

# Clinical Outcomes of the Traditional Latarjet Versus the Congruent Arc Modification for the Treatment of Recurrent Anterior Shoulder Instability

## A Meta-analysis

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**Background:** Few studies have compared clinical outcomes between the traditional Latarjet procedure for anterior shoulder instability and the congruent arc modification to the Latarjet procedure.

**Purpose:** To systematically evaluate the literature for the incidence of recurrent instability, clinical outcomes, radiographic findings, and complications for the traditional Latarjet procedure and the congruent arc modification and to compare results of each search.

**Study Design:** Systematic review; Level of evidence, 4.

**Methods:** A systematic review and meta-analysis was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. We included studies published between January 1990 and October 2020 that described clinical outcomes of the traditional Latarjet and the congruent arc modification with a follow-up range of 2 to 10 years. The difference in surgical technique was analyzed using a chi-square test for categorical variables, while continuous variables were evaluated using a Student *t* test.

**Results:** In total, 26 studies met the inclusion criteria: 20 studies describing the traditional Latarjet procedure in 1412 shoulders, and 6 studies describing the congruent arc modification in 289 shoulders. No difference between procedures was found regarding patient age at surgery, follow-up time, Rowe or postoperative visual analog scores, early or late complications, return-to-sport timing, or incidence of improper graft placement or graft fracture. A significantly greater proportion of male patients underwent glenoid augmentation using the congruent arc modification versus traditional Latarjet ( $P < .001$ ). When comparing outcomes, the traditional Latarjet procedure demonstrated a lower incidence of fibrous union or nonunion ( $P = .047$ ) and broken, loose, or improperly placed screws ( $P < .001$ ), and the congruent arc modification demonstrated improved outcomes with regard to overall return to sport ( $P < .001$ ), return to sport at the same level ( $P < .001$ ), incidence of subluxation ( $P = .003$ ) or positive apprehension ( $P = .002$ ), and revision surgery for recurrent instability ( $P = .027$ ).

**Conclusion:** Outcomes after the congruent arc modification proved at least equivalent to the traditional Latarjet procedure in terms of recurrent instability and return to sport, although early and late complications were equivalent. The congruent arc procedure may be an acceptable alternative to traditional Latarjet for the treatment of anterior shoulder instability with glenoid bone loss; however, long-term outcomes of this procedure are needed.

**Keywords:** traditional Latarjet; congruent arc; shoulder instability

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Owing to the natural bony architecture of the glenohumeral joint, the shoulder is inherently unstable, representing the most frequently dislocated joint in the human body.<sup>14,17</sup> After a traumatic anterior shoulder dislocation, glenoid bone

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loss (GBL) from the anteroinferior surface is common, occurring in up to 22% of initial dislocations and 90% of patients with recurrent shoulder instability.<sup>28,42,46,49</sup> In the US population alone, the reported incidence of glenohumeral joint instability is 23.9 cases per 100,000 patient-years,<sup>13,22</sup> with younger age, male sex, and involvement in contact sports or military duties being known risk factors for anterior instability after injury.<sup>13,51</sup>

In the setting of anterior inferior GBL, multiple investigations have reported inferior outcomes and a high rate of failure with recurrent instability after surgical stabilization using isolated arthroscopic soft tissue procedures.<sup>11</sup> In patients with GBL measuring as little as 13% of the glenoid width, bony augmentation is required to effectively restore shoulder stability.<sup>11,20,40</sup> The Latarjet procedure represents an acceptable treatment method for anterior GBL, capable of restoring bony stability through a transfer of coracoid process and conjoint tendon to the anterior glenoid.<sup>30,38,43</sup> The traditional Latarjet procedure requires an osteotomy at the elbow of the coracoid, followed by transfer and fixation of the coracoid to the anterior glenoid such that the lateral surface is flush with the articular surface of the glenoid.<sup>7-9</sup> The congruent arc modification to the Latarjet involves rotating the coracoid 90° along its longitudinal axis, allowing the curvature on the inferior surface to help re-create the natural curvature of the glenoid arc, reportedly improving joint congruity and stability.<sup>16,23</sup> Investigations have also reported that the congruent arc modification reduces the need for decortication of the coracoid while mitigating the glenohumeral contact forces experienced within the joint from the traditional Latarjet procedure.<sup>16,23</sup>

Although previous investigations have examined differences in radiographic outcomes between the traditional and congruent arc techniques, data regarding clinical outcomes between the techniques are limited. The purpose of this systematic review was to analyze patient-reported outcomes (PROs), the incidence of recurrent instability, return-to-sport (RTS) rates, and other complications in patients undergoing open traditional Latarjet versus congruent arc Latarjet for anterior shoulder instability with significant GBL. We hypothesized that there would be no significant differences on any postoperative outcome between techniques.

## METHODS

### Data Sources and Searches

A systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic

reviews and Meta-Analyses) guidelines.<sup>36</sup> We identified all literature related to clinical outcomes of the traditional Latarjet procedure and the congruent arc modification that was published from January 1990 to October 2020. Two reviewers (S.R.P.M. and M.W.K.) independently conducted searches in August 2020 using the following databases: PubMed, Biosis Previews, SPORTSDiscus, PEDro, and EMBASE. The search strategy for the classic Latarjet procedure included the following terms: “anterior shoulder instability” OR “shoulder instability” AND “Latarjet” OR “open Latarjet” OR “Latarjet procedure” OR “coracoid transfer”. A search of the congruent arc modification to the Latarjet procedure included the following terms: “anterior shoulder instability” OR “shoulder instability” AND “congruent arc” OR “modified Latarjet” OR “modified Bristow-Latarjet” OR “modified coracoid transfer.”

Inclusion criteria consisted of studies written in or translated into English that reported on patients with anterior shoulder instability and significant GBL who underwent open traditional Latarjet or the congruent arc modification with a minimum 2-year and maximum 10-year follow-up; the studies also needed to document PROs, the incidence of recurrent instability (characterized by dislocation, subluxation, or shoulder apprehension), postoperative radiographic findings, and/or any other postoperative complications. Exclusion criteria involved non-English language studies, studies utilizing free bone block procedure, cadaveric or laboratory studies, studies utilizing an arthroscopic approach, studies with less than 2-year or more than 10-year follow-up, studies failing to indicate fixation surface in the description of surgical technique, and studies not reporting PROs, recurrent instability, or other complications. Investigations from similar institutions were reviewed separately to identify studies potentially reporting on the same cohort of patients. When these were identified, the most comprehensive study was included, whereas the remaining studies were omitted after mutual discussion with the senior author (M.R.K.). After the literature search and application of inclusion/exclusion criteria, all articles selected for inclusion were cross-referenced to ensure no studies were overlooked during the initial search. No further articles were identified during this process.

