

# Primary Bankart Repair Versus Arthroscopic Anatomic Glenoid Reconstruction in Patients with Subcritical Bone Loss

## A Cost-Utility Analysis

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**Background:** Anterior shoulder instability and its treatment is a quickly evolving field of interest in orthopaedics, both for patients and for health-care systems. In this study, we aimed to evaluate the cost-effectiveness of arthroscopic anatomic glenoid reconstruction (AAGR) compared with Bankart repair in the treatment of anterior shoulder instability in patients with subcritical glenoid bone loss.

**Methods:** A cost-utility analysis was performed from the perspective of Canada's publicly funded health-care system. A decision-tree model was created to simulate the progression of patients undergoing either a primary Bankart repair or AAGR. Recently published data were used to determine the recurrence rate and level of glenoid bone loss for the AAGR procedure; the recurrence rate was 1.4% in a cohort with a mean glenoid bone loss of 25.3%. A literature review on the primary Bankart procedure in patients with at least subcritical levels of glenoid bone loss yielded a recurrence rate of 22.9% in patients with a mean glenoid bone loss of 17.5%. AAGR served as the revision surgery for both primary procedures. Health utility scores for anterior shoulder instability were obtained from published literature. Total procedure costs, including costs of operating-room consumables, anesthesia, diagnostic imaging, and rehabilitation, were sourced from a hospital database. A probabilistic sensitivity analysis using 5,000 Monte Carlo simulations was performed, and results were used to create a cost-effectiveness acceptability curve.

**Results:** The AAGR procedure was less costly and led to an improvement in quality-adjusted life years (QALYs) when compared with the arthroscopic Bankart repair in the treatment of patients with anterior shoulder instability with subcritical glenoid bone loss (AAGR, cost = \$16,682.77 [Canadian dollars] and QALYs = 5.76; Bankart, cost = \$16,720.29 and QALYs = 5.46), suggesting that the AAGR is dominant, i.e., lower costs with higher QALYs. Applying a commonly used willingness-to-pay threshold of \$50,000 per QALY gained, the probability that the primary AAGR was more cost-effective was 85.8%.

**Conclusions:** This study showed that, from the perspective of a publicly funded health-care system, AAGR was the economical treatment option when compared with Bankart repair in anterior shoulder instability with subcritical glenoid bone loss.

**Level of Evidence:** Economic and Decision Analysis Level III. See Instructions for Authors for a complete description of levels of evidence.

Anterior shoulder instability occurs when a patient has experienced soft-tissue or osseous insult that allows the humeral head to subluxate or dislocate from the glenoid fossa of the scapula. Bankart lesions are the most common pathology of anterior shoulder instability; however, osseous

defects of the glenoid or humeral head are present in up to 22% of those with initial dislocation and in 88% of cases of recurrent instability, and they are also associated with worse outcomes following stabilization<sup>1-3</sup>. The effect of glenoid bone loss on postoperative treatment failure was described by Burkhart and

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De Beer, who showed that patients with significant bone loss, as defined in their paper, had a higher recurrence rate compared with those without (89% versus 6.5%)<sup>4</sup>. Arthroscopic Bankart repair and arthroscopic anatomic glenoid reconstruction (AAGR) with distal tibial allograft (DTA) are procedures performed in cases of anterior shoulder instability<sup>5,6</sup>.

The arthroscopic Bankart procedure stabilizes the shoulder by using suture anchors to release, mobilize, and tension the glenoid labrum to repair Bankart lesions. Diagnostic arthroscopy is performed through the posterior portal, while anteroinferior and anterosuperior portals allow for the repair of the glenoid labrum<sup>7</sup>.

AAGR with DTA allows for reconstruction of the anterior glenoid without a subscapularis split, as described by Wong and Urquhart<sup>6</sup>. The patient is positioned laterally, and diagnostic arthroscopy is performed through the posterior portal, allowing assessment of glenoid bone loss to be compared with preoperative computed tomography (CT) imaging; the same portals and techniques as the Bankart procedure are used. A medial portal, known as the *Halifax portal*, is then created using an inside-out technique with a switching stick from the posterior portal, parallel to the glenoid, superior to the subscapularis, and lateral to the conjoined tendon. This Halifax portal is used to introduce the graft through the rotator interval. Following fixation of the graft with Kirschner wires and cannulated screws, a Bankart-like repair of the labrum is performed to augment the repair.

