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Management of bone loss in recurrent traumatic anterior shoulder instability: a survey of North American surgeons

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ABSTRACT

Background: Management of bone loss in recurrent traumatic anterior shoulder instability remains a topic of debate and controversy in the orthopedic community. The purpose of this study was to survey members of 4 North American orthopedic surgeon associations to assess management trends for bone loss in recurrent anterior shoulder instability.

Methods: An online survey was distributed to all members of the American Shoulder and Elbow Surgeons, American Orthopaedic Society for Sports Medicine, and Canadian Orthopaedic Association and to fellow members of the Arthroscopy Association of North America. The survey comprised 3 sections assessing the demographic characteristics of survey respondents, the influence of prognostic factors on surgical decision making, and the operative management of 12 clinical case scenarios of varying bone loss that may be encountered in clinical practice.

Results: A total of 150 survey responses were returned. The age of the patient and quantity of bone loss were consistently considered important prognostic criteria. However, little consensus was reached for critical thresholds of bone loss and how this affected the timing (ie, primary or revision surgery) and type of bony augmentation procedure to be performed once a critical threshold was reached, especially in the context of critical humeral and bipolar bone loss.

Conclusions: Consistent trends were found for the management of recurrent anterior shoulder instability in cases in which no bone loss existed and when isolated critical glenoid bone loss was present. However, inconsistencies were observed when isolated critical humeral bone loss and bipolar bone loss were present.

The glenohumeral joint is the most frequently dislocated large joint in the human body, with the majority of instability events occurring anteriorly.[5,8,14,55,58,85] Young male contact athletes are at the highest risk of experiencing recurrent shoulder instability.[8,14,15,19,61,65,66,70,80,85] This is particularly important because recurrent instability has been associated with bipolar bone loss,[1,9,37,45] osteoarthritis,[10,14,31,56,59,67] and lost time from both sports and work.[35,56-58,67] This has led to a paradigm shift in the management of first-time dislocations in the young and active population.[19,38,39]

The presence of bone loss plays an important role in the success of soft-tissue stabilization procedures.[4,7,8,13,16,17,27,40,41,49,51,68,71,76] An inverted pear–shaped glenoid (ie, glenoid erosion $\geq$ 25%) has been shown to predict failure after arthroscopic stabilization.[13,44,71] Previous studies have indicated that soft-tissue stabilization procedures fail in up to 89% of contact athletes with substantial glenoid bone loss.[8,13,36,71,75–77,81] Others have reported that glenoid bone loss > 25% predicts a 67%-75% failure rate after arthroscopic stabilization, a problem that is compounded in the presence of capsular laxity (Fig. 1).[7,12,13,44,71,75,81] Moreover, increased rates of recurrence have been found in patients with large Hill-Sachs

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

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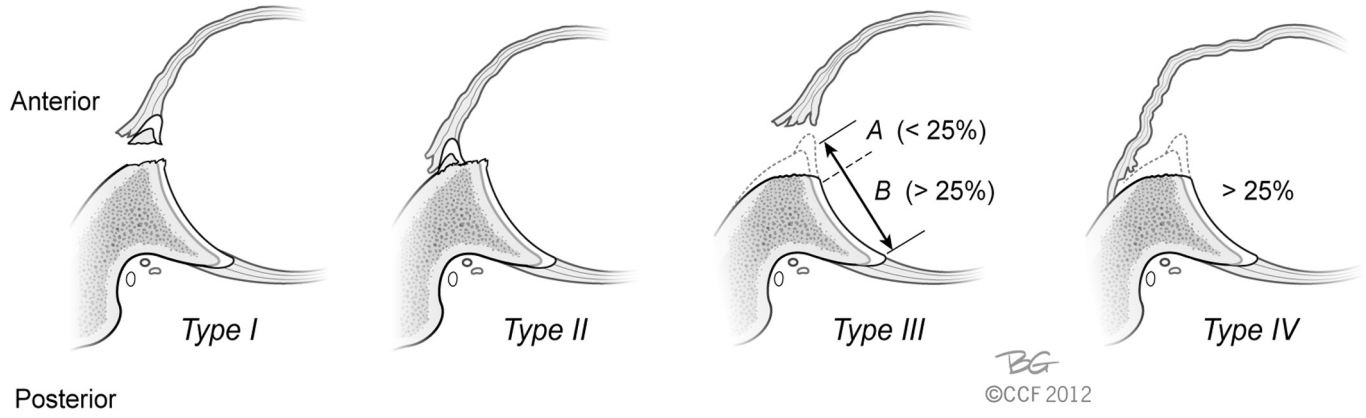

