Systematic Review

Bone Block Augmentation of the Posterior Glenoid for Recurrent Posterior Shoulder Instability Is Associated With High Rates of Clinical Failure: A Systematic Review

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Purpose: To determine whether posterior glenoid bone block augmentation performed for the treatment of recurrent posterior shoulder instability succeeds in restoring stability and is associated with rates of complications or clinical failures comparable to other glenoid bone augmentation procedures. **Methods:** A comprehensive search of PubMed, MEDLINE, and EMBASE databases was performed. Level of evidence studies I to IV pertaining to posterior bone block augmentation reporting on outcomes or complications were included. The search was carried out in accordance with the Preferred Reported Items for Systematic Reviews and Meta-analyses guidelines. **Results:** Screening of titles, abstracts, and manuscripts with application of inclusion and exclusion criteria yielded 17 full-text articles reporting on 269 shoulders undergoing bone block augmentation. Surgical technique varied between studies with regard to graft type (iliac crest, 13 studies; scapular spine, 2; acromion, 1; distal tibia allograft, 1), graft positioning (medial to 1.5 cm lateral to glenoid surface, equatorial to subequatorial), and open versus arthroscopic technique (open, 10 studies; arthroscopic, 4; both, 3). Four of the 8 studies with pre- and postoperative patient-reported outcomes (PROs) showed significant improvements in these outcomes at final follow-up. The postoperative outcomes ranged from 60 to 90 for Rowe scores (n = 7 studies) and 79 to 90 for Walch-Duplay scores (n = 7 studies). Complications were commonly encountered, with high rates of recurrent instability (0% to 73%) and revision procedures (0% to 67%) across different studies. **Conclusion:** Posterior bone block augmentation for recurrent posterior shoulder instability does not reliably yield substantial improvements in PROs, and complications are frequently observed. The substantial heterogeneity across studies and the small number of patients precludes any substantive judgements as to the superiority of one surgical technique over another. **Level of Evidence:** IV, systematic review of level III and IV studies.

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Symptomatic shoulder instability is common in young, active individuals, especially athletes involved in contact and overhead sports. Although anterior shoulder instability is more commonly encountered, posterior instability can also be a substantial source of shoulder dysfunction, occurring in 2% to 10% of cases of shoulder dislocations.[1,2] Conservative management of posterior shoulder instability with physical therapy can be pursued as a first-line treatment approach, particularly among overhead athletes, but arthroscopic capsulolabral repair remains the mainstay of treatment in refractory cases.[1,3-6] Although

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arthroscopic posterior stabilization procedures have been associated with excellent clinical outcomes, several risk factors for the failure of primary arthroscopic repair have been identified, including female sex, suture-only repairs, and decreased glenolabral complex width.[7-10]

For revision cases or cases involving considerable posterior glenoid bone loss or incompetent posterior soft tissues, posterior glenoid bone block augmentation has been proposed as a viable surgical option. However, the indications for this procedure remain relatively ill defined, as there is a paucity of literature related to the clinical outcomes associated with posterior bone block augmentation. A number of techniques have been described involving both open and arthroscopic approaches, with marked variability in the source of the bone block and the position in which it is fixed on the glenoid. Moreover, the strength of the conclusions reached by several recent retrospective case series are limited by small sample sizes and heterogeneous methods for assessing both radiographic and clinical outcomes.

The purpose of the current study was to determine whether posterior glenoid bone block augmentation performed for the treatment of recurrent posterior shoulder instability succeeds in restoring stability and is associated with rates of complications or clinical failures comparable to other glenoid augmentation procedures. It was hypothesized that posterior bone block augmentation would result in improved patient-reported outcomes (PROs) and rates of recurrent instability and complications comparable to other glenoid bone augmentation procedures.

Methods

Search Strategy

A comprehensive search of the PubMed, MEDLINE, and EMBASE databases was performed on March 16, 2021, pertaining to bone block augmentation of the posterior glenoid in accordance with Preferred Reported Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The search strategy is outlined in Appendix 1, and the PRISMA checklist can be found in Appendix 2.

Study Screening

Two reviewers (A.J.S., J.D.H.) independently screened the titles, abstracts, and full-text articles. When necessary, any disagreements were reconciled by another senior author (A.L.) to determine study inclusion. The references of the included studies were then scrutinized for additional studies that may have been relevant but were not included in the initial search.

Assessment of Study Eligibility

The purpose and study eligibility of this analysis were determined a priori. Articles met inclusion criteria if they were therapeutic, noncadaveric, human studies written in English (or with English translation available) reporting outcomes, including pain, PROs, return to sport, or complications on patients undergoing posterior glenoid bone block augmentation. Level I through IV studies pertaining to primary or revision, open or arthroscopic, and autograft or allograft procedures were eligible for inclusion. Studies reporting on <5 patients undergoing bone block augmentation were excluded, as were conference abstracts, book chapters, and review articles.

Data Abstraction

Two independent reviewers (J.C., M.A.F.) collated study data into a spreadsheet (Excel version 2016; Microsoft, Redmond, WA) designed a priori. For each study included in the final review, the following data were abstracted: authors, year of publication, level of evidence, sample size, follow-up interval, age, sex, direction of instability, hypermobility-associated condition, athletic status, history of recurrent dislocation, prior procedure, procedure performed, type of bone graft used, PROs, and complications.

Quality Assessment

Study quality was assessed and graded by 2 independent reviewers using the Methodological Index for Non-randomized Studies (MINORS) criteria. Each item in the MINORS Criteria is scored 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate), with a maximum score of 16 for non-comparative studies and 24 for comparative studies. To quantify agreement among reviewers regarding MINORS scoring, the intraclass correlation coefficient (ICC) was calculated. Agreement was characterized a priori by using the following thresholds: an ICC >0.9 is considered excellent agreement; 0.75 to 0.9, good; 0.5 to 0.75, moderate; and <0.5, poor. The κ statistic was calculated for the title, abstract, and full-text screening stages to assess inter-rater agreement. Agreement was characterized a priori by using the following thresholds: $\kappa > 0.61$ is considered substantial agreement; 0.21 to 0.60, moderate ; and <0.21, slight.

Statistical Analysis

Data from each study were abstracted, and where possible, if not explicitly reported in the manuscript, means and standard deviations were calculated for parameters of interest. Ranges for PROs and the incidence of demographics and complications in the included studies are reported. Given the heterogeneity in terms of methodology of the included studies, the results were not pooled, and instead are presented in a

descriptive manner. Forest plots were developed to depict the results reported in each study using StatsDirect statistical software (version 3.2.7, StatsDirect, Cheshire, UK). The I^2 test was used to assess statistical heterogeneity within dichotomous outcomes. Values of I^2 of 25% tp 49% were considered low statistical heterogeneity, 50% to 74% moderate, and >75% high.[11]

Results

Search and Study Characteristics

The initial literature search yielded 300 studies, with 17 studies meeting inclusion/exclusion criteria (Fig. 1). There was substantial agreement between reviewers at all phases of the review process, title ($\kappa = 0.66$), abstract ($\kappa = 0.94$), and manuscript ($\kappa = 0.86$) screen. There were 15 level IV case series and 2 level III case-control studies. Appendix 3 further details the included studies' designs. The comparative studies[12,13] received MINORS scores of 17, whereas the MINORS scores of the noncomparative studies ranged from 6.5 to 14.5. There was excellent agreement (ICC = 0.95) between reviewers with respect to MINORS score. Five studies disclosed possible conflicts of interest,[12,14-17] and 5 other studies reported no conflicts or funding for the research; 7 did not provide disclosure statements.