### Data Extraction and Quality Assessment

The modified Coleman Methodology Score (mCMS), methodological index for non-randomized studies (MINORS) scale, and Newcastle-Ottawa Scale (NOS) were used to

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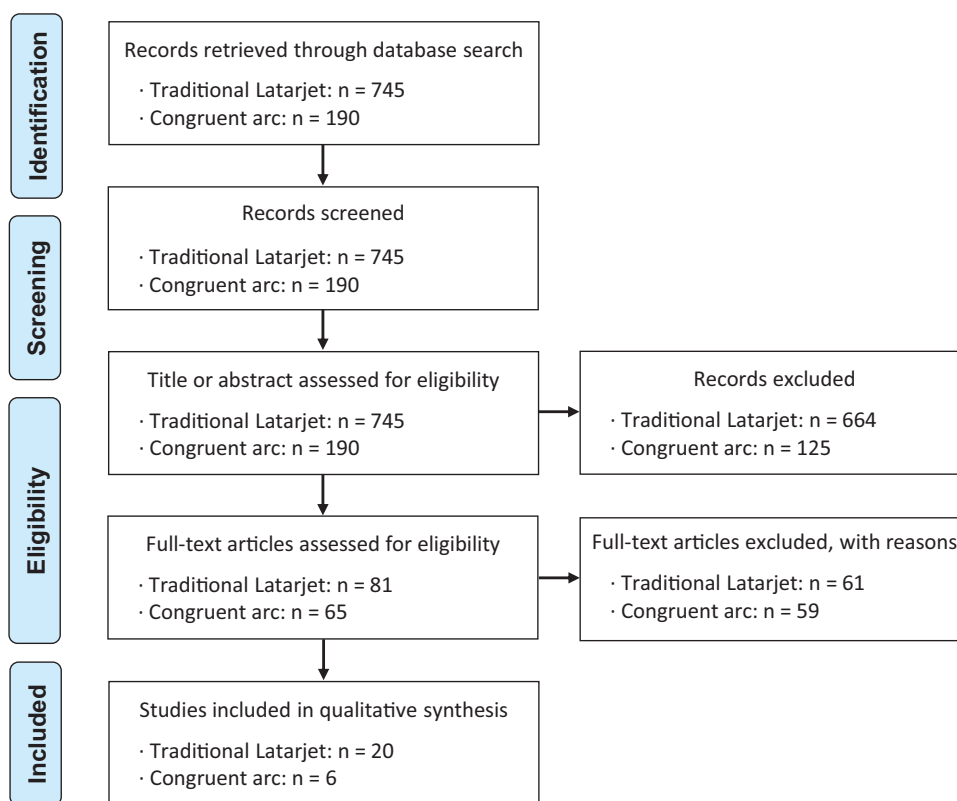
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**Figure 1.** PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) flowchart of the study search and inclusion process.

assess the quality of the studies identified in this investigation. The mCMS criteria for evaluation are based on subsections of the CONSORT (Consolidated Standards of Reporting Trials) statement for randomized controlled trials<sup>15</sup>; scoring follows a scale of 0 to 100, where scores from 85 to 100 are considered excellent, 70 to 84 good, 55 to 69 fair, and <55 poor. The MINORS score is a validated scale assessing nonrandomized case-control or cohort studies based on 12 criteria (8 criteria for noncomparative studies); each criterion is judged as 2 (indicating adequate), 1 (indicating inadequate), and 0 (indicating criterion was not reported).<sup>47</sup> Scores are reported as a percentage of total possible points. The NOS assesses the quality of case-control or cohort studies based on 10 criteria evaluating patient selection, comparability of data, and outcomes.<sup>48</sup> Each article was independently scored by 2 authors (S.R.P.M., M.W.K.) for each of the 3 assessment tools. Any discrepancies in the score were discussed with the senior author.

Data extracted from the selected articles included patient distribution of sex and age, mean follow-up time, incidence of recurrent instability, RTS, PROs, and other complications after treatment with either the traditional Latarjet or the congruent arc modification. Recurrent instability was characterized by the incidence of recurrent dislocation, subluxation, or positive apprehension and was analyzed separately owing to differences in reporting between studies. All other complications were characterized based on the incidence of permanent or transient nerve

injury; hematoma; infection; pathologic findings on imaging with a requirement for further intervention (eg, errors in screw fixation, graft fractures, pseudarthrosis, or incomplete bone union); and any other complication requiring reoperation or revision stabilization. Complications were further subdivided into early (nerve injury, hematoma, infection), late (screw fixation, graft fractures, pseudoarthrosis), and reoperations for continued instability. Radiographic findings of any type (symptomatic or asymptomatic) were noted separately and included incidental findings of errors in graft placement, errors in screw fixation, graft fractures, pseudarthrosis, or incomplete bone union with no clinical effect noted. Differences in surgical technique were analyzed using a chi-square test for categorical variables (patient sex, RTS rate, incidence of instability, and all other complications), whereas continuous variables (patient age, mean follow-up, RTS timing, visual analog scale [VAS], and Rowe scores) were evaluated using a Student *t* test. A *P* value <.05 was considered statistically significant for this study. All statistical analyses were performed using SPSS Version 23 (IBM) software.

## RESULTS

### Literature Selection

Results of the search process are displayed in Figure 1. A total of 745 studies describing the traditional Latarjet

procedure and 190 studies for the congruent arc technique were identified. After assessing the title and abstract, 81 Latarjet and 65 congruent arc articles were selected for further evaluation. Of these, 61 studies reporting on the Latarjet technique were excluded for the following reasons: follow-up time less than 2 years ( $n = 20$ ), follow-up time more than 10 years ( $n = 7$ ), surgical technique other than traditional Latarjet ( $n = 23$ ), inadequate description of the articulating surface used to fix the coracoid graft ( $n = 9$ ), and inability to discern results when 2 or more surgical methods were compared ( $n = 2$ ). Of the studies describing the congruent arc modification, 58 were excluded for the following reasons: not utilizing the congruent arc modification ( $n = 50$ ), follow-up time less than 2 years ( $n = 5$ ), arthroscopic approach ( $n = 2$ ), and failure to report on PROs in the postoperative period ( $n = 1$ ).

After application of the exclusion criteria, 20 studies on the traditional Latarjet procedure were selected for further analysis: 9 were prospective or comparative studies of evidence level 3, and 11 were level 4 case series. Initially, 7 studies on the congruent arc procedure were selected for further analysis; however, 2 studies from the same institution reported an overlapping group of patients, resulting in the earlier published study being eliminated. Therefore, 6 studies were ultimately included in the congruent arc search: 1 study was a level 3 prospective study and 5 studies were level 4 case series investigations.

No significant difference was found in overall quality between studies describing the traditional Latarjet versus the congruent arc modification, as indicated by scores on the mCMS ( $P = .246$ ), MINORS ( $P = .768$ ), and NOS ( $P = .770$ ). The individual and mean scores for the 3 assessment tools are reported in Table 1.

### Patient Characteristics

Patient baseline characteristics are described in Table 1. A total of 1412 shoulders were identified in 1388 patients undergoing traditional Latarjet, consisting of **83% (1112 of 1340) male patients**. Sex was not reported in 48 patients in 1 study.<sup>14</sup> Bilateral procedures were reported for 24 patients.<sup>7,8,19,24,52</sup> For the congruent arc modification, a total of 289 shoulders were identified in 288 patients with **93% (269 of 288) of patients being male**. One patient underwent bilateral augmentation in the congruent arc group.<sup>1</sup> Male patients made up a significantly greater proportion of patients undergoing stabilization using the congruent arc modification when compared with the traditional Latarjet cohort ( $P < .001$ ). No significant difference between the 2 groups was found in age at the time of surgery ( $P = .59$ ) or mean follow-up time ( $P = .26$ ).

### Recurrent Instability

Of the 26 included studies, recurrent instability was defined by recurrent dislocation only in 9 studies,<sup>1,2,5,8,14,24,33,35,41</sup> dislocation or subluxation in 13 studies,<sup>11</sup> and dislocation,

subluxation, or positive apprehension in 3 studies,<sup>29,53,54</sup> although 1 study did not report on recurrent instability.<sup>9</sup> Overall, recurrent instability was reported in 95% ( $n = 19$  of 20) of studies examining the traditional Latarjet procedure and 100% ( $n = 6$  of 6) of studies describing the congruent arc technique. Individual reports of recurrent instability are listed in Appendix Table A1, and overall incidence according to surgical procedure is summarized in Table 2. No significant difference between the groups was observed in the incidence of recurrent dislocation ( $P = .92$ ), although the incidence of recurrent subluxation ( $P < .001$ ) and positive apprehension ( $P = .001$ ) was significantly more common after the traditional Latarjet procedure.

