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SHOULDER

Outcomes are comparable using free bone block autografts versus allografts for the management of anterior shoulder instability with glenoid bone loss: a systematic review and meta-analysis of "The Non-Latarjet"

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Abstract

Purpose Glenoid augmentation using free bone blocks for anterior shoulder instability has been proposed as an alternative to or bail-out for the Latarjet procedure. The purpose of this investigation was to systematically review and compare outcomes of patients undergoing glenoid augmentation using free bone block autografts versus allografts.

Methods A systematic review using PubMed, MEDLINE, Embase, and the Cochrane Library databases was performed in line with the PRISMA statement. Studies reporting outcomes of patients treated with free bone block procedures for anterior shoulder instability with minimum 2-year follow-up were included. Random effects modelling was used to compare patient-reported outcomes, return to sports, recurrent instability, non-instability related complications, and development of arthritis between free bone block autografts and allografts.

Results Eighteen studies comprising of 623 patients met the inclusion criteria for this investigation. There were six studies reporting on the use of allografts (of these, two used distal tibial, three iliac crest, and one femoral head allograft) in 173 patients and twelve studies utilizing autografts (of these, ten used iliac crest and two used free coracoid autograft) in 450 patients. Mean age was 28.7 ± 4.1 years for the allograft group and 27.8 ± 3.8 years for the autograft group (n.s). Mean follow-up was 98 months in autograft studies and 50.8 months for allograft studies (range 24–444 months, n.s). Overall mean increase in Rowe score was 56.2 with comparable increases between autografts and allografts (n.s). Pooled recurrent instability rates were 3% (95% CI, 1–7%; $I^2 = 77\%$) and did not differ between the groups (n.s). Arthritic progression was evident in 11% of autografts (95% CI, 2–27%; $I^2 = 90\%$) and 1% (95% CI, 0–8%; $I^2 = 63\%$) of allografts (n.s). The overall incidence of non-instability related complications was 5% (95% CI, 2–10%; $I^2 = 81\%$) and was similar between the groups (n.s). Pooled return to sports rate was 88% (95% CI, 76–96%; $I^2 = 76\%$).

Conclusion Glenoid augmentation using free bone block autograft or allograft in the setting of recurrent anterior shoulder instability with glenoid bone loss is effective and safe. Outcomes and complication incidence using autografts and allografts were comparable. Due to the high degree of heterogeneity in the data and outcomes reported in available studies, which consist primarily of retrospective case series, future prospective trials investigating long-term outcomes using free bone block autograft versus allograft for anterior shoulder instability with glenoid bone loss are warranted.

Level of evidence IV.

Keywords Shoulder instability · Bone block · Glenoid reconstruction · Glenoid augmentation · Allograft · Autograft · Iliac crest bone graft · Distal tibial allograft

Introduction

Anteroinferior glenoid bone loss is common following traumatic anterior shoulder dislocation, occurring in 22% of initial dislocations and up to 90% of recurrent shoulder

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instability cases [19, 28, 34, 39]. In patients with significant glenoid bone loss undergoing isolated soft tissue stabilization, recurrent instability rates are reported to range between 11 and 35% [6, 14, 27, 40, 43]. As such, the extent of glenoid bone loss is critical in determining appropriate surgical management in patients with anterior shoulder instability [24]. Specifically, patients with significant anterior glenoid bone loss, traditionally greater than 20–25% of the glenoid width, and according to more recent data as little as 13.5% [13], require bony augmentation to the glenoid.

Effective glenoid augmentation can be achieved using a variety of techniques, namely coracoid transfer and free bone block grafting [38]. Coracoid transfer procedures, particularly the Latarjet procedure, remains the gold standard for the management of anterior glenoid bone loss. However, the Latarjet procedure produces a nonanatomic reconstruction, altering the normal position of the conjoint tendon with inability to reproduce the cartilaginous surface of the anterior glenoid [15, 46]. Moreover, long-term rates of recurrent instability following the Latarjet procedure vary, occurring in as low as 0% and up to 19.3% of patients [8, 15, 32, 46]. Outcomes following the Latarjet procedure may be also complicated by graft resorption and malunion, screw loosening, migration or breakage, loss of external rotation due to subscapularis scarring, musculocutaneous nerve injury, and development/progression of glenohumeral arthritis [7, 48, 50]. Glenoid reconstruction using a free bone block (Fig. 1a–e) was developed to combat some of the limitations of the Latarjet procedure, gaining popularity as an alternative or revision option in the setting of failed Latarjet [25, 29]. Sources of autograft bone blocks include iliac crest bone graft (ICBG) [2, 4, 9, 21, 24, 25, 35, 38, 45], distal clavicle [42], and free partial-thickness coracoid (leaving the conjoint tendon attached) [3, 44]. Sources of allograft bone blocks include distal tibia (DTA) [15, 29, 30], proximal tibia [36], distal femur [36], iliac crest [1, 41, 49], and femoral head [46]. Multiple studies have reported that free bone block reconstruction improves stability by creating a more anatomic reconstitution of the natural glenoid arc and concavity [16, 23], with reported recurrent instability rates ranging from 0 to 8.7% [4, 21, 24, 30]. Free bone block augmentation also serves as a revision option in the setting of a failed Latarjet procedure and in the setting of massive glenoid bone loss exceeding the dimensions that a coracoid autograft is capable of reconstituting [21, 30].

While several investigations have reported successful restoration of shoulder stability through various bone grafting procedures in patients with large glenoid defects, [2, 4, 9, 24, 30] no investigation has systematically analyzed and compared clinical outcomes following glenoid restoration utilizing autograft versus allograft free bone blocks. The purpose of this review was to evaluate the patient reported outcomes (PROs), recurrent instability rates, return to sport (RTS) rate, and all other complications following free bone block grafting while comparing outcomes between free bone block autografts versus allografts. We hypothesized that there would be no significant differences in outcomes, recurrent instability, return to sport, and other complication rates between free bone block autografts versus allografts for anterior shoulder instability.

Materials and methods

Data sources and searches

A systematic review was performed in line with the PRISMA guidelines. PubMed, MEDLINE, Embase, and Cochrane library were systematically searched for relevant articles from January 2000 to December 19, 2019. The reference lists of original and review articles were also screened. The search was limited to English language articles or articles with English translation. The search strategy combined the following search terms: [("glenoid" OR “glenohumeral” OR “shoulder instability”) AND (“*graft*” OR “bone block” OR reconstruct* OR augment*)].