The primary difference in indications for the 2 procedures is the amount of glenoid bone loss. In past years, osseous augmentation was recommended when glenoid bone loss exceeded 25% to 27%<sup>8</sup>. However, recent studies have suggested that subcritical thresholds as low as 13.5% may lead to clinically important decreases in functional outcomes compared with <13.5% bone loss<sup>9,10</sup>, suggesting that osseous procedures should be considered at lower levels of bone loss. As both the arthroscopic Bankart repair and AAGR have been shown to have excellent functional outcomes, it is also

important to assess which procedure may be more cost-effective<sup>5,11</sup>. The purpose of this study was to evaluate the cost-utility of primary AAGR with DTA and of primary arthroscopic Bankart repair in the treatment of anterior shoulder instability in patients with subcritical bone loss. This analysis may provide insight into health-care resource use and the cost-effectiveness of both procedures. Despite being a more expensive primary procedure, we hypothesized that the lower recurrence rate of a primary AAGR would result in the procedure being at least as cost-effective as a primary Bankart procedure in the treatment of anterior shoulder instability with subcritical bone loss.

## Materials and Methods

In this study, we performed a cost-utility analysis of primary AAGR compared with primary Bankart repair from the perspective of a publicly funded health-care system for anterior shoulder instability in the presence of subcritical bone loss.

### Decision Tree

A decision tree was developed in Excel (2011; Microsoft) to represent a patient's clinical pathways (Fig. 1). The model consisted of 2 treatment arms: (1) primary arthroscopic Bankart repair and (2) primary AAGR with DTA. Patients who underwent primary Bankart repair or AAGR could experience "treatment success" or "treatment failure." Following the first procedure, if revision was needed, both primary procedures were revised using AAGR. Patients either remained in this state as a "revision success" or entered the third cycle as a "revision failure."

The model utilized recurrence rates from the literature for the primary Bankart repair and the primary AAGR.

### Data Elements

#### Literature Review

Recently published data were used for the recurrence rate for the AAGR procedure. Wong et al. found a recurrence rate of

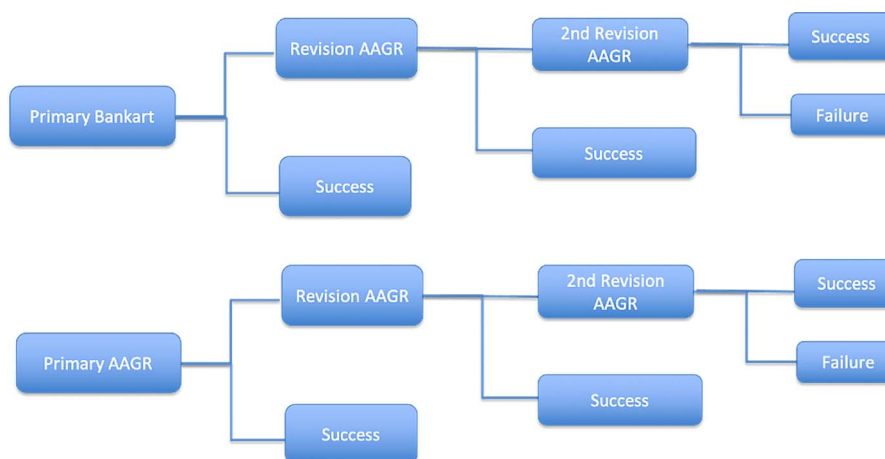


Fig. 1  
Decision tree for primary AAGR and primary Bankart repair.

**TABLE I Patient Demographics for Primary AAGR and Primary Bankart Repair**

	Primary AAGR: Wong et al. <sup>12</sup>	Primary Bankart: Jeon et al. <sup>13</sup>
No. of shoulders	73	118
Follow up* (yr)	4.7 ± 1.1	2.4 ± 0.5
Age* (yr)	28.8 ± 13.4	25.6 ± 5.1
No. (%) male	52 (71.2%)	104 (88.1%)
Bone loss*	25.3% ± 10.6%	17.5% ± 1.3%
Recurrence (no.)	1	27
Recurrence rate (%)	1.4%	22.9%

\*The values are given as the mean and standard deviation.