Figure 1 Modified classification of glenoid rim lesion types associated with anterior shoulder instability: type I, displaced avulsion fracture with attached capsule; type II, medially displaced fragment malunited to glenoid rim; type III, erosion of glenoid rim with <25% deficiency (type IIIA) or >25% deficiency (type IIIB); and type IV, erosion of glenoid rim with >25% deficiency combined with a stretched inferior glenohumeral ligament (ie, capsular laxity). (From Bois AJ, Miniaci A. Surgical management of instability with bone loss. In: Iannotti J, Miniaci A, Williams G, et al, editors. Disorders of the shoulder: diagnosis and management, vol. 2: sports injuries. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2013. p. 228-54. Reprinted with permission from Cleveland Clinic Center for Medical Art & Photography © 2012-2020. All rights reserved.)

lesions.[7,23] In a prospective case series of 194 patients undergoing arthroscopic Bankart repair, the recurrence rate in patients with "engaging" Hill-Sachs lesions was 14.3% (3 of 21 shoulders).[13] Such studies reinforce the importance of quantifying bone loss preoperatively to facilitate the surgical decision-making process.[8,46,79]

Multiple treatment algorithms for managing bone loss in recurrent anterior shoulder instability have been proposed.[2,8,9,16,17,29,30,51,54,64,78,83] However, there is currently no consensus regarding what is considered "critical" or "subcritical" glenoid and/or humeral bone loss, and no level I evidence is available to assist in surgical decision-making.[63] Therefore, the surgical management of critical bone loss remains a topic of debate in the orthopedic surgery community.

Given the lack of evidence available to assist in surgical decision-making in this clinical context, the purpose of this study was to evaluate the management trends among orthopedic surgeons for critical and subcritical bone loss in patients with recurrent anterior shoulder instability to determine whether a consensus opinion exists for managing this complex, controversial, and rapidly evolving shoulder problem. This study also evaluated

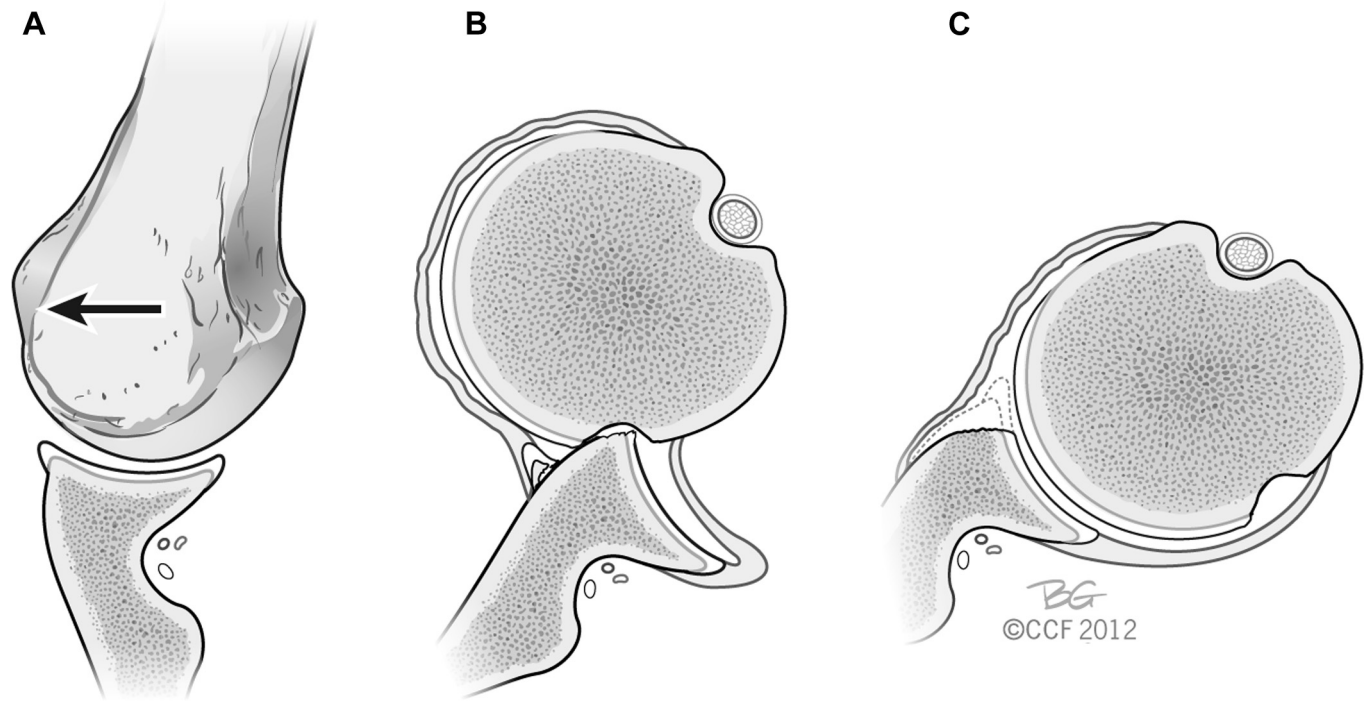

Figure 2 Characteristic bony lesions found in cases of anterior shoulder instability. The mechanism of injury typically involves external rotation and anterior translation (⟵) (**A**) to produce both glenoid and humeral lesions (**B** and **C**). (From Bois AJ, Miniaci A. Surgical management of instability with bone loss. In: Iannotti J, Miniaci A, Williams G, et al, editors. Disorders of the shoulder: diagnosis and management, vol. 2: sports injuries. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2013. p. 228-54. Reprinted with permission from Cleveland Clinic Center for Medical Art & Photography © 2012-2020. All rights reserved.)