### Patient-Reported Outcomes

Individual PROs are included in Appendix Table A1. No significant difference was noted in improvement in Rowe score ( $P = .29$ ) or postoperative VAS score ( $P = .65$ ) between the 2 techniques (Table 2).

### RTS Rate

The RTS rate was reported in 9 studies describing the traditional Latarjet procedure, consisting of 453 patients with 90.2% returning to any level of sport (409 of 453) (Appendix Table A1).<sup>8-10,17,21,29,32,41,52</sup> Postoperative level of competition was reported in 9 studies, with 56.1% of patients (254 of 453) participating in the same sport at the same level of competition as before surgery.<sup>8-10,17,21,29,32,41,52</sup> The RTS timing was noted in 3 studies (164 patients), with an overall mean time of 7.01 months (range, 6.3-8.1 months).<sup>9,10,41</sup>

For the congruent arc technique, 4 studies (226 patients) discussed RTS, with 97.3% of patients (220 of 226) able to return (Appendix Table A1).<sup>5,12,44,45</sup> Patient postoperative level of competition was included in 3 studies, with 91.2% of patients (156 of 171) competing at the same level of competition as they had been before surgery although the remainder reduced their level of competition, changed sports, or ceased competition.<sup>5,44,45</sup> The mean RTS time was reported in 2 studies (161 patients), with an overall mean of 5.02 months (range, 4.9-5.2 months).<sup>44,45</sup>

The overall RTS rate was significantly greater for patients who had undergone the congruent arc modification ( $P < .001$ ). In addition, return to the same sport at the same level was significantly greater after the congruent arc modification ( $P < .001$ ), although no significant difference was found in the mean RTS time was between the 2 groups ( $P = .081$ ) (Table 2).

### Other Complications

Fifteen studies utilizing the traditional Latarjet technique reported on postoperative clinical complications, with 56 total complications identified in 830 shoulders (6.7%) (Appendix Table A1).<sup>¶</sup> Five studies describing the congruent arc modification reported on the incidence of

<sup>||</sup>References 6, 7, 10, 12, 17, 19, 21, 25, 31, 32, 44, 45, 52.

<sup>¶</sup>References 2, 6-8, 10, 21, 24, 25, 29, 31, 35, 41, 52-54.

TABLE 1  
General Characteristics of Articles Included in Analysis<sup>a</sup>

Lead Author (Year)	LOE	Study Quality			No. of Shoulders	Sex, M/F, n	Age at Surgery, y, Mean (Range)	Mean Follow-up (mo)
		mCMS	MINORS, %	NOS				
Traditional Latarjet								
Ali <sup>2</sup> (2020)	3	54	62.50	6	15	12/3	28 (range NR)	30.5
Bah <sup>6</sup> (2018)	3	54	58.30	7	43	36/7	24.5 (16-37)	47.3
Balestro <sup>7</sup> (2015)	4	70	81.25	5	12	7/4	28.6 (16.6-43.3)	24
Bavarel <sup>8</sup> (2018)	3	71	62.50	5	110	88/18	22.1 (16-29.7)	46.3
Beranger <sup>9</sup> (2016)	4	63	50	5	47	46/1	27.9 (18-45.7)	46.8
Bessiere <sup>10</sup> (2013)	4	63	75	7	51	49/2	25 (16-45)	66
Cautiero <sup>14</sup> (2017)	4	57	43.75	4	48	NR	25.9 (18-46)	53
De Carli <sup>17</sup> (2019)	3	73	70.83	5	73	48/25	28 (16-41)	NR (min 72)
Di Giacomo <sup>19</sup> (2020)	4	70	75	5	358	287/57	30.6 (16-68)	75
Domos <sup>21</sup> (2020)	4	71	56.25	5	45	26/19	15.7 (13-17)	79.2
Ersen <sup>24</sup> (2017)	3	55	54.17	4	65	42/20	31.2 (range NR)	39.2
Flinkkilä <sup>25</sup> (2015)	4	57	56.25	4	52	45/7	28.4 (17-62)	50
Jeon <sup>29</sup> (2018)	3	62	58.33	5	31	26/5	27.4 (21-46)	30.9
Kee <sup>31</sup> (2017)	4	62	50	5	110	100/10	23.8 (14-52)	31
Kee <sup>32</sup> (2018)	4	63	50	4	56	54/2	27.2 (18-43)	67.1
Lateur <sup>35</sup> (2018)	4	52	50	5	32	27/5	30.5 (16-57)	48
Privitera <sup>41</sup> (2018)	4	71	50	5	73	64/9	25.8 (15-58)	51.6
Yang <sup>52</sup> (2016)	3	55	62.50	5	54	41/11	23.2 (15-51)	42
Zhu <sup>53</sup> (2017)	3	77	87.50	6	44	32/12	34.8 (range NR)	37.4
Zimmermann <sup>54</sup> (2016)	3	66	66.67	5	93	82/11	30.8 (range NR)	120
Overall mean/total	—	63.3	61	5.1	1412	1112/228	27.46	51.81
Congruent Arc								
Abdelhady <sup>1</sup> (2015)	4	57	50	5	14	9/4	24.4 (18-29)	33.64
Aurich <sup>5</sup> (2015)	4	67	43.75	5	6	5/1	26.5 (16-41)	36
Burkhardt <sup>12</sup> (2007)	4	68	68.75	5	102	46/1 (NR in 55)	26.5 (16-41)	59
Khatar <sup>33</sup> (2016)	4	77	56.25	4	62	54/2	26.8 (19-40)	28
Ranalletta <sup>44</sup> (2018)	4	65	62.50	6	65	63/2	26.8 (17-58)	44
Rossi <sup>45</sup> (2018)	3	69	75	6	100	92/8	26.6 (17-50)	58
Overall mean/total	—	67.2	59	5.2	289	269/19	26.58	47.13
<i>P</i> value <sup>b</sup>		.246	.768	.770		<b>&lt;.001</b>	.59	.26

<sup>a</sup>F, female; LOE, level of evidence; M, male; mCMS, modified Coleman Methodology Scale; min, minimum; MINORS, methodological index for non-randomized studies; NOS, Newcastle Ottawa Scale; NR, not reported; -, not relevant.

<sup>b</sup>Bold *P* value indicates a statistically significant difference in mean values between procedures.

postoperative complications; 9 complications were identified in 287 shoulders (3.1%).<sup>1,5,12,44,45</sup> The overall incidence of postoperative complications was significantly higher for the traditional Latarjet procedure than for the congruent arc procedure ( $P = .024$ ). On subset analysis, no difference between procedures was seen in the incidence of early complications ( $P = .45$ ) or late complications ( $P = .41$ ), although the incidence of reoperation for instability was significantly higher for the traditional Latarjet procedure ( $P = .022$ ) (Table 2).

### Radiographic Findings

Postoperative radiographs were obtained for 554 shoulders in the traditional Latarjet cohort and 212 shoulders in the congruent arc modification cohort. Radiographic

findings reported for individual studies are included in Table 2. Incidence of osteoarthritis was available for 312 shoulders in 6 studies describing the traditional Latarjet, with new cases or progression of osteoarthritis identified in 13.4% of shoulders ( $n = 42$  of 312; 27 new, 15 progressions).<sup>2,21,31,32,35,52</sup> Incidence of osteoarthritis was available for 65 shoulders in 1 study describing the congruent arc modification based on imaging taken at 3 months postoperatively, with osteoarthritis identified in 1.5% of shoulders ( $n = 1$  of 65; 1 new).

