieved >90% consensus for a nonoperative recommendation (Table III). More than 90% of experts recommended against surgery for patients of all ages who are not athletes and have no apprehension and no bone loss. The strength of this recommendation was also deemed very strong.

Analysis of individual features and their effect on probability of recommending surgery

A univariate mixed-effects model determined the ORs for individual features regarding the probability of recommending surgery (Table IV). Regarding the effect of age, surgery was less likely to be recommended in patients aged < 14 years or > 30 years than in those aged 14-30 years. The physical examination findings of generalized ligamentous laxity had some effect on the probability that

Table III Clinical scenarios that reached 90% nonoperative consensus

Age, yr	Sport and/or position played	If athlete, timing in season	Physical examination findings	Imaging findings	% Recommending surgery	Strength of recommendation when recommending surgery	Strength of recommendation when recommending nonoperative treatment
18-22	Noncontact athlete	Early in season or at midseason	Generalized laxity	No meaningful bone loss	8.5	3.67 ± 1.37	3.47 ± 1.07
23-30	Non-athlete		Generalized laxity	No meaningful bone loss	8.5	2.83 ± 1.33	3.73 ± 0.96
<14	Noncontact athlete	Early in season or at midseason	Positive apprehension sign	No meaningful bone loss	8.5	3.50 ± 0.84	3.70 ± 1.81
23-30	Noncontact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	7.0	3.40 ± 1.52	3.68 ± 1.02
23-30	Noncontact athlete	End of season	Negative apprehension sign	No meaningful bone loss	7.0	3.60 ± 1.52	3.48 ± 1.06
<14	contact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	7.0	3.80 ± 1.30	3.89 ± 1.09
<14	Noncontact athlete	End of season	Negative apprehension sign	No meaningful bone loss	7.0	3.00 ± 1.00	3.97 ± 0.97
14-18	Non-athlete		Generalized laxity	No meaningful bone loss	5.6	3.00 ± 0.82	3.73 ± 1.14
18-22	Noncontact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	5.6	4.50 ± 0.58	3.67 ± 1.04
23-30	Non-athlete		Negative apprehension sign	No meaningful bone loss	5.6	3.25 ± 1.71	3.83 ± 1.08
>30	contact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	4.2	3.00 ± 0.00	3.54 ± 1.15
>30	Noncontact athlete	Early in season or at midseason	Generalized laxity	No meaningful bone loss	4.2	3.33 ± 0.58	3.63 ± 1.13
14-18	Noncontact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	4.2	4.33 ± 1.15	3.75 ± 1.01
18-22	Non-athlete		Negative apprehension sign	No meaningful bone loss	4.2	3.67 ± 0.58	3.81 ± 1.02
>30	Non-athlete		Generalized laxity	No meaningful bone loss	2.8	3.50 ± 0.71	3.79 ± 1.15
>30	Noncontact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	2.8	2.00 ± 1.41	3.76 ± 1.08
14-18	Non-athlete		Negative apprehension sign	No meaningful bone loss	2.8	2.50 ± 2.12	3.99 ± 1.06
<14	Non-athlete		Generalized laxity	No meaningful bone loss	2.8	3.00 ± 1.14	4.16 ± 0.97
>30	Non-athlete		Negative apprehension	No meaningful bone loss	1.4	2.00 ± NA	3.87 ± 1.12

(*continued on next page*)

Table III Clinical scenarios that reached 90% nonoperative consensus (*continued*)

Age, yr	Sport and/or position played	If athlete, timing in season	Physical examination findings	Imaging findings	% Recommending surgery	Strength of recommendation when recommending surgery	Strength of recommendation when recommending nonoperative treatment
			sign				
<14	Non-athlete		Negative apprehension sign	No meaningful bone loss	1.4	1.00 ± NA	4.23 ± 0.93
<14	Noncontact athlete	Early in season or at midseason	Generalized laxity	No meaningful bone loss	1.4	3.00 ± NA	4.06 ± 0.97
<14	Noncontact athlete	Early in season or at midseason	Negative apprehension sign	No meaningful bone loss	1.4	2.00 ± NA	4.10 ± 0.89

NA, Not Applicable.
The strength of recommendation should be interpreted as follows: score of 0-1.49, ambivalent about the recommendation; 1.5-2.49, somewhat strong; 2.5-3.49, moderately strong; 3.5-4.49, very strong; and >4.5, emphatic.

surgery would be recommended (OR, 1.96; 95% CI, 1.76-2.18), whereas apprehension on examination profoundly influenced the likelihood that surgery would be recommended (OR, 5.60; 95% CI, 5.05-6.25). Similarly, the presence of meaningful bone loss had a profound effect on influencing the decision for surgery (OR, 6.85; 95% CI, 6.24-7.52).

Athletes at the end of the season were more likely to have surgery recommended than those early in the season or at midseason (OR, 2.31; 95% CI, 2.10-2.54) (Table IV). Similarly, contact athletes were more likely to have a surgery recommendation than non-athletes (OR, 1.93; 95% CI, 1.76-2.13).