**TABLE II Health Utility EQ-5D Scores**

State of Shoulder	Associated EQ-5D Utility Score
Stable shoulder after Bankart procedure <sup>15</sup>	0.930
Stable shoulder after AAGR procedure (assumed)	0.930
Unstable shoulder <sup>15</sup>	0.794
Nonfunctional shoulder <sup>15</sup>	0.084

1.4% in a cohort with mean bone loss of 25.3% and a minimum of 2 years of follow-up<sup>12</sup>. A targeted literature search was conducted to determine the recurrence rate of the arthroscopic Bankart procedure in the presence of subcritical glenoid bone loss. A study by Jeon et al. was chosen because of its minimum 2-year follow-up and the selection of patients with at least subcritical glenoid bone loss in order to help mitigate differences between the 2 study populations. The overall average recurrence rate for arthroscopic Bankart repair was 22.9%<sup>13</sup>. Patient demographics from the 2 studies are shown in Table I.

### Cost

This economic analysis was performed from the Canadian publicly funded health-care perspective and, as such, only direct costs were used. Procedure costs were sourced from a hospital database, with the highest available costs being selected for both procedures. These included the costs of consumables, diagnostic imaging, rehabilitation, anesthesia, and preoperative and postoperative appointment costs. Cost data are presented in 2020 Canadian dollars (CAD). The cost of a primary arthroscopic Bankart repair was reported to be \$9,893.71, and the cost of a primary AAGR was reported to be \$15,436.24.

### Health Utility

Quality-adjusted life-years (QALYs) are a composite measure incorporating both the quantity and quality of a patient's life and can be used to inform health-care resource allocation decisions<sup>14</sup>.

The analysis used EuroQol-5 Dimension (EQ-5D) scores from the work of Min et al. (Table II) on the cost-effectiveness of the arthroscopic Bankart repair versus the open Latarjet procedure<sup>15</sup>. The EQ-5D questionnaire analyzes 5 health utilities: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, generating a score ranging from -0.109, a health state worse than death, to 1.000, a state of perfect health. Min et al. prospectively collected health utility states and compared the preoperative and postoperative data of patients undergoing primary arthroscopic Bankart or open Latarjet procedures with no bone defects and at least 2 years of follow-up<sup>15</sup>. To calculate the average utility score per type of primary surgery, it was assumed that patients undergoing a successful procedure entered a "stable shoulder" state after Bankart or AAGR procedure as shown in the study by Min et al. (0.930). Patients experiencing treatment failure, and therefore requiring revision, were assumed to have remained in the "unstable shoulder" state (0.794). Patients experiencing a second revision failure were assumed to enter the "nonfunctional shoulder" state (0.084) (Table II).

### Incremental Cost-Effectiveness Ratio

An incremental cost-effectiveness ratio (ICER) is the primary outcome measure of cost-effectiveness analyses and functions by comparing an intervention's cost-effectiveness with the cost-effectiveness of an alternate intervention. The formula for this equation is shown in Figure 2. The ICER is commonly given in terms of the incremental cost per unit of QALY.

### Sensitivity Analyses

One-way sensitivity analyses were performed for several parameters of the decision analytic model. The parameters that were deemed to have a large impact on the cost-effectiveness findings were (1) the cost of DTA, (2) the recurrence rate of the Bankart procedure, and (3) the recurrence rate of the AAGR procedure. Because of the lack of currently available published literature regarding the AAGR procedure, a range for recurrence could not be established to perform the sensitivity analysis. The net monetary benefit was calculated according to both the lower and upper ends of the range for the 2 parameters with available ranges. The range for the cost of graft was established from a hospital database that included costs from industry partners (range: \$805 to \$2,937). The range for the Bankart recurrence at levels of subcritical bone loss was established by sourcing available upper and lower limits of recurrence found in the literature (range: 18.8% to 42.9%)<sup>10,16</sup>.

$$\text{Incremental Cost Effectiveness Ratio} = \frac{\text{Cost A} - \text{Cost B}}{\text{Effectiveness A} - \text{Effectiveness B}}$$

Fig. 2

Incremental cost-effectiveness ratio formula.