Selection criteria

Predefined eligibility criteria were clinical trials and observational studies (cohort studies and case-series) that reported clinical outcomes following anterior shoulder stabilization using a free bone block procedure with minimum of five patients and 2-year follow-up. Exclusion criteria consisted of: (1) studies not providing PROs or recurrent instability rate, (2) studies reporting the use of bone blocks in the setting of shoulder arthroplasty, (3) case reports and technique articles reporting the outcomes of less than five patients, and (4) medical conference abstracts. Investigations from the same institutions were separately reviewed to identify studies likely reporting on the same cohort of patients. When these were identified, the most comprehensive study was included, while the rest were omitted following mutual discussion with the senior author.

Data extraction and quality assessment

The initial screening of records was performed based on titles and abstracts. Three reviewers (R.G., E.D.H.,D.M.K.) reviewed the articles and extracted manuscripts independently. Screening of the articles was performed in the following systematic approach: assessment of duplicate articles, content within the article title, content of the abstract, and full-text review. Full-text review was performed during the study selection process if necessary, to determine if the articles satisfied inclusion and exclusion criteria.

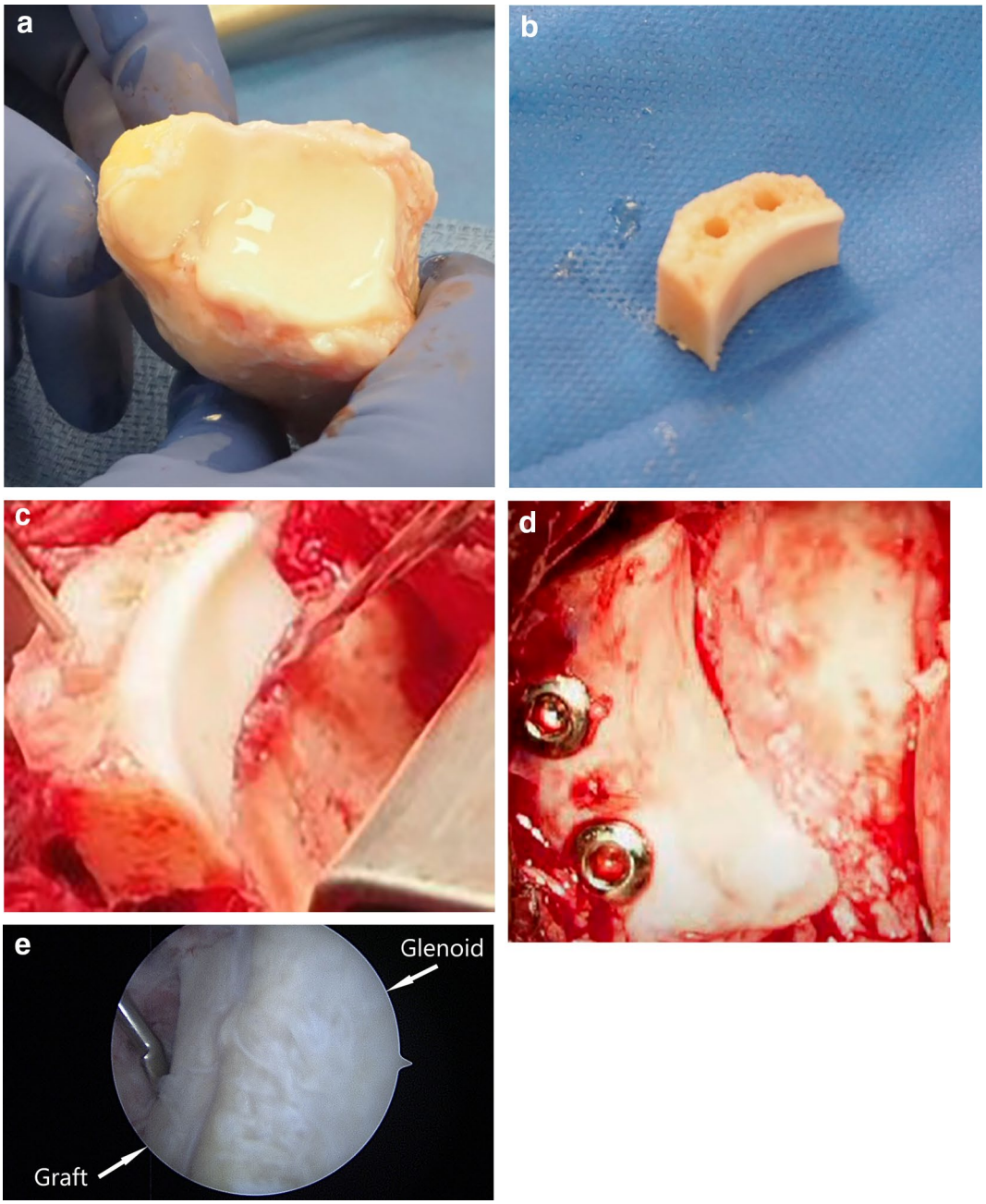


Fig. 1 **a–e** Left shoulder of a 42-year-old male with recurrent instability following arthroscopic Bankart repair and an open Latarjet procedure. The patient underwent glenoid reconstruction using a distal tibial allograft. **a** A distal tibial allograft articular surface. **b** A prepared allograft. **c** Temporary fixation of the allograft using a K-wire. **d** Fixation of the allograft to the glenoid using two screws. **e** Second-look arthroscopic view from a posterior viewing portal of the glenoid and adjacent graft

Discrepancies were resolved by mutual discussions, of which none were encountered. The following information was extracted: publication year, study design, level of evidence, mean age, sample size, approach, graft type (autograft/allograft), graft origin (e.g., iliac crest, distal tibia, etc.), follow-up (minimum, mean, and range), prior surgeries, radiographic and clinical outcomes, complications, and specific remarks. We corresponded with study authors to provide additional information when necessary.

Quality assessment was performed using The Methodological Index for Non-randomized Studies (MINORS) checklist [18] and the Newcastle–Ottawa Quality Assessment Scale [37]. Studies were grouped according to free bone block graft source (autograft versus allograft). Baseline comparison of patient characteristics between groups were

