Outcomes of the Latarjet procedure with minimum 5- and 10-year follow-up: A systematic review

Ron Gilat^{1,2} , Ophelie Lavoie-Gagne¹ , Eric D Haunschild¹,
Derrick M Knapik³ , Kevin C Parvaresh¹, Michael C Fu¹,
Brian Forsythe¹, Nikhil Verma¹ and Brian J Cole¹

Abstract

Background: The purpose of this study was to evaluate mid- and long-term outcomes following the Latarjet procedure for anterior shoulder instability.

Methods: PubMed, MEDLINE, Embase, and Cochrane libraries were systematically searched, in line with PRISMA guidelines, for studies reporting on outcomes following the Latarjet procedure with minimum five-year follow-up. Outcomes of studies with follow-up between 5 and 10 years were compared to those with minimum follow-up of 10 years.

Results: Fifteen studies reporting on 1052 Latarjet procedures were included. Recurrent instability occurred in 127 patients, with an overall random summary estimates in studies with a minimum five-year follow-up of 0–18% ($I^2 = 90\%$) compared to 5–26% ($I^2 = 59\%$) for studies with a minimum 10-year follow-up. Overall rates for return to sports, non-instability related complications, and progression of arthritis estimated at 65–100% ($I^2 = 87\%$), 0–20% ($I^2 = 85\%$), and 8–42% ($I^2 = 89\%$) for the minimum five-year follow-up studies and 62–93% ($I^2 = 86\%$), 0–9% ($I^2 = 28\%$), and 9–71% ($I^2 = 91\%$) for the minimum 10-year follow-up studies, respectively. All studies reported good-to-excellent mean PRO scores at final follow-up.

Conclusions: The Latarjet is a safe and effective procedure for patients with shoulder instability. The majority of patients return to sport, though at long-term follow-up, a trend towards an increased incidence of recurrent instability is appreciated, while a significant number may demonstrate arthritis progression.

Keywords

Latarjet, coracoid transfer, shoulder instability

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Introduction

As the most inherently unstable joint in the human body, shoulder dislocations comprise 50% of all joint dislocations with a reported incidence of 12 per 100,000/year.^{1–3} Bone loss at the anteroinferior glenoid is common following anterior shoulder dislocations and is reported to occur in up to 22% of initial injuries and 90% of those with recurrent instability.^{4–6} Operative intervention is typically required in the setting of glenoid bone loss to restore stability, thereby minimizing pain and functional restrictions.⁷ Bony augmentation procedures are recommended in patients with as little

as 13.5% glenoid bone loss,⁸ as inferior outcomes with higher rates of recurrent instability are reported in patients treated with isolated soft tissue procedures.^{9–12}

¹Midwest Orthopaedics, Rush University Medical Center, Chicago, IL, USA

²Department of Orthopaedic Surgery, Shamir Medical Center and Tel Aviv University, Tel Aviv, Israel

³Department of Orthopaedic Surgery, University Hospitals Cleveland Medical Center, Cleveland, OH, USA

Corresponding author:

Ron Gilat, 1611 W Harrison St, Chicago, IL 60612, USA.
Email: ron.gilat@gmail.com

A common and effective treatment of recurrent anterior instability with significant glenoid bone loss is the Latarjet procedure.^{13,14} Multiple investigations of the Latarjet procedure have demonstrated excellent short-term patient-reported outcomes (PROs) and low recurrent instability rates of 0 to 12%.^{15–18}

The goal of the Latarjet procedure is to not only preserve shoulder stability in the short- to mid-term follow-up period, but also to help conserve the long-term health and integrity of the glenohumeral joint.¹⁷ Long-term data have demonstrated that even a single dislocation event is associated with arthritis in 56% of shoulders at 25-year follow-up.¹⁹ Glenoid augmentation using the Latarjet technique theoretically helps protect against dislocation arthropathy development and progression by reducing the rate of recurrent instability,^{9,10} while simultaneously preserving long-term patient functionality and satisfaction.^{15,17} Due to the increasing number of Latarjet procedures performed in younger patients (age < 20 years) with active lifestyles,²⁰ mid- and long-term outcomes are of particular interest as this is also the population with highest postoperative instability rates.^{19,21,22} Few large-scale investigations have reported on long-term outcomes following Latarjet augmentation.^{23–26} Moreover, potential etiologic factors accounting for arthritic development and progression remain controversial,^{19,20} with potential risks including patient age at the time of surgery,²⁰ lateral graft placement with resultant joint incongruity,^{21,23,24,27} and intra-articular graft placement or screw penetration.¹⁷

In order to evaluate the efficacy of the Latarjet procedure in mitigating anterior shoulder instability, an understanding of the mid- and long-term outcomes following augmentation is warranted. The purpose of this investigation was, therefore, to evaluate mid- and long-term outcomes following the Latarjet procedure for anterior shoulder instability. We will also compare outcomes at a minimum of 5 years versus those at a minimum of 10 years' follow-up to determine if there are any time-dependent associations. Our hypothesis is that there will be no differences in outcomes between studies with a minimum 5 years versus those at a minimum of 10 years' follow-up.

Methods

Data sources and searches

A systematic review was performed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.²⁸ Medical databases were searched from January 1995 to December 2019 and included the PubMed, MEDLINE, Embase, and Cochrane libraries.

The search was limited to English language articles or articles with English translation with the following search strategy: ((“glenoid” OR “glenohumeral” OR “shoulder instability” OR “anterior shoulder instability”) AND (“Latarjet”)). Reference lists of original and review articles were screened for additional studies not included in the original search.