Patient Demographics and Instability Characteristics

There were 269 shoulders included overall. The mean age of patients across all included studies ranged from 19 to 42.4 years. Two studies[18,19] reported that a subset of their patients included manual laborers, and 8 studies reported results in athletes, 6 of which further differentiated noncontact from contact athletes. Nine studies reported on patients who had undergone prior soft tissue procedures; however, only 1 study, by Fronek et al.,[13] detailed differences between patients with prior procedures, noting more advanced intra-articular pathology at the time of bone block augmentation.

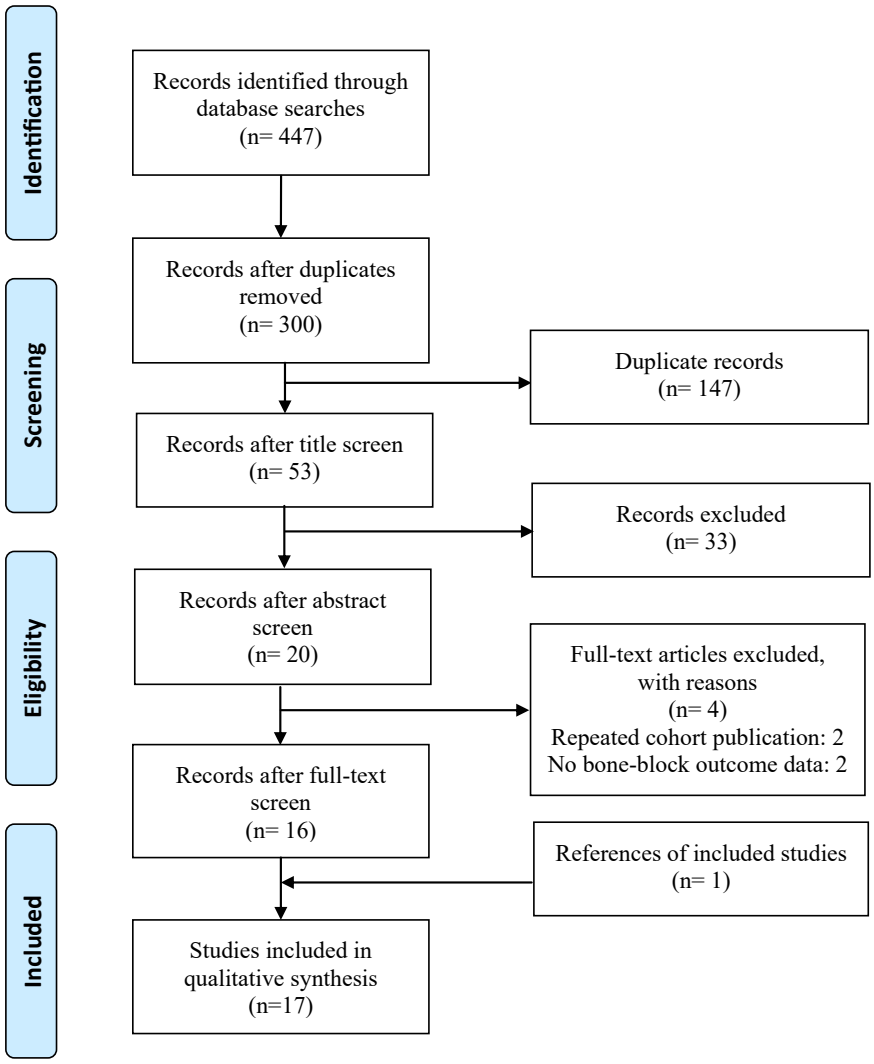

Fig 1. Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) flow diagram.

Table 1. Study characteristics and baseline demographic information

Reference	Year	LoE	MINORS Score	Shoulders	Study Period	Sex, M/F	Age (y)	Follow-Up (mo)	Shoulders with Prior Procedures	Shoulders with Recurrent Dislocations	Approach	Surgery Performed	Bone Block Source
Ahlgren et al.[28]	1978	IV	7	5	NR	4/1	18 to 64	Minimum 15	NR	NR	Open	Posterior bone block ± infraspinatus tendon/ capsular repair 4 cases	Iliac crest
Aksekili et al.[26]	2015	IV	10.5	10	2004 to 2011	9/0	42.4 (23 to 53)	40.6 (24 to 55)	2 (20)	10 (100)	Open	Posterior bone block ± reverse Hill-Sachs grafting in 8 cases	Iliac crest
Barbier et al.[19]	2009	IV	10.5	8	1996 to 2006	8/0	28.7 (23 to 33)	34 (10 to 60)*	3 (38)	8 (100)	Open	Posterior bone block + capsular repair	Iliac crest
Bessems et al.[27]	1995	IV	7.5	13	1978 to 1994	8/2	19 (15 to 27)	108 (12 to 192)*	NR	NR	Open	Glenoplasty with bone graft	Iliac crest
Boileau et al.[15]	2013	IV	8.5	15	NR	12/3	27 (14 to 58)	17.6	NR	NR	Arthroscopic	Posterior bone block + capsulolabral repair	Iliac crest
Camenzind et al.[14]	2021	IV	12	19	2008 to 2013	16/2	33.9 (22 to 68)	87.6 (60 to 120)	9 (47)	NR	Arthroscopic	Posterior bone block	Iliac crest
Clavert et al.[14]	2017	IV	10	66	NR	55/11	27.8 ± 10.3 (15 to 58)	44 (12 to 156)	0 (0)	NR	Arthroscopic and open	Posterior bone block	Iliac crest and acromion
Fronek et al.[13]	1989	III	17	5	1978 to 1984	5/0	16.8 ± 2.17	Minimum 24	4 (80)	NR	Open	Posterior bone block + capsulorrhaphy, anterior release (n = 1)	Scapular spine
Gilat et al.[16]	2021	IV	9.5	10	2011 to 2019	8/2	24 (17 to 35)	33.6 ± 20.4 (13.2 to 75.6)	7 (70)	NR	Arthroscopic, Open, Combined	Posterior bone block ± capsule and/or labral repair (5 capsular repairs, 4 labral repairs, 2 capsular plications. 1 HAGL repair)	Distal tibia allograft
Hinojosa et al.[21]	1989	IV	6.5	5	1967 to 1984	NR	23.2 ± 4.6	105.6 ± 40.8	1 (20)	4 (80)	Open	Posterior bone block + capsular retention, 1 case infraspinatus advancement	NR
Langlais et al.[12]	2020	III	17	18	1999 to 2015	NR	NR	84 ± 60	0 (0)	NR	Arthroscopic (15) and open (3)	Posterior bone block + capsulolabral repair	Autograft (17), allograft (1)
Meuffels et al.[20]	2010	IV	10	11	1985 to 1995	6/5	25.8 (16 to 57)†	219.6 (153.6 to 282)*	3 (23)	11 (100)	Open	Posterior bone block	Iliac crest
Mowery et al.[18]	1997	IV	6.5	5	1975 to 1982	3/2	28.6 (17 to 44)	50.4 (30 to 96)	0 (0)	5 (100)	Open	Posterior bone block + capsular repair	Posterior iliac crest
Schwartz et al.[23]	2013	IV	10	19	2008 to 2009	13/5	29.85 (15 to 56)	20.5 (13.5 to 32)	5 (26)	NR	Arthroscopic	Posterior bone block ± capsulorrhaphy (n = 2)	Iliac crest
Servien et al.[25]	2007	IV	10.5	21	1984 to 2001	19/1	24.8 (17 to 40)	72 (24 to 228)	0 (0)	16 (76)	Open	Posterior bone block, 1 concomitant osteotomy	Iliac crest
Struck et al.[22]	2015	IV	14.5	15	2001 to 2010	7/8	20 (17 to 32)	46.3 (12 to 120)	2 (13)	15 (100)	Open	Posterior bone block	Scapular spine and iliac crest
Wellmann et al.[24]	2018	IV	12.5	24	2011 to 2014	NR	22 (15 to 48)	26.4 (14 to 44)	1 (4)	19 (79)	Arthroscopic	Posterior bone block + capsular repair	Iliac crest

Data are n, mean (range), range, or mean ± standard deviation (range), unless noted otherwise.