evaluated using weighted means, independent *t* tests, and two-proportion *z*-tests. Studies were expected to have high-levels of heterogeneity due to non-identical patient populations, varying indications for surgery, variable surgical techniques, and non-consistent reporting of outcomes. Therefore, we used the DerSimonian–Laird method [10–12, 17] to calculate pooled effect sizes. Heterogeneity was evaluated using the I^2 value [17] and pooled effects reported with 95% confidence intervals (CI95%). Binomial data was assessed using a random effect meta-analysis of proportions to synthesize rates of recurrent instability, other complications, development and progression of glenohumeral arthropathy, and return to sports. Glenohumeral arthropathy was defined in all available studies by the presence of glenohumeral arthritis based on the classification system by Samilson and Prieto [33]. Continuous data was analyzed using random effect meta-analysis of pooled means to report differences in PROs including the Visual Analog Scale (VAS), Rowe score, American Shoulder and Elbow Score (ASES), Western Ontario Shoulder Instability Index (WOSI), subjective shoulder value for sports (SSVS), Constant score, University of California, Los Angeles (UCLA) shoulder score, Walch-Duplay, simple shoulder test (SST), Oxford Shoulder Instability Score (OSIS), Disabilities of the arm, shoulder and hand (DASH) score, Oxford Shoulder Score (OSS), and Single Assessment Numeric Evaluation (SANE) questionnaires. Only PROs with a minimum of two studies in each treatment group reporting on change from preoperative to postoperative scores were analyzed in the meta-analysis. Outliers were defined as studies with effects that had an upper bound of CI95% lower than the minimum pooled effect or studies with effects that have a lower bound of CI95% higher than the maximum pooled effect. Outliers were then removed from the pooled analysis to minimize distortion of results. Forest plots were used to present summarized results of the meta-analyses. Statistical significance was determined as $p < 0.05$. All statistical analyses were performed using R software (Version 3.6.2).

Results

Literature selection

A literature search of the PubMed, MEDLINE, Embase, and Cochrane Library databases was performed yielding a total of 2016 studies. After removal of duplicates, a total of 1364 abstracts were identified. Screening abstracts and full manuscripts resulted in 18 studies meeting inclusion criteria. Of these, one study was supplied to us by the authors, as our search only produced a presentation abstract of the study [30]. The PRISMA flow diagram is presented in Fig. 2.

There were six studies reporting on the use of allografts in 173 patients (of these, two used distal tibial, three iliac crest, and one femoral head allograft), while 12 studies used autografts in 450 patients (of these, ten used iliac crest and two used free partial-thickness coracoid autograft). There was one Level I study [25], and 17 level III or IV studies. Overview of studies reporting on outcomes of glenoid reconstruction using autografts and allografts are presented in detail in Tables 1 and 2, respectively.

Patient demographics

Average age at the time of surgery for patients undergoing glenoid reconstruction with an autograft and allograft was 28.7 ± 4.1 and 27.8 ± 3.8, respectively (n.s). At least 263 patients in the autograft studies and 66 patients in the allograft studies had a prior stabilization procedure. Mean follow-up was 98 months in the autograft studies and 50.8 months for allograft studies (range 24–444 months, n.s).

Surgical characteristics

Seventy-nine patients who had autograft reconstruction underwent an arthroscopic procedure, while the remaining ($n = 357$) patients were treated using an open procedure. Surgical approach was not reported in a single study comprising 14 patients [9]. Seventy-eight patients receiving an allograft reconstruction underwent an arthroscopic procedure compared to 95 patients undergoing an open approach.

Of the patients who underwent bone augmentation procedure using an allograft, grafts were obtained from the iliac crest ($n = 83$), distal tibia ($n = 81$), and femoral head ($n = 9$). Patients treated with autografts had bone obtained from the iliac crest ($n = 332$) or coracoid ($n = 118$).

Outcomes

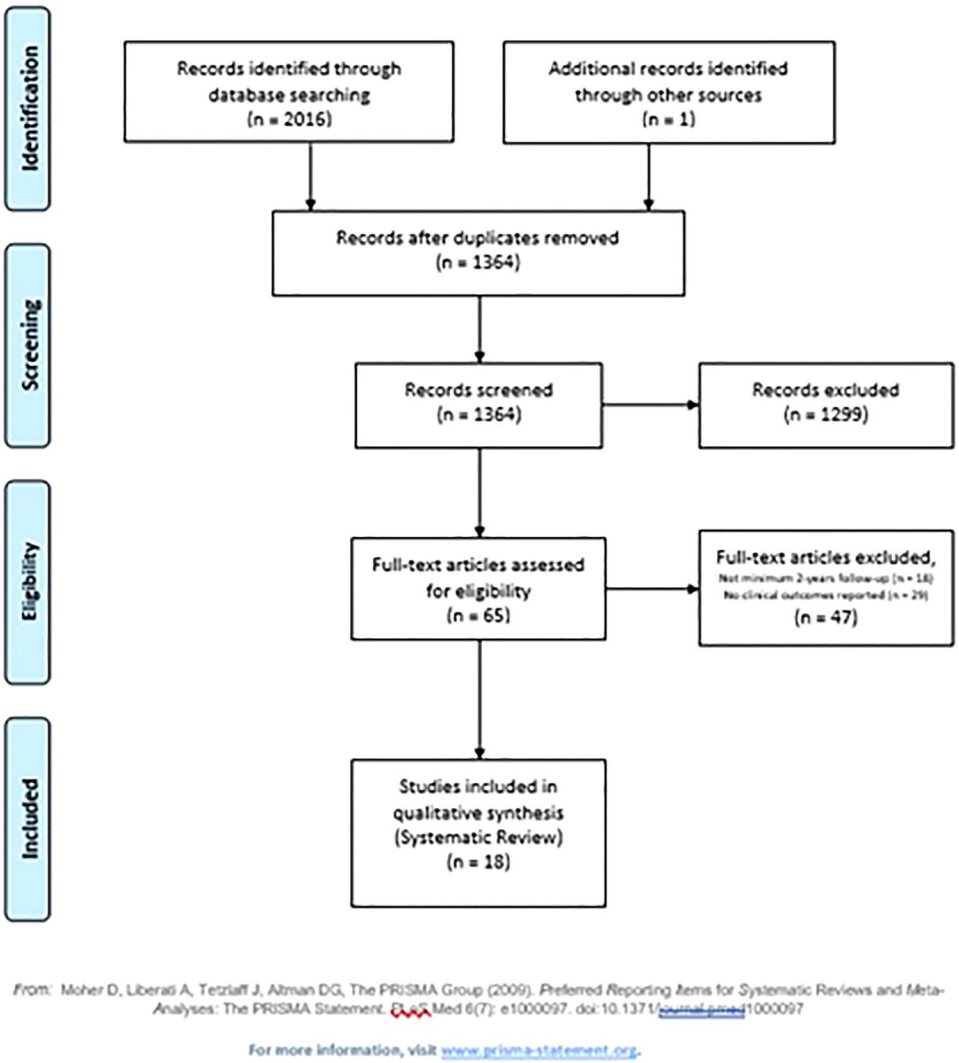
Outcomes of individual studies are reported in detail in Table 3 for autografts and Table 4 for allografts.

Recurrent instability

A total of 40 patients reported recurrent instability following free bone block procedures.