Selection criteria

Studies included in the review were those meeting the following criteria: (1) clinical trials and observational studies reporting long-term clinical outcomes following the Latarjet procedure for anterior shoulder instability, (2) a sample size of >5 patients, and (3) studies reporting a minimum post-operative follow-up of 5 years. Excluded studies included those not providing PROs or recurrent instability rates, case reports and technique articles reporting the outcomes of less than five patients, and medical conference abstracts. Investigations from the same institutions were separately reviewed to identify studies likely reporting on the same cohort of patients. When these were identified, the most comprehensive study was included, while the rest were omitted following mutual discussion with the senior author.

Data extraction and quality assessment

The initial screening of records was performed based on titles and abstracts. Three reviewers (RG, EDH, DMK) reviewed the articles and extracted manuscripts independently with mutual discussion and resolution of discrepancies. The following information was extracted: publication year, study design, level of evidence, mean age, gender, sample size, approach, follow-up (minimum, mean, and range), prior surgeries, radiographic and clinical outcomes, complications, and specific remarks.

Quality assessment was performed by two independent reviewers (DMK, MCF) using The Methodological Index for Non-randomized Studies (MINORS) checklist²⁹ and the Newcastle-Ottawa Quality Assessment Scale (NOS).³⁰ Differences in MINORS or NOS scores were resolved by mutual discussion. Studies were grouped according to minimum follow-up time-point ranges. Studies defined with a minimum follow-up of greater than 5 years, but less than 10 years were classified into one group whereas those with a minimum follow-up >10 years were classified into a second group. Baseline comparisons of patient characteristics between groups were evaluated using weighted means, independent t tests, and two-proportion z-tests. A random effects modeling with the DerSimonian-Laird method was used to calculate pooled effect sizes due to

high study heterogeneity.^{31–34} Heterogeneity was evaluated using the I^2 value³⁴ and pooled effects reported with 95% confidence intervals (95%CI). Binomial data were assessed using a random effect analysis of proportions to summarize rates of recurrent instability, other complications, progression of osteoarthritis, and return to sports (RTS). Continuous data were analyzed using random effect analysis of means to report differences in PROs. Only PROs with a minimum of two studies in each treatment group reporting on change from pre-operative to postoperative scores were to be included in the random effects modeling. Outliers were defined as studies with effects that have an upper bound of 95%CI lower than the minimum pooled effect or studies with effects that have a lower bound of 95%CI higher than the maximum pooled effect. Outliers were removed from the pooled effect to minimize distortion of results. Forest plots were used to present results of the analyses. Statistical significance was determined as $p < 0.05$. All statistical analyses were performed using R software (Version 3.6.2).

Results

Literature search and selection

PubMed, MEDLINE, Embase, and Cochrane Library databases were searched in December 2019 using the described search methodology, yielding a total of 1097 studies. There were 643 abstracts following removal of duplicates. Screening of abstracts resulted in 116 articles requiring full-text review. A total of 14 studies satisfied the inclusion criteria and were included in the present systematic review. An additional study was identified using a manual search of systematic review, meta-analyses, and references.²⁰ A PRISMA flow diagram is presented in Figure 1.

A total of 15 studies reporting on 1052 Latarjet procedures were included in this systematic review. Of these, nine were level IV studies^{17,21,24,26,27,35–37} and six level III studies.^{7,14,15,38–40} Characteristics of studies reporting outcomes of Latarjet procedures at a minimum 5- and 10-year follow-up are presented in Table 1.

Patient demographics

Weighted mean age at time of the Latarjet procedure was 29.7 ± 8.3 years (range 15–66) for patients in studies with a 5-year minimum follow-up and 25.7 ± 3.3 years (range 15–58) for patients in studies with a 10-year minimum follow-up ($p = 0.455$). There was no significant difference in gender proportions between studies with minimum 5- versus 10-year follow-up ($p = 0.223$). Several studies included patients who underwent a prior stabilization procedure,^{17,21,24,27,37,39} while several

other studies excluded patients with a prior surgical procedure to the index shoulder.^{7,14,15,35,38} Mean follow-up was 9.2 ± 3.5 years for studies with a minimum 5-year follow-up and 22.6 ± 7.5 years for studies with a minimum 10-year follow-up ($p = 0.017$).

Outcomes

Outcomes of individual studies following Latarjet procedures at a minimum 5- and 10-year follow-up are reported in detail in Table 2.

Recurrent instability

The incidence of recurrent instability was reported in all included studies with minimum 5-year (8 studies; $n = 647$ shoulders)^{7,14,27,35,37–40} and 10-year (7 studies; $n = 405$ patients)^{15,17,20,21,24,26,36} follow-up. A total of 127 patients experienced recurrent instability following the Latarjet. Of these, 29 patients experienced frank dislocations, 60 had subluxations, and 38 reported apprehension. The overall random pooled summary estimate of the proportion of patients with recurrent instability following a Latarjet procedure in studies with a minimum 5-year follow-up was 4% (95% CI, 0–10%; $I^2 = 90\%$) while those with a minimum 10-year follow-up was 11% (95% CI, 7–17%; $I^2 = 59\%$). There was a trend towards a time-dependent increase in recurrent instability rates ($p = 0.063$) (Figure 2).

Patient-reported outcomes

PROs were reported in all included studies at minimum 5-year (8 studies; $n = 647$ shoulders)^{7,14,27,35,37–40} and 10-year (7 studies; $n = 405$ patients)^{15,17,20,21,24,26,36} follow-up. All studies reported improved mean PRO scores at final follow-up, regardless of the PRO used. Overall, weighted mean postoperative Rowe, Walch-Duplay, and Subjective Shoulder Value Scores were 90.8 ± 5.8 , 88.6 ± 4.3 , and 84.4 ± 7.4 , respectively. Only a few studies reported on mean change from pre-operative to postoperative scores using several different PROs thus precluding the use of pooled mean estimates and comparisons.