Analysis of active-duty military population

A multivariate mixed-effects model helped to determine the importance of individual features to predict surgery in the active-duty military population (Table V). This analysis demonstrated a profound effect of apprehension (OR, 27.63; 95% CI, 14.58-52.38) and meaningful bone loss (OR, 22.4; 95% CI, 13.14-38.20). When the interplay of various features was analyzed, it was clear that the presence of both apprehension and bone loss substantially increased the likelihood that surgery would be recommended in this population (Fig. 1). Although a recommendation for surgery was more likely for age < 30 years than for age >30 years, the magnitude of the age effect was far less profound.

Analysis of non-athlete population

In the non-athlete population, the mixed-effects model demonstrated the effect of age, showing that age of 18-22 years had the highest probability of a recommendation for surgery (OR, 9.17; 95% CI, 5.62-14.95), with surgery less likely to be recommended at younger and older ages. Meaningful bone loss had the highest probability of a surgery recommendation (OR, 35.1; 95% CI, 23.91-51.53), and the effect of having apprehension substantially influenced the probability of recommending surgery (OR, 24.48; 95% CI, 16.0-37.45) (Table VI). These effects were multiplied when these features were found together (Fig. 2).

Analysis of noncontact athlete population

In the noncontact athlete population, similar to the other populations, meaningful bone loss (OR, 16.76; 95% CI, 6.30-44.58) and apprehension (OR, 6.39; 95% CI, 2.33-17.53) drove the decision to recommend surgery (Table VII). These features, when combined, had a profound effect on the probability that surgery would be recommended (Supplementary Appendix S7, Fig. 3).

Analysis of contact athlete population

Similar to the decisions for surgery in the noncontact athlete, those in the contact athlete are profoundly influenced by meaningful bone loss (OR, 13.95; 95% CI, 6.54-29.78) and apprehension (OR, 10.39; 95% CI, 4.85-22.24) (Table VIII). Bone loss significantly influences the decision for surgery in the contact athlete, especially when combined with apprehension. However, it is interesting to note that in the contact athlete who had an FTAGD without bone loss, the presence of apprehension substantially increased the likelihood that surgery would be recommended, particularly in contact athletes aged > 14 years and < 30 years (Supplementary Appendix S8, Fig. 4).

Table IV Univariate mixed models for logistic regression

Feature	Odds ratio	95% CI	*P* value
Effect of age on probability of surgery*			
Reference: age < 14 yr	0.36	0.28-0.46	<.00001
Age 14-18 yr	2.35	2.05-2.70	<.00001
Age 18-22 yr	2.64	2.30-3.03	<.00001
Age 23-30 yr	2.56	2.23-2.94	<.00001
Age > 30 yr	1.58	1.37-1.81	<.00001
Effect of physical examination findings on probability of surgery†			
Reference: no apprehension, no generalized ligamentous laxity	0.32	0.25-0.41	<.00001
Generalized ligamentous laxity	1.96	1.76-2.18	<.00001
Apprehension	5.60	5.03-6.25	<.00001
Effect of significant bone loss on probability of surgery			
Reference: no meaningful bone loss	0.26	0.20-0.34	<.00001
Meaningful bone loss	6.85	6.24-7.52	<.00001
Effect of time in season loss on probability of surgery‡			
Reference: early in season or at midseason	0.53	0.42-0.67	<.00001
End of season	2.31	2.10-2.54	<.00001
Effect of contact athletes on probability of surgery			
Reference: non-athlete	0.58	0.46-0.73	<.00001
Contact athlete	1.93	1.76-2.13	<.00001

CI, confidence interval.
Data from the third survey with clinical scenarios underwent analysis with a univariate mixed model to determine odds ratios for features on the probability of recommending surgery.
* This analysis excluded the active-duty military population as their age range was limited; all ages were compared with those aged < 14 years as the reference group.
† Patients with generalized ligamentous laxity or positive apprehension test findings were compared with those without those findings as the reference group.
‡ This analysis excluded non-athletes and the active-duty military population, whose activities are not seasonal.

Discussion

Controversy exists regarding the treatment of patients who sustain an FTAGD. Some clinicians recommend surgery for most patients in an effort to reduce recurrence and its sequelae; others are more conservative. It is interesting to note that our survey of experts in shoulder instability using the Delphi process revealed that for most clinical scenarios constructed with highly impactful features that would lead toward surgery, the experts (all surgeons) would not recommend surgery after an FTAGD for most clinical scenarios. Only 8 of 162 scenarios achieved a consensus >90% for operative recommendation.

Table V Odds ratios derived from mixed-effects model for active-duty military population

Feature	Odds ratio	95% CI
Reference	0.11	0.05-0.23
Age > 30 yr	0.44	0.29-0.67
Meaningful bone loss	22.40	13.14-38.20
Generalized ligamentous laxity	2.71	1.65-4.45
Apprehension	27.63	14.58-52.38

CI, confidence interval.
All comparisons showed $P < .0002$; however, the global interaction test yielded $P = .374$. Interactions were not included in the model.