The overall random pooled summary estimate of the proportion of patients with recurrent instability following glenoid reconstruction with an autograft was 3% (95% CI, 0–8%; $I^2 = 81\%$), while patients with allograft reconstruction was 3% (95% CI, 0–9%; $I^2 = 62\%$). (Fig. 3a, b) No statistically significant difference in recurrent instability was appreciated between allografts and autografts (n.s) (Fig. 3).

Fig. 2 PRISMA flow chart



Patient-reported outcomes (PROs)

All studies reporting preoperative PROs demonstrated significant improvement at final follow-up. Relatively high shoulder-specific PRO scores and a high patient satisfaction rate was reported in all studies regardless of graft type (Tables 3 and 4).

Overall pooled increase in Rowe scores was 56.2, while no statistically significant difference in the increase in Rowe scores was appreciated when comparing allografts (58.2 pooled increase) and autografts (50.9 pooled increase, n.s) (Fig. 4).

Athletes and return to sports

RTS rate was reported in nine studies with a minimum return to sports rate of 67% [1–4, 21, 24, 41, 44, 45]. Only one study with 26 patients reported RTS rate after glenoid reconstruction with allograft (RTS rate = 67%), while the remaining studies used autografts (RTS rate = 90%, n.s). Overall pooled return to sports rate was 88% (Fig. 5).

Complications

Complications are reported in Table 3 (autograft) and Table 4 (allograft). Three patients (0.5%) were reported to have hardware failure or screw pullout [18, 49]. Four patients (0.6%), from four different studies had postoperative fracturing of the graft [2, 4, 24, 25]. Two patients (0.3%) had postoperative subscapularis insufficiency [15, 38]. One patient (0.2%) required shoulder arthrodesis following a failed rotational osteotomy for recurrent dislocations [21]. Two procedures (0.3%) were reported to be complicated by a superficial surgical site infection [21, 44]. Three of the eight studies reporting on the use of ICBG autografts reported variable rates of donor site discomfort, hypoesthesia or superficial donor site infection [21, 25, 45].

Table 1 Overview of studies on glenoid reconstruction with autografts

Study	Journal (y)	Study design (LOE)	No. shoulders	Mean patient age (y)	Graft type	Graft origin	Approach	Mean follow up (range) (m)	Prior surgery	MINORS	NOS
Lunn et al. [21]	J Shoulder Elbow Surg (2008)	Case series (IV)	46	24.6	Autograft	ICBG	Open	80 (24–192)	Failed Latarjet in all patients	9	5
Rahme et al. [31]	J Shoulder Elbow Surg (2003)	Case series (IV)	77	26	Autograft	ICBG	Open	348 (264–444)	NR	8	6
Scheibel et al. [35]	Arch Orthop Trauma Surg (2008)	Case series (IV)	10	28.7	Autograft	ICBG	Open	37.9 (24–49)	5 with prior stabilization surgery	12	6
Steffen et al. [38]	J Shoulder Elbow Surg (2013)	Case series (IV)	48	25	Autograft	ICBG	Open	110 (60–228)	20 primary cases, 28 revision cases	9	6
Warner et al. [45]	Am J Sports Meds (2006)	Case series (IV)	11	30	Autograft	ICBG	Open	33 (24–60)	9 with prior stabilization surgery	13	6
Anderl et al. [2]	Am J Sports Meds (2016)	Case series (IV)	15	30	Autograft	ICBG (J-bone graft)	Arthroscopic	25.9	8 with prior stabilization surgery	14	6
Auffarth et al. [4]	Am J Sports Meds (2008)	Case series (IV)	47	30.4	Autograft	ICBG (J-bone graft)	Open	90	36.2% with one prior stabilization surgery, 8.5% with 2 prior surgeries	13	6
Deml et al. [9]	Am J Sports Meds (2016)	Case series (IV)	14	36.7	Autograft	ICBG (J-bone graft)	NR	127 (120–131)	NR	12	4
Moroder et al. [24]	Am J Sports Meds (2018)	Case series (IV)	35	30	Autograft	ICBG (J-bone graft)	Arthroscopic	216 (180–276)	16 with prior stabilization surgery	11	5
Moroder et al. [25]	J Shoulder Elbow Surg (2019)	Prospective, randomized controlled trial (I)	29	29	Autograft	ICBG (J-bone graft)	Arthroscopic	24	All with failed prior stabilization	–	–
Arianjam et al. [3]	Shoulder and Elbow (2015)	Case series (IV)	34	21	Autograft	Free coracoid	Open	36 (24–60)	17 with prior stabilization surgery	12	6
Venkatachalam et al. [44]	Shoulder and Elbow (2016)	Case series (IV)	84	33	Autograft	Free coracoid	Open	48 (36–84)	All with failed prior stabilization	10	6

Y years, *LOE* level of evidence, *m* months, *MINORS* methodological index for non-randomized studies, *NOS* Newcastle–Ottawa Scale, *NR* not recorded, *ICBG* iliac crest bone graft, *DTA* distal tibial allograft

Table 2 Overview of studies on glenoid reconstruction with allografts

Study	Journal (y)	Study design (LOE)	No. shoulders	Mean patient age (y)	Graft type	Graft origin	Approach	Mean follow up (range) (m)	Prior surgery	MINORS	NOS
Frank et al. [15]	Am J Sports Meds (2018)	Cohort study (III)	50	25	Allograft	DTA	Open	45 (24–111)	32 with prior surgery	24	9
Provencher et al. [28]	Am J Sports Meds (2019)	Case series (IV)	31	25.5	Allograft	DTA	Open	47 (36–60)	Failed Latarjet in all patients	14	6
Abdelshahed et al. [1]	J Orthop (2018)	Case series (IV)	5	30	Allograft	Cryopreserved iliac crest	Open	54 (27–109)	NR	10	5
Taverna et al. [41]	Knee Surg Sports Trauma Arthroscopy (2018)	Case series (IV)	26	25.5	Allograft	Iliac crest	Arthroscopic	29.6 (24–33)	NR	15	6
Zhao et al. [49]	Am J Sports Meds (2014)	Case series (IV)	52	26.3	Allograft	Iliac crest	Arthroscopic	39 (24–64)	NR	10	6
Weng et al. [46]	Am J Sports Meds (2009)	Case series (IV)	9	34.6	Allograft	Femoral head	Open	90 (54–168)	3 with prior stabilization surgery	14	6

Y years, *LOE* level of evidence, *m* months, *MINORS* methodological index for non-randomized studies, *NOS* Newcastle–Ottawa Scale, *NR* not recorded, *ICBG* iliac crest bone graft, *DTA* distal tibial allograft

There was no significant difference in the pooled estimate of the number of complications between autograft and allograft studies (n.s) (Fig. 6).