Athletes and RTSs

RTS was reported in five studies ($n = 209$ shoulders)^{7,27,35,37,38} with minimum 5-year follow-up and five studies ($n = 360$ shoulders)^{15,17,20,24,36} with 10-year follow-up. Of those reporting RTS rates, there was a high RTS rate of 82%. There was no significance difference found between studies with a minimum 5- (81%) versus 10-year (82%) follow-up ($p = 0.929$) (Figure 3).

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

Complications

All included studies with minimum 5-year (8 studies; $n = 647$ shoulders)^{7,14,27,35,37–40} and 10-year (7 studies; $n = 405$ patients)^{15,17,20,21,24,26,36} follow-up reported the incidence of non-instability related complications. There was a low overall complication rate, with a total of 48 non-instability related complications (Table 3). The majority of complications were related to hardware failure or removal (1.6%), surgical site infection (0.6%), graft fracture or dislocation (0.6%), hematoma (0.5%), and persistent pain (0.4%). Nerve injuries were reported in one patient in studies with minimum 5-year⁴⁰ and one patient in studies with minimum 10-year²⁰ follow-up, both consisting of transient musculocutaneous nerve palsies. The overall random pooled summary estimate of the proportion of patients with a non-instability related complication following a Latarjet procedure in studies with a

minimum 5-year follow-up was 4% (95% CI, 1–10%; $I^2 = 85\%$) while those with a minimum 10-year follow-up was 3% (95% CI, 1–6%; $I^2 = 28\%$). There was no significant difference in the pooled estimate of non-instability related complications between the follow-up timepoints ($p = 0.765$) (Figure 4).

Reoperations to address instability-related and non-instability related complications did not significantly differ between the groups ($p = 0.118$), with a total of 32 (4.9%) reoperations reported in studies with a minimum 5-year follow-up and 12 (3%) in studies with a minimum 10-year follow-up.

Radiographic outcomes and development of arthritis

Reports on radiographic outcomes and progression of glenohumeral arthritis were reported in four studies ($n = 424$ shoulder)^{27,35,38,39} with minimum 5-year follow-up and all seven studies ($n = 405$ patients)^{15,17,}

Table 1. Overview of included studies.

Study	Journal (y)	Study design	Level of evidence	Minimum follow-up (m)	Average follow-up (range) (m)	No. shoulders	Mean patient age (range) (y)	Gender	Approach	Prior operations	MINORs	NOS
Minimum 5-year follow-up	De Carli et al. ⁷	<i>Int Orthop</i> (2019)	Cohort	III	72	(72–108)	28 (16–41)	16 Females 24 Males	Open deltopectoral	None	–	–
	Dumont et al. ³⁷	<i>Am J Sport Med</i> (2014)	Case series	IV	61.2	76.4 (61.2–100.7)	29.4 (17.1–57.4)	9 Females 55 Males	Arthroscopic	Bankart repair (n = 12)	10	6
	Ernstbrunner et al. ²⁷	<i>Am J Sport Med</i> (2019)	Case series	IV	96	132 (96–192)	48 (40–66)	5 Females 35 Males	Open deltopectoral	Soft tissue stabilization (n = 15)	9	6
	Hovelius et al. ³⁹	<i>J Shoulder Elbow Surg</i> (2012)	Cohort	III	60	(60–276)	27 (15–57)	52 Females 267 Males	Open deltopectoral	Stabilization procedures (n = 23)	–	–
	Neyton et al. ³⁵	<i>J Shoulder Elbow Surg</i> (2012)	Case series	IV	68	144 (68–237)	19.9 (15–30)	37 males	Open deltopectoral	Exclusion of patients with prior surgery	11	5
	Shih et al. ³⁸	<i>Formosan J MSK Disorders</i> (2012)	Cohort	III	86	108.2 (86–126)	23.3 (18–32)	7 Females 21 Males	Open deltopectoral	Exclusion of patients with prior surgery	13	7
	Xu et al. ⁴⁰	<i>J Orthop Surg Res</i> (2019)	Cohort	III	60	67.6 (60–72)	31.2 (25.1–37.3)	18 Females 34 Males	Open deltopectoral	NR	11	6
	Zimmermann et al. ¹⁴	<i>J Bone Joint Surg Am</i> (2016)	Cohort	III	96	119 (96–142)	30.8 (19.4–42.4)	11 Females 82 Males	Open deltopectoral	Exclusion of patients with prior surgery	18	8
	Allain et al. ²⁴	<i>J Bone Joint Surg Am</i> (1998)	Case series	IV	120	171.6 (120–276)	27.5 (15–58)	15 Females 43 Males	Open deltopectoral	Bankart repair (n = 2)	12	7
	Bouju et al. ¹⁷	<i>Orthop Trauma Surg Res</i> (2014)	Case series	IV	120	156 (120–180)	26.7 ± 8.4	20 Females 48 Males	Open deltopectoral	Arthroscopic exploration (n = 10)	11	8
Minimum 10-year follow-up	Gordins et al. ²¹	<i>J Shoulder Elbow Surg</i> (2015)	Case series	IV	396	396 (396–420)	26.7 (15–39)	8 Females 23 Males	Open deltopectoral	Prior stabilization (n = 11)	10	6
	Lädermann et al. ²⁰	<i>Int Ortho</i> (2013)	Case series	IV	120	194.4 (120–266.4)	22.8 (16–55)	35 Females 82 Males	Open deltopectoral	NR	14	7
	Mizuno et al. ¹⁵	<i>J Shoulder Elbow Surg</i> (2014)	Cohort	III	216	240 (216–264)	29.4 (16–58)	14 Females 54 Males	Open deltopectoral	Exclusion of patients with prior surgery	9	6
	Schroder et al. ³⁶	<i>Am J Sports Med</i> (2006)	Case series	IV	296.4	316.8 (296.4–338.4)	20.5 (18–22)	1 Female 56 Males	Open deltopectoral	NR	14	7
	Singer et al. ²⁶	<i>J Bone Joint Surg Br</i> (1995)	Case series	IV	240	246 (240–270)	25 (18–36)	6 Females 8 Males	Open deltopectoral	NR	12	6

y, years; m, months; MINORS, Methodological Index for Non-randomized Studies; NOS, Newcastle-Ottawa Scale; NR, not recorded.