No significant difference was found in the incidence of improper graft placement (either medialization or lateralization of the graft) ( $P = .15$ ) or incidence of graft fracture ( $P = .59$ ) between the 2 groups, although the congruent arc group demonstrated a higher incidence of fibrous or non-union ( $P = .047$ ) and broken, loose, or improperly placed screws ( $P < .001$ ) (Table 2).

TABLE 2  
Comparison of Outcomes Between Traditional Latarjet and the Congruent Arc Modification

Outcome	Traditional Latarjet	Congruent Arc	P Value
Recurrent instability, n/N (%)			
Dislocation	32/1155 (2.8)	10/349 (2.9)	.92
Subluxation	37/1059 (3.5)	0/267 (0)	<.001
Apprehension	56/457 (12.3)	2/112 (1.8)	.001
Patient-reported outcomes, mean (range)			
Rowe improvement	48.5 (21.7-51.1)	58.1 (43.6 to 78.3)	.29
Postoperative VAS	1.44 (0.7-2.8)	1.3 (1.2 to 1.4)	.65
RTS, n/N (%)			
Overall	409/453 (90.3)	220/226 (97.3)	<.001
Same sport, same level	254/453 (56.1)	156/171 (91.2)	<.001
RTS timing, mo, mean (range)	7.01 (6.3-8.1)	5.02 (4.9 to 5.2)	.081
Complications, n (%)	(n = 830 shoulders)	(n = 287 shoulders)	
Overall	56 (6.7)	9 (3.1)	.024
Early complications	12 (1.4)	6 (2.1)	.45
Late complications	25 (3.0)	6 (2.1)	.41
Reoperation for instability	15 (1.8)	0 (0)	.022
Radiographic findings			
Graft placement, n (%)			.15
Medialized	8 (3.2)	4 (2.4)	
Lateralized	21 (8.5)	8 (4.9)	
Acceptable	219 (88.3)	152 (92.7)	
Errors in screw fixation: n/N (%)	2/176 (1.1)	4/ 212 (1.9)	<.001
Graft fracture: n/N (%)	4/208 (1.9)	2/165 (1.2)	.59
Fibrous union/nonunion: n/total (%)	16/487 (3.3)	14/212 (6.6)	.047

Bold *P* values indicate a statistically significant difference between groups ( $P < .05$ ). RTS, return to sport; VAS, visual analog scale.

## DISCUSSION

Of the 26 studies we identified for this review, no significant difference was observed between the 2 procedures regarding age at the time of surgery (27.46 vs 26.58;  $P = .59$ ), postoperative follow-up time (51.81 vs 47.13;  $P = .26$ ), difference in Rowe score (38.5 vs 58.1;  $P = .29$ ) or postoperative VAS score (1.44 vs 1.3;  $P = .65$ ), early (1.4% vs 2.1%;  $P = .45$ ) or late complications (3.0% vs 2.1%;  $P = 0.41$ ), graft placement ( $P = .15$ ), or incidence of graft fracture (1.9% vs 1.2%;  $P = .59$ ). Male patients were significantly more likely to undergo augmentation using the congruent arc modification versus traditional Latarjet ( $P < .001$ ). When comparing procedures, we found that the incidence of all instability events, specifically recurrent subluxation and positive apprehension, was significantly higher in patients after traditional Latarjet compared with the congruent arc modification (3.5% vs 0%;  $P < .001$  and 12.3% vs 1.8%;  $P = .001$ , respectively). Furthermore, fewer reoperations for instability were reported for the congruent arc modification ( $P = .022$ ). The overall RTS rate as well as RTS at the same level of competition were significantly greater with the congruent arc modification ( $P < .001$  for both), although no difference between procedures was found in time to RTS ( $P = .081$ ). The incidence of fibrous or nonunion and radiographic findings of broken, loose, or improperly placed screws was greater for the congruent arc modification ( $P < .001$  and  $P = .047$ , respectively).

Regarding baseline patient characteristics, both cohorts consisted predominantly of men in the third decade of life. These findings are consistent with previous epidemiological

studies identifying male sex and age between 20 and 29 years as the most heavily weighted nonmodifiable risk factors associated with recurrent anterior shoulder instability requiring bony augmentation.<sup>13,22,34,50</sup> Anterior shoulder dislocation generally occurs as a result of acute trauma to the shoulder in abduction. Therefore, the higher incidence of male patients' experiencing anterior shoulder instability with significant GBL may be related to greater male participation in contact sports or involvement in military training.<sup>13,50,51</sup> However, it is unclear why we found a greater proportion of men were treated with the congruent arc modification compared with traditional Latarjet, as the rationale behind surgeon preference was not documented in most studies.

When examining recurrent instability, no differences were observed in the rate of recurrent dislocations, although patients undergoing surgery with the traditional Latarjet were more likely to report recurrent subluxation and positive apprehension. Improved stability with the congruent arc modification may be explained by anatomic differences in the reconstituted glenoid surface during glenoid augmentation. Previous anatomic and computed tomography studies have aimed to quantify the amount of bone available for glenoid surface augmentation with the coracoid process seated in different positions. These investigations have demonstrated the reconstruction of 29% to 36% of the glenoid surface area using the traditional Latarjet procedure, although up to 53% of the glenoid may be restored using the congruent arc modification.<sup>4,27,37,39</sup> Restoration of a larger surface area of contact at the

glenohumeral joint may translate to greater stability among patients undergoing surgical correction with the congruent arc procedure. However, underreporting of instability among the congruent arc studies should also be considered, as only 3 studies analyzed subluxation and 2 studies reported the incidence of positive apprehension for the congruent arc modification compared with 13 studies and 8 studies for the traditional Latarjet procedure, respectively.

Patients undergoing coracoid transfer using the congruent arc modification performed better in RTS measures, including overall RTS incidence and return to prior level of competition, although differences in RTS timing were not significant between procedures. Multiple studies have previously identified arm-intensive sports or collision sports as risk factors for failed RTS, with a large portion of patients undergoing both traditional Latarjet and congruent arc modification competing in contact or collision sports.<sup>5,10,12,32,41,44</sup> Therefore, a difference in preoperative classification of sports activity cannot readily explain the disparity between postoperative outcomes. However, a previous study evaluating patients who had undergone arthroscopic shoulder stabilization found additional factors including kinesiophobia (fear of recurrent injury), aging, and changes in social support or interest as influential in the decision to return to play. Two studies on the traditional Latarjet procedure reported that the primary motivator for patients to change or cease sports was fear of recurrent injury, although a change in career interest for competitive athletes was noted as a secondary cause.<sup>17,32</sup> In our analysis, a greater incidence of apprehension was reported for the traditional Latarjet procedure. In addition, although not significantly different, the mean age of patients treated with traditional Latarjet was almost 1 year older and the mean follow-up time was approximately 6 months greater than that of patients treated with the congruent arc modification. As such, fear of recurrent injury in the setting of apprehension and changes in interest because of age may contribute to the significant differences found in time to RTS between the 2 procedures.