Radiographic outcomes

Reported union rates of the graft to the glenoid were at least 78% [3, 30, 41], with several studies reporting a solid union in all patients (Tables 3, 4) [35, 45, 46, 49]. Data regarding graft resorption was inconsistent, with several studies reporting no graft resorption [2, 4, 35, 46], while several other studies reported graft resorption at various rates [3, 21, 30, 49]. Data was not sufficient to allow for comparative analysis between graft type.

Glenohumeral arthropathy

Six studies using autografts and two studies using allografts reported on the rates of glenohumeral arthropathy as defined by Samilson and Prieto [2, 4, 21, 24, 33, 35, 38, 41, 49]. Patients with reported glenohumeral arthritis had predominately grade 1 arthropathy and if progression was noted, the increase was primarily by 1 grade of arthritis [33]. However, several patients were reported to develop moderate-to-severe dislocation arthropathy [24, 38, 49]. While progression of arthropathy was reported in some studies [4, 21, 45], other studies did not find progression of arthropathy [2, 49]. Pooled arthritic progression rates were 11% for the autograft studies (95% CI, 2–27%; $I^2 = 90\%$) and 1% (95% CI, 0–8%; $I^2 = 63\%$) for the allograft studies (n.s) (Fig. 7).

Discussion

The main findings from this study were that glenoid augmentation using either free bone block autograft or allograft was successful in restoring shoulder stability, with low rates of recurrent instability following surgery regardless of graft type. There was a significant improvement in PROs scores and RTS rates were good to excellent in both groups. All other complications were uncommon, while radiographic evaluation of graft union was limited based on reported data. In the patients that developed arthropathy, most had mild disease, with few developing moderate or severe arthropathy. A trend, though not statistically significant, for arthropathy progression was appreciated with use of autograft versus allograft.

Patients with recurrent anterior shoulder instability with significant glenoid bone loss are better managed with glenoid augmentation compared to soft-tissue procedures [5, 9]. When utilizing a free bone block, graft bone can be obtained from a variety of sources. The choice of graft is often dictated by prior surgeries, with allograft or autograft harvested

Table 3 Outcomes of studies utilizing autograft bone block procedures

Study (y)	Radiographic outcomes	Clinical outcomes	Instability	Other complications	Return to sport
Lunn et al. [21]	Graft lysis in 6 patients. Development of OA in 4 patients	NR	Dislocation: 4 patients One patient with recurrent dislocations underwent arthrodesis following failure of rotational osteotomy	Three patients with donor site pain, 2 patients with donor site hypoesthesia. One patient with superficial surgical site infection that resolved without sequelae	68% returned to their preinjury sports level
Rahme et al. [31]	Glenohumeral arthrosis in 35 shoulders	Rowe—84 ± 15, Constant—84 ± 14	Dislocation: 18 patients	NR	NR
Scheibel et al. [35]	Three patients with OA development. All patients with graft consolidation without signs of resorption	Constant score = 88.3, Rowe score = 89.5, Walch-Duplay score = 83.5, WOSI = 82.6%, MISS = 80.6	None	None	NR
Steffen et al. [38]	Nineteen patients with development of mild OA and 1 patient had moderate OA. OA progression by 1 stage in 7 patients	OSIS = 18.1	Dislocation: 1 patient Sensation of instability: 3 patients	Eight patients with residual pain. One patient with subscapularis insufficiency. One patient underwent revision surgery after 6 years, further details not provided	NR
Warner et al. [45]	Graft incorporation with preservation of glenoid contour in all patients	ASES from 65 to 94, UCLA score from 18 to 33, Rowe from 28 to 94	None	Most patients reported discomfort over the donor site	All returned to preinjury sports level
Anderl et al. [2]	Significant increase in glenoid area, no signs of osteolysis or gapping. 10 patients with mild instability arthropathy, however, no progression over time	Improvement in all PROs ROWE from 57.6 to 98.6, Constant score from 70.9 to 96.3, VAS from 4.4 to 0.2. SSVS from 31.4% to 95.6%	None	1 patient had traumatic graft fracture during follow-up	All returned to preinjury sports level

Table 3 (continued)

Study (y)	Radiographic outcomes	Clinical outcomes	Instability	Other complications	Return to sport
Auffarth et al. [4]	No bony resorption. Of the 17 patients without arthritis prior to surgery, 6 developed arthritis	Rowe score = 94.3, Constant score = 93.5	None	1 patient had a traumatic graft fracture	93.8% returned to their preinjury sports level
Deml et al. [9]	Subchondral mineralization present bilaterally in 85.7%	Constant score = 92.5	None	NR	NR
Moroder et al. [24]	75% of patients with some degree of instability arthropathy	WOSI = 295, Rowe score = 94, SSVS = 95%. Decreased external and internal rotation was seen in the affected shoulder	None	1 patient had a traumatic graft fracture	20% reported sports performance impairment following surgery
Moroder et al. [25]	Significantly lower defect area when compared to Latarjet in all patients	No difference in PROs between ICBG and Latarjet. Internal rotation decreased in the Latarjet group when compared to ICBG	Subluxations: 2 patients	1 patient had graft fracture after a traumatic fall, 8 with donor site sensory disturbances and two patients with donor site superficial wound infection	NR
Arianjam et al. [3]	Solid graft union in 78%. One patient with complete resorption of the graft and three patients with slight graft resorption	Improvement in ROWE from 32.4 to 77.2	Dislocation: 2 patients Subluxation: 2 patients	None	76% returned to their preinjury sports level
Venkatachalam et al. [44]	NR	OSIS-43	Dislocation: 1 patient	One patient had a superficial infection treated with antibiotics. Two patients required screw removal	By 6 months 85% returned to preinjury sports level

OA osteoarthritis, *NR* not recorded, *WOSI* Western Ontario Shoulder Instability Index, *MISS* Melbourne Instability Shoulder Score, *OSIS* Oxford Shoulder Instability Score, *ASES* American Shoulder and Elbow Surgeons score, *UCLA* University of California, Los Angeles shoulder score, *SSVS* Subjective Shoulder Values Score, *VAS* visual analog scale, *PROs* patient-reported outcomes, *ICBG* iliac crest bone graft, *SANE* single assessment numeric evaluation, *SLAP* superior labral, anterior posterior

