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Clinical and radiographic outcomes of primary vs. revision arthroscopic anatomic glenoid reconstruction with distal tibial allograft for anterior shoulder instability with bone loss

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Background: The purpose of this study was to assess the clinical and radiographic outcomes of arthroscopic anatomic glenoid reconstruction (AAGR) used for primary vs. revision surgery for addressing anterior shoulder instability with bone loss.

Methods: We performed a retrospective review on consecutive patients who underwent AAGR from 2012 to 2020. Patients who received AAGR for anterior shoulder instability with bone loss and had a minimum follow-up of 2 years were included. Exclusion criteria included patients with incomplete primary patient-reported outcome scores (PROs), multidirectional instability, glenoid fracture, nonrigid fixation and concomitant humeral avulsion of the glenohumeral ligament, or rotator cuff repair. Our primary outcome was measured using the Western Ontario Shoulder Instability Index (WOSI) scores. Secondary outcomes included postoperative Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) scores, complications, recurrence of instability and computed tomographic (CT) evaluation of graft position, resorption, and healing.

Results: There were 73 patients (52 primary and 21 revision) finally included. Both groups had comparable demographics and preoperative WOSI and DASH scores. The primary group had significantly better postoperative WOSI and DASH scores at final follow-up when compared to the revision group (WOSI: 21.0 vs. 33.8, $P = .019$; DASH: 7.3 vs. 17.2, $P = .001$). The primary group also showed significantly better WOSI scores than the revision group at the 6-month, 1-year, and 2-year time points ($P = .029$, .022, and .003, respectively). The overall complication rate was 9.6% (5 of 52) in the primary group and 23.8% (5 of 21) in the revision group. Both groups showed good graft healing and placement in the anterior-to-posterior and mediolateral orientation and had a similar rate of graft resorption and remodeling. There was no difference between the groups in the remainder of the CT measurements.

Conclusion: Functional outcome scores and stiffness were significantly worse in patients undergoing an AAGR procedure after a failed instability surgery when compared with patients undergoing primary AAGR. There were no differences in postoperative recurrence of instability or radiographic outcomes. As a result, AAGR should be considered as a primary treatment option within current treatment algorithms for shoulder instability.

This study was performed at Queen Elizabeth Health Sciences Center, Halifax, Nova Scotia, Canada.
Ethics approval was obtained from the Nova Scotia Health Research Ethics Board, file number 1025519.

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The treatment of recurrent anterior shoulder instability has evolved over the past decade because of an increasing understanding of instability-related bone deficits. Glenoid bone loss is reported in up to 22% of primary dislocations and 90% of recurrent dislocations,[10,17] and it can lead to an unacceptably high failure rate of soft tissue stabilization procedures, ranging from 3.4% to 33.3%.[8] Currently, the North American standard for treatment is typically a soft tissue stabilization procedure. In contrast, the European approach tends toward the primary use of the Latarjet procedure, which despite exhibiting a lower recurrence rate, is accompanied by a high complication rate ranging from 15% to 30%.[14] More recent development has introduced a third option, in the form of free bone block procedures. These procedures have gained attention because of their notably low reported complication rates and their efficacy in mitigating recurrence of instability.[13] In light of these new techniques and an evolving understanding of influencing factors, there is much debate over optimal timing for these bony procedures.

Arthroscopic anatomic glenoid reconstruction (AAGR) is a free bone block technique using distal tibial allograft. It was first described by Wong and Urquhart in 2015 to gain access to the anterior glenoid rim for graft placement without the need for a subscapularis split.[42] Since 2015, it has been evaluated by cadaveric studies, radiographic analysis, and short- and midterm outcome studies.[1,25,26,40,41] A midterm follow-up study conducted over an average period of 4.7 years on 73 patients reported no neurovascular injuries, no redislocations, and sustained improvement in patient-reported outcomes (PROs).[40] In a systematic review of 27 AAGR studies, recurrence of instability was reported to be 5%.[23] However, despite these promising outcomes of AAGR, uncertainty remains around the efficacy of primary AAGR, used as an initial surgical procedure, vs. revision AAGR, used as a salvage procedure following the failure of an initial soft tissue procedure. Therefore, the purpose of this study was to assess the clinical and radiographic outcomes of AAGR used for primary vs. revision surgery for addressing anterior shoulder instability associated with bone loss to determine where it best fits in the algorithm for the management of anterior shoulder instability.

Methods

Ethics approval was obtained through the Nova Scotia Health Authority Research Ethics Board. All operations were performed by the senior author (I.W.). A retrospective cohort study using prospectively collected data was performed to compare patients who underwent revision AAGR after a failed soft tissue stabilization surgery, vs. those who underwent primary AAGR. All patients who had an AAGR procedure with distal tibial allograft between 2012 and 2020 were identified. Patients were included if they were >18 years of age, had recurrent anterior shoulder instability requiring a glenoid bone graft, and had a minimum of 2 years of clinical follow-up. Indications for a glenoid bone graft was the presence of ≥13.5% glenoid bone loss on preoperative en face 3D computed tomography (CT) scan using the PICO method.[3,37] Those with incomplete primary patient-reported outcome scores (PROs), multidirectional instability, glenoid fracture, nonrigid fixation and concomitant humeral avulsion of the glenohumeral ligament, or rotator cuff repair were excluded. Patients were then separated into 2 groups: those who received AAGR as a primary procedure vs. those who received it as a revision to a prior soft tissue stabilization surgery.