HAGL, humeral avulsion of glenohumeral ligament; LoE, level of evidence; MINORS, Methodological Index for Non-Randomized Studies; NR, not reported.

*Median (range).

†Reported in Gilat et al.[29]

Table 2. Summary of outcomes

Reference	Preoperative Scores	Postoperative Scores	Subjective Satisfaction
Ahlgren et al.[28]	NR	NR	Satisfied: 3; somewhat satisfied: 2
Aksekili et al.[26]	NR	Constant: 81.3 ± 17.8 (55 to 98)	NR
Barbier et al.[19]	Constant: 82.5 (70 to 100)	Constant: 96.3 (85 to 100) Walch-Duplay: 90 (70 to 100)	Satisfied: 80%
Bessems et al.[27]	NR	NR	Satisfied: 13
Boileau et al.[15] (n = 5)	NR	Rowe: 87 Walch-Duplay: 89	NR
Camenzind et al.[17]	ASES: 57 ± 18; Constant: 63 ± 18; Rowe: 37 ± 23; SSV: 58 ± 20; VAS: 5.6 ± 2.5; Walch-Duplay: 34 ± 31	ASES: 81 ± 18; Constant: 80 ± 18; Rowe: 79 ± 24; SSV: 76 ± 24; VAS: 2.3 ± 2.3; Walch-Duplay: 79 ± 22	VAS satisfaction (1 to 10): 8.4 ± 2.1
Clavert et al.[14]	Constant: 76.1; VAS: 4.7	Constant: 86.0; VAS: 1.6; Rowe: 86.5 (20 to 100); Walch-Duplay: 81.5 (25 to 100)	Very satisfied: 58%; satisfied: 27%; somewhat satisfied: 6%; disappointed: 9%
Fronek et al.[13,†]	Instability rating scale: 0 (0 to 1)*; pain rating scale: 1 (0 to 2)*	Instability rating scale: 1 (3 to 3)*; pain rating scale: 3 (2 to 3)*	Satisfied: 5
Gilat et al.[16]	SF-12 physical: 32.5; mental: 57.3	SF-12 physical: 41.8; mental: 46.5	NR
Hinojosa et al.[21]	NR	NR	Excellent: 2; poor: 1; failure: 2
Langlais et al.[12]	NR	SSV: 77 ± 20; SSV sport: 68 ± 29; VAS: 2 ± 2	Very satisfied or satisfied: 83%
Meuffels et al.[20]	VAS*: 70 ± 29	Rowe 6 years: 90 (55 to 100)*; 18 years: 60 (15 to 100)*; VAS: 40 ± 31 (0 to 87)*; WOSI: 60 (37 to 100)*	Very satisfied: 3; satisfied: 3; dissatisfied: 4; no opinion: 1
Mowery et al.[18]	NR	NR	Excellent: 4; good: 1
Schwartz et al.[23]	Rowe: 18.4; Walch-Duplay: 37.4	Rowe: 82.1; Walch-Duplay: 82.9	Excellent: 9; satisfied: 7; unsatisfied: 3
Servien et al.[25]	NR	Constant: 93.3 (80 to 103); Walch-Duplay: 85.6 (40 to 100)	Very satisfied: 12; satisfied: 8
Struck et al.[22]	NR	Constant: 82 (64 to 98); Rowe: 88 (48 to 98); Walch-Duplay: 81 (0 to 100); WOSI: 77% (33 to 99)	NR
Wellmann et al.[24]	Constant: 82; Rowe: 50; WOSI: 37%	Constant: 82; Rowe: 75; WOSI: 66%	NR

Data are mean ± standard deviation (range) or mean (range) unless noted otherwise.

ASES, American Shoulder and Elbow Score; NR, not reported; SF-12, 12-item Short Form; SSV, Subjective Shoulder Value; VAS, visual analog scale; WOSI, Western Ontario Shoulder Instability Index.

*Median.

†Instability and pain rating scale from Fronek et al.[13]: 0, symptoms with activities of daily living, minimal exercise; 1, symptoms with moderate activity, recreational sports; 2, symptoms only with strenuous activity, competitive sports; 3, no symptoms with strenuous activity.

When reported, rates of recurrent dislocation preoperatively were high for the included study populations (76% to 100%) (Table 1). Classification of instability on the basis of volition with or without secondary gain/concomitant psychologic disorder was inconsistently reported, but 1 study attempted to compare involuntary (at onset) instability to voluntary instability that later became involuntary,[12] 2 studies noted inclusion of patients who had voluntary instability, and 2 studies reported on patients who were habitual dislocators.[13,14,20,21]

Glenoid bone loss or erosion and reverse Hill-Sachs lesions were reported in 11 studies; however, only 2 studies specifically quantified the amount of posterior bone loss.[16,22] Glenoid dysplasia was much less common, with Schwartz et al.[23] including 3 shoulders with dysplasia, Mowery et al.[18] and Camenzind et al.[17] including 2 dysplastic cases each, and Barbier et al.[19] and Gilat et al.[16] noting 1 glenoid each with hyperplasia and hypoplasia, respectively. With respect to glenoid version, 4 studies[12,19,24,25] quantified mean retroversion (range: 9.6° to 20°), and 3 studies strictly described subsets of patients as having increased retroversion.[17,22,23]

Posterior bone block augmentation was performed as both primary and revision stabilization procedure (Table 1). Surgeries performed before posterior bone block augmentation included anterior stabilization procedures (Latarjet procedure[17,19] and anterior capsulolabral repairs[13,17,19,21,23]) and posterior stabilization procedures (capsulolabral repairs[13,16,22-24] and posterior Putti-Platt procedures,[20] one of which had a concomitant glenoid osteotomy).