Table 4 Outcomes of studies utilizing allograft bone block procedures

Study (y)	Radiographic outcomes	Clinical outcomes	Instability	Other complications	Return to sport
Frank et al. [15]	NR	VAS-1.8, ASES-89.7, WOSI-89.7, SANE-90	Dislocation: 1 patient	Two patients with persistent pain, 2 underwent reoperation: 1 hardware failure, 1, and subscapularis failure	NR
Provencher et al. [28]	Complete union observed in 92% of patients. Superior graft resorption at the periphery seen in 24 patients	Improvement in all PROs ASES from 40 to 92, SANE from 44 to 91, WOSI from 1300 to 310. ROM: Significant improvement in forward flexion, abduction and external rotation	None	None	NR
Abdelshahed et al. [1]	All radiographs showed intact screw in good alignment with bone adjacent to the congruent glenoid surface	All patients were "satisfied" or "extremely satisfied" with the procedure. PROs: final follow-up ASES = 92, WOSI = 315 (15%). ROM: No significant difference between pre and post op	Dislocation: 1 patient	One patient underwent SLAP repair following a subsequent injury	NR
Taverna et al. [41]	Healing rate of 92.3%. One patient developed grade 1 arthritic changes	SSVS = 87.4, Rowe score = 96.4, Walch-Duplay score = 93.2	None	2 patients with postoperative hematoma that resolved spontaneously. One patient with a traumatic posterior shoulder dislocation	67% returned to their preinjury sports level
Zhao et al. [49]	All grafts healed to the glenoid. Mean graft resorption was 32.3%. 14 patients developed mild arthrosis and 2 with moderate arthrosis; however, no progression of arthrosis was seen	OSIS from 29.7 to 42.4, Rowe from 34.7 to 91.8	Dislocation: 1 patient Sensation of instability: 2 patients	6 patients reported slight pain	NR
Weng et al. [46]	Bony union seen in all patients. No signs of significant resorption	Rowe from 24 to 84. Mean loss of 7° external rotation	Dislocation: 1 patient Subluxation: 1 patient	NR	NR

OA osteoarthritis, *NR* not recorded, *WOSI* Western Ontario Shoulder Instability Index, *MISS* Melbourne Instability Shoulder Score, *OSIS* Oxford Shoulder Instability Score, *ASES* American Shoulder and Elbow Surgeons score, *UCLA* University of California, Los Angeles shoulder score, *SSVS* Subjective Shoulder Values Score, *VAS* visual analog scale, *PROs* patient-reported outcomes, *ICBG* iliac crest bone graft, *SANE* single assessment numeric evaluation, *SLAP* superior labral, anterior posterior

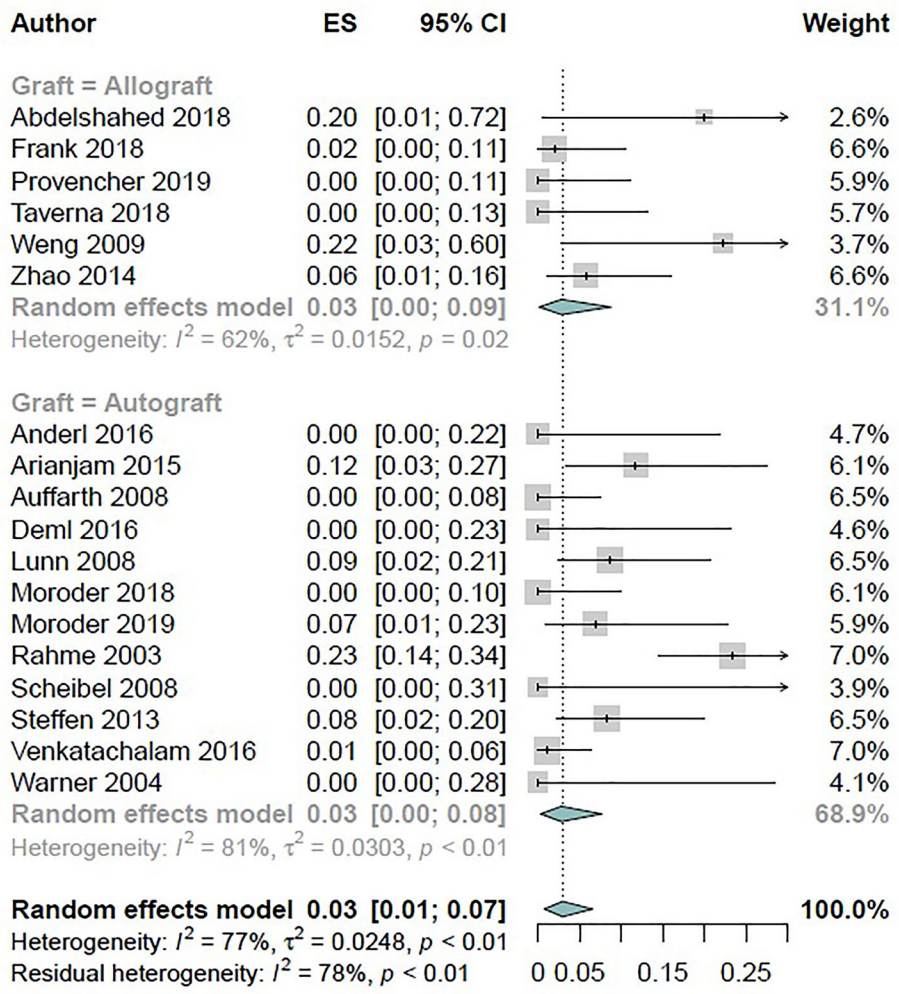


Fig. 3 Random effects modeling for proportion of patients undergoing glenoid augmentation using allografts (upper section) and autografts (lower section) with reported recurrent instability. *95%CI* confidence interval, *ES* effect size

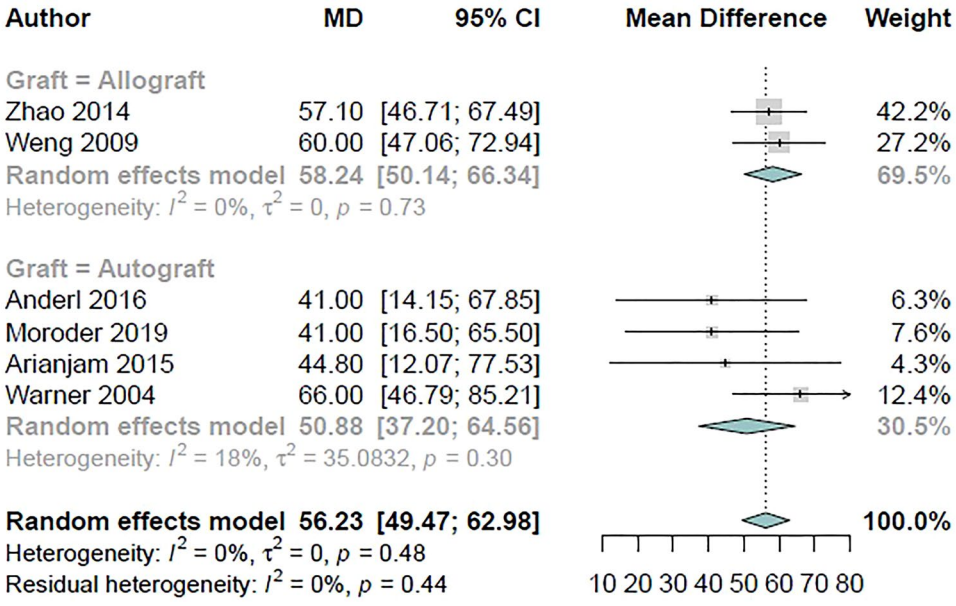


Fig. 4 Random effects modeling comparing mean Rowe scores between patients undergoing glenoid augmentation using allografts (upper section) and autografts (lower section). *95%CI* confidence interval, *ES* effect size