Surgical technique

Both primary and revision surgeries were performed arthroscopically by a single surgeon using the technique described by Wong and Urquhart.[42] The patient is placed in the standard lateral decubitus position, under general anesthesia with the arm placed in a pneumatic arm holder in 45° of abduction. A diagnostic arthroscopy is performed, followed by débridement of the rotator interval, exposing the conjoint tendon and coracoacromial ligament (Fig. 1, *A*). If an on-track Hill-Sachs defect was identified, anchors were placed for a remplissage, which were tied down at the end of the procedure. A traction suture is passed around the labrum at the 3-o'clock position, followed by a longitudinal incision of the labrum, just anterior to the biceps anchor. The labral and capsular tissue is then elevated from the anterior glenoid rim toward the 6-o'clock position, and a bur is used to flatten the anteroinferior surface of the glenoid. The glenoid is measured with a calibrated probe and compared to measurements obtained from the preoperative CT scan. A fresh frozen distal tibial allograft bone block is then prepared using the anterolateral surface of the distal tibia (Fig. 1, *B*). The width of the graft is determined by the width of the glenoid face, with a goal postoperative glenoid + graft anterior-posterior width of 32 mm. The Halifax portal is then established by an inside-out technique: a switching stick is passed through the posterior portal parallel to the glenoid, kept superior to the subscapularis, and lateral to the conjoint tendon, directed through the deltopectoral interval and toward the axilla. A 4-cm incision is made over the switching stick and 2 half-pipe cannulas are inserted into the Halifax portal. The graft is then shuttled through the 2 half-pipe cannulas and advanced toward the anteroinferior glenoid. The graft is fixed to the glenoid using 2 cannulated screws, with the graft centered at the 3-o'clock position on the native glenoid (Fig. 1, *C*). Lastly, the capsulolabral

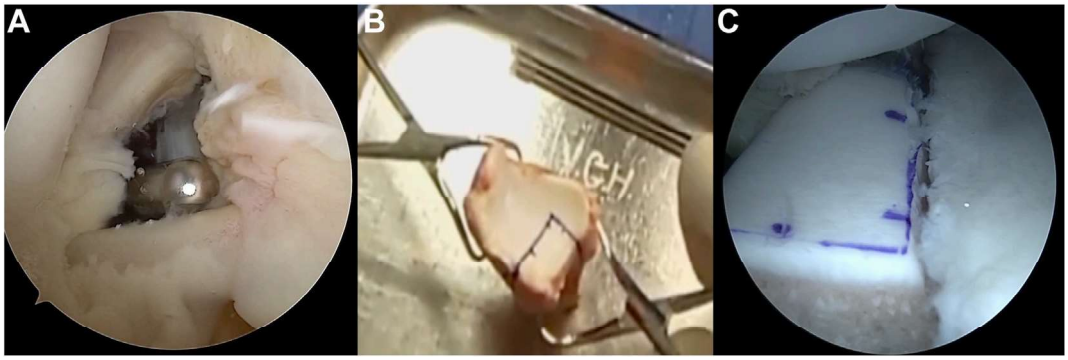

Figure 1 (**A**) Arthroscopic image from a posterior viewing portal in a left shoulder in lateral decubitus. Débridement of the rotator interval, exposing the conjoint tendon and coracoacromial ligament is performed. (**B**) The anterolateral surface of a fresh frozen distal tibial allograft is cut. The width of the graft is determined by the width of the glenoid face, with a goal postoperative glenoid + graft anterior-posterior width to be equal to the opposite side or the predicted glenoid size. (**C**) Arthroscopic image from an anterosuperior viewing portal in a right shoulder. The graft is shuttled through the Halifax portal and is fixed to the glenoid using 2 cannulated screws, with the graft centered at the 3-o'clock position on the native glenoid.

tissue is reduced over the graft and anchored to the native glenoid, keeping the allograft extra-articular.

Outcome measures

Our primary outcome measure was the Western Ontario Shoulder Instability Index (WOSI) score at 2 years postoperation.[22] Secondary outcome measures included the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) score at 2 years postoperation, recurrence of instability, complications, and CT evaluation of graft position, resorption, and healing.[16] PROs were completed preoperatively and postoperatively at 6 months, 1 year, and annually thereafter. The WOSI is a condition-specific questionnaire designed for patients with shoulder instability and has shown a high degree of validity, reliability, and responsiveness.[20,22,33] The DASH has been found to be moderately responsive in patients with shoulder instability.[16,29] The minimal clinically important difference has been reported as 10% for WOSI and 10.2% for DASH.[20,43] The patient acceptable symptom state has been reported as 27.2% for WOSI and 43% for DASH.[6,24]