Surgical Procedures

Regarding the bone block augmentation procedures, 4 studies reported results of arthroscopic augmentation, 10 reported results of an open approach, and 3 studies

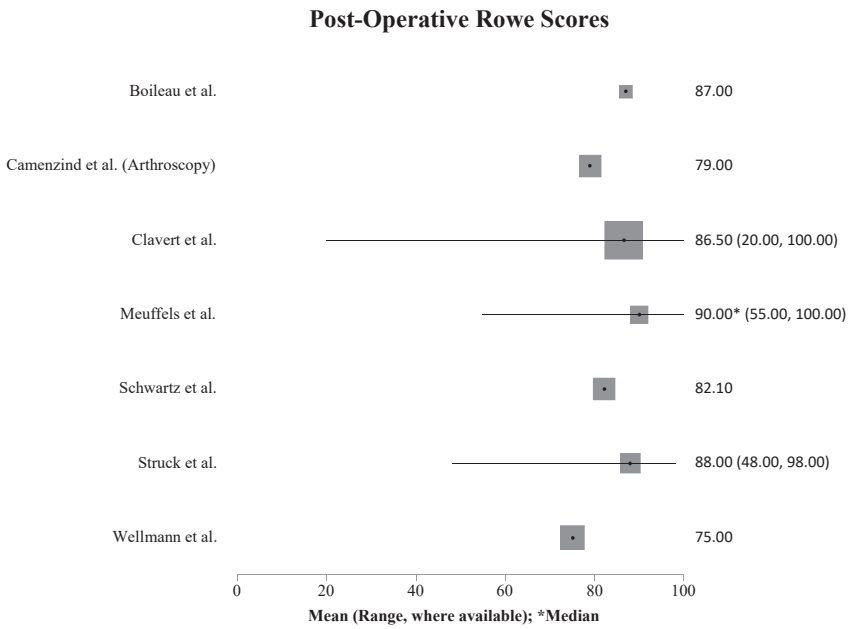

Fig 2. Forest plot of postoperative Rowe scores.

reported results from both. Posterior capsular or labral procedures were frequently performed as concomitant procedures (Table 1). Less commonly performed adjuncts included glenoid osteotomy,[25] reverse humeral avulsion of glenohumeral ligament (HAGL) repair,[16] reverse Hills-Sachs bone grafting,[26] and anterior capsular release.[13] One study (n = 13 shoulders) by Bessems et al.[27] reported a variant of bone block augmentation that combined a glenoid osteotomy with fixation of a posterior bone block to extend the glenoid surface and correct glenoid version.

The source of the glenoid bone block augmentation also varied among studies. Iliac crest bone graft (n = 13 studies) was used most commonly, followed by the

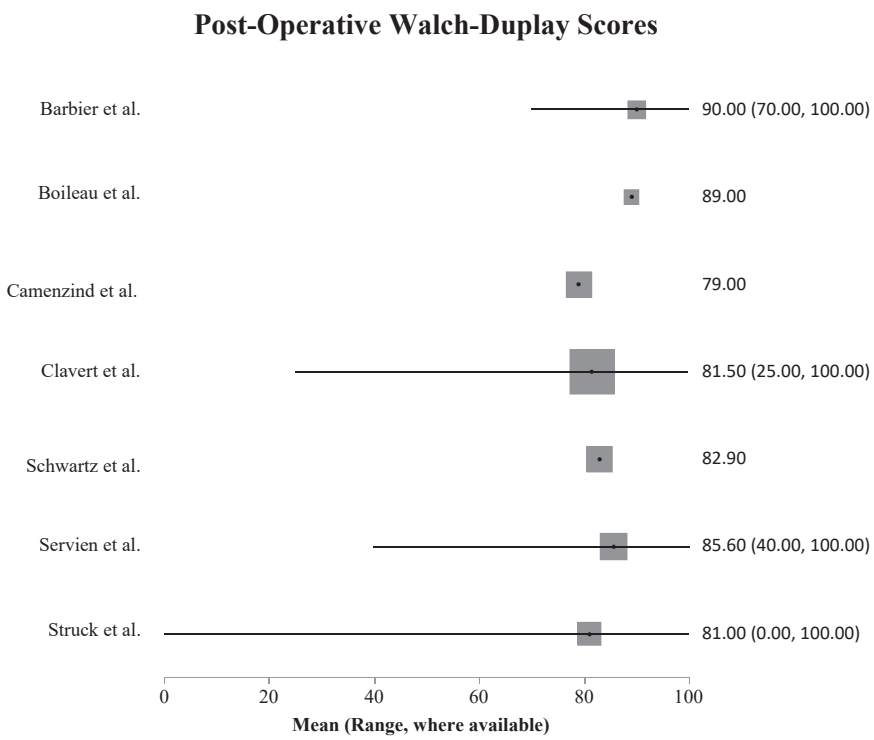

Fig 3. Forest plot of postoperative Walch-Duplay scores.

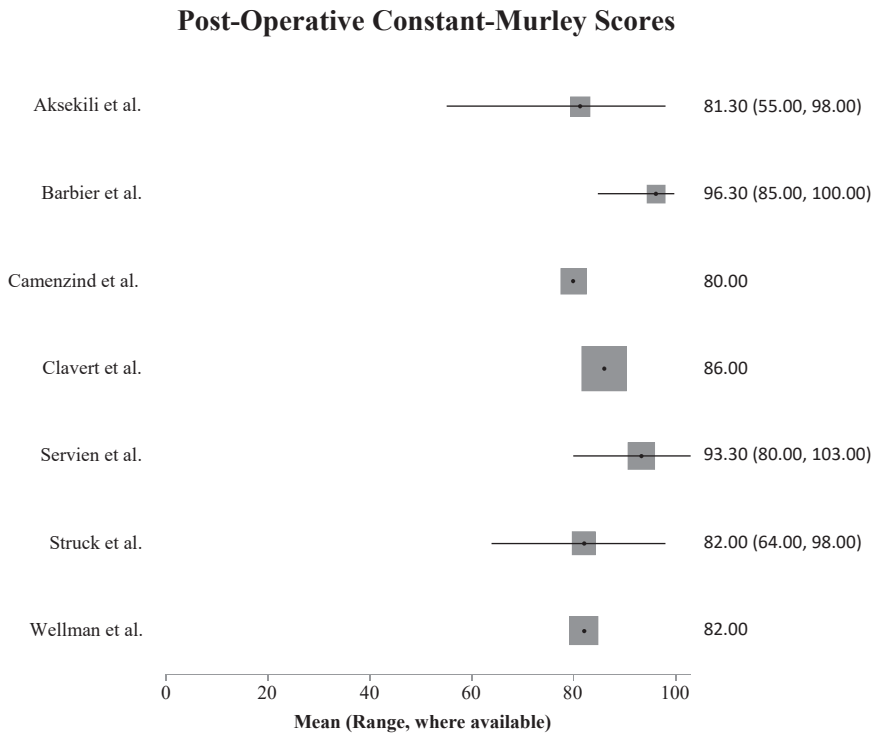

Fig 4. Forest plot of postoperative Constant-Murley scores.

scapular spine (n = 2 studies), acromion (n = 1 study), and distal tibia allograft (n = 1 study), whereas 2 studies[12,21] did not report the donor graft location. Substantial variability was noted with regard to the preferred position of the bone block on the posterior glenoid. In the earliest study by Ahlgren et al.,[28] the position of the bone block was not specified, but representative radiographs demonstrated graft placement well medial to the glenoid articular surface, whereas 2 other reports[18,21] advocated for graft placement 1.5 cm lateral to the glenoid. The remaining studies reported a range of planned placement locations, with multiple studies advocating for a subequatorial or flush position of the bone block relative to the articular surface.[13-17,19,20,22-24] Three studies[14,15,19] reported postoperative findings regarding placement of the grafts, with 2 studies each reporting instances of misplaced grafts, one of which was deemed equatorial (>25% of the graft above the equator) and one of which was overhanging excessively (>10 mm) laterally.[15] The study by Schwartz et al.[23] mentioned that a prominent graft may have contributed to humeral head erosion. Two studies assessed bone block position with postoperative computerized tomography (CT) scans, with all but one of the grafts across the studies deemed to be in an appropriate position (flush with the articular portion of the glenoid and subequatorial).[15,19]

Patient-Reported Outcomes

The most commonly reported PROs across the included studies were the Rowe score, Walch-Duplay score, Western Ontario Shoulder Instability Index

Table 3. Characterization of reported return to sport data

Studies Reporting Return to Sport	Athletes	Contact Sport Athletes	Athletes Who Returned to Sport
Barbier et al.[19]	7	4 (57)	4 (57)
Camenzind et al.[14]	1*	NR	1 (100)
Clavert et al.[14]	51	NR	34 (67)
Fronek et al.[13]	4	3 (75)	NR
Mowery et al.[18]	1	1 (100)	1 (100)
Schwartz et al.[23]	18	13 (72)	14 (78)
Servien et al.[25]	19	11 (58)	17 (89)
Struck et al.[22]	12	4 (33)	10 (83)

Data are n or n (%).
NR, not reported.
*Patient with Ehlers-Danlos syndrome.