whether any practice differences exist in management trends between shoulder and elbow specialists, sports medicine specialists, and generalists or other specialists. We hypothesized that management trends would be consistent for cases without bone loss or with isolated critical glenoid bone loss but that inconsistencies would exist in the management of cases with isolated critical humeral or bipolar (ie, both humeral and glenoid) bone loss.

Methods

Study population

Four North American orthopedic associations were targeted to capture information from shoulder and elbow specialists, sports medicine specialists, and generalists or other specialists who manage patients with recurrent anterior shoulder instability: American Shoulder and Elbow Surgeons (ASES), American Orthopaedic Society for Sports Medicine (AOSSM), Arthroscopy Association of North America (AANA), and Canadian Orthopaedic Association (COA). Eligible participants had to be either enrolled in an orthopedic surgery fellowship training program or a practicing orthopedic surgeon.

Survey distribution and development

An invitation to participate in the study was distributed by e-mail in an anonymous fashion within a 3-month interval in 2011 using www.SurveyMonkey.com (SurveyMonkey Inc., San Mateo, CA, USA) to approximately 346 members of the ASES (8.2%), 2500 members of the AOSSM (59.4%), 1250 members of the COA (29.7%), and 112 orthopedic surgery fellow members of the AANA (2.7%), for a total sample size of 4208. The purpose and objectives of the study were clearly outlined within the invitation e-mail and in the introduction section of the survey (Supplementary Appendix S1).

The first section of the survey included questions related to respondents' demographic characteristics (ie, type of surgical practice, years in practice, and number of shoulder stabilization procedures performed). The second section assessed how prognostic factors (ie, patient age, number of dislocations, and quantity of bone loss) would affect respondents' surgical decision-making process. The last section included 12 clinical cases that may be encountered in clinical practice that focused on the surgical management of recurrent anterior instability and (1) normal bone stock (ie, no bone loss), (2) humeral bone loss, (3) erosive glenoid bone loss (ie, excluding bony Bankart lesions), and (4) bipolar bone loss (Fig. 2). For each clinical case, respondents were provided a list of 15 possible treatment strategies to manage the defined problem (ie, based on the available English-language literature) and an option to list their preferred treatment if it was not listed. Respondents could choose >1 form of treatment if applicable (Supplementary Appendix S1).

Study conceptualization and development of the first draft of survey questions and response options were performed by the primary author (A.J.B.); further survey development was then performed and consensus was established along with the 2 senior authors (M.H.J. and A.M.) prior to survey distribution. The survey questions were designed to incorporate general descriptive terms of bone loss (ie, critical), quantifiable or numerical values of bone loss (ie, increasing size or magnitude including subcritical bone loss), and additional prognostic variables (ie, revision surgery). Survey questions were designed to highlight both known topics and areas in which modest data exist and controversy remains. A glossary of terms was listed on the introductory page of the survey to help standardize question comprehension and reduce ambiguity.

Statistical analysis

Responses were collected within the SurveyMonkey platform and subsequently exported into Microsoft Excel (Microsoft, Redmond, WA, USA). Data were then transferred to and analyzed using SAS software (Version 9.2; SAS Institute, Cary, NC, USA) and the R package (Version 2.12.2; R Foundation for Statistical Computing, Vienna, Austria). The responses were categorized into 3 groups: shoulder and elbow specialists, sports medicine specialists, and generalists or other orthopedic surgeons. The responses to the demographic questions in the survey were reported using descriptive statistics (absolute values and percentages). The responses to the survey questions were reported using frequencies and percentages. A consensus was considered to have been reached on an individual question or clinical case if >50% of respondents provided the same response.[18,22,33]

Results

Demographic characteristics

Table I includes the demographic information of the respondents. A total of 150 responses were returned, with an overall response rate of 3.6%. In total, of the respondents, 48.7% were involved in academic practice, 47.3% were involved in nonacademic practice, and 4% were involved in another type of practice not specified (Table I). By subspecialty type, 61.3% of respondents were sports medicine specialists, 26% were shoulder and elbow specialists, and 12.7% were generalists or other orthopedic surgeons. Respondents had been in surgical practice for 12.5 years on average. Instability surgical procedures accounted for 41% of annual cases performed by respondents (16.3 per year).