CT scans were acquired preoperatively, and then at 2 years postoperatively to evaluate graft healing, resorption, and placement. All CT scans were reviewed by a fellowship-trained orthopedic surgeon (K.K.). Graft resorption was assessed on the axial CT images using a modification of the Zhu classification for coracoid graft resorption[40] (Fig. 2): grade 0: no resorption of the graft; grade I: exposure of the top-hat washer corresponding roughly to <25% graft resorption; grade II: exposure of half the screw shaft length within the graft, corresponding to roughly <50% graft resorption; grade III: exposure of 50% of the screw shaft length within the graft, corresponding to ≥50% graft resorption. The alpha angle was measured on axial CT as the angle between the axis of the screw shaft and the native glenoid rim.[5] Graft height was measured on the en face view of the sagittal CT, classifying it as high, medium, and low, based on the position of the graft being higher than, at, or lower than the normal anterior glenoid bone would be. Mediolateral position and step formation of the graft was measured on axial view at the junction of the graft and native glenoid. Lines tangential to each of the graft and glenoid surfaces were drawn, and the distance between them at the junction was the value for the step deformity. Bony union was defined as the presence of bridging trabecular bone between the graft and the native glenoid on axial CT.[41] Glenoid diameter was defined as the distance from the posterior glenoid rim to the apex of the anterior glenoid bone graft at the craniocaudal midpoint on axial images. The diameter of the native glenoid and graft were measured in the same fashion.

Statistical analysis

Descriptive statistics were performed for both groups. Continuous data including demographic data, outcome scores, alpha angle and glenoid dimensions were compared between both groups using a 2-tailed independent *t* test or Mann-Whitney *U* test depending on the results of Levene test and normality test. Outcome scores were compared within both groups using a paired sample *t* test or Wilcoxon signed-rank test depending on the results of Levene test and normality test. Categorical data including complications, graft healing, resorption, and position were compared between the 2 groups using χ^2 test or Monte Carlo simulation with 99% CI if the assumptions of χ^2 test were not met. Statistical analysis of the data was carried out using SPSS (version 25; IBM Corp., Armonk, NY, USA). All analyses were performed at a 95% significance level ($\alpha = 0.05$).

Results

A total of 149 patients had AAGR with distal tibial allograft between 2012 and 2020. Fifty-two patients were excluded because of missing primary outcomes scores or concurrent pathology. An additional 10 patients were lost to follow-up, and 14 patients did not fill out the questionnaires properly and were excluded. As a result, 73 patients were included in the analysis. Among the included patients, 52 patients underwent AAGR as a primary procedure and 21 patients had AAGR as a revision procedure (Fig. 3).

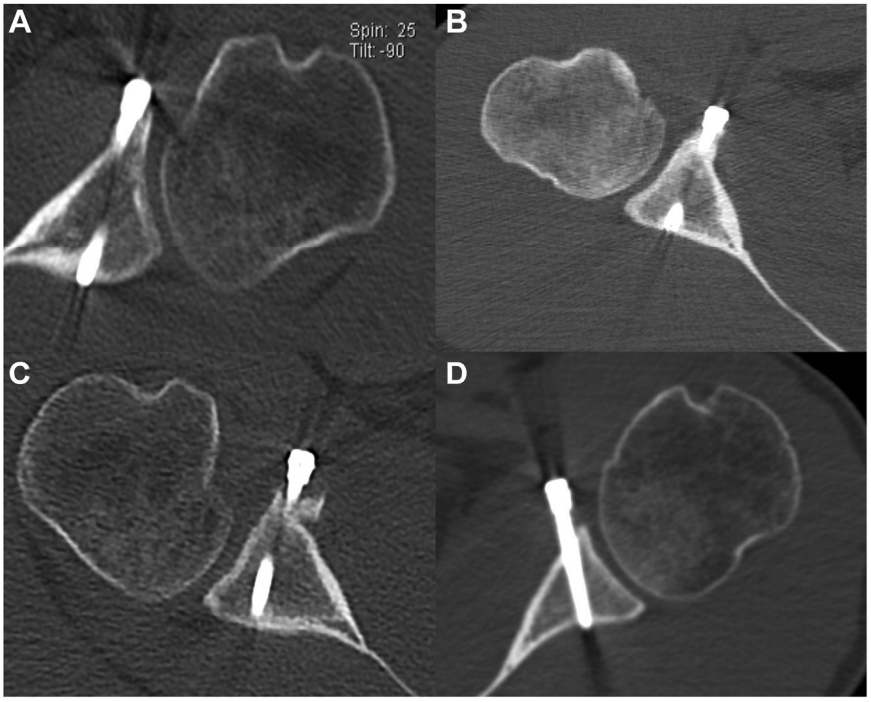

Figure 2 Graft resorption was assessed on the axial computed tomographic images using a modification of the Zhu classification for coracoid graft resorption. (**A**) Grade 0: no resorption of the graft. (**B**) Grade I: Exposure of the top-hat washer corresponding roughly to <25% graft resorption. (**C**) Grade II: Exposure of half the screw shaft length within the graft, corresponding to roughly <50% graft resorption. (**D**) Grade III: 50% of the screw shaft length within the graft was exposed, corresponding to ≥50% graft resorption.

The mean clinical follow-up was 3.2 ± 1.2 years in the primary group and 3.1 ± 1.1 years in the revision group. There were no differences in age, gender, or body mass index between the 2 cohorts (Table I). There was no difference in the average amount of glenoid bone loss measured on preoperative CT scans between the 2 groups (20.5% ± 6.9% in the primary group and 23.3% ± 8.3% in the revision group; $P = .140$).