The overall incidence of complications was higher in patients treated using the traditional Latarjet procedure compared with the congruent arc group. Specifically, the reoperation rate for instability was significantly higher for traditional Latarjet, although early and late complications owing to surgical technique were not significantly different between techniques. The greater incidence of instability necessitating reoperation may be due to the reduced surface area of articulation reconstructed during the traditional Latarjet procedure when compared with the congruent arc modification, as discussed previously.<sup>4,27,37,39</sup> In contrast, the congruent arc modification resulted in a greater incidence of complications due to surgical technique encompassing symptomatic errors in screw fixation and fibrous/nonunion, although no difference was found in graft positioning. Previous studies involving computer and cadaveric models have consistently demonstrated a reduced surface area for fixation with the congruent arc modification when compared with the traditional Latarjet technique.<sup>23,27,39</sup> Based on these results,

more frequent complications of graft malpositioning, errors in screw fixation, and rates of nonunion or fibrous union are anticipated with the congruent arc modification because of the technical challenges associated with a smaller area of fixation.

The findings of this investigation, as well as results from previously published studies, reflect a concern for new-onset or worsening osteoarthritis in patients treated with the traditional Latarjet procedure.<sup>3,39</sup> The congruent arc modification demonstrates greater success in restoration of the native radius of curvature of the glenoid and provides a greater articulating surface during augmentation.<sup>18,39</sup> Previous anatomical and biomechanical studies show these factors as leading to reduced contact pressures at the glenohumeral joint, which may subsequently result in better long-term results in the development of postsurgical osteoarthritis.<sup>26,39</sup> However, in our analysis, only 1 study<sup>44</sup> describing clinical outcomes of the congruent arc reported on incidence or progression of postsurgical osteoarthritis. Therefore, future investigation reporting long-term results is warranted to better understand the incidence of osteoarthritis for the congruent arc modification.

Although RTS and complication rates favored the use of the congruent arc modification, subjective PROs did not vary significantly between the 2 procedures. Specifically, improvement in Rowe scores and postoperative VAS scores were comparable, though slightly better for patients who had received stabilization with the congruent arc modification. These findings may be related to the decreased incidence of subluxation, apprehension, complication rates, and higher RTS rates after the congruent arc modification as well as to anatomic improvements in glenoid arc restoration.

## Limitations

This study is not without limitations. In our search, 20 studies comprising 1412 shoulders were identified describing the traditional Latarjet procedure, although only 6 studies comprising 288 shoulders were identified describing the congruent arc modification. Overall, these findings demonstrate a relative paucity of literature describing clinical outcomes after the congruent arc modification. Therefore, the results of this study must be interpreted with caution when comparing the clinical outcomes of the 2 techniques. Owing to the inherent nature of a systematic review, substantial heterogeneity existed between study populations regarding PRO scores. As current practice in orthopaedic surgery offers no guidelines designating a standardized clinical shoulder evaluation tool, we identified a total of 16 different clinical measurement tools utilized among the 26 studies analyzed. Therefore, direct comparison of postoperative functional status was limited, and only Rowe score and VAS score were reported consistently enough to allow for any meaningful statistical analyses between groups. Future efforts should be made to establish a standard, clinically validated shoulder assessment tool or a methodology to compare different shoulder scores. Moreover, despite the reported statistical values, the true clinical relevance or clinically significant benefit

between techniques was not established, warranting future investigations evaluating thresholds required to achieve meaningful clinical outcomes based on PROs after both techniques. Finally, we could not identify any studies on the long-term outcomes of the congruent arc modification to the Latarjet procedure.<sup>44</sup> Therefore, the incidence of arthritis in comparison with the traditional Latarjet procedure remains largely unknown.

## CONCLUSION

In this comparison of current clinical data between the traditional Latarjet procedure and the congruent arc modification, no difference was found in patient age at the time of surgery, Rowe or postoperative VAS scores, early or late complications, or incidence of radiographic errors in screw fixation, graft fracture, or fibrous union. A significantly greater proportion of men underwent glenoid augmentation using the congruent arc modification versus Latarjet. The congruent arc modification demonstrated improved outcomes with regard to RTS, the incidence of subluxation or positive apprehension, revision surgery for recurrent instability, and graft placement when compared with the traditional Latarjet procedure. Based on the results of our investigation, the congruent arc procedure remains an acceptable modification to the traditional Latarjet procedure, providing at least comparable midterm clinical outcomes in RTS, instability, and complications, although these findings are limited by a scarcity of literature describing clinical outcomes of the congruent arc modification. Further studies are necessary to evaluate osteoarthritic changes in patients undergoing shoulder stabilization with the congruent arc modification as well as long-term outcomes of both surgical techniques.

## REFERENCES

- Abdelhady A, Abouelsoud M, Eid M. Latarjet procedure in patients with multiple recurrent anterior shoulder dislocation and generalized ligamentous laxity. *Eur J Orthop Surg Traumatol*. 2015;25(4):705-708.
- Ali J, Altintas B, Pulatkan A, et al. Open versus arthroscopic Latarjet procedure for the treatment of chronic anterior glenohumeral instability with glenoid bone loss. *Arthroscopy*. 2020;36(4):940-949.
- Allain J, Goutallier D, Glorion C. Long-term results of the Latarjet procedure for the treatment of anterior instability of the shoulder. *J Bone Joint Surg Am*. 1998;80(6):841-852.
- Armitage MS, Elkinson I, Giles JW, Athwal GS. An anatomic, computed tomographic assessment of the coracoid process with special reference to the congruent-arc Latarjet procedure. *Arthroscopy*. 2011;27(11):1485-1489.
- Aurich M, Hofmann GO, Gras F. Reconstruction of the coracoacromial ligament during a modified Latarjet procedure: a case series. *BMC Musculoskelet Disord*. 2015;16:238.
- Bah A, Lateur GM, Kouvidjin BT, et al. Chronic anterior shoulder instability with significant Hill-Sachs lesion: arthroscopic Bankart with remplissage versus open Latarjet procedure. *Orthop Traumatol Surg Res*. 2018;104(1):17-22.
- Balestro JC, Young A, Maccioni C, Walch G. Graft osteolysis and recurrent instability after the Latarjet procedure performed with bioabsorbable screw fixation. *J Shoulder Elbow Surg*. 2015;24(5):711-718.
- Baverel L, Colle PE, Saffarini M, Anthony Odri G, Barth J. Open Latarjet procedures produce better outcomes in competitive athletes compared with recreational athletes: a clinical comparative study of 106 athletes aged under 30 years. *Am J Sports Med*. 2018;46(6):1408-1415.
- Beranger JS, Klouche S, Bauer T, Demoures T, Hardy P. Anterior shoulder stabilization by Bristow-Latarjet procedure in athletes: return-to-sport and functional outcomes at minimum 2-year follow-up. *Eur J Orthop Surg Traumatol*. 2016;26(3):277-282.
- Bessiere C, Trojani C, Pelegri C, Carles M, Boileau P. Coracoid bone block versus arthroscopic Bankart repair: a comparative paired study with 5-year follow-up. *Orthop Traumatol Surg Res*. 2013;99(2):123-130.
- Burkhart SS, De Beer JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion. *Arthroscopy*. 2000;16(7):677-694.
- Burkhart SS, De Beer JF, Barth JR, et al. Results of modified Latarjet reconstruction in patients with anteroinferior instability and significant bone loss. *Arthroscopy*. 2007;23(10):1033-1041.
- Cameron KL, Mauntel TC, Owens BD. The epidemiology of glenohumeral joint instability: incidence, burden, and long-term consequences. *Sports Med Arthrosc Rev*. 2017;25(3):144-149.
- Cautiero F, Russo R, Di Pietto F, Sabino G. Computerized tomographic assessment and clinical evaluation in shoulder instability treated with the Latarjet-Patte procedure using one screw and washer. *Muscles Ligaments Tendons J*. 2017;7(1):26-33.
- Coleman BD, Khan KM, Maffulli N, Cook JL, Wark JD. Studies of surgical outcome after patellar tendinopathy: clinical significance of methodological deficiencies and guidelines for future studies. Victorian Institute of Sport Tendon Study Group. *Scand J Med Sci Sports*. 2000;10(1):2-11.
- De Beer JF, Roberts C. Glenoid bone defects—open Latarjet with congruent arc modification. *Orthop Clin North Am*. 2010;41(3):407-415.
- De Carli A, Vadalà A, Proietti L, et al. Latarjet procedure versus open capsuloplasty in traumatic anterior shoulder dislocation: long-term clinical and functional results. *Int Orthop*. 2019;43(1):237-242.
- Dehaan A, Munch J, Durkan M, Yoo J, Crawford D. Reconstruction of a bony Bankart lesion: best fit based on radius of curvature. *Am J Sports Med*. 2013;41(5):1140-1145.
- Di Giacomo G, Peebles LA, Midtgaard KS, et al. Risk factors for recurrent anterior glenohumeral instability and clinical failure following primary Latarjet procedures: an analysis of 344 patients. *J Bone Joint Surg Am*. 2020;102(19):1665-1671.
- Dickens JF, Owens BD, Cameron KL, et al. The effect of subcritical bone loss and exposure on recurrent instability after arthroscopic Bankart repair in intercollegiate American football. *Am J Sports Med*. 2017;45(8):1769-1775.
- Domos P, Chelli M, Lunini E, et al. Clinical and radiographic outcomes of the open Latarjet procedure in skeletally immature patients. *J Shoulder Elbow Surg*. 2020;29(6):1206-1213.
- Dumont GD, Russell RD, Robertson WJ. Anterior shoulder instability: a review of pathoanatomy, diagnosis and treatment. *Curr Rev Musculoskelet Med*. 2011;4(4):200-207.
- Dumont GD, Vopat BG, Parada S, et al. Traditional versus congruent arc Latarjet technique: effect on surface area for union and bone width surrounding screws. *Arthroscopy*. 2017;33(5):946-952.
- Erşen A, Bayram S, Birişik F, Atalar AC, Demirhan M. The effectiveness of the Latarjet procedure for shoulder instability in patients with epilepsy. *Orthop Traumatol Surg Res*. 2017;103(8):1277-1282.
- Flinkkilä T, Simiö K. Open Latarjet procedure for failed arthroscopic Bankart repair. *Orthop Traumatol Surg Res*. 2015;101(1):35-38.
- Ghodadra N, Gupta A, Romeo AA, et al. Normalization of glenohumeral articular contact pressures after Latarjet or iliac crest bone-grafting. *J Bone Joint Surg Am*. 2010;92(6):1478-1489.
- Giles JW, Puskas G, Welsh M, Johnson JA, Athwal GS. Do the traditional and modified Latarjet techniques produce equivalent reconstruction stability and strength? *Am J Sports Med*. 2012;40(12):2801-2807.