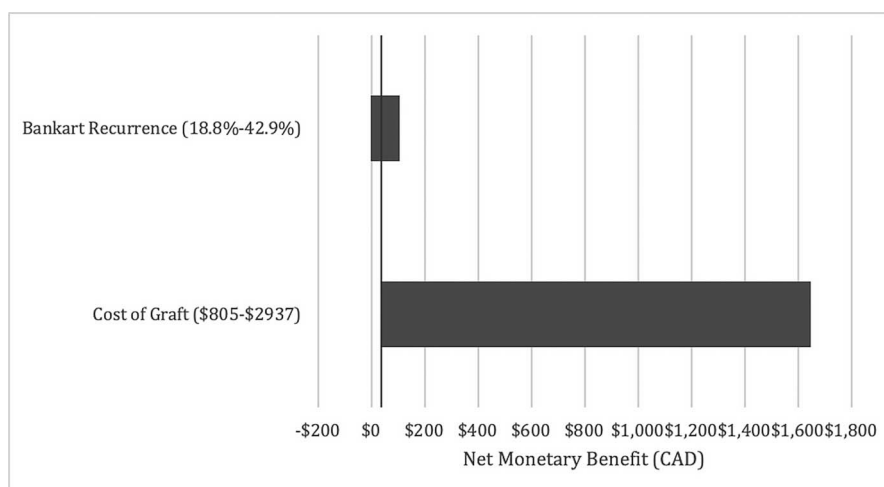


Fig. 3  
Tornado plot showing the net monetary benefit (Canadian dollars) of select parameters tested in the 1-way sensitivity analysis.

### Probabilistic Sensitivity Analysis

We conducted a probabilistic sensitivity analysis using Monte Carlo simulations with 5,000 iterations. This enabled us to create a cost-effectiveness acceptability curve, representing the probability that an intervention is cost-effective over varying willingness-to-pay thresholds of \$0 to \$100,000 per QALY gained.

### Source of Funding

The authors received no financial support for this study.

### Results

The study showed that primary AAGR was dominant, as it was associated with the lower overall costs and higher QALYs. Primary AAGR had an expected cost of \$16,682.77,

and primary Bankart repair had an expected cost of \$16,720.29. Primary AAGR was more effective than primary Bankart repair and had an expected increase of 0.299 QALYs (AAGR, 5.7563, versus Bankart, 5.4579;  $p < 0.001$ ).

### Sensitivity Analysis

Figure 3 displays the results of the 1-way sensitivity analysis of the tested parameters. The net monetary benefit for the base-case scenario was \$37.52, suggesting that AAGR is cost-effective at a willingness-to-pay threshold of \$50,000 per QALY gained. The graft cost was the most influential factor, causing large variation in the net monetary benefit. However, varying both parameters still indicated that the AAGR procedure was the more cost-effective procedure.

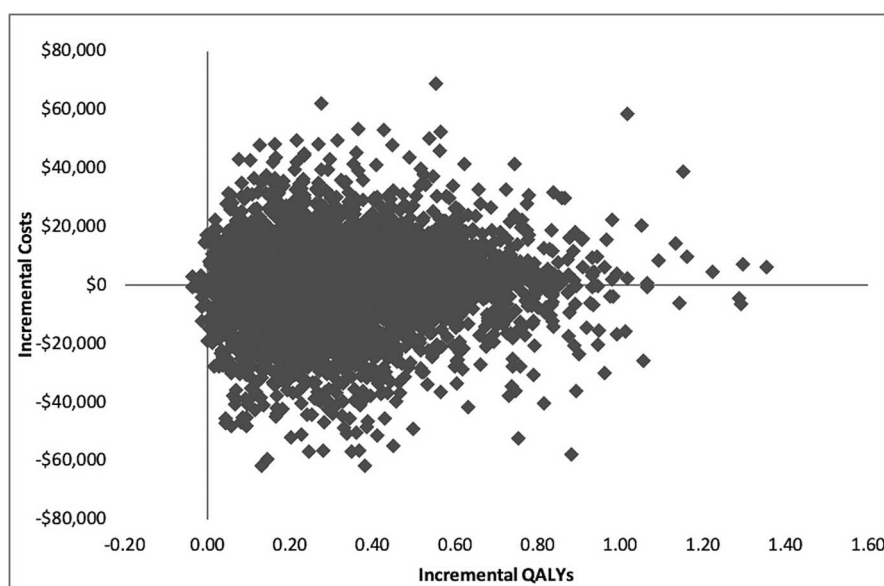


Fig. 4  
Probabilistic sensitivity analysis.