Risk factors and critical bone loss

A consensus was reached across shoulder and elbow specialists (71.8%), sports medicine specialists (84.4%), and generalists or other orthopedic surgeons (61.1%) who agreed or strongly agreed that there is a direct relationship between the total number of shoulder dislocations and the magnitude of bone loss (Supplementary Table S1). Of those who agreed or strongly agreed, a consensus was reached among generalists or other orthopedic surgeons (60%)

Table I
Demographic characteristics of survey respondents (N = 150)

Surgeon category	Survey response
Resident country, n (%)	
United States	103 (68.7)
Canada	37 (24.7)
Other	10 (6.7)
Type of practice, n (%)	
Academic	73 (48.7)
Nonacademic	71 (47.3)
Other	6 (4)
Subspecialty type, n (%)	
Sports medicine	92 (61.3)
Shoulder and elbow	39 (26)
Generalist or other	19 (12.7)
Surgeon experience	
Years in practice	12.5
Instability surgical procedures	16.3/yr
Yearly proportion, %	41

Table II
Importance of bone loss quantity for surgical decision making

	Shoulder and elbow specialists	Sports medicine specialists	Generalists or other specialists
Anatomic site: "A patient may fail a soft tissue (ie, capsulolabral/Bankart) stabilization procedure when they have critical bone loss on [which of the following anatomic sites]."			
Humeral side only, %	0	1.1	0
Glenoid side only, %	10.3	11.1	11.1
Both sides of glenohumeral joint, %	89.7	87.8	88.9
Bone loss does not affect success of soft-tissue stabilization procedure, %	0	0	0
Prognostic factor: "The decision to perform a 'bone augmentation procedure' (biologic or artificial) to address glenohumeral bone loss depends on the QUANTITY of bone loss present"			
Strongly agree, %	46.2	36.7	33.3
Agree, %	48.7	61.1	50
Neutral, %	0	2.2	5.6
Disagree, %	5.1	0	11.1
Strongly disagree, %	0	0	0

that 2-5 dislocations influence the development of critical humeral bone loss (Supplementary Table S2). Although a consensus was not reached regarding the influence between the total number of dislocations and the development of critical glenoid bone loss, a trend was observed across all subspecialties that the occurrence of between 2 and 5 dislocations influences the development of critical glenoid bone loss.

Prognostic factors and surgical decision making—general

A consensus was reached across shoulder and elbow specialists (61.6%), sports medicine specialists (52.3%), and generalists or other orthopedic surgeons (55.5%) who agreed or strongly agreed that the age of the patient influences whether a bony augmentation procedure is performed when critical bone loss exists. Of those who agreed or strongly agreed, a consensus was reached between shoulder and elbow (54.2%) and sports medicine (59.6%) specialists that patients aged < 30 years would be considered for a bony augmentation procedure when critical humeral bone loss exists. Although a consensus was not reached, a trend was observed for all subspecialties that a bony augmentation procedure would be appropriate in patients aged between 20 and 50 years when critical glenoid or bipolar bone loss exists.

A consensus was reached across shoulder and elbow specialists (94.9%), sports medicine specialists (97.8%), and generalists or other orthopedic surgeons (83.3%) who agreed or strongly agreed that the decision to perform a bony augmentation procedure to address glenohumeral bone loss depends on the quantity of bone loss present (Table II).

Regarding the third section of the survey, a consensus was reached across all subspecialties that the primary surgical procedure of choice for a patient presenting with recurrent anterior shoulder instability, normal bone stock, and no previous surgery would be a capsulolabral (ie, Bankart) stabilization procedure (case 1, Table III). A consensus was also reached across subspecialties that a soft-tissue (ie, capsulolabral or Bankart) stabilization procedure may fail in a patient who has critical bone loss on both sides of the joint (ie, bipolar bone loss) (Table II). However, a consensus was not reached across subspecialties regarding failure of soft-tissue stabilization procedures in patients in whom critical bone loss exists on the glenoid or humeral side alone (Table II).

Management of isolated humeral bone loss

A consensus was reached across subspecialties that the surgical management in a patient with recurrent instability, isolated critical humeral bone loss, and no previous surgery would be a Bankart repair (case 2, Table III). Moreover, a consensus was reached among shoulder and elbow specialists (51.3%) that a remplissage procedure (ie, soft-tissue interposition of the humeral head defect) could also be considered (Table III). In the setting of isolated humeral bone loss of 0%-20% (ie, subcritical) and a failed previous Bankart repair, a consensus was reached only among shoulder and elbow specialists (61.5%) that the surgical management would be a revision Bankart repair combined with a remplissage procedure (case 3, Table III). Although a consensus was not reached, a small trend was observed across subspecialties with the second most common response of either a Latarjet (osteotomy at coracoid base) or remplissage procedure (Table III). Finally, no consensus was reached in the setting of isolated humeral bone loss of 30%-45% and a failed previous Bankart repair (case 4, Table III). The most common responses varied between a Latarjet procedure (shoulder and elbow specialists and generalists or other specialists) and humeral head osteoarticular allograft procedure (sports medicine specialists) (Table III).