28. Itoi E, Lee SB, Berglund LJ, Berge LL, An KN. The effect of a glenoid defect on anteroinferior stability of the shoulder after Bankart repair: a cadaveric study. *J Bone Joint Surg Am.* 2000;82(1):35-46.
  29. Jeon YS, Jeong HY, Lee DK, Rhee YG. Borderline glenoid bone defect in anterior shoulder instability: Latarjet procedure versus Bankart repair. *Am J Sports Med.* 2018;46(9):2170-2176.
  30. John R, Wong I. Innovative approaches in the management of shoulder instability: current concept review. *Curr Rev Musculoskelet Med.* 2019;12(3):386-396.
  31. Kee YM, Kim HJ, Kim JY, Rhee YG. Glenohumeral arthritis after Latarjet procedure: progression and its clinical significance. *J Orthop Sci.* 2017;22(5):846-851.
  32. Kee YM, Kim JY, Kim HJ, Lim CT, Rhee YG. Return to sports after the Latarjet procedure: high return level of non-collision athletes. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(3):919-925.
  33. Khater AH, Sobhy MH, Said HG, et al. Latarjet procedure for anterior shoulder instability due to tramadol-induced seizures: a multicenter study. *Am J Sports Med.* 2016;44(4):957-962.
  34. Kraeutler MJ, McCarty EC, Belk JW, et al. Descriptive epidemiology of the MOON shoulder instability cohort. *Am J Sports Med.* 2018;46(5):1064-1069.
  35. Lateur G, Pailhe R, Refaie R, et al. Results of the Latarjet coracoid bone block procedure performed by mini invasive approach. *Int Orthop.* 2018;42(10):2397-2402.
  36. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ.* 2009;339:B2700.
  37. Ljungquist KL, Butler RB, Griesser MJ, Bishop JY. Prediction of coracoid thickness using a glenoid width-based model: implications for bone reconstruction procedures in chronic anterior shoulder instability. *J Shoulder Elbow Surg.* 2012;21(6):815-821.
  38. McHale KJ, Sanchez G, Lavery KP, et al. Latarjet technique for treatment of anterior shoulder instability with glenoid bone loss. *Arthrosc Tech.* 2017;6(3):e791-e799.
  39. Montgomery SR, Katthagen JC, Mikula JD, et al. Anatomic and biomechanical comparison of the classic and congruent-arc techniques of the Latarjet procedure. *Am J Sports Med.* 2017;45(6):1252-1260.
  40. Moroder P, Schulz E, Wierer G, et al. Neer Award 2019: Latarjet procedure vs. iliac crest bone graft transfer for treatment of anterior shoulder instability with glenoid bone loss: a prospective randomized trial. *J Shoulder Elbow Surg.* 2019;28(7):1298-1307.
  41. Privitera DM, Sinz NJ, Miller LR, et al. Clinical outcomes following the Latarjet procedure in contact and collision athletes. *J Bone Joint Surg Am.* 2018;100(6):459-465.
  42. Provencher MT, Bhatia S, Ghodadra NS, et al. Recurrent shoulder instability: current concepts for evaluation and management of glenoid bone loss. *J Bone Joint Surg Am.* 2010;92(suppl\_2):133-151.
  43. Rabinowitz J, Friedman R, Eichinger JK. Management of glenoid bone loss with anterior shoulder instability: indications and outcomes. *Curr Rev Musculoskelet Med.* 2017;10(4):452-462.
  44. Ranalletta M, Rossi LA, Bertona A, et al. Modified Latarjet procedure without capsulolabral repair for the treatment of failed previous operative stabilizations in athletes. *Arthroscopy.* 2018;34(5):1421-1427.
  45. Rossi LA, Bertona A, Tanoira I, et al. Comparison between modified Latarjet performed as a primary or revision procedure in competitive athletes: a comparative study of 100 patients with a minimum 2-year follow-up. *Orthop J Sports Med.* 2018;6(12):2325967118817233.
  46. Sayegh ET, Mascarenhas R, Chalmers PN, et al. Allograft reconstruction for glenoid bone loss in glenohumeral instability: a systematic review. *Arthroscopy.* 2014;30(12):1642-1649.
  47. Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (MINORS): development and validation of a new instrument. *ANZ J Surg.* 2003;73(9):712-716.
  48. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol.* 2010;25(9):603-605.
  49. Sugaya H, Moriishi J, Dohi M, Kon Y, Tsuchiya A. Glenoid rim morphology in recurrent anterior glenohumeral instability. *J Bone Joint Surg Am.* 2003;85(5):878-884.
  50. Szyluk K, Jasinski A, Niemiec P, et al. Male gender and age range 20-29 years are the most important non-modifiable risk factors for recurrence after primary post-traumatic shoulder dislocation. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(8):2454-2464.
  51. Wasserstein DN, Sheth U, Colbenson K, et al. The true recurrence rate and factors predicting recurrent instability after nonsurgical management of traumatic primary anterior shoulder dislocation: a systematic review. *Arthroscopy.* 2016;32(12):2616-2625.
  52. Yang JS, Mazzocca AD, Cote MP, Edgar CM, Arciero RA. Recurrent anterior shoulder instability with combined bone loss: treatment and results with the modified Latarjet procedure. *Am J Sports Med.* 2016;44(4):922-932.
  53. Zhu Y, Jiang C, Song G. Arthroscopic versus open Latarjet in the treatment of recurrent anterior shoulder dislocation with marked glenoid bone loss: a prospective comparative study. *Am J Sports Med.* 2017;45(7):1645-1653.
  54. Zimmermann SM, Scheyerer MJ, Farshad M, et al. Long-term restoration of anterior shoulder stability: a retrospective analysis of arthroscopic Bankart repair versus open Latarjet procedure. *J Bone Joint Surg Am.* 2016;98(23):1954-1961.
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## APPENDIX