Table 2. Long-term outcomes of included studies.

Study	Radiographic outcomes	PRO reported	Recurrent instability	Other complications	Return to sports rate
Minimum 5-year follow-up					
De Carli et al. ⁷	NR	Rowe, UCLA, WOSI	None	None	72.5%
Dumont et al. ³⁷	NR	WOSI	Subluxation (n = 1)	Postoperative Hematoma (n = 3) Displaced coracoid graft (n = 1) Prominent screw requiring ROH (n = 8) TSA for OA (n = 1)	93.5%
Ernstbrunner et al. ²⁷	Progression of arthropathy 2 or more grades (45%; n = 17 patients) ^a	Constant, Walch-Duplay, SSV	Subluxation (n = 3) Apprehension (n = 5)	Persistent pain (n = 5) Screw loosening (n = 1) Graft failure (n = 1)	74%
Hovellius et al. ³⁹	Fibrous union (13%) Graft migration > 5mm (5%)	SSV, WOSI, DASH	Dislocation (n = 16) Subluxation (n = 41)	IA graft position requiring revision (n = 1) Postoperative infection (n = 3) Postoperative hematoma (n = 1) Hardware failure (n = 1) Graft fracture (n = 1)	NR
Neyton et al. ³⁵	Graft healed inferior to equator (89%; n = 33 cases) Bone block not fully healed (11%; n = 3 cases graft fracture; n = 1 case pseudoarthrosis) Minor arthritic changes (30%; n = 11 cases)	Walch-Duplay, Rowe	Apprehension (n = 5)	Graft fracture (n = 3; w/ n = 1 undergoing revision) Postoperative hematoma (n = 1)	65%
Shih et al. ³⁸	Progression of arthropathy I stage (11%; n = 3) ^a Loose screw (n = 1) Fibrous union (n = 1)	ASES, Rowe, WOSI	None	None	100%

(continued)

Table 2. Continued.

Study	Radiographic outcomes	PRO reported	Recurrent instability	Other complications	Return to sports rate
Xu et al. ⁴⁰	NR	ASES, UCLA, Rowe, SSV	None	None	NR
Zimmermann et al. ¹⁴	NR	SSV	Dislocation (n = 1) Subluxation (n = 2) Apprehension (n = 8)	Postoperative hematoma (n = 1) ROH due to irritation (n = 1) Screw exchange (n = 1)	NR
Minimum 10-year follow-up					
Allain et al. ²⁴	Graft non-union (n = 2 cases) Graft osteolysis (n = 10 cases)	Rowe, Constant	Subluxation (n = 1) Apprehension: (n = 6)	Postoperative infection requiring revision (n = 3) Adhesive capsulitis (n = 1) further complicated by humerus fracture during MUA (n = 1)	81%
Bouju et al. ¹⁷	Osteolysis (n = 7 total; n = 2 partial) Graft non-union (n = 4) Development of arthropathy (Stage I) (n = 3) ^a Preoperative glenoid fracture (n = 2)	Walch-Duplay, SSV, WOSI	Dislocation (n = 1) Apprehension (n = 10)	Complex regional pain syndrome (n = 1)	Return to sports rate was 83%. Only 61% resumed previous sports activity. Fifty-nine played sports, including 25 at competition level and 35 practicing at-risk sport (volleyball, handball, judo).
Gordins et al. ²¹	Fibrous graft union (13%; n = 4) Graft migration > 5mm (13%, n = 4) Mild arthropathy (27%) Moderate arthropathy (23%) Severe arthropathy (11%) ^a	WOSI, SSV, SASF	Dislocation (n = 2) Subluxation (n = 6)	None	NR

(continued)

Table 2. Continued.

Study	Radiographic outcomes	PRO reported	Recurrent instability	Other complications	Return to sports rate
Lädermann et al. ²⁰	Grade 1 arthropathy (30%) Grade 2 arthropathy (3%) Grade 3 arthropathy (3%) ^a	Walch-Duplay	Dislocation/ Subluxation (n = 2) Apprehension (n = 4)	Postoperative infection (n = 1) Transient MSK nerve neuropathy (n = 1) Superficial vein thrombosis (n = 1)	83%
Mizuno et al. ¹⁵	Postoperative dislocation arthropathy developed in 23.5%, majority classified as mild	Rowe, SSV	Dislocation (n = 2) Subluxation (n = 2)	Screw fracture (n = 1) Screw loosening w/ revision (n = 2)	Sixty-one patients (89.7%) participated in sports (26 patients [38.2%] competitively and 35 patients [51.4%] recreationally), and 13 patients (19.1%) were classified as participating in contact collision sports.
Schroder et al. ³⁶	Advanced arthropathy (n = 4)	Rowe, Sane, WOSI	Dislocation (n = 5) Subluxation (n = 3)	Screw removal (n = 2)	All patients able to graduate from Naval Academy passing stringent physical examination tests
Singer et al. ²⁶	Grade 1 arthropathy (n = 6) Grade 2 arthropathy (n = 3) Grade 3 arthropathy (n = 1) ^a	Rowe, Constant	Subluxation (n = 1)	None	NR

ROH, removal of hardware; TSA, total shoulder arthroplasty; OA, osteoarthritis; WOSI, Western Ontario Shoulder Index; SSVS, Subjective Shoulder Values Score; UCLA, University of California Los Angeles Shoulder Score; VAS, visual analog score; IA, intra-articular; DASH, Disabilities of the Arm, Shoulder and Hand Score; SANE, Single Assessment Numeric Evaluation; SASF, Subjective assessment of shoulder function; MUA, manipulation under anesthesia; SST, Simple Shoulder Test; MSK, musculoskeletal; ASES, American Shoulder and Elbow Surgeons Score; PRO: patient-reported outcome.