Management of isolated glenoid bone loss

A consensus was reached across all subspecialty groups that the surgical management of a patient with recurrent instability, no previous surgery, and isolated critical glenoid bone loss would be a Latarjet procedure (case 5, Table IV). A consensus was also reached between sports medicine specialists and generalists or other orthopedic surgeons that the second most common type of surgical management would be a Bankart repair. A consensus was reached among sports medicine specialists (69.6%) that the surgical management of a patient with isolated glenoid bone loss of 0%-10% (ie, subcritical) and a failed previous Bankart repair would not involve a bony augmentation procedure but rather a revision Bankart repair (case 6, Table IV). Although a consensus was not reached, the most common survey response from the shoulder and elbow specialists was a Latarjet procedure (48.7%) whereas that from generalists or other orthopedic surgeons was a surgical procedure that would

Table III
Clinical vignettes of normal bone stock and humeral bone loss

	Shoulder and elbow specialists	Sports medicine specialists	Generalists or other specialists
Case 1: no previous surgery; no humeral or glenoid bone loss			
Most common response	Capsulolabral (Bankart) repair (100%)	Capsulolabral (Bankart) repair (98.9%)	Capsulolabral (Bankart) repair (94.4%)
Second most common response	NA	Bony augmentation—glenoid (1.1%)	Bony augmentation—glenoid (5.6%)
Case 2: no previous surgery; isolated critical humeral head bone loss			
Most common response	Capsulolabral (Bankart) repair (79.5%)	Capsulolabral (Bankart) repair (72.8%)	Capsulolabral (Bankart) repair (63.2%)
Second most common response	Remplissage procedure (51.3%)	Remplissage procedure (48.9%)	Remplissage procedure (42.1%)
Case 3: failed previous capsulolabral (Bankart) stabilization; isolated humeral head bone loss of 0%-20%			
Most common response	Remplissage procedure (61.5%)	Augmentation not required (38%)	Augmentation not required (42.1%)
Second most common response	Latarjet procedure (15.4%)	Remplissage procedure (34.8%)	Latarjet procedure (21%)
Case 4: failed previous capsulolabral (Bankart) stabilization; isolated humeral head bone loss of 30%-45%			
Most common response	Latarjet procedure (28.2%)	Humeral head osteoarticular allograft (33.7%)	Latarjet procedure (21%)
Second most common response	Humeral head osteoarticular allograft (25.6%)	Latarjet procedure (27.2%)	Remplissage procedure (21%)

NA, not applicable.

not involve bony augmentation (47.4%). Finally, a consensus was reached across subspecialty groups that the surgical management in a patient with isolated glenoid bone loss of >25%-30% and a failed previous Bankart repair would be a Latarjet procedure (case 7, Table IV). Although a consensus was not reached, the second most common responses from all subspecialty groups included other types of bony augmentation procedures to address glenoid bone loss.

Management of combined humeral and glenoid (bipolar) bone loss

A consensus was reached across subspecialty groups that the surgical management in a patient with recurrent instability, a previous Bankart repair, and critical humeral and glenoid bone loss would be a Latarjet procedure (case 8, Table V). A consensus was reached across subspecialty groups that the surgical management in a patient with combined glenoid bone loss < 10% and humeral bone loss < 20% and a failed previous Bankart repair would be a revision Bankart repair (case 9, Table V). Although a consensus was not reached, a trend was demonstrated across all subspecialties (ie, second most common response) to perform a Latarjet procedure (Table V).

A consensus was reached only among sports medicine specialists (62%) that the surgical management in a patient with combined glenoid bone loss < 10% and humeral bone loss of 30%-45% and a failed previous Bankart repair would be a revision Bankart repair (case 10, Table V). Although a consensus was not reached, the second most common survey response from all subspecialties was a revision Bankart repair combined with either remplissage or humeral head osteoarticular allograft.

A consensus was reached across subspecialty groups that the surgical management in a patient with combined glenoid bone loss > 25%-30% and humeral bone loss < 20% and a failed previous Bankart repair would be a Latarjet procedure (case 11, Table V). The

Table IV
Clinical vignettes of glenoid bone loss

	Shoulder and elbow specialists	Sports medicine specialists	Generalists or other specialists
Case 5: no previous surgery; isolated critical glenoid bone loss			
Most common response	Latarjet procedure (76.9%)	Latarjet procedure (68.5%)	Latarjet procedure (57.9%)
Second most common response	Capsulolabral (Bankart) repair (41%)	Capsulolabral (Bankart) repair (52.2%)	Capsulolabral (Bankart) repair (63.2%)
Case 6: failed previous capsulolabral (Bankart) stabilization; isolated glenoid bone loss of 0%-10%			
Most common response	Latarjet procedure (48.7%)	Augmentation not required (69.6%)	Augmentation not required (47.4%)
Second most common response	Augmentation not required (41%)	Latarjet procedure (20.7%)	Latarjet procedure (26.3%)
Case 7: failed previous capsulolabral (Bankart) stabilization; isolated glenoid bone loss > 25%-30%			
Most common response	Latarjet procedure (66.7%)	Latarjet procedure (78.3%)	Latarjet procedure (68.4%)
Second most common response	Glenoid augmentation using iliac crest autograft or allograft (23.1%)	Glenoid augmentation using iliac crest autograft or allograft (9.8%)	Bristow procedure (10.5%)