Both groups had comparable baseline WOSI and DASH scores preoperatively ($P = .318$ and $P = .616$, respectively) and both showed a significant improvement in WOSI and DASH scores at final follow-up within each group (primary: $P < .001$ and $P < .001$, respectively; revision: $P < .001$ and $P = .002$, respectively) (Figs. 4 and 5). Patients who underwent revision AAGR demonstrated significantly worse postoperative WOSI and DASH scores compared to patients undergoing primary AAGR at final follow-up ($P = .019$ and $P = .001$, respectively). Additionally, the superiority of the primary group was also found at the 6-month ($P = .029$), 1-year ($P = .022$), and 2-year ($P = .003$) follow-up visits, demonstrated by significantly better WOSI scores when compared to the revision group (Fig. 6). An identical trend in DASH scores was also identified at the 6-month ($P = .03$), 1-year ($P = .03$), and 2-year ($P = .013$) follow-up visits (Fig. 7). The percentage of patients who reached the minimal clinically important difference of WOSI (90% in primary and 76% in revision) and DASH (98% in primary and 83% in revision) scores was higher in the primary group than that of the revision group; however, it did not reach statistical significance ($P = .139$ and $P = .125$, respectively). The primary group had a significantly higher percentage of patients who met the patient acceptable symptom state of WOSI than the revision group (71% vs. 43%, $P = .033$); however, this statistical significance was not found in the comparison of the patient acceptable symptom state of DASH between the 2 groups at final follow-up (100% in primary and 90% in revision, $P = .080$). The number of patients who reported their level of apprehension of the shoulder as >50% on the WOSI questionnaire was 3.8% (2 of 51) in the primary group and 14.3% (3 of 21) in the revision group ($P = .139$).

The overall complication rate was 9.6% (5 or 52) in the primary group and 23.8% (5 of 21) in the revision group ($P = .139$). At the time of final follow-up, there was only 1 frank dislocation reported in the primary group, which was related to a seizure event, and no redislocations were reported in the revision group. Three cases of hardware irritation were observed in the primary group, and 1 was found in the revision group. This clinically presented as anterior shoulder pain with activation of the subscapularis muscle in all affected patients. Three of these 4 patients elected for a hardware removal procedure, as noted in the revision surgery row (Table II). All patients undergoing removal of hardware returned to full range of motion (ROM), including full external rotation at final follow-up. One revision surgery was performed in the primary group,