Certain features in the clinical scenarios were found to increase the likelihood that surgery would be recommended (Table IV). These included age between 14 and 30 years and whether or not the patient was a contact athlete and, if so, the timing within his or her season. Furthermore, the presence of apprehension on examination was influential in the treatment recommendation, as was the presence of bone loss. In general, these factors agreed with data in the published literature.

Regarding age, Olds et al[19] reported that patients aged between 15 and 20 years have a risk of recurrence > 50%. Wasserstein et al[28] reported that patients aged < 20 years have a 13 times higher risk of recurrence than those aged > 20 years. Conversely, an additional study by Olds et al[18] found that younger children (aged < 14 years) were 24 times less likely to sustain recurrent instability than their adolescent counterparts (aged 14-18 years). In our study, scenarios with age < 14 years were far less likely to render an operative recommendation than scenarios that included ages 14 and 30 years (Table IV).

Regarding athletic status, we found that contact athletes were more likely to have surgery recommended after an FTAGD than non-athletes (Table IV). For athletes, whether

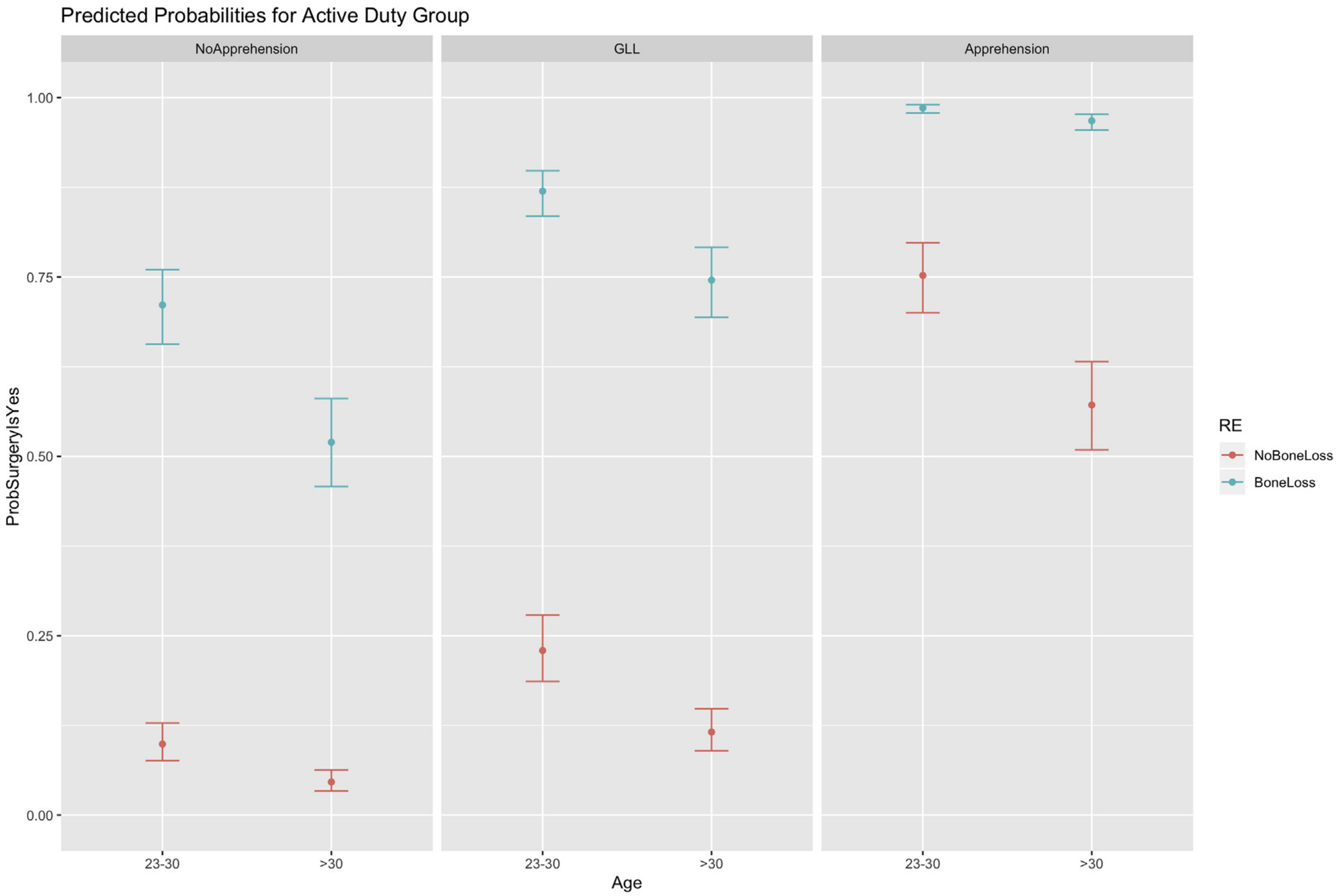

Figure 1 Multivariate mixed-effects model for active-duty military population. This analysis allows us to interpret the influence of multiple features on the model-based predicted probability *(Prob)* of surgery for the active-duty military patient. The 3 charts represent patients without apprehension *(left)*, those with generalized ligamentous laxity *(GLL) (middle)*, and those with apprehension *(right)*. The effect of age (<30 years and >30 years) can be determined by comparing the data points within each graph. The effect of meaningful bone loss can be determined by comparing the data points for meaningful bone loss *(blue)* with those for no meaningful bone loss *(red)*.