^aBased on Samilson-Prieto classification.

Figure 2. Random effects model for proportion of patients undergoing a Latarjet procedure at a minimum 5-year follow-up (lower section) and minimum 10-year follow-up (upper section) with reported recurrent instability. CI: confidence interval; ES: effect size.

20,21,24,26,36 with 10-year follow-up. Of the currently available data on these outcomes, non-union rates may be estimated at approximately 3.4–5.9%,^{17,24} and fibrous union rates at 3.5–13%.^{21,38,39} Osteolysis was only reported in two studies, with an estimated rate of 13.2–17%.^{17,24} Graft resorption was not quantified consistently in the included studies. Union status and osteolysis were appreciated using radiographs in most studies.

Eleven studies reported on the development and progression of arthritis, following a total of 158 Latarjet procedures.^{15,17,20,21,24,26,27,35,36,38,39} Glenohumeral instability arthropathy was classified according to the original Samilson-Prieto criteria⁴¹ in two studies^{35,38} (n = 65 shoulder) with minimum 5-year follow-up and five studies^{17,20,21,26,36} (n = 279 shoulder) with minimum 10-year follow-up. The modified version of the Samilson-Prieto criteria was utilized in one study²⁷ (n = 40 shoulders) with minimum 5-year follow-up and two studies^{15,24} (n = 126 shoulders) with minimum 10-year follow-up. Arthropathy progression was reported in approximately 28% of patients. While most patients had mild progression with a one grade increase in instability arthropathy, some studies reported progression of two or more arthropathy grades²⁷ with severe instability arthropathy noted in up to 11% of patients post-operatively.²¹ Pooled arthropathy rates were 21%

(95% CI, 7–40%; $I^2 = 84\%$) for studies with a minimum 5-year follow-up and 33% (95% CI, 19–49%; $I^2 = 91\%$) for studies with a minimum 10-year follow-up. There was no significant difference in the pooled estimate of arthritis progression rate between the groups ($p = 0.309$) (Figure 5).

Discussion

The purpose of this study was to evaluate the mid- and long-term outcomes following the Latarjet procedure for anterior shoulder instability. We found a high rate of RTS (81% and 82%), low rate of recurrent instability (4% and 11%), moderate rate of progression to arthritis (21% and 33%), and low rate of other non-instability related complications (4% and 3%) at mid- (minimum 5–10 years) and long-term (≥ 10 years) post-operative follow-up, respectively. While no significant differences between mid- and long-term outcomes were appreciated, there was a trend towards a significant time dependent increase in recurrent instability ($p = 0.063$).

As traumatic anterior shoulder dislocation with resultant instability requiring bony augmentation is commonly seen in athletic individuals,⁴² many patients are concerned about the ability to RTS following surgery.⁴³ There are a number of variables that may affect

Figure 3. Random effects model for proportion of patients undergoing a Latarjet procedure at a minimum 5-year follow-up (lower section) and minimum 10-year follow-up (upper section) who returned to sports at their pre-injury level. CI: confidence interval; ES: effect size.

Table 3. Non-instability related complications.

Complication	N (%)
Hardware failure/removal	17 (1.6%)
Surgical site infection	7 (0.6%)
Graft fracture/dislocation	7 (0.6%)
Postoperative hematoma	6 (0.5%)
Persistent pain	5 (0.4%)
Frozen shoulder/Adhesive capsulitis	1 (0.1%)
Total shoulder arthroplasty due to arthritis	1 (0.1%)
Musculocutaneous nerve neuropathy	1 (0.1%)
Humeral fracture during manipulation	1 (0.1%)
Complex regional pain syndrome	1 (0.1%)
Superficial vein thrombosis	1 (0.1%)

RTS, including social, scholastic, surgical, and rehabilitation factors.⁴⁴ Level of competition, type of sport, and quality of performance may also affect the ability of patients to return at their desired functional status.⁴⁵ Unfortunately, no universal consensus on the definition of RTS was present in the studies analyzed; thus, we reported on RTS as defined by each individual study. Fortunately, we found a high rate of RTS that was supported across all studies. These high rates match those reported in other systematic reviews^{46,47} and, notably, were not found to decline long-term. In their study evaluating outcomes following Latarjet surgery with minimum 10-year follow-up of 822 patients ($n = 845$ shoulder), Hurley et al. reported a RTS rate of 84.9%, with 76.3% of patients returning to the same level of play. While further sport-specific considerations remain to be determined, the findings from our investigation and others^{46,47} demonstrate that Latarjet procedures confer a high rate of RTS among athletes.

Recurrence of instability is another major concern for patients with anterior shoulder instability. A broad range of recurrence for anterior shoulder

Figure 4. Random effects model for proportion of patients undergoing a Latarjet procedure at a minimum 5-year follow-up (lower section) and minimum 10-year follow-up (upper section) who experienced a postoperative complication not related to instability. CI: confidence interval; ES: effect size.

instability after the Latarjet procedure has been reported in the aforementioned studies, ranging from 0 to 12%. Overall, our study demonstrated a relatively low pooled recurrence rate at mid- (4%) and long-term (11%) follow-up. These rates of recurrent instability are comparable to those previously reported.^{16,46,48} The systematic review by Rollick et al.⁴⁸ evaluating 684 patients undergoing Latarjet surgery from 11 studies with a mean follow-up of 212 months reported recurrent instability occurring in 2.7% of patients. Meanwhile, a systematic review by Bhatia et al.¹⁶ found that in eight studies analyzing outcomes following Latarjet, the reported rate of recurrent shoulder instability was 0–8%. Importantly, significant factors associated with instability, such as age and gender, did not differ between mid- and long-term outcomes studies. While a trend towards increased recurrence in patients with long-term (≥ 10 years) follow-up was observed, it is possible the studies included in our review were underpowered to detect these differences. Moreover, there may be a degree of sampling bias as long-term studies are more likely to have patients experiencing clinical issues at long-term follow-up as opposed to those without functional limitations.