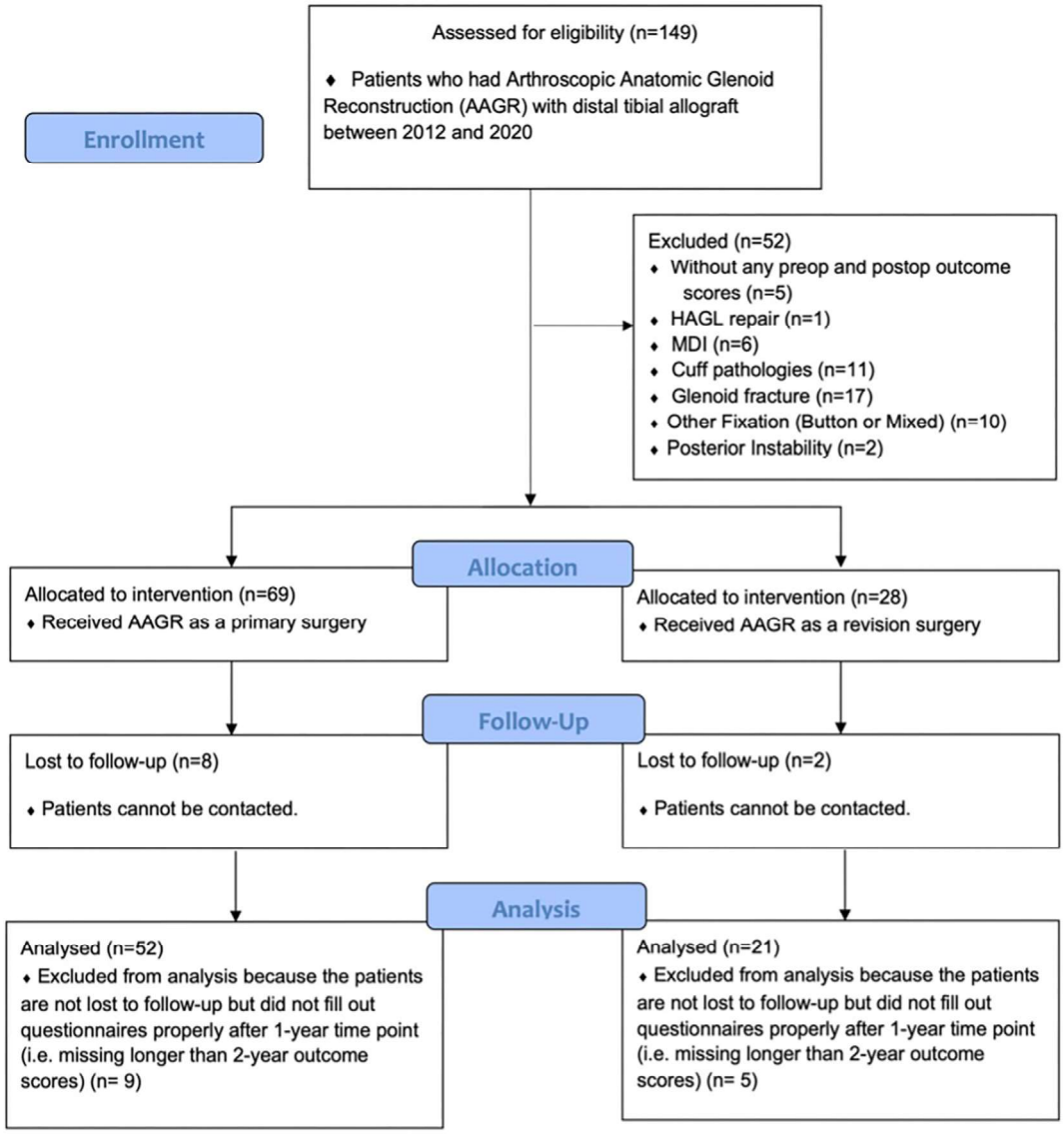

Figure 3 CONSORT flowchart of patient selections. A total of 149 patients had AAGR with distal tibial allograft between 2012 and 2020. Fifty-two patients were excluded because of missing primary outcomes scores or concurrent pathology. An additional 10 patients were lost to follow-up and 14 patients did not fill out the questionnaires properly and were excluded. As a result, 73 patients were included in the analysis. Among those included, 52 patients underwent AAGR as a primary procedure and 21 had AAGR as a revision procedure. *AAGR*, arthroscopic anatomic glenoid reconstruction; *HAGL*, humeral avulsion of the glenohumeral ligament; *MDI*, Multidirectional instability.

which was a revision for redislocation, and 1 revision surgery was performed in the revision group, which was a diagnostic arthroscopy to address postoperative stiffness. There were no significant differences between the 2 groups for postoperative complication rates, except for stiffness and adhesive capsulitis (Table II). Three patients reported stiffness or adhesive capsulitis in the revision group, but none were found in the primary group ($P = .021$).

Postoperative CT scans were performed in 64 patients (86.5% [45] in the primary group and 90.5% [19] in the revision group), as 9 patients' images were not accessible on the local PACS (picture archiving and communication system) for measurement. There were no differences between the groups in the CT measurements (Table III). Both groups showed good graft healing and placement in the anterior-to-posterior and mediolateral orientation and had a similar rate of graft resorption (Table III). The mean glenoid + graft diameter was 31 ± 3 mm in the primary group and 32 ± 5 mm in the revision group. Postoperative glenoid and graft dimensions compared with each graft resorption level is displayed in Table IV.

Table I Demographic information

Variables	Primary (n = 52)	Revision (n = 21)	*P* value, alpha = 0.05
Age at surgery, yr	26.5 ± 9.9	30.8 ± 10.6	.110
BMI	25.7 ± 4.7	27.0 ± 5.9	.550
Clinical follow-up, yr	3.2 ± 1.2	3.1 ± 1.1	.923
Radiographic follow-up, yr	1.5 ± 1.3	1.3 ± 1.4	.527
Percentage of glenoid bone loss on preoperative CT	20.5 ± 6.9	23.3 ± 8.3	.140
Sex, n			.765
Male	40	15	
Female	12	6	
Side, n			.121
Left	26	15	
Right	26	6	

BMI, body mass index; *CT*, computed tomography.
Unless otherwise noted, values are mean ± standard deviation.

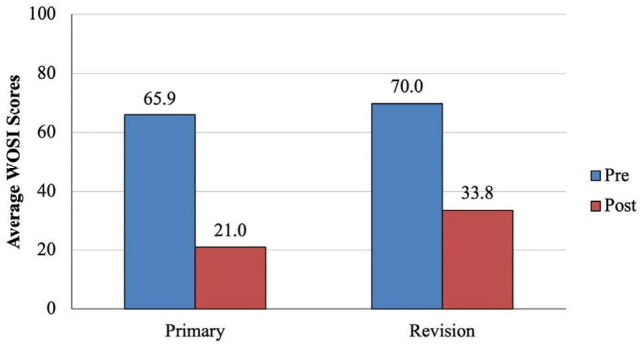

Figure 4 A comparison of average WOSI scores in the primary and revision groups at baseline and at final follow-up. The primary group showed a significant improvement from preoperatively 65.9 ± 15.3 to postoperatively 21.0 ± 16.7 ($P < .001$). The revision group also showed a significant improvement from preoperatively 70.0 ± 17.5 to postoperatively 33.8 ± 23.7 ($P < .001$). *WOSI*, Western Ontario Shoulder Instability Index.