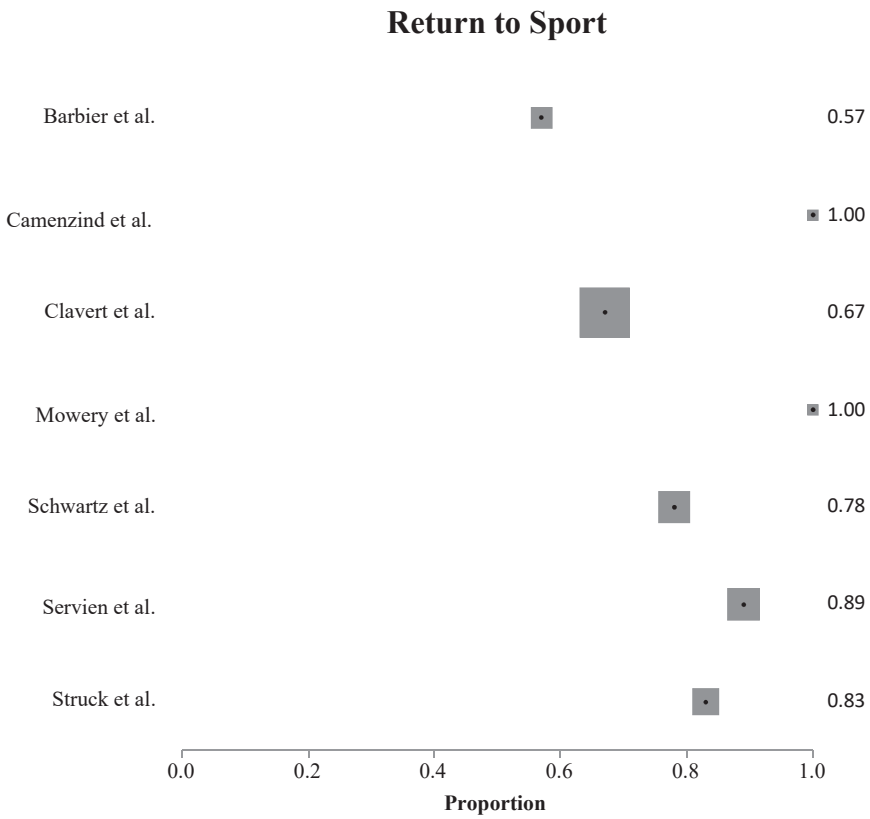

Fig 5. Forest plot of rate of return to sport.

(WOSI), and Constant-Murley (CM) score. No single PRO was measured across each of the 17 studies, and preoperative scores for comparison were reported in only 8 studies (Table 2). Four studies that recorded pre- and postoperative outcome scores found significant improvements in Rowe scores,[17,23,24] Walch-Duplay scores,[17,23] WOSI,[24] CM scores,[14,17] American Shoulder and Elbow Score (ASES),[17] Subjective Shoulder Value (SSV),[17] and visual analog scale (VAS) for pain.[14,17] Overall, the postoperative Rowe scores ranged from 60 to 90 (n = 7 studies); however, it should be noted that this range is bookended by results from midterm (6 years, Rowe score 60) and long-term (18 years, Rowe score 90) follow-up from Meuffels et al.[20] (Fig. 2, Table 2).[20] Postoperative Walch-Duplay scores at final follow-up ranged from 79 to 90 (n = 7 studies) (Fig. 3). Postoperative CM scores ranged from 80 to 96.3 (n = 7 studies) (Fig. 4).

With respect to clinical outcomes as a function of either arthroscopic or open procedures, postoperative Rowe scores ranged from 75 to 87 (n = 4 studies) and 60 to 90 (n = 2 studies), respectively. The CM scores ranged from 81.3 to 96.3 (n = 4 studies) for open procedures and 80 to 82 for the arthroscopic procedures (n = 2 studies). Lastly, Walch-Duplay scores for open approaches ranged from 81 to 90 (n = 3 studies), similar to the arthroscopic score range of 79 to 89 (n = 3 studies) (Table 2).

Return to Sport

Eight studies reported on athletes who underwent posterior bone block procedures. Return-to-sport (RTS) rates after surgery ranged from 57% to 100% ($I^2 = 0\%$, 95% confidence interval [CI] 0% to 58.5%) (Table 3, Fig. 5). No inferences could be made regarding the return to sport or level of return for contact or overhead athletes.

Complications

Complications were frequently reported in the literature, with a large range of rates of revision surgery after bone block augmentation (0% to 67%) (Table 4, Fig. 6). Apart from revision surgical procedures, recurrent instability (0% to 73%), symptomatic hardware (0% to 67%), and the development of osteoarthritis (0% to 100%) were commonly noted (Table 4, Fig. 7). Partial or complete osteolysis (0% to 100%) of the bone block was also commonly observed, although the clinical consequences of this phenomenon were not noted. In those patients undergoing arthroscopic posterior bone block augmentation, the majority of revision surgeries were attributed to symptomatic hardware (Table 4). However, in 1 study, the use of suture anchors for bone block fixation, as opposed to screws, resulted in 0 reported cases of symptomatic hardware.[15]

Table 4. Reported complications

Reference	Shoulders	Revision Surgery†	Recurrent Instability	Symptomatic Hardware	Osteoarthritis	Osteolysis
Arthroscopic						
Boileau et al.[15]	15	0 (0)	0 (0)	0 (0)	0 (0)	15 (100)
Camenzind et al.[14]	19	8 (42)	4 (21)	7 (37)	NR	19 (100)
Schwartz et al.[23]	19	7 (37)	0 (0)	6 (32)	NR	3 (16)
Wellmann et al.[24]	24	16 (67)	3 (13)	16 (67)	3 (13)	NR
Overall		0 to 67	0 to 21	0 to 67	0 to 13	16 to 100
Open						
Ahlgren et al.[28]	5	NR	2 (40)	0 (0)	NR	NR
Aksekili et al.[26]	10	2 (20)	0 (0)	1 (10)	7 (70)	NR
Barbier et al.[19]	8	3 (38)	0 (0)	3 (38)	0 (0)	0 (0)
Bessems et al.[27]	13	0 (0)	0 (0)	0 (0)	1 (8)	0 (0)
Fronek et al.[13]	5	0 (0)	0 (0)	NR	0 (0)	5 (100)
Hinojosa et al.[21]	5	0 (0)	2 (40)	1 (20)	2 (40)	1 (20)
Meuffels et al.[20]	11	3 (23)	8 (73)	2 (18)	9 (100)*	2 (18)
Mowery et al.[18]	5	2 (40)	1 (20)	1 (20)	NR	0 (0)
Servien et al.[25]	21	3 (14)	3 (14)	0 (0)	4 (19)	NR
Struck et al.[22]	15	4 (27)	1 (7)	4 (27)	1 (7)	1 (7)
Overall		0 to 40	0 to 73	0 to 38	0 to 100	0 to 100
Arthroscopic and open						
Clavert et al.[14]	66	0 (0)	8 (12)	0 (0)	NR	33 (50)
Gilat et al.[16]	10	2 (20)	1 (10)	1 (10)	NR	6 (86, n = 7)
Langlais et al.[12]	18	3 (16)	4 (22)	NR	NR	4 (25, n = 16, complete lysis)
Overall		0 to 20	12 to 22	0 to 10	NR	25 to 86

Data are n (%) or range.