Table V
Clinical vignettes of humeral and glenoid (bipolar) bone loss

	Shoulder and elbow specialists	Sports medicine specialists	Generalists or other specialists
Case 8: failed previous capsulolabral (Bankart) stabilization; critical humeral and glenoid bone loss			
Most common response	Latarjet procedure (69.2%)	Latarjet procedure (70.7%)	Latarjet procedure (68.4%)
Second most common response	Humeral head osteoarticular allograft (25.6%)	Remplissage procedure (29.4%)	Remplissage procedure (21%)
Case 9: failed previous capsulolabral (Bankart) stabilization; glenoid bone loss < 10%; humeral bone loss < 20%			
Most common response	Capsulolabral (Bankart) repair (53.9%)	Capsulolabral (Bankart) repair (76.1%)	Capsulolabral (Bankart) repair (63.2%)
Second most common response	Latarjet procedure (38.5%)	Latarjet procedure (25%)	Latarjet procedure (21%)
Case 10: failed previous capsulolabral (Bankart) stabilization; glenoid bone loss < 10%; humeral bone loss of 30%-45%			
Most common response	Capsulolabral (Bankart) repair (38.5%)	Capsulolabral (Bankart) repair (62%)	Capsulolabral (Bankart) repair (42.1%)
Second most common response	Remplissage procedure (33.3%)	Humeral head osteoarticular allograft (32.6%)	Remplissage procedure (15.8%); humeral head osteoarticular allograft (15.8%)
Case 11: failed previous capsulolabral (Bankart) stabilization; glenoid bone loss > 25%-30%; humeral bone loss < 20%			
Most common response	Latarjet procedure (74.4%)	Latarjet procedure (72.8%)	Latarjet procedure (73.7%)
Second most common response	Capsulolabral (Bankart) repair (30.8%)	Capsulolabral (Bankart) repair (44.6%)	Capsulolabral (Bankart) repair (36.8%)
Case 12: failed previous capsulolabral (Bankart) stabilization; glenoid bone loss > 25%-30%; humeral bone loss of 30%-45%			
Most common response	Latarjet procedure (59%)	Latarjet procedure (67.4%)	Latarjet procedure (57.9%)
Second most common response	Humeral head osteoarticular allograft (33.3%)	Humeral head osteoarticular allograft (35.9%)	Capsulolabral (Bankart) repair (31.6%)

second most common survey response across all subspecialty groups was a revision Bankart procedure; however, a consensus was not reached. Finally, a consensus was reached across subspecialty groups that the surgical management in a patient with combined glenoid bone loss > 25%-30% and humeral bone loss of 30%-45% and a failed previous Bankart repair would be a Latarjet procedure (case 12, Table V). Although a consensus was not reached, the second most common survey response from both shoulder and elbow (33.3%) and sports medicine (35.9%) subspecialists was a revision Bankart repair combined with humeral head osteoarticular allograft whereas that from generalists or other specialists was a revision Bankart repair (31.6%) (Table V).

Discussion

The purpose of this survey study was to determine the different strategies used by shoulder and elbow specialists, sports medicine specialists, and generalists or other orthopedic surgeons to manage critical and subcritical bone loss in patients with recurrent anterior shoulder instability. Survey respondents were considered knowledgeable and experienced in shoulder instability management: 87.3% of respondents were shoulder and elbow or sports medicine specialists, the respondents had a mean of 12.5 years in practice, and 41% of annual cases performed by respondents were shoulder instability surgical procedures. There was also a nearly equal distribution between academic (48.7%) and nonacademic (47.3%) surgeons in our study cohort.

Regarding known risk factors associated with critical bone loss, a consensus was reached across subspecialties that the total number of shoulder dislocations directly affects the magnitude of bone loss. In 2019, Dickens et al[19] conducted a prospective cohort study of athletes over a 4-year period to determine the amount of glenoid bone loss related to first-time and recurrent instability events. After a first-time dislocation, the average loss of glenoid width was 6.8%, which increased to 22.8% after a second instability episode. In a 2017 systematic review by Gottschalk et al,[25] among studies reporting the percentage loss of glenoid width, 23.6% of shoulders had a loss of glenoid width between 10% and 25%. Furthermore, in a prospective multicenter cohort study, Rugg et al[69] demonstrated that first-time shoulder dislocators were less likely to have bone loss or biceps pathology and were more frequently managed with an arthroscopic capsulolabral repair. However, recurrent dislocators were more likely to require an open Bristow-Latarjet procedure to manage critical bone loss.[69] These studies support the relationship between recurrent instability and the creation of critical bone loss.