Nonetheless, the low rates of recurrent instability support the efficacy of the Latarjet procedure as an effective, durable treatment option for patients with anterior shoulder instability.

The development of dislocation arthropathy is a known sequelae of anterior shoulder instability. Initial studies by Hovelius et al. demonstrated 20% of patients with instability had signs of radiographic arthritis at 10 years post-injury,⁴⁹ which increased in a follow-up study to 56% at 25 years.⁵⁰ Our findings are in line with these historical values and other long-term reviews which show rates of arthritis present in upwards of 30% of patients sustaining dislocations. Despite these high rates of arthritic development, functional impairment is not necessarily directly correlated to the severity of radiographic changes. The degree to which dislocation arthropathy limits long-term shoulder function, therefore, remains to be determined with future prospective investigations.

The incidence of mid- and long-term complications excluding recurrent instability with the Latarjet procedure were low at both mid- (4%) and long- (3%) term follow-up, while no significance in the incidence of non-instability related complications between groups was appreciated. These rates are low when compared to

Figure 5. Random effects model for proportion of patients undergoing a Latarjet procedure at a minimum 5-year follow-up (lower section) and minimum 10-year follow-up (upper section) with documented progression of instability arthropathy. CI: confidence interval; ES: effect size.

complications rates reported in prior studies with shorter-term follow-up.^{13,51,52} At a mean follow-up of 9.4 months following open Latarjet, the case series of 45 patients by Shah et al. reported a postoperative infection rate requiring operative irrigation and debridement of 6% ($n=3$ of 48), while neurologic injury, attributed to nerve traction and patient positioning, was recorded in 10% ($n=5$ of 48) of patients. Moreover, Athwal et al. reported a 10% complication rate following arthroscopic Latarjet surgery in 83 patients at a mean follow-up of 17 months, primarily related to hardware removal, neurovascular injury, and deep infection necessitating irrigation and debridement. The majority of complications reported in our investigation examining patients with greater follow-up were related to hardware failure or removal, infection, graft fracture or dislocation, hematoma, and persistent pain, with few reported nerve injuries. As such, given the technically demanding aspects of both open and arthroscopic Latarjet augmentation, surgeons must be

caution for the high potential of short-term, non-instability related complications.

Only one arthroscopic study met inclusion criteria,³⁷ while all other studies utilized an open deltopectoral approach. As a relatively novel approach, the arthroscopic Latarjet procedure has been described as minimally invasive with fewer early complications.^{53–55} However, the arthroscopic approach is a technically demanding procedure requiring specialized instrumentation and training,⁵⁶ and thus may be more costly.⁵⁷ Currently, outcomes following arthroscopic Latarjet augmentation are relatively unknown. Dumont et al.³⁷ reported in their series of 62 patients ($n=64$ shoulder) with minimum 5-year follow-up (mean 76.4 months) recurrent instability in 1.6% ($n=1$ of 64) of shoulders with no reported dislocations. However, comprehensive long-term outcomes following arthroscopic Latarjet surgery remain to be determined, warranting further research to improve our evidence basis for this evolving approach.

There are a number of strengths and weaknesses to this study. While RTS was provided by a number of studies, the quality of performance was not necessarily indicated. As with any systematic review, the combination of heterogeneous populations may not necessarily allow for a direct comparison of isolated independent variables. While we aimed to include a homogenous group of studies performing the Latarjet procedure, surgical techniques may have varied across studies, and some studies may have included patients who underwent other modifications of coracoid transfer techniques. Nonetheless, these data still represent the best available knowledge in the literature and our study is unique in evaluating mid- versus long-term outcomes. As data from the included studies were primarily reported at final follow-up, the authors are unable to infer the timing of complications based on when they were first diagnosed and the extent to which they progressed during the follow-up period. As emphasized by Harris et al.,⁵⁸ an additional significant limitation is the relatively heterogeneous data from level III and level IV evidence studies. This resulted in high degree of heterogeneity in the outcomes reported at both 5-year and 10-year follow-up. However, level I and level II studies with such long-term follow-up are non-existent at this time and most likely will not be available anytime soon. Meanwhile, the abundance of lower level of evidence studies should not be disregarded and may still allow for a significant cumulative interpretation of mid- to long-term outcomes following the Latarjet procedure. While we do present some data using pooled statistics such as weighted means and standard deviations, it is important to interpret these with caution to avoid potentially inaccurate conclusions.

Conclusions

The Latarjet procedure is a safe and effective procedure for patients with anterior shoulder instability. The majority of patients RTS, though a significant number may be expected to have radiographic signs of arthritis progression at long-term follow-up. There were no statistically significant differences between mid- and long-term PROs, but a trend towards time-dependent increase in recurrent instability rate and a significant increase in arthritis progression was observed.

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Ethical Review and Patient Consent

Informed consent was not sought for this article because this was a systematic review and meta-analysis without the enrollment of any new patients. Ethical approval was not sought for this article because this was a systematic review and metaanalysis of already published studies only. All studies included had declared ethical approval separately.