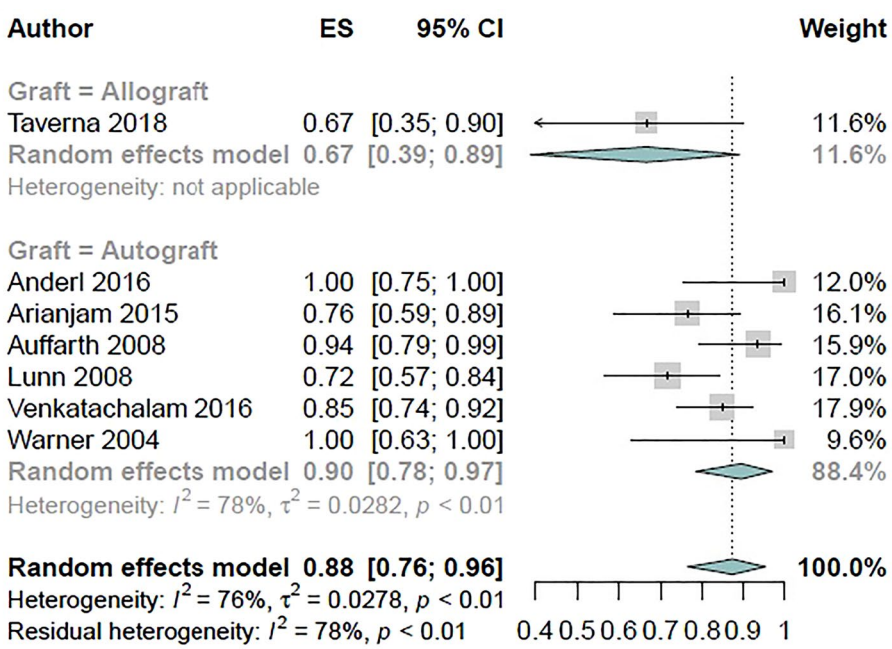


Fig. 5 Random effects modeling for proportion of patients undergoing glenoid augmentation using allografts (upper section) and autografts (lower section) who returned to sports. *95%CI* confidence interval, *ES* effect size

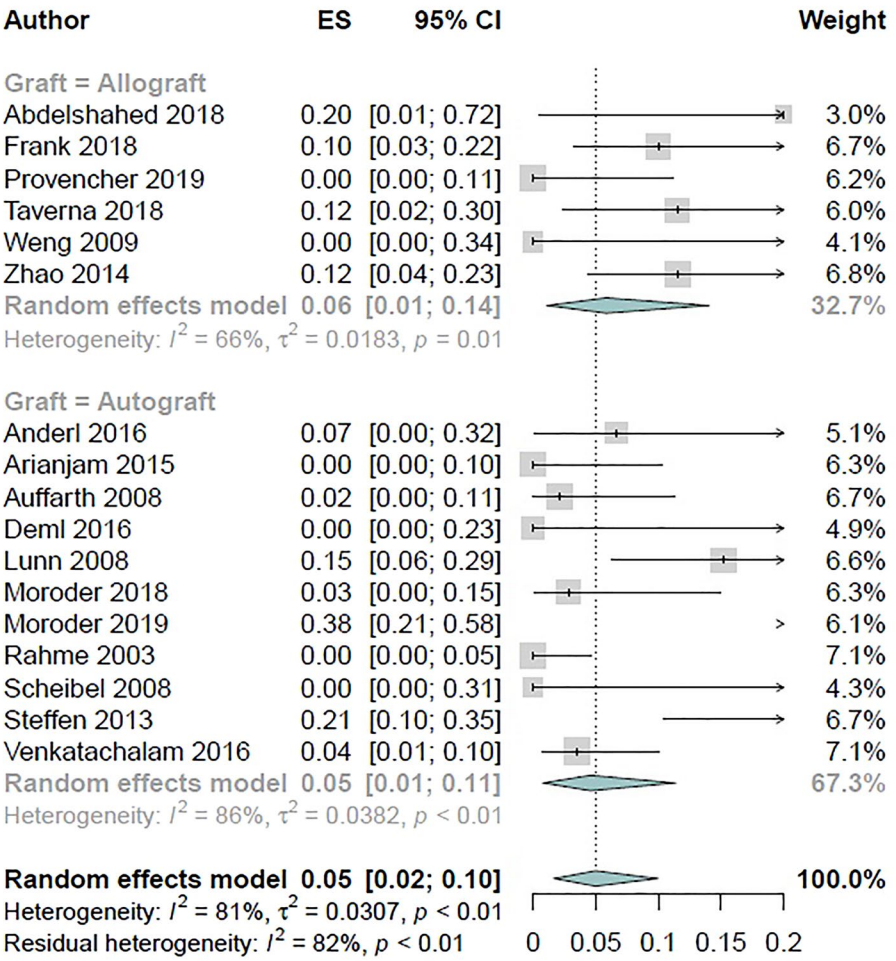


Fig. 6 Random effects modeling for proportion of patients undergoing glenoid augmentation using allografts (upper section) and autografts (lower section) who experienced a non-instability related postoperative complication. *95%CI* confidence interval, *ES* effect size