A consensus was reached across subspecialties that the age of the patient influences whether a bony augmentation procedure is performed when critical bone loss is present. The current literature reflects this consensus given that younger age is considered a contributing factor to recurrent instability.[14,19,42,61,62,65,66] Robinson et al[66] demonstrated in a prospective cohort study that male patients aged < 25 years had a 78% chance of recurrent instability within 2 years of injury, which increased to 85% within 5 years of injury when patients were managed nonoperatively. Our survey also found a trend toward surgeon consideration of a bony augmentation procedure when critical bone loss is encountered in middle-aged patients younger than 50 years. These findings have been reinforced in the current literature.[28] However, surgeons should be aware of certain complications (eg, progression of

dislocation arthropathy) that seem to occur more frequently in patients who undergo an augmentation procedure at an older age.[20]

Each surgical subspecialty reached a consensus that the quantity of bone loss present affects the decision to perform a bony augmentation procedure. The primary surgical procedure of choice for a patient with recurrent anterior instability and "normal" bone stock was a capsulolabral (ie, "anatomic" soft-tissue) stabilization procedure. Although not explicitly stated in this survey case, there are parallels with this case and the controversy that surrounds the management of first-time dislocators (ie, managing the patient with less invasive, anatomic soft-tissue techniques before critical bone loss develops). In a systematic review of 5 level I and II studies, Barlow et al[3] revealed that the pooled postoperative recurrence rate following a Bankart procedure in patients with 1 preoperative instability episode was 7.1%; in comparison, the recurrence rate in patients with more than one preoperative event ranged between 0%-59.4%. This paradigm shift of earlier surgical management in first-time dislocators, as compared with a wait-and-see approach, has been shared by other authors[11] and increasingly adopted in other parts of the world.[48] Furthermore, in another recently performed systematic review (9 studies, 822 shoulders) analyzing the long-term results of arthroscopic Bankart repair in patients with recurrent instability, Murphy et al[53] found an overall recurrent instability rate of 31.2% and revision surgery rate of 17%. Such information should be discussed with patients preoperatively to ensure that appropriate patient expectations for such surgical procedures have been established.

Regarding the management of isolated critical humeral bone loss and no previous surgery, a consensus was reached across all subspecialties that a Bankart repair with or without remplissage would be performed. A critical review conducted by Provencher et al[63] established algorithms for treating different types of bone loss. The results of their review, as well as a systematic review and meta-analysis conducted in 2018 by Liu et al,[43] support our findings that combined Bankart repair and remplissage are appropriate for managing recurrent instability with humeral head bone loss of 20%-25% and subcritical glenoid bone loss. However, of the 22 level III and IV studies (representing 694 shoulders) included in the review by Liu et al, only 4 (18.2%) quantified glenoid bone loss, only 3 (13.6%) quantified humeral bone loss, and recurrence rates ranged as high as 20%. Therefore, without a clear definition of the pathology being surgically addressed (ie, quantity of bone loss), strong conclusions cannot be made from this study.

For patients with isolated humeral head bone loss (subcritical) and a previous failed Bankart repair, a consensus was reached only within 1 subspecialty group (shoulder and elbow specialists) that the surgical management of humeral bone loss of 0%-20% would be a revision Bankart repair combined with a remplissage procedure. Although the clinical vignettes of isolated critical humeral bone loss are largely theoretical and aimed at assessing surgeons' treatment of humeral lesions, the survey findings reinforce the continuing controversy and lack of evidence available to help guide the surgical management of critical humeral bone loss.

For patients with isolated critical glenoid bone loss and no previous surgery, a consensus was reached across all subspecialty groups that a Latarjet procedure would be performed. In the revision case scenario (ie, failed previous Bankart repair) with isolated subcritical glenoid bone loss, a consensus was surprisingly only reached by sports medicine specialists (69.6%) that a bony augmentation procedure was not required. In a clinical cohort study by Shaha et al,[71] glenoid bone loss as low as 13.5% (ie, subcritical) led to a clinically significant decrease in Western Ontario Shoulder Instability index scores following an arthroscopic Bankart repair, even in patients who did not experience recurrent instability postoperatively. This lower threshold of isolated glenoid bone loss has also been established in recent biomechanical[73] and clinical studies.[72]

Once glenoid bone loss reached higher magnitudes, a consensus was reached across all subspecialty groups that a bony augmentation (ie, Latarjet procedure) was required to restore the safe arc of the glenoid fossa. This finding is in keeping with the current clinical and biomechanical literature, regardless of surgical timing (ie, primary or revision surgical procedure).[4,7,13,24,27,34,44,51,82] Although a satisfactory result can be expected after a Latarjet procedure when used in the revision setting after failed soft-tissue stabilization, complication rates remain higher in patients with $\geq$2 previous surgical procedures (40%) than in patients with only 1 previous surgical procedure (21%).[50] Furthermore, a Latarjet procedure following failed soft-tissue stabilization remains a cost-effective treatment option compared with revision arthroscopic instability repair.[47]