Discussion

The primary finding of this study is that the primary AAGR cohort had significantly better postoperative PROs than the revision group, with no differences in recurrence of instability or radiographic outcomes. Additionally, the revision group had significantly more cases of postoperative stiffness compared with the primary group. An important strength of our study is the postoperative evaluation of DTA consolidation and positioning with CT. We found no significant difference in graft consolidation between the

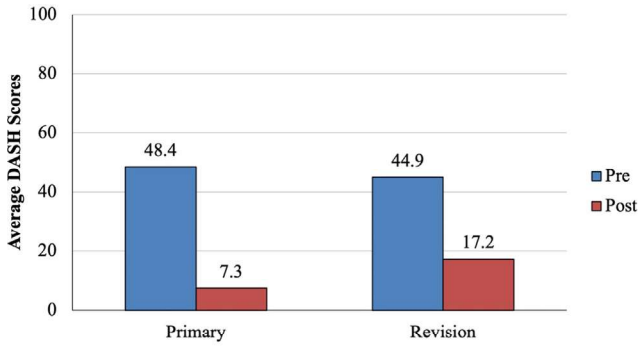

Figure 5 A comparison of average DASH scores in the primary and revision groups at baseline and at final follow-up. The primary group showed a significant improvement from preoperatively 48.4 ± 20.3 to postoperatively 7.3 ± 9.6 ($P < .001$). The revision group also showed a significant improvement from preoperatively 44.9 ± 25.1 to postoperatively 17.2 ± 14.9 ($P = .002$). *DASH*, Disabilities of the Arm, Shoulder, and Hand questionnaire.

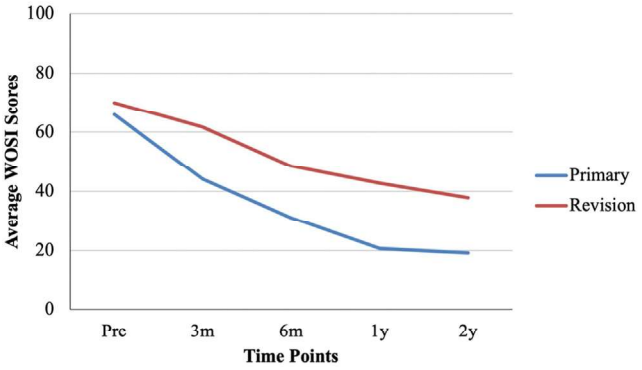

Figure 6 Comparison of the WOSI scores between primary and revision groups from preoperative to postoperative at 3 months, 6 months, 1 year, and 2 years. The primary group showed significantly better WOSI scores than the revision group at 6 months, 1 year, and 2 years postoperation ($P = .029$, .022, and .003, respectively). *WOSI*, Western Ontario Shoulder Instability Index.

groups. Furthermore, the DTA graft was accurately positioned in the axial plane in all of the patients, showing similar screw position angles and good postoperative glenoid diameter for glenoid reconstruction size, which is similar to results reported in the literature.[1,40]

Although multiple studies have investigated patient-reported outcomes in AAGR procedures, they have typically failed to distinguish outcomes between primary and revision cases.[1,2,4,12,27] In contrast, the Latarjet literature offers a more robust body of work, with several studies evaluating the differences between primary and revision surgeries, with varying results.[7,11,31,32,39,44] Similar to the results of our current study, several authors have found inferior outcomes following revision Latarjet procedures. Flinkkilä et al[11] described prior Bankart repairs as an independent risk factor for inferior outcome of the Latarjet

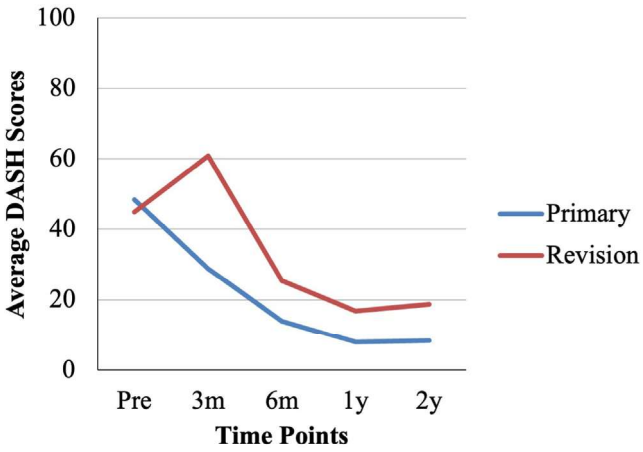

Figure 7 Comparison of DASH scores between the primary and revision groups from preoperative to postoperative at 3 months, 6 months, 1 year, and 2 years. The primary group showed significantly better DASH scores than the revision group at 3 months, 1 year, and 2 years postoperation ($P = .03$, .03, and .013, respectively). *DASH*, Disabilities of the Arm, Shoulder, and Hand questionnaire.

Table II Comparison of postoperative complications between the 2 groups

	Primary (n = 52)	Revision (n = 21)	*P* values
Frank dislocation	1	0	.999
Subluxation	1	0	.999
Infection	0	0	—
Hardware complications, n (%)	3 (5.8)	1 (4.8)	.999
Graft or glenoid fracture	0	0	—
Chondrolysis	0	0	—
Neurovascular deficit	0	0	—
Stiffness or adhesive capsulitis, n (%)	0	3 (14.3)	**.021**
Revision surgery, n (%)	3* (5.8)	2* (9.5)	.621
Arthritis, n (%)	0	1 (4.8)	.288

Boldface indicates significance ($P < .05$).