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RG: Conceptualization; Project administration; Data curation; Writing—original draft, Writing—review and editing. OLG: Data curation; Writing—original draft; Statistics. EDH: Data curation; Writing—original draft. DMK: Data curation; Writing—original draft. KCP: Data curation;

Writing—original draft. MCF: Writing—original draft and review and editing. BF: Writing, reviewing and editing. Nikhil Verma: Writing—review and editing. Brian J Cole: Conceptualization; Project administration; Writing—original draft, Writing—review and editing. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

ORCID iDs

Ron Gilat <https://orcid.org/0000-0002-9283-1439>

Ophelie Lavoie-Gagne <https://orcid.org/0000-0002-1197-747X>

Derrick M Knapik <https://orcid.org/0000-0001-8692-4746>

References

1. Leroux T, Ogilvie-Harris D, Veillette C, et al. The epidemiology of primary anterior shoulder dislocations in patients aged 10 to 16 years. *Am J Sports Med* 2015; 43: 2111–2117.
2. Shah A, Judge A, Delmestri A, et al. Incidence of shoulder dislocations in the UK, 1995–2015: a population-based cohort study. *BMJ Open* 2017; 7: e016112.
3. Zacchilli MA and Owens BD. Epidemiology of shoulder dislocations presenting to emergency departments in the United States. *J Bone Joint Surg Am* 2010; 92: 542–549.
4. Sayegh ET, Mascarenhas R, Chalmers PN, et al. Allograft reconstruction for glenoid bone loss in glenohumeral instability: a systematic review. *Arthroscopy* 2014; 30: 1642–1649.
5. Provencher CMT, 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: 133–151.
6. Itoi E, Lee S-B, Berglund LJ, et al. The effect of a glenoid defect on antero-inferior stability of the shoulder after Bankart repair: a cadaveric study. *J Bone Joint Surg Am* 2000; 82: 35–46.
7. 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: 237–242.
8. 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: 1769–1775.
9. Bessière C, Trojani C, Carles M, et al. The open Latarjet procedure is more reliable in terms of shoulder stability than arthroscopic Bankart repair. *Clin Orthop Relat Res* 2014; 472: 2345–2351.
10. Bessiere C, Trojani C, Pélégri C, et al. Coracoid bone block versus arthroscopic Bankart repair: a comparative paired study with 5-year follow-up. *Orthop Traumatol Surg Res* 2013; 99: 123–130.
11. Kavaja L, Pajarinen J, Sinisaari I, et al. Arthrosis of glenohumeral joint after arthroscopic Bankart repair: a long-term follow-up of 13 years. *J Shoulder Elbow Surg* 2012; 21: 350–355.
12. Voos JE, Livermore RW, Feeley BT, et al. Prospective evaluation of arthroscopic Bankart repairs for anterior instability. *Am J Sports Med* 2010; 38: 302–307.
13. Schmid SL, Farshad M, Catanzaro S, et al. The Latarjet procedure for the treatment of recurrence of anterior instability of the shoulder after operative repair: a retrospective case series of forty-nine consecutive patients. *J Bone Joint Surg Am* 2012; 94: e75.
14. 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: 1954–1961.
15. Mizuno N, Denard PJ, Raiss P, et al. Long-term results of the Latarjet procedure for anterior instability of the shoulder. *J Shoulder Elbow Surg* 2014; 23: 1691–1699.
16. Bhatia S, Frank RM, Ghodadra NS, et al. The outcomes and surgical techniques of the Latarjet procedure. *Arthroscopy* 2014; 30: 227–235.
17. Bouju Y, Gadéa F, Stanovici J, et al. Shoulder stabilization by modified Latarjet-Patte procedure: results at a minimum 10 years' follow-up, and role in the prevention of osteoarthritis. *Orthop Traumatol Surg Res* 2014; 100: S213–S218.
18. Young AA, Maia R, Berhouet J, et al. Open Latarjet procedure for management of bone loss in anterior instability of the glenohumeral joint. *J Shoulder Elbow Surg* 2011; 20: S61–S69.
19. Hovelius L, Olofsson A, Sandström B, et al. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger: a prospective twenty-five-year follow-up. *J Bone Joint Surg Am* 2008; 90: 945–952.
20. Lädermann A, Lubbeke A, Stern R, et al. Risk factors for dislocation arthropathy after Latarjet procedure: a long-term study. *Int Orthop* 2013; 37: 1093–1098.
21. Gordins V, Hovelius L, Sandström B, et al. Risk of arthropathy after the Bristow-Latarjet repair: a radiologic and clinical thirty-three to thirty-five years of follow-up of thirty-one shoulders. *J Shoulder Elbow Surg* 2015; 24: 691–699.
22. Cameron KL, Mountcastle SB, Nelson BJ, et al. History of shoulder instability and subsequent injury during four years of follow-up: a survival analysis. *J Bone Joint Surg Am* 2013; 95: 439–445.
23. Hovelius L, Sandström B and Saebö M. One hundred eighteen Bristow-Latarjet repairs for recurrent anterior dislocation of the shoulder prospectively followed for fifteen years: study II—the evolution of dislocation arthropathy. *J Shoulder Elbow Surg* 2006; 15: 279–289.
24. Allain J, Goutallier D and 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: 841–852.
25. Hovelius LK, Sandström BC, Rösmark DL, et al. Long-term results with the Bankart and Bristow-Latarjet procedures: recurrent shoulder instability and arthropathy. *J Shoulder Elbow Surg* 2001; 10: 445–452.