Table VI Odds ratios derived from mixed-effects model for non-athlete population

Feature	Odds ratio	95% CI
Reference	0.001	0.00-0.00
Age 14-18 yr	5.14	3.18-8.31
Age 18-22 yr	9.17	5.63-14.95
Age 23-30 yr	6.89	4.25-11.17
Age > 30 yr	2.78	1.72-4.49
Meaningful bone loss	35.10	23.91-51.53
Generalized ligamentous laxity	3.29	2.27-4.77
Apprehension	24.48	16.00-37.45

CI, confidence interval.
All comparisons showed $P < .00001$; however, the global interaction test yielded $P = .351$. Interactions were not included in the model.

the FTAGD occurred in season or at the end of the season influenced treatment recommendations, with end-of-season dislocations 2.3 times more likely to result in an operative recommendation (Table IV). This is likely influenced by 2 articles in the literature that address the in-season athlete with shoulder instability. Buss et al[4] reported on a population of high school athletes who sustained an in-season anterior instability event. They reported that 87% of patients successfully returned to sport in the same season at an average of 10 days. Dickens et al[8] performed a multicenter prospective study on a population of collegiate athletes who sustained a first-time instability event. They found that 73% of patients returned to sport at an average of 6 days. Both studies concluded that nonoperative management of the in-season athlete was successful in returning the athlete to complete his or her season.

Several physical examination findings influenced treatment recommendations (Table IV). The presence of generalized ligamentous laxity increased the probability that surgery would be recommended after an FTAGD; however, a patient with a positive apprehension sign after an FTAGD was 5.6 times more likely to be offered surgery.

Finally, bone loss was a significant driver to recommend surgery (OR, 6.85; 95% CI, 6.24-7.52) (Table IV). This