Other mentioned complications included hardware cut-out/breakage, superficial wound infections, adhesive capsulitis, failure of deltoid repair, lateral femoral cutaneous nerve injury from graft harvest, and postoperative pneumothorax.

NR, not reported.

*At final follow up two patients had undergone arthrodesis, 9/9 (100%) had osteoarthritis otherwise.

†Revision surgery after undergoing bone block augmentation.

Discussion

Based on the results reported by a relatively small number of retrospective case series, posterior bone block augmentation for recurrent posterior shoulder instability does not reliably yield successful clinical outcomes and is generally associated with high rates of complications. Postoperative radiographic assessments of bone block position were inconsistently reported among included studies, and a lack of long-term radiographic follow-up did not allow for a qualitative analysis of mid- to long-term radiographic outcomes. The heterogeneity in demographics and techniques and the small number of patients across all studies precludes any substantive judgements as to the superiority of one surgical technique over another. Thus, the main hypothesis was not proven.

In the absence of consistent preoperative outcome reporting, results from anterior glenoid bone block augmentation procedures can serve as insightful comparators for their posterior counterparts. Ten studies included in this review reported recurrent instability rates of ≥10%, with 6 studies reporting rates of ≥20%, whereas a systematic review of anterior bone block augmentation procedures demonstrated low recurrent instability rates of 3% and 5% for free bone block and Latarjet procedures, respectively.[29] However, this comparison is imperfect, as the clinical presentation for recurrent anterior and posterior instability (pain versus subjective instability) is markedly different, and the reporting of instability can be variable and ambiguous. Nevertheless, inconsistent restoration of shoulder stability across the included studies of this review generates concerns about the reliability and reproducibility of the various posterior glenoid augmentation techniques.

Aside from reported rates of recurrent instability, the rates of other complications were also quite high among the included studies. Revision surgical procedures were frequently required, and it is noteworthy that 2 studies that reported on outcomes of arthroscopic bone block augmentation using screw fixation noted high rates of symptomatic hardware (32% to 67%) that ultimately required a revision procedure.[23,24] The results of the technique described by Boileau et al.,[15] which incorporates suture anchors as opposed to screws for graft fixation, may be a promising alternative, as these authors noted no instances of symptomatic hardware and no evidence of compromised bone block fixation or issues with graft healing.

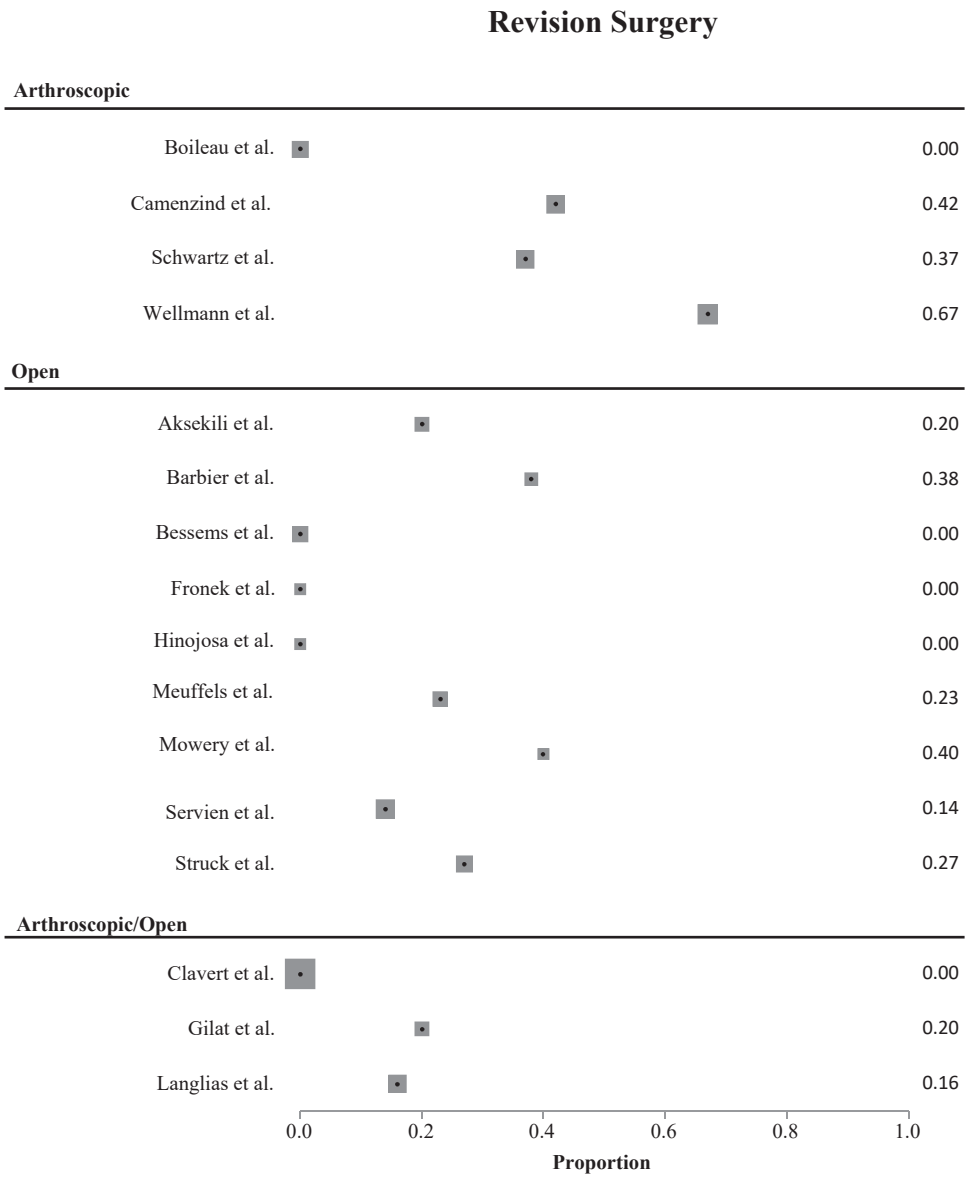

Fig 6. Forest plot of revision surgery rates after bone block augmentation.

Among the studies included in this systematic review, posterior glenoid bone loss was commonly observed. However, the magnitude of bone loss was inconsistently reported. In fact, only 2 reports quantified bone loss, which obviates the ability to draw any conclusions regarding surgical indications for posterior bone block augmentation.[16,22] Two recent studies[30,31] reporting on outcomes of posterior soft tissue stabilization procedures among active duty military members have attempted to define a "subcritical" threshold for posterior glenoid bone loss that is predictive of diminished functional outcomes, but the results were discordant, highlighting the need for iterative investigation of the 13.5% bone loss threshold that was extrapolated and applied from anterior glenohumeral instability.[30-32] The location and orientation of posterior glenoid bone loss relative to the face of the glenoid also have potential implications for surgical technique.