* Two of 3 revision surgeries in the primary group are hardware removal, and 1 of the 2 revision surgeries in the revision group is hardware removal.

procedure, based on worse postoperative WOSI scores and instability recurrence in their revision group. Rodkey et al[31] also describes worsening outcomes with prior Bankart repairs for revision Latarjet as compared to primary Latarjet, with primary Bankart repairs greatly increasing the rate of instability recurrence. In contrast, others have reported equivalent results between primary and revision Latarjet procedures.[7,32,44] Yapp et al examined 205 open Latarjet cases (145 primary; 60 revision) and found no differences in postoperative complications, WOSI, DASH or recurrence of instability.[44] Additionally, a recent systematic review and meta-analysis of primary vs. revision Latarjet procedures found no difference between clinical outcomes and recurrence of instability between the groups; however, they did find a higher infection rate in revision procedures (2.6% vs. 1.2%).[18] Although our primary comparative data are from the Latarjet literature, care should be taken when interpreting the results. A higher infection rate was not seen in our study, likely because of the all-arthroscopic nature of AAGR. Arthroscopic procedures have shown an exceedingly low rate of infection compared with open surgery and therefore should be less of a concern when considering revision surgery.[30,45]

The algorithm for the management of anterior shoulder instability is continuously debated, with emphasis more recently on the significance of addressing functional bone loss. As a result, the use of bone block procedures has increased and there has been a growing advocacy for AAGR as a primary intervention for patients with shoulder instability. A recent study by Tucker et al[38] has provided compelling evidence, demonstrating superior outcomes of primary AAGR compared to primary Bankart repair. A total of 174 patients were retrospectively examined (107 with primary Bankart repair vs. 67 with AAGR) with 25 frank dislocations noted in the primary Bankart repair group, whereas none were observed in the AAGR group. Our study's finding of worse outcomes in the context of revision procedures thereby strengthens the argument to consider AAGR as a primary intervention for management of shoulder instability with glenoid bone loss. Primary AAGR is currently indicated in the senior author's practice for patients with ≥13.5% glenoid bone loss; however, with the presence of a large off-track Hill-Sachs defect, AAGR should be considered for lesser amounts of glenoid bone loss in order to restore a more anatomic glenoid track. With the addition of a Bankart repair over the graft and the ability to simultaneously perform a remplissage if necessary, AAGR is a versatile procedure that allows for correction of all intra-articular pathology.

Worsened functional outcomes in the absence of recurrence of instability has previously been reported in the literature[35]; however, it is still not clear why this is observed in our revision population. It is possible that damage occurs during the initial recurrence of instability and in the interim before the revision procedure, potentially leading to irreversible cartilage and soft tissue damage. These changes could account for the differences seen in midterm outcomes in the PROs, without causing recurrence. Duchman et al found that 47.6% of revision stabilizations surgeries displayed concurrent bone-cartilage lesions, in contrast to the only 18.4% observed in primary surgeries among 545 shoulders.[9] Similarly, Orvets et al reported that 73% of patients undergoing magnetic resonance imagining more than 6 months after their initial dislocation exhibited cartilage damage, compared with only

Table III Comparison of postoperative radiographic variables between the 2 groups

	Primary (n = 45)*	Revision (n = 19)*	*P* values
Alpha angle, degrees, mean ± SD	21 ± 9	21 ± 7	.994
AP glenoid + graft dimensions, mm, mean ± SD	31 ± 3	32 ± 5	.104
AP graft dimension, mm, mean ± SD	8 ± 2	10 ± 4	.071
AP glenoid dimension, mm, mean ± SD	23 ± 3	22 ± 3	.724
ML position step, mm, mean ± SD	−0.1 ± 0.6	−0.3 ± 0.7	.413
Graft healing, n (%)	44 (97.8)	19 (100)	.999
Graft resorption, n (%)			.093 (CI .085, .100)
Grade 0	5 (11.1)	5 (26.3)	
Grade I	18 (40.0)	6 (31.6)	
Grade II	12 (26.7)	1 (5.3)	
Grade III	10 (22.2)	7 (26.6)	
Graft positions (3-5 o'clock, ie, ideal position)	45 (100)	19 (100)	—

SD, standard deviation; *AP*, anteroposterior; *ML*, mediolateral.

* Nine patients' postoperative computed tomographs (CTs) were not accessible on the local PACS (picture archiving and communication system) for measurement; therefore, only 64 patients' postoperative CTs were included in the analysis.

Table IV Comparison of postoperative anterior-posterior dimensions between the 2 groups in terms of each graft resorption level

Graft resorption grade	AP dimensions								
	Glenoid + graft, mm			Graft, mm			Glenoid, mm		
	Primary	Revision	*P* value	Primary	Revision	*P* value	Primary	Revision	*P* value
Grade 0	35 ± 5	38 ± 4	.265	12 ± 4	15 ± 3	.119	23 ± 3	23 ± 3	.912
Grade I	30 ± 2	29 ± 4	.449	9 ± 1	9 ± 1	.955	22 ± 2	21 ± 4	.419
Grade II	30 ± 4	30	.894	7 ± 1	9	.181	23 ± 3	21	.462
Grade III	29 ± 3	31 ± 4	.234	6 ± 2	7 ± 3	.356	24 ± 4	24 ± 3	.833

AP, anteroposterior.

Values are mean ± standard deviation, unless otherwise noted.