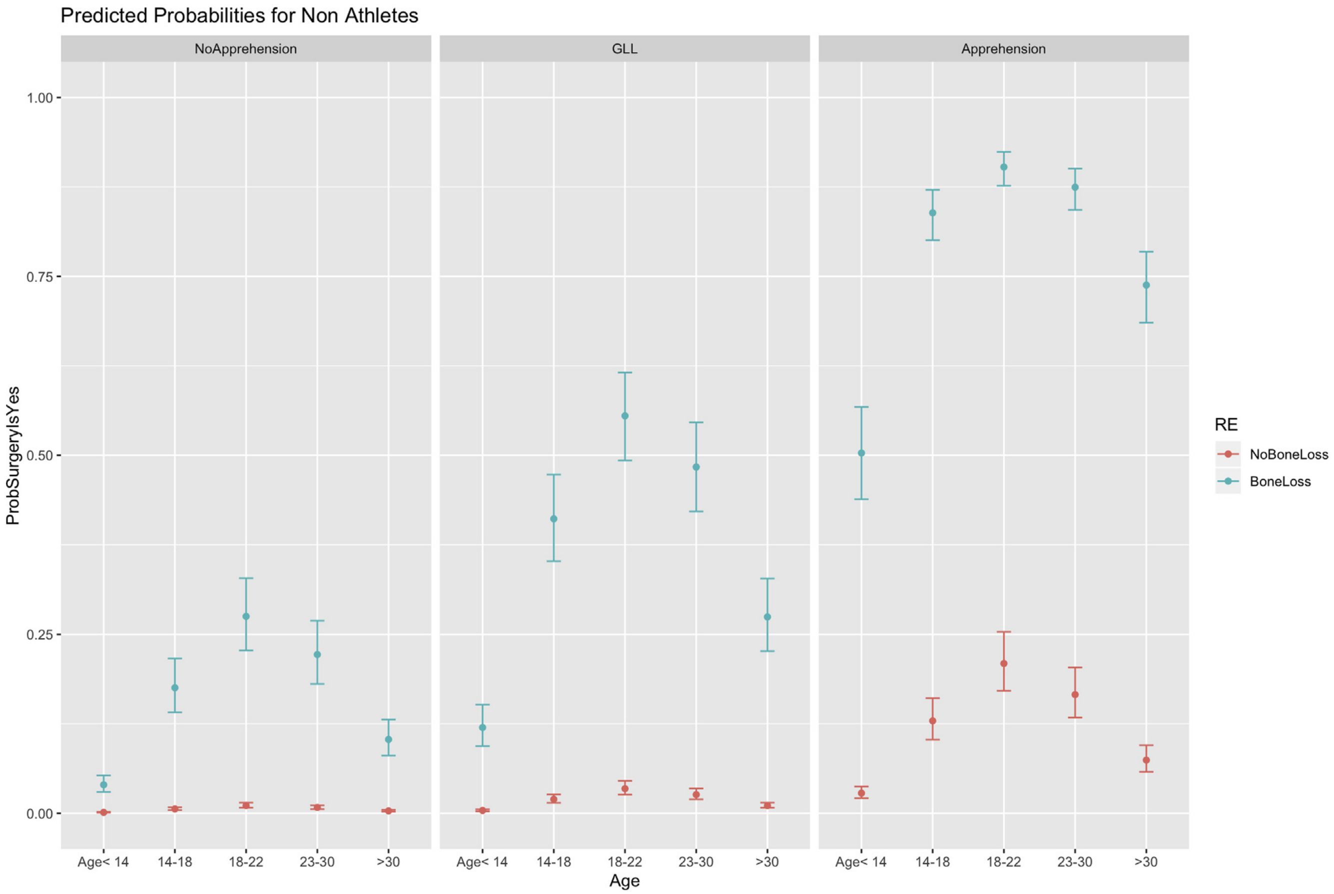

Figure 2 Multivariate mixed-effects model for non-athlete population. This analysis allows us to interpret the influence of multiple features on the predicted probability *(Prob)* of surgery for the non-athlete. The 3 charts represent patients without apprehension *(left)*, those with generalized ligamentous laxity *(GLL) (middle)*, and those with apprehension *(right)*. The effect of age can be determined by comparing the data points within each graph. The effect of meaningful bone loss can be determined by comparing the data points for meaningful bone loss *(blue)* with the data points for no meaningful bone loss *(red)*. We can see the effect of age: Patients aged 18-22 years, particularly those with meaningful bone loss, are more likely to receive a recommendation for surgery, and this effect is magnified if apprehension is also present. Meaningful bone loss with apprehension substantially raises the probability of a recommendation for surgery compared with bone loss without apprehension in this population.

Table VII Odds ratios derived from mixed-effects model for noncontact athlete population

Feature	Odds ratio	95% CI	*P* value
Reference	0.02	0.00-0.05	<.00001*
Age 14-18 yr	2.13	0.71-6.44	.179
Age 18-22 yr	2.66	0.90-7.82	.075
Age 23-30 yr	1.89	0.61-5.79	.268
Age > 30 yr	1.89	0.61-5.79	.268
Meaningful bone loss	16.76	6.30-44.56	<.00001*
Generalized ligamentous laxity	2.94	1.01-8.56	.047*
Apprehension	6.39	2.33-17.53	<.00001*

CI, confidence interval.
Two-way and 3-way interactions were included in the model but are not shown. The global interaction test yielded $P = .028$.
* Statistically significant ($P < .05$).

factor was perhaps the most controversial factor considered for inclusion in the final survey. Several members of the committee voiced concern that significant bone loss "doesn't happen" in the first-time dislocator, and therefore they argued that clinical scenarios with bone loss in the first-time dislocator are not clinically relevant. However, early in our data collection, Dickens et al 9 published a prospective evaluation designed to assess bone loss after an FTAGD. They determined that 17% of first-time dislocators in their study had bone loss $\geq$ 13.5% of the glenoid width, and no glenoid had bone loss > 20%. As a result of their study, the committee chose to eliminate glenoid bone loss > 25% as a feature. Shaha et al[25] demonstrated that bone loss > 13.5% results in higher recurrence rates and worse Western Ontario Shoulder Instability scores than in patients who present with less bone loss. Given these data, we