Initially, Nacca et al.[33] used cadaveric biomechanical testing to define 20% posterior bone loss as a critical threshold in which soft tissue repair alone could no longer restore glenohumeral stability. However, the bone loss, which was engineered directly posterior on the glenoid, is different from that of clinically observed bone loss seen in recurrent posterior shoulder instability.[33] A recent analysis by Dekker et al.[34] showed that posterior instability in fact resulted in posteroinferior bone loss. This result suggests that a subequatorial position for the bone block on the glenoid may be preferable, helping to recreate the native glenoid architecture. Subsequent efforts to understand the biomechanical and clinical sequalae of posterior glenoid augmentation

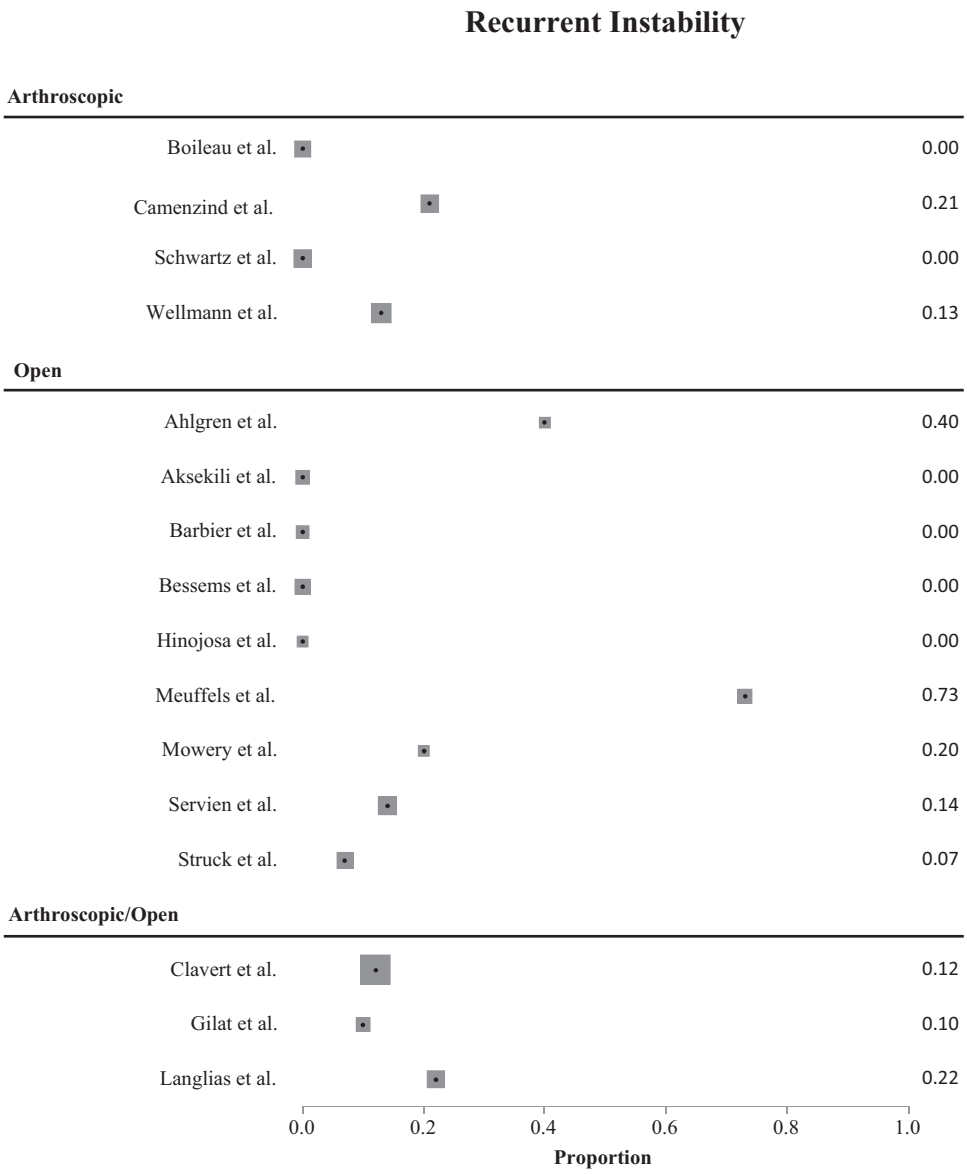

Fig 7. Forest plot of recurrent instability rates after bone block augmentation.

procedures should be executed with these facts in mind so as to facilitate refinement of surgical techniques. Thus, it is incumbent upon surgeons to report not only the magnitude and orientation of bone loss, but also bone block positioning postoperatively. The use of postoperative advanced imaging (e.g., CT) assuredly aids in an assessment of the initial graft position, as well as the magnitude of the stabilizing effect of the procedure and the amount of graft resorption over time. To this point, Camenzind et al. performed a radiographic subanalysis of their previously published series, using CT scans obtained postoperatively from 17 patients at a mean follow-up of 6.6 ± 2.8 years.[17,35] The authors noted significant changes in several important radiographic parameters, including glenoid retroversion (preprocedure 17° ± 13.5° versus postprocedure −9.9° ± 11.9°; $P < .001$) and posterior humeral head subluxation (preprocedure: 57.1% ± 10.4% versus 51.8% ± 6%; $P < .001$), after posterior bone block augmentation. Of note, the graft surface area decreased from 24% ± 9% to 17% ± 10% ($P < .001$) at final follow-up. Analyses such as this provide important information pertaining to the procedure's capacity to restore and maintain glenoid width and version while potentially helping to define the clinical sequalae of various graft positions. This is particularly relevant given the wide variability in preferred placement of the graft in the medial to lateral plane. One study noted that medial to lateral position of the graft did not seem to affect PROs, pain, or mobility,[14] but another study hypothesized that a prominent graft laterally contributed to humeral head erosion.[23] Ideally, the graft will be

positioned in such a way as to confer stability while minimizing the likelihood of complications, but at this time, there remains no consensus as to the optimal position.

Limitations

The main limitations of this study are related to a lack of high-level evidence and heterogeneity in terms of the described surgical techniques, including ideal bone block position, graft source, and fixation method. Minimum clinical follow-up of <2 years was not exclusionary in this review, as this would have markedly decreased the number of available studies for final analysis, which was believed to be detrimental to the review's purpose and its ability to provide a broad but relevant overview of the available literature. A great deal of demographic heterogeneity was noted among patients being treated with posterior bone block augmentation. For these reasons, any summary data from this review must be interpreted with caution. Ambiguous terminology, such as voluntary, habitual, bone loss, increased retroversion, and laxity, were also not adequately explained or quantified to allow for meaningful analysis. A lack of appropriate controls and mostly retrospective designs increased bias while limiting the applicability and relevance of results. Finally, a number of different PROs were used across studies, which further limits direct comparisons of clinical outcomes between included studies.

Conclusions

Posterior bone block augmentation for recurrent posterior shoulder instability does not reliably yield substantial improvements in PROs, and complications were frequently observed. The substantial heterogeneity across studies and the small number of patients precludes any substantive judgements as to the superiority of one surgical technique over another.