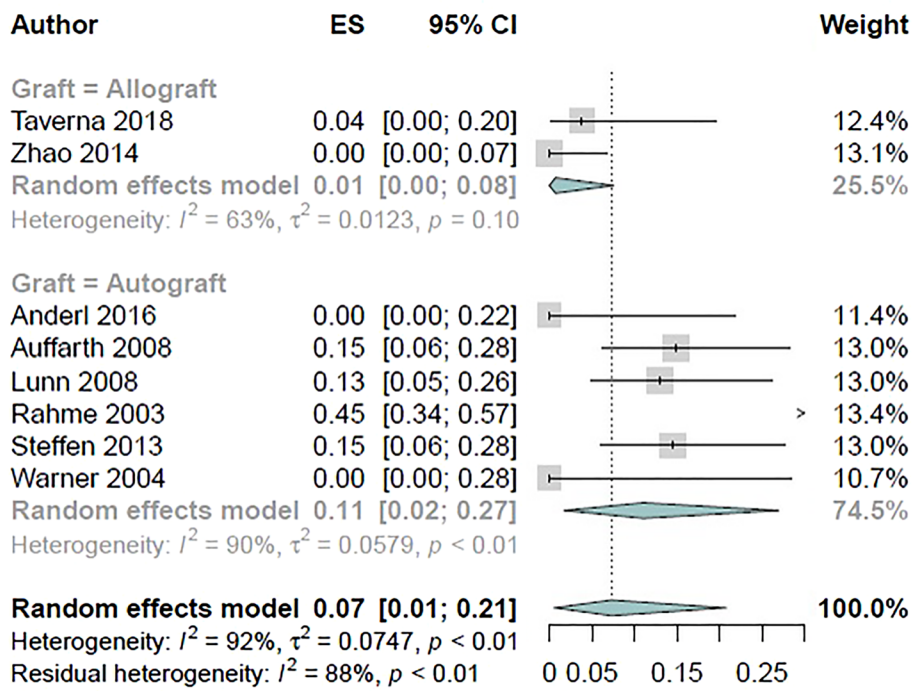


Fig. 7 Random effects modeling for proportion of patients undergoing glenoid augmentation using allografts (upper section) and autografts (lower section) with documented progression of dislocation arthropathy. *95%CI* confidence interval, *ES* effect size

from a remote site for patients with recurrent instability following a failed Latarjet procedure. The majority of patients in this review had a prior soft tissue stabilization procedure, with others reporting history of a failed bone augmentation procedure. As such, graft choice is dictated by multiple variables, including the size of bone necessary to successfully reconstitute the deficient glenoid, availability of allografts and surgeon comfort. As graft selection was not explicitly discussed in the majority of studies, further investigations examining patient and surgeon factors dictating appropriate graft selection are warranted.

Failure of free bone block augmentation, defined by recurrent shoulder instability, occurred infrequently, with comparable rates between treatment groups. The study by Rahme et al. [44] reported on the use of the Eden–Hybinette technique, involving harvest and fixation of iliac crest bone graft to the anterior glenoid. The authors reported recurrent instability in 20% of patients, with 44% requiring reoperation. The Eden-Hybinette procedure has been criticized for inferior results with higher rates of recurrence and arthritic development [45], leading the technique to fall into disuse in recent decades. However, others studies continue to advocate its use as a viable option for the management of recurrent instability [31, 45]. Overall this review demonstrates that both free autograft and allograft bone grafts are effective in successfully augmenting significant glenoid bone loss with low rates of recurrent instability, with neither group demonstrating superior outcomes.

While pooled data analysis was limited due to the heterogeneity of reported outcomes, PROs demonstrated improvement following both allograft and autograft procedures. The Rowe score for instability was found to increase approximately 50 points (on 100-point scale) after both autograft and allograft procedures, with no significant difference between the graft types. As reported by Plath et al. [26], patients undergoing shoulder stabilization possess high preoperative expectations, with up to 99% of patients expecting a normal or nearly normal shoulder following surgery. Moreover, 95% of patients expect to RTS at the same level with slight to no restrictions, with 71% expecting no pain, and 61% anticipating no risk of developing glenohumeral arthritis. Excellent PROs and a high RTS rate were reported in the studies included in our analysis, demonstrating that the outcomes following free bone block procedures using either autograft or allograft are likely to meet patient expectations when successfully performed in patients with appropriate clinical indications.

No difference in the rates of glenohumeral arthropathy was appreciated when comparing outcomes following autograft versus allograft. The development or progression of glenohumeral arthritis remains one of the primary concerns in patients with recurrent anterior instability. Restoring glenohumeral stability using glenoid augmentation is critical to minimize the risk for arthritis development and progression, especially in younger patients [28, 34]. Studies have shown that approximately 20% of patients with instability and bone loss from the anteroinferior glenoid requiring bony augmentation develop arthritis, with approximately 50% of patients possessing preexisting arthritis experiencing progression [20, 22]. Multiple investigations have identified

lateral overhang of the graft, resulting in an incongruent joint surface, as a risk factor for the development of arthritis and worse outcomes [47, 48]. As such, appropriate graft placement and evaluation for the development or progression of glenohumeral arthropathy following glenoid augmentation using a free bone block autograft or allograft is essential to ensure successful outcomes.

The high rate of glenohumeral arthropathy following free bone block autograft in our review is attributed primarily to the findings reported by Rahme et al., with 47% of patients developing glenohumeral arthritis following bone block autograft using the Eden-Hybinette technique [31]. A possible technical issue accounting for the high rate of arthropathy may be secondary to shortening of the subscapularis by 1 cm, as the authors found patients developing arthropathy reported more limitations in shoulder external rotation postoperatively. It is also important to note that Rahme et al. reported outcomes with an average follow-up of 29 years (range 22–37 years), the longest follow up of any study in this review [31]. As such, the average follow-up time of the studies in this review may be too short to accurately predict the long-term incidence of dislocation arthropathy, warranting additional studies examining long-term outcomes using free bone block augmentation.

This review was not without limitations. The majority of studies in this review were of lower levels of evidence, with 16 case series, one cohort study, and one randomized controlled trial. Data analysis was limited by the heterogenous reporting of outcomes in the individual studies, primarily in regard to radiographic analysis of the bony augmentation, assessment of arthritis, and return to activities and sports rates. Moreover, different PROs were collected in each study, further limiting our ability to perform any meaningful comparisons between studies and groups. Aside from the different origins of the bone block itself, the surgical techniques were heterogenous as the performance of capsular closure, capsulorraphy, and subscapularis management were inconsistent, introducing a number of potential confounding variables into our analysis. The development of glenohumeral arthropathy has generally been observed in patients with longer-term follow up [22]; however, few studies in this analysis had follow up greater than 15 years. Finally, the indications for use of a free bone block and the decision to use allograft versus autograft were infrequently reported and cannot be inferred based on the available data.

Conclusions

Glenoid augmentation using free bone block autograft or allograft in the setting of recurrent anterior shoulder instability with glenoid bone loss is effective and safe. Outcomes and complication rates using autografts and allografts were comparable. Due to the high degree of heterogeneity in the data and outcomes reported in available studies, which consist primarily of retrospective case series, future prospective trials investigating long-term outcomes using free bone block autograft versus allograft for anterior shoulder instability with glenoid bone loss are warranted.

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Compliance with ethical standards

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Ethical approval Ethical approval was not sought for this article, because this was a systematic review and meta-analysis of already published studies only. All studies included had declared ethical approval seperately.

Informed consent Informed consent was not sought for this article, because this was a systematic review and meta-analysis without the enrollment of any new patients.

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