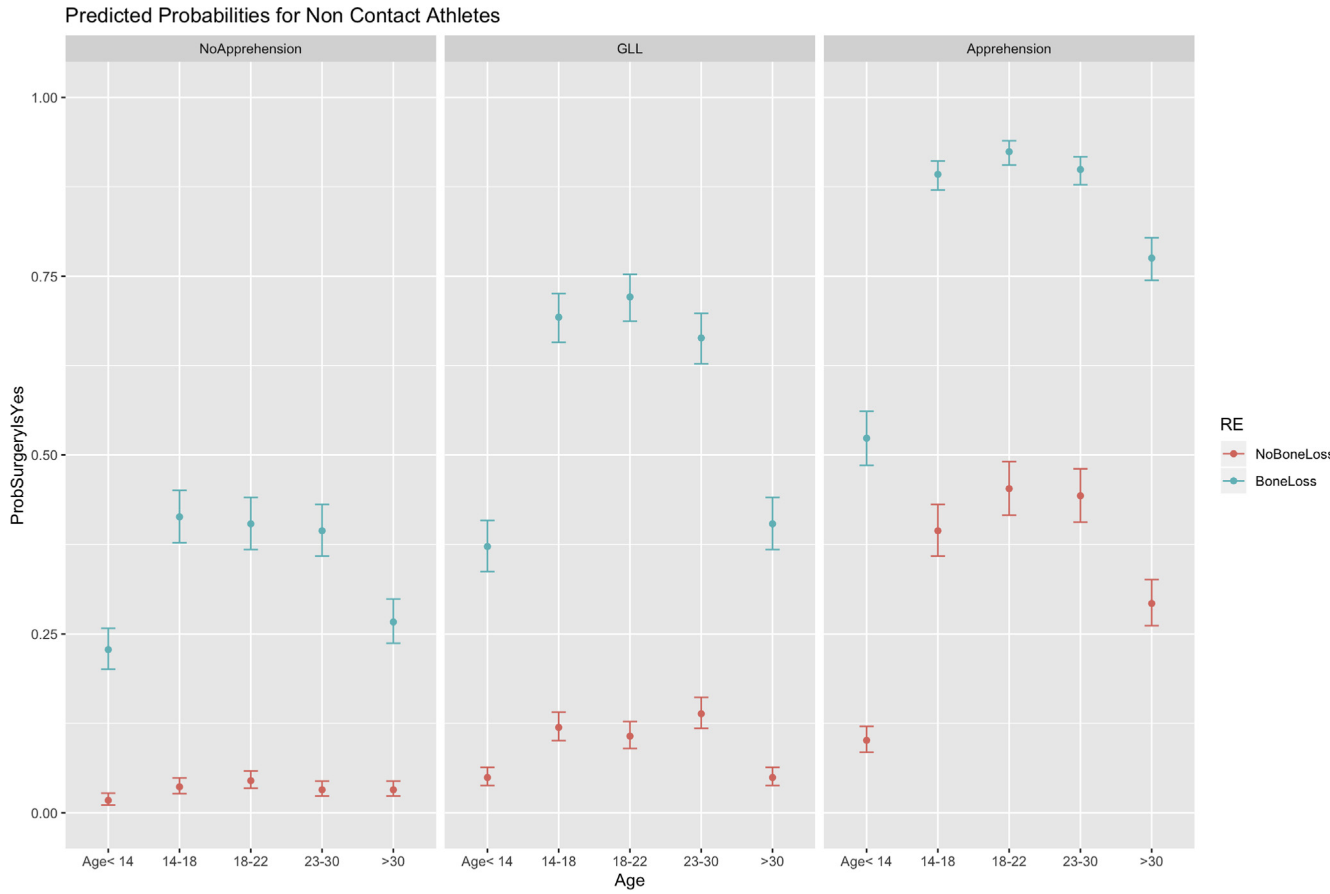

Figure 3 Multivariate mixed-effects model for noncontact athlete population. This analysis allows us to interpret the influence of multiple features on the likelihood of surgery for the noncontact athlete. The 3 charts represent patients without apprehension *(left)*, those with generalized ligamentous laxity *(GLL) (middle)*, and those with apprehension *(right)*. The effect of age can be determined by comparing the data points within each graph. The effect of meaningful bone loss can be determined by comparing the data points for meaningful bone loss *(blue)* with the data points for no meaningful bone loss *(red)*. We can see the effects that patients aged 14-30 years, particularly with meaningful bone loss, are more likely to receive a recommendation for surgery, and the effect is magnified if apprehension is also present. Apprehension seems to drive surgery, even without meaningful bone loss. *Prob*, probability.

Table VIII Odds ratios derived from mixed-effects model for contact athlete population

Feature	Odds ratio	95% CI	*P* value
Reference	0.05	0.03-0.11	<.00001*
Age 14-18 yr	3.62	1.63-8.01	.001*
Age 18-22 yr	3.03	1.36-6.77	.007*
Age 23-30 yr	2.87	1.28-6.44	.010*
Age > 30 yr	0.73	0.28-1.86	.506
Meaningful bone loss	13.95	6.54-29.78	<.00001*
Generalized ligamentous laxity	2.67	1.19-6.01	.017*
Apprehension	10.39	4.85-22.24	<.00001*

CI, confidence interval.
Two-way and 3-way interactions were included in the model but are not shown. The global interaction test yielded $P = .021$.
* Statistically significant ($P < .05$).

decided to include bone loss > 13.5% of the glenoid width, defined as meaningful bone loss, in the clinical scenarios in our third survey. It is interesting to note that the literature is not clear on whether a bony Bankart lesion after a first dislocation is related to recurrence. Salomonsson et al[24] suggested that bony Bankart lesions decrease the recurrence risk, whereas Olds et al[20] reported that bony Bankart lesions increase the recurrence risk. Recent systematic reviews have shown that a bony Bankart lesion after a first dislocation has no effect on recurrence.[28]

Combining these factors into the final survey resulted in 162 clinical scenarios. It is important to note that 90% of the experts in shoulder instability identified within the Neer Circle membership completely filled out these scenarios, which speaks to the integrity of the group and the persistence of the committee. We found the results of the final