Regarding the management of combined critical humeral and glenoid (ie, bipolar) bone loss and a previous failed Bankart repair, a consensus was reached across all subspecialty groups that a Latarjet procedure would be performed. In the revision cases in which subcritical glenoid bone loss was held constant and humeral bone loss was adjusted, the most common response for all subspecialties was a revision capsulolabral repair. In a biomechanical study evaluating the relationship of bipolar bone loss, bony reconstruction was indicated for humeral head defects as small as 19% (ie, relative to the humeral head diameter) and glenoid defects as small as 10% to 20% of the glenoid width.[26]

For revision bipolar bone loss cases in which glenoid bone loss was held constant and humeral bone loss was adjusted, a consensus was reached across all subspecialty groups that a Latarjet procedure would be performed. Although other bony augmentation procedures were listed as potential options for survey respondents, the Latarjet procedure was the most common bony augmentation procedure selected. In a recently performed systematic review (13 studies, 845 shoulders) analyzing the long-term results of the Latarjet procedure, Hurley et al[32] found an overall high rate of return to sports (84.9%) and low rate of recurrent instability (8.5%). The rates of return to sports and recurrent instability found by Hurley et al remain significantly better than those reported following arthroscopic Bankart repair.[86] On the basis of our survey findings, what seems to influence the surgical decision to perform a bony augmentation procedure in the setting of bipolar lesions is an increasing magnitude of glenoid bone loss, not humeral bone loss. Moving forward, surgeons should be aware that the previously established thresholds of critical bone loss are not equally relevant in the presence of bipolar lesions. This concept was first described in 2007 with the introduction of the glenoid track, as the "interaction" of combined glenoid and humeral head lesions[83]; our understanding of the glenoid track continues to evolve to this day.[29] For bipolar lesions, this often necessitates a bony augmentation procedure, and with higher magnitudes of combined bone loss, both the humeral and glenoid sides need to be addressed.[26,60,63,84]

There are several study strengths that deserve mentioning: (1) A detailed investigation of the management trends for bone loss in recurrent instability was performed, despite a low response rate; (2) responses were received from orthopedic surgeons practicing in different contexts in an attempt to make the results generalizable to different surgeon groups (eg, generalists vs. specialists and academic vs. nonacademic surgeons); and (3) specific clinical vignettes were created to better define management trends in different clinical contexts in an attempt to identify potential knowledge gaps and help guide future research.

Limitations of our investigation include an overall low response rate, which could be explained by the increasing frequency of survey distribution within the orthopedic surgery community. Members of only 4 associations within North America were surveyed; therefore, our findings may not be generalizable to other surgeon groups. Moreover, 10 members (6.7%) who completed the survey resided outside North America; therefore, the views discussed in this study are not entirely those of North American surgeons. Many shoulder surgeons are knowledgeable with respect to "best practice" as it relates to the management of bone loss and shoulder instability; however, this may not reflect their behavior in their individual surgical practices (ie, response bias). In addition, the surgical recommendations of inexperienced or young surgeons (ie, AANA fellows) were treated equally to those of more experienced surgeons; overall, respondents represented early- to mid-career surgeons (ie, average 12.5 years in practice), and the results do not necessarily reflect the opinions of more experienced surgeons. Survey vignettes were designed around specific prognostic factors related to surgical failure following an arthroscopic Bankart repair (eg, age of patient, revision surgery, and presence of bone loss). However, we did not include all known prognostic factors (eg, type of sports participation and capsular laxity) or the surgical method used for the revision procedure (ie, arthroscopic vs. open) in an effort to limit the total number of clinical cases and lower the response burden (Fig. 1).[2] Finally, the time interval between survey administration and dissemination of the study results limits our ability to evaluate evolving concepts in shoulder instability management. Some evolving concepts include the lower acceptable critical thresholds of bone loss,[26,71] trends in treatment algorithms for the surgical management of the first-time dislocator,[3,11,39] the glenoid track,[21,29,42,83] and emerging trends in surgical techniques for addressing critical bone loss.[6,52,74] Despite these weaknesses, the data presented in this study could be used as a baseline and for hypothesis generation to guide further research.

Conclusion

This survey study demonstrates that a cohort of early- to mid-career surgeons tended to reach a consensus for managing recurrent shoulder instability when no bone loss exists and when isolated critical glenoid bone loss is present. The survey findings reinforce the continuing controversy and lack of evidence available to guide surgeons on the management of critical humeral bone loss. In the setting of bipolar bone loss, what seems to influence surgical decision making is an increased magnitude of glenoid bone loss, not humeral bone loss. Additional studies are warranted to further understand the role of subcritical and bipolar bone loss in recurrent anterior shoulder instability.

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Supplementary data

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