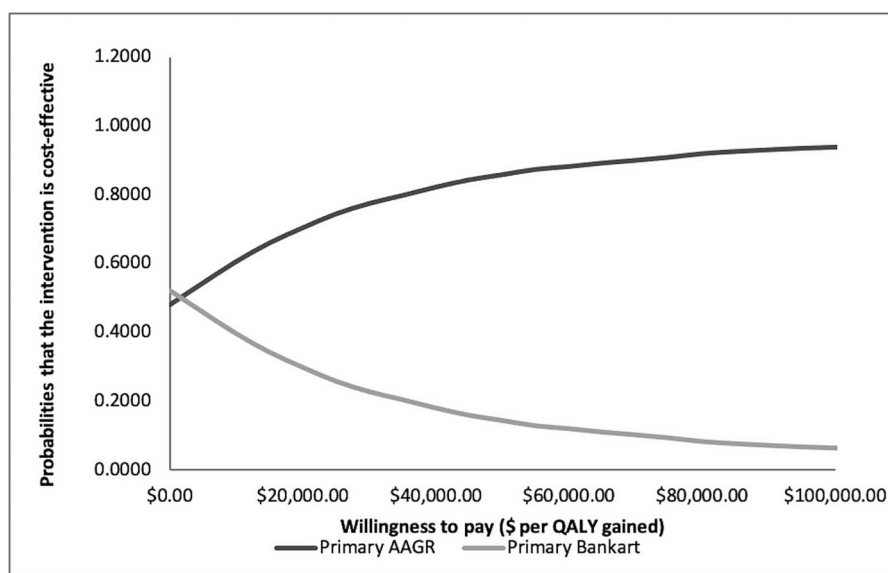


Fig. 5  
Cost-effectiveness acceptability curves.

Figure 4 shows the results of the 5,000 Monte Carlo simulations; the calculated ICERs were scattered across 4 quadrants, suggesting high uncertainty in the cost-effectiveness findings. On the basis of a willingness-to-pay threshold of \$50,000 per QALY gained, the probability that primary AAGR was more cost-effective was 85.8% (Fig. 5).

## Discussion

Our findings demonstrated that primary AAGR (estimated cost = \$16,683; QALYs = 5.76) was less costly and led to an improvement in QALYs when compared with arthroscopic Bankart repair (estimated cost = \$16,720; QALYs = 5.46) in the treatment of anterior shoulder instability with subcritical bone loss. While AAGR is a more costly primary procedure, its association with a lower rate of recurrence of shoulder instability appears to make it a more effective option in preventing further revision surgeries. Therefore, according to the costs within the Canadian health-care system, AAGR is more cost-effective than the arthroscopic Bankart procedure.

We found that the use of primary AAGR instead of primary Bankart repair for anterior shoulder instability yielded a gain of 0.299 QALYs (AAGR, 5.7563, versus Bankart, 5.4579;  $p < 0.001$ ). Min et al. found that the primary Bankart and primary Latarjet procedures had large gains in QALYs compared with nonoperative treatment, with the Bankart having significantly greater gains in QALY than the Latarjet procedure (Bankart, 5.5, and Latarjet, 5.0;  $p < 0.001$ )<sup>15</sup>. However, the costs of the procedures in their study were higher than in this study (\$20,385 and \$21,389). While their study showed large gains in QALYs, they were not comparing the procedures to one another. Huang et al. found that double-row rotator cuff repair had an increase of 0.018 QALYs compared with single-row repair<sup>17</sup>. Genuario

et al. reported an increase in QALYs of 0.0022 QALY for rotator cuff tears of  $<3$  cm and 0.0027 QALY for tears of  $\geq 3$  cm when comparing double-row fixation to single-row fixation<sup>18</sup>.

The rate of revision was a major variable in the cost-effectiveness analysis because of its influence on the number of revision procedures in the Monte Carlo simulation. As shown in Table I, Wong et al. performed AAGR procedures in patients with a mean 25.3% bone loss<sup>12</sup>. The patient population in the study by Jeon et al. was selected as a comparative study population because of similar minimum follow-up and glenoid bone loss<sup>13</sup>. In the study by Jeon et al., patients had a mean of 17.5% bone loss. Furthermore, the 1-way sensitivity analysis (Fig. 3) demonstrated that a decrease in recurrence after Bankart repair did not significantly impact the AAGR's net monetary benefit.

The cost of the graft was an important variable in this study. Our institution benefits from reduced costs of grafts from the Nova Scotia Health Authority (NSHA) Regional Tissue Bank compared with the higher industry costs presented as the upper limit in the 1-way sensitivity analysis. Graft costs may vary in other locations. However, even at the higher graft cost, there was still a net monetary benefit from using the AAGR procedure.