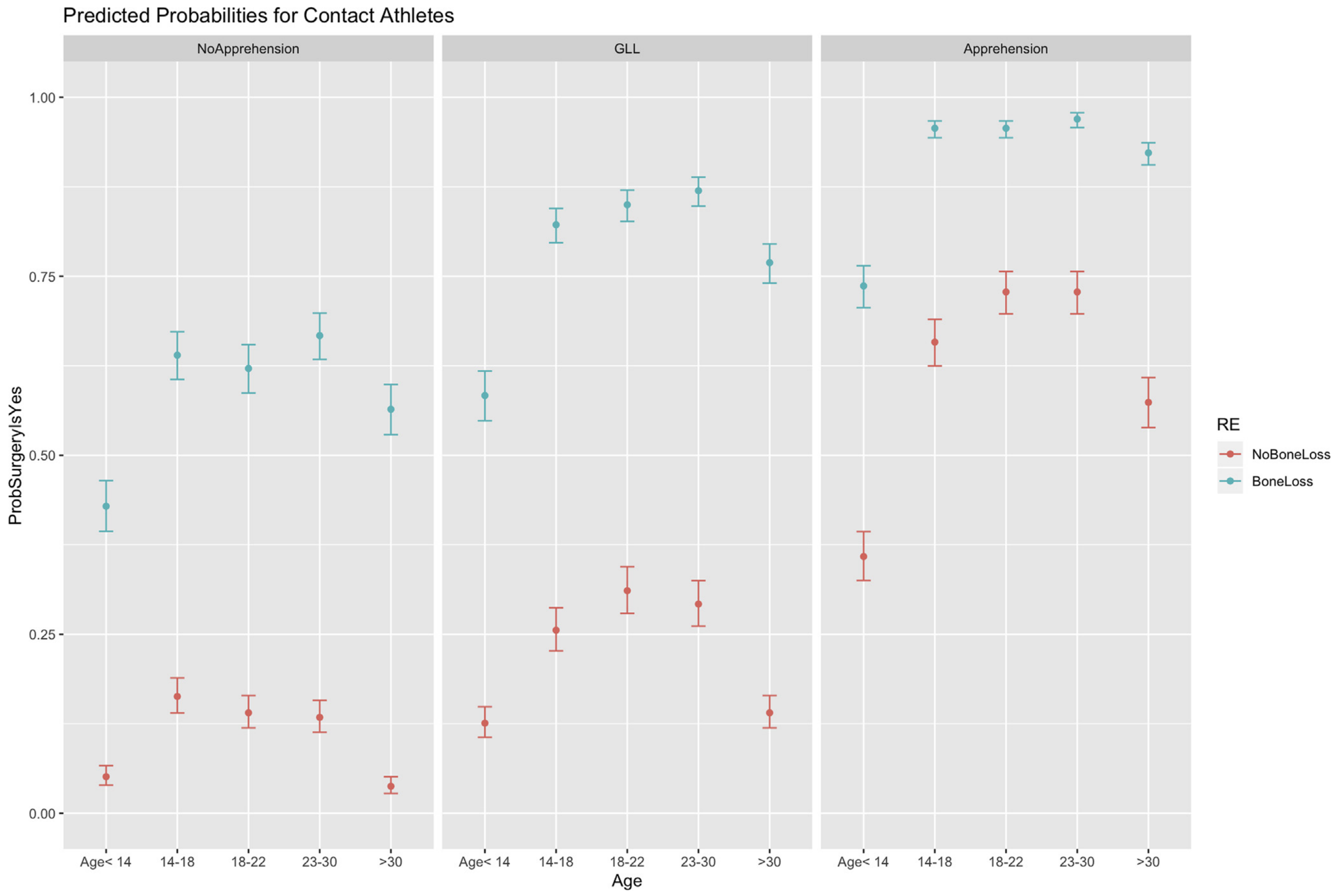

Figure 4 Multivariate mixed-effects model for contact athlete population. This analysis allows us to interpret the influence of multiple features on the likelihood of surgery for the contact athlete. The 3 charts represent patients without apprehension *(left)*, those with generalized ligamentous laxity *(GLL) (middle)*, and those with apprehension *(right)*. The effect of age can be determined by comparing the data points within each graph. The effect of meaningful bone loss can be determined by comparing the data points for meaningful bone loss *(blue)* with the data points for no meaningful bone loss *(red)*. Overall, contact athletes are more likely than noncontact athletes to have surgery recommended. The presence of bone loss is highly predictive of surgery, even without apprehension. Apprehension is highly predictive of surgery, even without meaningful bone loss. *Prob*, probability.

survey somewhat surprising in that the number of clinical scenarios achieving operative consensus was quite low (5%). There are many studies in the literature that have reported on the dangers of neglecting the unstable shoulder. Recurrence of instability events is associated with higher failure rates with surgery,[15,27] as well as the development of glenohumeral joint osteoarthritis.[3,13,17] Jakobsen et al[14] performed a randomized clinical trial of operative vs. nonoperative treatment with 10-year follow-up. They reported a recurrence rate of 56% in the nonoperative group compared with 3% in the operative group. At 10 years, 72% of patients in the operative group had good or excellent results whereas 75% of those in the nonoperative group had unsatisfactory outcomes. Shin et al[26] compared 33 first-time dislocators who underwent surgery with 89 age-matched controls who were initially treated nonoperatively and underwent eventual operative fixation. The early-surgery group had a failure rate of 3% compared with an 18% failure rate in the delayed-surgery group, and the delayed-surgery group had more anterior periosteal sleeve avulsions (ALPSAs) and glenoid damage than the early-surgery group. No study in the literature has shown better findings in a nonoperative group compared with an operative group. Nevertheless, consensus for an operative recommendation did not occur frequently. No single factor achieved 90% consensus, and achieving this level of consensus required athletes to be at the end of their season, to present with apprehension, and to demonstrate meaningful bone loss.