TABLE A1  
Outcomes After Glenoid Augmentation Based on Technique<sup>a</sup>

Lead Author (Year)	Recurrent Instability	RTS, n/N	Clinical Outcomes (Mean Values)	Complications, n/N	Radiographic Findings
Traditional Latarjet					
Ali <sup>2</sup> (2020)	D: 3/15 S: 0 A: NR	NR	n = 15 · Rowe (post): 78 · WOSI (post): 670 · ROM (post): - FF: loss of 17° - Abd: loss of 32° - IR: loss of 9° - ER: loss of 16°	n = 2/15 (1 reoperation) · Recurrent instability: 3 (1 treated with iliac crest graft) · Broken screw with instability	n = 15 Arthritis: 1 mild
Bah <sup>6</sup> (2018)	D or S: 5 A: 6/43	NR	n = 43 · Rowe (post): 92.8 · WDS (pre vs post): 37.2 vs 93.6 · SSV (pre vs post): 26.6 vs 89.5 · VAS (pre vs post): 6.01 vs 2.8 · ROM (pre vs post): - FF: 155.6° vs 163.1° - ER at 0°: 60.2° vs 56.5° - ER at 90°: 72.5° vs 72.2°	n = 2/43 (1 reoperation) · Recurrent instability: 1 (treated with iliac crest graft) · Vascular necrosis of graft: 1	NR
Balestro <sup>7</sup> (2015)	D: 1/12 S: 3/12 A: NR	NR	n = 12 · SSV (post): 90.8 · WDS (post): - Excellent: 3/12 (25%) - Good: 4 (33.3%) - Medium: 3 (25%) - Poor: 2 (16.6%)	n = 1/12 (reoperation for recurrent instability)	n = 12 · Graft placement: all acceptable · Osteolysis: 8 partial, 4 severe
Baverel <sup>8</sup> (2018)	D: 3/110 S: 0/110 A: 12/110	· Overall: 102/106 · Same level: 66/106 · RTS timing: NR	n = 106 · Rowe (pre vs post): 55.7 vs 77.4 · SSV (pre vs post): 50 vs 89 · SPORTS (pre vs post): 5.3 vs 7.8 · WOSI (pre vs post): 1094 vs 271	n = 5/110 (all reoperations) · Recurrent instability: 2 (required iliac crest graft)	n = 110 · Graft fracture: 1 · Fibrous/nonunion: 2 · Osteolysis: 3 severe
Beranger <sup>9</sup> (2016)	NR	· Overall: 47/47 · Same level: 37/47 · RTS timing: 6.3	n = 47 · WOSI (post): 276.4	NR	NR
Bessiere <sup>10</sup> (2013)	D: 5/51 S: NR A: 16/51	· Overall: 40/50 · Same level: 36/50 · RTS timing: 6.34	n = 51 · ASES (post): 85 · SF-12 (post): 109.3 · SST (post): 11 · SSV (post): 90.9 · VAS (post): 1.62	n = 3/51 (all reoperations) · Revision of instability: 1 (with nonunion) · Painful screw: 1 (required operative removal) · Infection: 1 (required open lavage)	NR
Cautiero <sup>14</sup> (2017)	D: 1/48 S: NR A: NR	100% (No. NR)	n = 25 · QuickDASH (post): 1.9 · Rowe (post): 94.7 · ROM (vs nonop side): - ER at 0°: -13° - ER at 90°: -12°	NR	n = 22 · Fibrous/nonunion: 3 · Osteolysis: 13 partial
De Carli <sup>17</sup> (2019)	D: 0/40 S: 0/40 A: 2/40	· Overall: 36/40 · Same level: 29/40 · RTS timing: NR	n = 40 · Rowe (post): 95.6 · UCLA (post): 32.2 · WOSI (post): 111 · ER at 0° (post): 4.1° loss	NR	NR

(continued)

TABLE A1 (continued)

Lead Author (Year)	Recurrent Instability	RTS, n/N	Clinical Outcomes (Mean Values)	Complications, n/N	Radiographic Findings
Di Giacomo <sup>19</sup> (2020)	D: 5/358 S: 12/358	NR	n = 358 · SANE (post): 88 · WOSI (post): 265	NR	NR
Domos <sup>21</sup> (2020)	D: 2/45 S: 1/45 A: 11/45	· Overall: 40/40 · Same level: 30/40 · RTS timing: NR	n = 45 · CMS (post): 84 · Rowe (post): 95 · SSV (post): 95 · WDS (post): 85	n = 8/45 (6 reoperations) · Painful screw: 5 (required arthroscopic screw removal) · Infection: 1 (required open lavage) · Wound problems (unspecified): 2	n = 45 Arthritis: 4 new OA
Ersen <sup>24</sup> (2017)	D: 2/65 S: NR A: NR	NR	· ASES (pre vs post): 55.7 vs 92.9 · CMS (pre vs post): 55.7 vs 91.6 · Rowe (pre vs post): 24.5 vs 94.3	n = 1/65 (reoperation) · Broken screw: 1 (required surgical revision)	n = 65 Fibrous/nonunion: 3
Flinkkilä <sup>25</sup> (2015)	D: 1/49 S: 6/49 A: NR	NR	n = 49 · Oxford (post): 19.9 · SSV (post): 84.9 · WOSI (post): 89.3	n = 1/52 (reoperation) · Surgical stabilization for instability: 1	NR
Jeon <sup>29</sup> (2018)	2/31 (not specified)	· Overall: 30/31 · Same level: 6/31 · RTS timing: NR	n = 31 · Rowe (pre vs post): 41 vs 91.1 · UCLA (pre vs post): 22.3 vs 32.3 · VAS (pre vs post): 1.8 vs 0.7 · ROM (pre vs post): - FF: 166.6° vs 162.9° - ER at 0°: 65.2° vs 57.9° - ER at 90°: 79.2° vs 68.9°	n = 0/31	NR
Kee <sup>31</sup> (2017)	D: 2/110 S: 4/110 A: NR	NR	n = 110 · Rowe (pre vs post): 36.5 vs 87.6 · UCLA (pre vs post): 23.6 vs 32.6 · VAS (pre vs post): 3.1 vs 1.6 · ROM (pre vs post): IR, ER, FF, Abd = NS	n = 5/110 (2 reoperations) · Screw loosening with recurrent dislocation: 1 (revision with iliac graft) · Traumatic dislocation: 1 (required subscapularis repair) · Musculocutaneous neuropathy 3 (transient)	n = 110 · Graft placement: 6 medialized, 11 lateralized, 93 acceptable · Broken/loose screw: 1 · Fibrous/nonunion: 4 · Arthritis: 12 new OA, 8 OA progression
Kee <sup>32</sup> (2018)	D: 1/56 S: 2/56 A: NR	· Overall: 54/56 · Same level: 9/56 · RTS timing: NR	n = 56 · Rowe (pre vs post): 51 vs 88.6 · UCLA (pre vs post): 23.2 vs 31.6 · VAS (pre vs post): 3.4 vs 1.4 · ROM (pre vs post): FF, ER at 0°, IR = NS	NR	n = 56 · Graft placement: 0 medialized, 4 lateralized, 52 acceptable · Fibrous/nonunion: 1 · Arthritis: 2 new OA, 2 OA progression