The cost of the procedure was also an important variable of the cost-effectiveness analysis. The arthroscopic AAGR was more expensive than the arthroscopic Bankart procedure (AAGR, \$15,436.24, versus Bankart, \$9,893.71). This is less expensive than in previous reports of the arthroscopic Bankart and open Latarjet procedures in the literature. Min et al. found that the arthroscopic Bankart procedure cost was \$20,385<sup>15</sup>. Meanwhile, Makhni et al. found that the arthroscopic Bankart procedure cost was \$15,287<sup>19</sup>. Both of these economic analyses compared the



arthroscopic Bankart to the open Latarjet procedure<sup>19</sup>. Min et al. found that the open Latarjet procedure was more expensive than the arthroscopic Bankart procedure, while Makhni et al. found the opposite<sup>15,19</sup>. To our knowledge, costs of an AAGR procedure have not been reported in the literature, with this being the first economic analysis of the procedure. However, the quotes for the costs were from the same industry partners for both procedures. This highlights the possibility that differences in prices at different institutions may vary the results.

Our findings showed that AAGR is favorable compared to the arthroscopic Bankart repair in the treatment of anterior shoulder instability and suggest that performing a primary AAGR both decreases spending and provides patients with increased QALYs. To provide perspective, ICER calculations for other shoulder procedures in the literature were evaluated. Min et al. found that both primary arthroscopic Bankart and primary open Latarjet procedures were cost-effective compared with nonoperative management (Bankart ICER, \$4,214, and Latarjet ICER, \$4,681)<sup>15</sup>. Makhni et al. found that both revision arthroscopic Bankart and revision open Latarjet procedures were cost-effective for the treatment of recurrent shoulder instability compared with nonoperative management (Bankart ICER, \$3,082; Latarjet ICER, \$1,141)<sup>19</sup>. Huang et al. found that both double- and single-row fixation were cost-effective procedures in arthroscopic rotator cuff repair but found double-row to be more costly and more cost-effective compared with single-row repair (ICER = \$26,666.75 per QALY gained for double-row relative to single-row)<sup>17</sup>. Makhni et al. also reported on arthroscopic rotator cuff repair and reverse total shoulder arthroplasty in the treatment of massive rotator cuff tears and found both procedures to be cost-effective compared with nonoperative management (arthroscopic ICER, \$15,500, and reverse total shoulder ICER, \$37,400)<sup>20</sup>.

There were several limitations to this study. First, there is a lack of unbiased comparative efficacy and safety of the 2 procedures discussed in this study. Next, the model was based on several assumptions. Survivorship and recurrence rates are limited by the strength of the literature. Furthermore, costs for both procedures were assigned using the highest costs from our hospital's database, which sources consumables from different industry partners. These are likely to vary depending on location; however, it is important to note that at our institution, the cost of the arthroscopic Bankart repair was lower than the cost of such procedures reported in the literature. The costs in this study also assumed that revision procedures had the same cost as primary procedures. The financial impact of complications was

not included in this analysis. Available literature for the AAGR procedure demonstrated 5 cases of hardware failure in a population of 66 patients (7.6%), which is higher than the 1.6% reported in the recent systematic review by Williams et al.<sup>12,21</sup>. The financial impact of the AAGR procedure's higher complication rate could be a factor on the procedure's cost-effectiveness; however, it is difficult to quantify this in this study because of the wide range of possible complications and their different treatment mechanisms. The limited published literature on the AAGR procedure was also a limiting factor in this study. While there are more long-term data available for the arthroscopic Bankart procedure, we are not aware of any long-term data available to date regarding the AAGR procedure. Therefore, in order to match the patient cohorts, the short follow-up of 2 years was established. It would be reasonable to consider repeating this study in several years with the hope that an increased amount of literature and longer follow-up for the AAGR procedure will allow for stronger conclusions to be drawn.

### Conclusions

Our findings showed that, from the perspective of a publicly funded health-care system, AAGR is the economical treatment option when compared with Bankart repair in anterior shoulder instability with subcritical bone loss. While AAGR is a more costly primary procedure, its association with a lower rate of recurrence of shoulder instability appears to make it a more effective option in preventing further revision surgeries. Although the economics of treatment options should not be the final decider, it is important to note that performing an AAGR within a population with subcritical bone loss may reduce the costs of treatment. ■

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