Similarly, nonoperative consensus was difficult to achieve at the 90% level. No single factor resulted in consensus, and similarly to the operative consensus results, nonoperative consensus at the 90% level required a combination of factors including non-athlete or in-season athlete status, a negative apprehension sign on physical examination, and the absence of bone loss.

It is interesting to see how the different features combined in different populations affect the recommendation for surgery (Figs. 1-4). Some observations of these data include that the influence of meaningful bone loss combined with a positive apprehension sign substantially increased the likelihood that surgery would be recommended. Although these are treated as independent variables, it is not known whether they are independent variables. In addition, the effect of combining these features was most profound regarding non-athletes. These data would suggest that surgeons would be unlikely to recommend surgery for an FTAGD in a non-athlete unless these features are present and, if they are present, the likelihood that surgery would be recommended is increased substantially.

Limitations

This study has a number of limitations that should caution the reader against wholesale adoption of our findings. First, this is a survey of a specific group of surgeons singled out for their participation in the Neer Circle. Although all of these members are well recognized in their roles and contributions to the field of shoulder surgery, their "expertise" is not validated and their opinions represent level V evidence. Nevertheless, in the absence of higher levels of evidence, such a group may provide credible guidance to the less experienced surgeon who is presented with similar scenarios.

Second, all participants in the survey were surgeons. This may be expected to present a bias toward the over-recommendation of operative treatment. However, because this research question pertained to indications for surgery, we believe it was inappropriate to include nonsurgeons in this consensus process.

Third, the final inclusion of influencing factors was not exhaustive. For example, the committee elected to remove certain factors such as history of a collagen disorder or presence of a HAGL (humeral avulsion of the glenohumeral ligament) deformity. Thus, there may be influencing factors that would have achieved consensus that were not included by the committee. Other factors were combined to keep the final number of scenarios manageable. For example, we did not differentiate between the competitive swimmer and overhead thrower, and we lumped together athletes as either contact or noncontact athletes. There may be certain categories of athlete that would have been influential that we missed by combining factors in our item reduction. It should be noted, however, that even with the item reduction, 162 scenarios were required, which met with no small amount of commentary by the respondents.

Fourth, we only inquired about the treatment of an FTAGD. We cannot extrapolate to the patient who has had more than 1 event. The literature clearly shows that early operative intervention outperforms shoulders with chronic instability. There is some literature suggesting that patients could have a second episode without influencing the failure rate of surgery,[27] and this may have influenced the thinking of some experts. Therefore, it should be understood that a nonoperative recommendation might not be the final recommendation.

Fifth, we chose a fairly high level (>90%) to define consensus. This was a somewhat arbitrary delineation, and less stringent values might be equally influential in guiding treatment. For example, had we dropped our level of consensus to 80%, we would have found 17 scenarios that achieved consensus for operative treatment and 51 scenarios that would have achieved nonoperative consensus. Supplementary Appendix S6 is offered to clinicians who might encounter patients with different clinical presentations to see how many experts would recommend surgery for a particular scenario.

Finally, we did not take into consideration patient desires or input from patient confidants in the scenarios. For example, many of the scenarios may well have been influenced by the wishes of the patient and his or her parents or other family members or, potentially, coaches, agents, and employers. Many of the scenarios undoubtedly would be affected by a patient's strong desire for a particular treatment option. Despite these limitations, we were able to perform the first Delphi consensus to address the treatment of the FTAGD patient.

With these limitations in mind, we would offer this information to clinicians, who should also use all clinical, social, and patient desires to help make decisions regarding surgery. This information should not be used to establish a standard of care, nor should it be used to determine appropriateness for surgery or to make reimbursement decisions.

Conclusion

There remains considerable controversy regarding treatment recommendations for the patient with an FTAGD. This is true even among surgeons with considerable experience in the field. The following conclusions can be derived from the first consensus process of the Neer Circle of ASES on the treatment of the patient with an FTAGD:

1. Experts do not believe that surgery should be a standard for all patients with first-time dislocations.
2. Contact athletes who were at the end of their competitive season and were aged > 14 years with apprehension and meaningful bone loss had a very high level of surgery being recommended (>90%), with very strong recommendations to do so.
3. Non-athletes of all ages without apprehension and without meaningful bone loss had an extremely low level of surgical recommendation (<6%), with very strong recommendations against surgery.

4. Patient features that strongly influenced the decision to perform surgery were meaningful bone loss and apprehension.
5. Age followed a distribution such that patients aged < 14 years or > 30 years were less likely to receive a surgical recommendation.

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Supplementary data

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