(continued)

TABLE A1 (continued)

Lead Author (Year)	Recurrent Instability	RTS, n/N	Clinical Outcomes (Mean Values)	Complications, n/N	Radiographic Findings
Lateur <sup>35</sup> (2018)	D: 1/32 S: NR A: 1/31	NR	n = 32 · ASES (post): 95.87 · CMS (post): 94.9 · SSV (post): 96.9 · WOSI (post): 42.44 · VAS (post): 0.65	n = 3/32 (1 reoperation) · Impingement: 1 (surgically corrected) · Intraoperative fracture: 1 (required tenodesis)	n = 32 · Graft placement: 2 medialized, 6 lateralized, 24 acceptable · Graft fracture: 1 · Fibrous/nonunion: 2 · Osteolysis: 1 partial, 1 severe · Arthritis: 2 new OA NR
Privitera <sup>41</sup> (2018)	D: 6/73 S: 0/73 A: 10/73	· Overall: 55/73 · Same level: 36/73 · RTS timing: 8.1	n = 73 · ASES (post): 87.9 · VAS (post): 1.3 · WOSI (post): 557	n = 7/73 (5 reoperations) · Paresthesia: 1 (no intervention) · Painful screws: 1 (surgical removal) · Impingement: 1 (surgical subacromial and subcoracoid decompression) · Traumatic posterior instability: 1 (posterior capsular plication) · Biceps tenosynovitis: 1 (biceps tenodesis) · Rotator cuff tear: 1 (reverse total shoulder arthroplasty) · Painful traumatic graft fracture: 1 (nonop treatment)	NR
Yang <sup>52</sup> (2016)	D: 1/54 S: 7/54 A: NR	· Overall: 5/10 · Same level: 5/10 · RTS timing: NR	n = 52 · SANE (post): 83.6 · WOSI (post): 385	n = 13/52 (all reoperations) · Revisions for instability: 4 (all with iliac crest graft) · Infection: 3 (all required open lavage) · Painful hardware: 5 (required removal) · Broken screw: 1 (required removal)	n = 54 · Broken/loose screw: 1 · Graft fracture: 2 · Fibrous/nonunion: 2 · Osteolysis: 17 partial · Arthritis: 6 new OA, 5 OA progression
Zhu <sup>53</sup> (2017)	D: 0/44 S: 0/44 A: 0/44	NR	n = 44 · ASES (pre vs post): 77.6 vs 93.3 · CMS (pre vs post): 89.5 vs 96.5 · Rowe (pre vs post): 39.8 vs 97.1	n = 0/44	n = 38 · Graft placement: all acceptable · Fibrous/nonunion: 0 · Osteolysis: 32 partial, 4 severe
Zimmermann <sup>54</sup> (2016)	D: 1/93 S: 2/93 A: 8/93	NR	n = 93 · SSV (post): 89 (change, pre vs post: 37.95)	n = 5/93 (all reoperations) · Reoperation for instability: 1 · Hematoma: 1 (required surgical evacuation) · Removal of hardware: 1 · Screw replacement: 1 · SLAP tear: 1 (required repair)	NR

(continued)

TABLE A1 (continued)

Lead Author (Year)	Recurrent Instability	RTS, n/N	Clinical Outcomes (Mean Values)	Complications, n/N	Radiographic Findings
Congruent Arc					
Abdelhady <sup>1</sup> (2015)	D: 1/14 S: NR A: NR	NR	n = 14 · Rowe (pre vs post): 47.5 vs 91.1	n = 0/14	NR
Aurich <sup>5</sup> (2015)	D: 0/6 S: NR A: NR	· Overall: 6/6 · Same level: 3/6 · RTS timing: NR	n = 6 · Rowe (pre vs post): 16.67 vs 95	n = 0/6	NR
Burkhardt <sup>12</sup> (2007)	D: 4/102 S: 0/102 A: 1/47	· Overall: 53/55 · Same level: NR · RTS timing: NR	n = 47 · CMS (post): 94.4 · WDS (post): 91.7 · ROM (post): - FF: 179.6° (2.4° gain) - ER at 0°: 50.2° (5.1° loss)	n = 2/102 · Hematoma: 2 (1 required drainage)	n = 47 · Broken/loose screw: 2 · Fibrous/nonunion: 1
Khatar <sup>33</sup> (2016)	D: 0/62 S: NR A: NR	NR	n = 62 · ASES (pre vs post): 44.09 vs 90.87 · Rowe (pre vs post): 20.26 vs 83.95 · ROM (pre vs post): - Abd: 143.68° vs 169.12° - ER: 51.58° vs 77.63° - IR: 50.09° vs 67.28° - FF: 152.11° vs 168.77°	NR	NR
Ranalletta <sup>44</sup> (2018)	D: 0/65 S: 0/65 A: 1/65	Overall: 65/65 Same level: 62/65 RTS timing: 5.2 mo	· ASOSS (pre vs post): 40 vs 86 · Rowe (pre vs post): 37.5 vs 90 · VAS (pre vs post): 3.4 vs 1.4 · ROM (pre vs post): FF, ER, IR = NS	n = 3/65 (2 reoperations) · Painful screw: 1 (surgically removed) · Infection: 2 (1 treated with open lavage, 1 treated with oral antibiotics)	n = 65 · Graft position: 1 medialized, 3 lateralized, 61 acceptable · Broken/loose screw: 1 · Graft fracture: 1 · Fibrous/nonunion: 5 · Arthritis: 1 new OA, 0 OA progression
Rossi <sup>45</sup> (2018)	D: 0/100 S: 0/100 A: NR	Overall: 96/100 Same level: 91/100 RTS timing: 4.9 mo	· ASOSS (pre vs post): 46.3 vs 88.1 · Rowe (pre vs post): 43.8 vs 96.1 · VAS (pre vs post): 3.3 vs 1.2 · ROM (pre vs post): FF, ER, IR = NS	n = 4/100 (3 reoperations) · Painful screw: 2 (surgically replaced, 1 surgically removed) · Infection: 2 (1 with open lavage and intravenous antibiotics, 1 oral antibiotics)	n = 100 · Graft position: 3 medialized, 5 lateralized, 91 acceptable · Broken/loose screw: 1 · Graft fracture: 1 · Fibrous/nonunion: 8

<sup>a</sup>Abd, abduction; A, apprehension; ASES, American Shoulder and Elbow Surgeons; ASOSS, Athletic Shoulder Outcome Scoring System; CMS, Constant-Murley score; D, dislocation; ER, external rotation; FF, forward flexion; IR, internal rotation; NR, not reported; NS, not significant; OA, osteoarthritis; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; ROM, range of motion; RTS, return to sport; S, subluxation; SANE, Single Assessment Numeric Evaluation; SF-12, 12-Item Short Form Health Survey; SLAP, superior labrum anterior to posterior; SPORTS, subjective patient outcome for return to sports; SST, Simple Shoulder Test; SSV, Subjective Shoulder Value; UCLA, University of California, Los Angeles; VAS, visual analog scale; WDS, Walch-Duplay Score; WOSI, Western Ontario Shoulder Instability.