23% when the magnetic resonance imagining was completed within 6 months of the initial dislocation.[28] Kim et al's[21] research involving 33 primary dislocations and 111 recurrent dislocations revealed a higher incidence of capsular laxity and labral injury in patients who suffered recurrent dislocations compared with those who only experienced a primary dislocation. These studies suggest that a prolonged state of shoulder instability contributes to cartilage and soft tissue damage. Given that revision patients inherently experience another period of instability prior to their second surgery, it stands to reason that further damage can occur during this period.

In the revision group, a higher number of patients reported the feeling of apprehension in the shoulder on WOSI at final follow-up (15% vs. 4.1%, respectively), despite no occurrences of dislocation or subluxation. This may be due to the complex potential factors of shoulder apprehension that could affect postoperative outcomes of revision patients. Functional magnetic resonance imagining studies looking at patients with clinically identified shoulder apprehension showed neuronal processing associated with shoulder apprehension, suggesting a neurological component.[15,36] Shitara et al further describe that shoulder apprehension is induced by instability and memory/imagery of dislocation.[15] They described 2 separate patterns of brain activity for motor and memory-induced apprehension. In revision patients where instability is more prolonged and reoccurs, further priming of apprehension could ensue and memory-induced apprehension could exist postrevision. This may also be a potential cause for the higher number of patients with postoperative stiffness reported in the revision group. A delayed rehabilitation process early in the postoperative course due to memories of frequent instability events preoperatively could result in increased stiffness at final follow-up. Future research could focus on range of motion differences between primary and revision surgery at early postoperative follow-up to further assess this hypothesis.

Grade III graft resorption was seen in 10 patients (22.2%) in the primary group and in 7 patients (36.8%) in the revision group. Despite the high degree of graft resorption, the mean anterior to posterior diameter of the reconstructed glenoid in these patients was 29 ± 3 mm in the primary group and 31 ± 4 mm in the revision group.

Interestingly, patients with grade I and grade II resorption had similar final glenoid dimensions. A possible reason for this may be the differences in graft preparation technique at the time of surgery. While this technique was being developed, larger grafts were initially used in an attempt to make supraphysiologic-sized glenoids, in a strategy to accommodate a larger anatomic space. Notable work by Kee et al[19] has demonstrated that bone grafts undergo remodeling over time, and ultimately result in dimensions akin to the original glenoid. Consequently, the technique was modified later on to instead make smaller grafts in order to re-create the size of the contralateral glenoid. Therefore, although there was a higher degree of graft resorption in a subset of patients in our study, the desired size of the glenoid was achieved, indicating that physiologic glenoid diameter was maintained regardless of resorption.

One of the advantages of AAGR is its low incidence of complications, with one study finding a similar complication rate to Bankart repair procedures (11.9% vs. 11.2%, respectively).[38] Our investigation revealed a similarly low overall complication rate in the primary group (9.6%) with a notably higher rate in the revision group (23.8%), indicating its suitability as a primary procedure for shoulder instability. In comparison to the Latarjet procedure, a study by Shah et al[34] reported a complication rate of 25%, with 6% attributed to superficial infections and 10% to neurologic injuries. Additionally, in the context of revision surgery, open Latarjet procedures may carry an even more pronounced risk of infection.[18] Despite the higher rate of complications seen in the revision group in our cohort, only minor complications were seen (3 patients with stiffness, 1 patient with hardware irritation, and 1 patient with early arthritic changes), with no incidence of fracture, infection, chondrolysis, or neurovascular deficits in either group. Therefore, although revision AAGR may exhibit less favorable functional outcomes and a higher complication profile compared with primary AAGR, it remains an efficacious option following a failed instability surgery, given its low risk of recurrence, infection, and serious complications. This is particularly appealing when weighed against arthroscopic Latarjet, as AAGR with DTA demonstrates a shorter learning curve and is faster to perform, making it an attractive option for surgeons[25]; however, notable barriers to performing AAGR worldwide remain the cost and availability of allograft.

Limitations

There were several limitations to this study. This is a retrospective review of prospectively collected data, with all procedures being done at a single center by a single surgeon; therefore, conclusions obtained from this study will be susceptible to inherent biases such as selection bias. Some of the primary soft tissue procedures in the revision group were performed by external surgeons who were not proficient in AAGR; this could represent a potential confounding factor if unnecessary cartilage damage was incurred at the time of the index procedure. The small sample size for our revision patients, although not different from available literature, limits our statistical power in identifying differences with the primary cohort. Additionally, 10% of the patients were lost to follow-up, and we had a relatively short minimum follow-up of 2 years, which may have limited our ability to detect a difference between the groups. For the strengths of this study, all patients had an arthroscopic Bankart repair as an initial surgery in the revision group, we had strong radiologic follow-up of these patients, highlighting good union and radiographic outcomes. To better appreciate differences between primary and revision AAGR surgeries, further study with larger populations is needed.

Conclusion

Functional outcome scores and stiffness were significantly worse in patients undergoing an AAGR procedure after a failed instability surgery when compared with patients undergoing primary AAGR. There were no differences in postoperative recurrence of instability or radiographic outcomes. As a result, AAGR should be considered as a primary treatment option within current treatment algorithms for shoulder instability.

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