26. Singer G, Kirkland P and Emery R. Coracoid transposition for recurrent anterior instability of the shoulder. A 20-year follow-up study. *J Bone Joint Surg Br* 1995; 77: 73–76.
27. Ernstbrunner L, Wartmann L, Zimmermann SM, et al. Long-term results of the open Latarjet procedure for recurrent anterior shoulder instability in patients older than 40 years. *Am J Sports Med* 2019; 47: 3057–3064.
28. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009; 151: 264–269.
29. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. *BMJ* 2003; 327: 557–560.
30. 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: 603–605.
31. DerSimonian R. Meta-analysis in the design and monitoring of clinical trials. *Stat Med* 1996; 15: 1237–1248.
32. DerSimonian R and Laird N. Meta-analysis in clinical trials revisited. *Contemp Clin Trials* 2015; 45: 139–145.
33. DerSimonian R and Laird N. Meta-analysis in clinical trials. *Contemp Clin Trials* 1986; 7: 177–188.
34. Higgins JP and Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002; 21: 1539–1558.
35. Neyton L, Young A, Dawidziak B, et al. Surgical treatment of anterior instability in rugby union players: clinical and radiographic results of the Latarjet-Patte procedure with minimum 5-year follow-up. *J Shoulder Elbow Surg* 2012; 21: 1721–1727.
36. Schroder DT, Provencher MT, Mologne TS, et al. The modified Bristow procedure for anterior shoulder instability: 26-year outcomes in Naval Academy midshipmen. *Am J Sports Med* 2006; 34: 778–786.
37. Dumont GD, Fogerty S, Rosso C, et al. The arthroscopic Latarjet procedure for anterior shoulder instability: 5-year minimum follow-up. *Am J Sports Med* 2014; 42: 2560–2566.
38. Shih W-Y, Cheng K-C, Hung S-T, et al. Clinical results of shoulder arthroscopy combined with an open modified Latarjet procedure for chronic anterior shoulder instability with glenoid bony loss. *Formosan J Musculoskelet Disord* 2012; 3: 126–131.
39. Hovelius L, Sandström B, Olofsson A, et al. The effect of capsular repair, bone block healing, and position on the results of the Bristow-Latarjet procedure (study III): long-term follow-up in 319 shoulders. *J Shoulder Elbow Surg* 2012; 21: 647–660.
40. Xu Y, Wu K, Ma Q, et al. Comparison of clinical and patient-reported outcomes of three procedures for recurrent anterior shoulder instability: arthroscopic Bankart repair, capsular shift, and open Latarjet. *J Orthop Surg Res* 2019; 14: 326.
41. Samilson R and Prieto V. Dislocation arthropathy of the shoulder. *J Bone Joint Surg Am* 1983; 65: 456–460.
42. Trojan JD, Meyer LE, Edgar CM, et al. Epidemiology of shoulder instability injuries in collision collegiate sports from 2009 to 2014. *Arthroscopy* 2020; 36: 36–43.
43. Glogovac G, Schumaier AP and Grawe BM. Return to sport after coracoid transfer in athletes with anterior shoulder instability: a systematic review. *Sports Health* 2019; 11: 402–408.
44. Tjong VK, Devitt BM, Murnaghan ML, et al. A qualitative investigation of return to sport after arthroscopic Bankart repair: beyond stability. *Am J Sports Med* 2015; 43: 2005–2011.
45. Beranger JS, Klouche S, Bauer T, et al. 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: 277–282.
46. Hurley ET, Jamal MS, Ali ZS, et al. Long-term outcomes of the Latarjet procedure for anterior shoulder instability: a systematic review of studies at 10-year follow-up. *J Shoulder Elbow Surg* 2019; 28: e33–e39.
47. An VVG, Sivakumar BS, Phan K, et al. A systematic review and meta-analysis of clinical and patient-reported outcomes following two procedures for recurrent traumatic anterior instability of the shoulder: Latarjet procedure vs. Bankart repair. *J Shoulder Elbow Surg* 2016; 25: 853–863.
48. Rollick NC, Ono Y, Kurji HM, et al. Long-term outcomes of the Bankart and Latarjet repairs: a systematic review. *Open Access J Sports Med* 2017; 8: 97.
49. Hovelius L, Augustini B, Fredin H, et al. Primary anterior dislocation of the shoulder in young patients. A ten-year prospective study. *J Bone Joint Surg Am* 1996; 78: 1677–1684.
50. Hovelius L and Saeboe M. Arthropathy after primary anterior shoulder dislocation—223 shoulders prospectively followed up for twenty-five years. *J Shoulder Elbow Surg* 2009; 18: 339–347.
51. Athwal GS, Meislin R, Getz C, et al. Short-term complications of the arthroscopic Latarjet procedure: a North American experience. *Arthroscopy* 2016; 32: 1965–1970.
52. Shah AA, Butler RB, Romanowski J, et al. Short-term complications of the Latarjet procedure. *J Bone Joint Surg Am* 2012; 94: 495–501.
53. Lafosse L and Boyle S. Arthroscopic Latarjet procedure. *J Shoulder Elbow Surg* 2010; 19: 2–12.
54. Malahias M-A, Fandridis E, Chytas D, et al. Arthroscopic versus open Latarjet: a step-by-step comprehensive and systematic review. *Eur J Orthop Surg Traumatol* 2019; 29: 957–966.
55. Hurley ET, Lim Fat D, Farrington SK, et al. Open versus arthroscopic Latarjet procedure for anterior shoulder instability: a systematic review and meta-analysis. *Am J Sports Med* 2019; 47: 1248–1253.
56. Lafosse L, Lejeune E, Bouchard A, et al. The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability. *Arthroscopy* 2007; 23: 1242. e1241–1242; e1245.
57. Randelli P, Fossati C, Stoppani C, et al. Open Latarjet versus arthroscopic Latarjet: clinical results and cost analysis. *Knee Surg Sports Traumatol Arthrosc* 2016; 24: 526–532.
58. Harris JD, Brand JC, Cote MP, et al. Research pearls: the significance of statistics and perils of pooling. Part 3: pearls and pitfalls of meta-analyses and systematic reviews. *Arthroscopy* 2017; 33: 1594–1602.