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Appendix 1. Search strategy

Search Date: March 16, 2021								
Pubmed			Medline			Embase		
#	Searches	Results	#	Searches	Results	#	Searches	Results
1	Posterior shoulder instability OR posterior shoulder dislocation OR posterior glenoid bone loss OR reverse bony Bankart	2384	1	(Posterior shoulder instability OR posterior shoulder dislocation OR posterior glenoid bone loss OR reverse bony Bankart).mp [mp= title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	449	1	'Posterior shoulder instability' OR 'posterior shoulder dislocation' OR 'posterior bone loss' OR 'reverse bony Bankart'	563
2	Bone graft OR bone block OR allograft OR autograft	344,821	2	(Bone graft OR bone block OR allograft OR autograft).mp	78,605	2	'Bone graft' OR 'bone block' OR 'allograft' OR 'autograft'	157,073
3	#1 AND #2	267	3	#1 AND #2	78	3	#1 AND #2	102

Appendix 2. PRISMA checklist

Section/topic	#	Checklist Item	Reported on page #
Title			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Page 3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Page 3-4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. https://www.crd.york.ac.uk/PROSPERO/	CRD42020200456
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Page 5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Page 4
Search	8	Present full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Page 4-5, Figure 1
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Page 5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Page 5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Page 5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Page 5-6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Page 6

(continued)

Appendix 2. Continued

Section/topic	#	Checklist Item	Reported on page #
Risk of Bias Across studies	15	Specify any Assessment of Risk of Bias that may Affect the Cumulative Evidence (e.g., Publication Bias, Selective Reporting within studies).	Page 5
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Page 6 Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Page 6-7 Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Page 7
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Figures 2-7
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Page 7
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Page 11
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Page 14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Page 14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	No funding

From Moher et al.[36]

Appendix 3. Study design

Reference	Retrospective or Prospective	Type of Study	Investigational Site	Study Inclusion	Study Exclusion
Ahlgren et al.[28]	Retrospective	Case series	NR	Posterior instability	NR
Aksekili et al.[26]	Retrospective	Case series	Single surgeon	Chronic posterior shoulder dislocations undergoing posterior glenoid bone block augmentation	Connective tissue disease, congenital glenoid failure, acute interventions <8 wk, those requiring only soft tissue procedures
Barbier et al.[19]	Retrospective	Case series	Single surgeon	Consecutive series of congenital or acquired involuntary posterior shoulder instability, no age or sex criteria	Voluntary shoulder instability
Bessems et al.[27]	Retrospective	Case series	Two surgeons	Recurrent posterior shoulder instability	NR
Boileau et al.[15]	Retrospective	Case series	Single center	Recurrent posterior shoulder instability undergoing novel suture anchor—based fixation of posterior glenoid bone block	NR
Camenzind et al.[14]	Retrospective	Case series	Single center	Patients undergoing ICBG for recurrent posterior shoulder instability due to glenoid dysplasia, posterior glenoid bone loss, or irreparable soft-tissue defect, and in case of revision for persistent instability in patients after failed posterior Bankart repair	Concurrent procedures or clinical follow-up <5 y
Clavert et al.[14]	Retrospective	Case series	Multicenter	Unidirectional posterior shoulder instability treated with open or arthroscopic bone block augmentation; 3 broad clinical pictures included: (1) recurrent traumatic posterior instability (dislocation or subluxation); (2) recurrent voluntary posterior instability (dislocation or subluxation) that became involuntary; (3) unstable painful shoulder	Uncategorized instability, unstable painful shoulder, had undergone revision surgery, or had neglected posterior dislocation
Fronek et al.[13]	Prospective	Case-control, nonoperative vs operative	Single surgeon	Recurrent posterior subluxation of the glenohumeral joint, non-operative (Group 1): moderate symptoms, operative (Group 2): incapacitating symptoms or substantial disability, posterior capsulorrhaphy with adjunct bone block augmentation if posterior capsule was deficient or infraspinatus was appreciably thinned.	Multidirectional instability, psychiatric disorder, neuromuscular disease
Gilat et al.[16]	Retrospective	Case series	Three surgeons	All patients undergoing posterior glenoid reconstruction with DTA with minimum 1-y follow-up	Multidirectional instability, <1-y follow-up, inflammatory arthropathy, graft other than DTA
Hinojosa et al.[21]	Retrospective	Case series	Single center	Posterior shoulder subluxation, habitual or inhabitual	NR

(continued)

Appendix 3. Continued

Reference	Retrospective or Prospective	Type of Study	Investigational Site	Study Inclusion	Study Exclusion
Langlais et al.[12]	Retrospective	Case-control, involuntary instability at onset vs voluntary instability that progressed to involuntary	Single center	Involuntary shoulder instability undergoing posterior stabilization (posterior bone block and/or posterior capsular shift), >18 years of age, involuntary shoulder instability classified as voluntary becoming involuntary or involuntary at onset	Voluntary posterior instability; multidirectional instability (posterior displacement associated with anterior and/or inferior displacement); previous failed stabilization; static posterior subluxation (index of glenohumeral subluxation >55% in the supine position and with the arm in neutral position on CT scan); glenoid dysplasia; underlying connective tissue pathology; neurological problem (epileptic seizures, neuromuscular disorders); psychiatric disorder
Meuffels et al.[20]	Prospective	Case series	Single center	Symptomatic involuntary recurrent posterior dislocation of the shoulder undergoing posterior bone block procedure; all had followed and failed extensive conservative treatment program for >1 y	NR
Mowery et al.[18]	Retrospective	Case series	NR	Recurrent posterior dislocations treated with posterior bone block augmentation	NR
Schwartz et al.[23]	Retrospective	Case series	Single surgeon	All patients with posterior instability undergoing arthroscopic posterior bone block	NR
Servien et al.[25]	Retrospective	Case series	Single center	Two forms of involuntary posterior instability treated with posterior bone block augmentation: recurrent posterior dislocations, which includes both recurrent dislocations and dislocation followed by recurrent subluxations, and recurrent posterior subluxations that become painful, or an episode of acute posterior instability that was self-reduced	Chronic posterior dislocation and prior procedures

(continued)

Appendix 3. Continued

Reference	Retrospective or Prospective	Type of Study	Investigational Site	Study Inclusion	Study Exclusion
Struck et al.[22]	Retrospective	Case series	Single center	Consecutive series of unvoluntary recurrent unidirectional posterior instability treated with bone block augmentation; high prevalence of hyperlaxity 14 patients, Gerber B3 instability	Multidirectional and voluntary instability
Wellmann et al.[24]	Prospective	Case series	Single center	Clinical and pathologic criteria for inclusion of patients with recurrent dislocation or subluxation to be enrolled and undergo arthroscopic posterior bone block augmentation and capsular reconstruction; clinical criteria: positive Jerk's and Kim's tests; pathologic criteria: posterior instability with local postero-inferior glenoid dysplasia or posteroinferior glenoid erosion; posterior instability with elongated, weak posterior capsule and hypoplastic labrum; posterior instability with a chronic bony Bankart lesion; posterior instability after failed previous capsulolabral surgery	Global glenoid dysplasia and voluntary shoulder dislocation defined as shoulder dislocation near the neutral position of the arm caused by scapula winging and muscle patterning

CT, computed tomography; DTA, distal tibia allograft; ICBG, iliac crest bone graft; NR, not reported.