European Journal of Orthopaedic Surgery & Traumatology (2019) 29:957–966
https://doi.org/10.1007/s00590-019-02398-3

GENERAL REVIEW • SHOULDER - ARTHROSCOPY

Arthroscopic versus open Latarjet: a step-by-step comprehensive and systematic review

Michael-Alexander Malahias[1] · Emmanouil Fandridis[2] · Dimitrios Chytas[3] · Efstathios Chronopulos[3] · Emmanouil Brilakis[1] · Emmanouil Antonogiannakis[1]

Received: 31 August 2018 / Accepted: 9 February 2019 / Published online: 7 March 2019

Abstract

Purpose To investigate whether arthroscopic Latarjet procedure significantly differs from the open procedure as for the clinical, functional and radiographic outcomes.

Methods Two reviewers independently conducted a systematic search according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses using the MEDLINE/PubMed database and the Cochrane Database of Systematic Reviews. These databases were queried with the terms "shoulder" AND "anterior" AND "instability" AND "Latarjet".

Results From the 259 initial papers, we finally assessed five clinical studies which were eligible to our inclusion–exclusion criteria. The mean modified Coleman score for methodological deficiencies of the studies was 65.4/100, whereas it ranged from 53/100 to 77/100. The arthroscopic technique illustrated comparable results to the open technique regarding the postoperative recurrence rate. No significant difference was found amongst groups in relation to the postoperative osteoarthritis, infection rates, soft tissue healing, postoperative mean American Shoulder and Elbow Surgeons score, mean Walch–Duplay score, fatty infiltration of the subscapularis muscle and posterior protrusion of the screw. The arthroscopic technique yielded significantly superior results as for the non-union rate of the graft, the total graft osteolysis and graft resorption, the mean Western Ontario Shoulder Instability Index score and the early postoperative pain.

Conclusions Both the open and the arthroscopic Latarjet procedures led to satisfactory radiographic and clinical outcomes for the treatment of patients with recurrent anterior shoulder instability and significant glenoid bone loss. However, the overall quality of the studies ranged from low to moderate.

Level of evidence Comprehensive and systematic review of level II–III therapeutic studies.

Keywords Arthroscopic Latarjet · Bristow–Latarjet · Bone block procedures · Glenoid bone loss · Recurrent shoulder instability · Open versus arthroscopic Latarjet

Introduction

In 1954, Latarjet described his treatment for recurrent dislocation of shoulder by transposing the coracoid process on the neck of the scapula and securing it with a screw [1]. The following steps were usually followed: coracoid preparation and osteotomy, subscapularis muscle split, preparation of the anterior glenoid neck and fixation of the coracoid graft to the anterior side of the glenoid with two 3.5-mm cannulated cortical screws [2–4].

The open Latarjet technique with a few modifications remains "the gold standard" procedure even today with a reported major complications' rate around 1% [5–8]. It addresses anterior shoulder instability with significant bone loss by the triple locking mechanism: bone surface augmentation, subscapularis lowering with the conjoined tendon adding a "muscle lock" or "hammock" effect or "sling effect" and capsular reattachment on the coracoacromial ligament [9]. However, a number of issues regarding the optimal position of the bone block have been identified in

✉ Michael-Alexander Malahias
alexandermalahias@yahoo.gr

1 3rd Orthopaedic Department, Hygeia Hospital, Erythrou Stavrou 4, Marousi, 15123 Athens, Greece

2 Hand-Upper Limb and Microsurgery Department, Hospital KAT, Athens, Greece

3 2nd Orthopaedic Department, School of Medicine, National and Kapodistrian University of Athens, Agias Olgas 3, Nea Ionia, 14233 Athens, Greece

association with the open Latarjet procedure. Hovelius et al. [10] found a 67% incidence level of incorrect graft positioning after the open technique using simple radiographic evaluations. Placing the bone block too medially could result in an increased rate of recurrence [11]. Conversely, too lateral graft placement is considered as being associated with a higher incidence of degenerative changes [6, 7]. Another point of possible complications was related to the angle between screws and glenoid articular surface. Increasing this angle could potentially result in impingement of the screw heads against the humeral head as well as jeopardizing the suprascapular nerve [12].

A relatively new, minimally invasive technique, which has gained increased popularity amongst physicians, is the arthroscopic Latarjet procedure. This technique was introduced by Lafosse et al. [13], who described its early results in 2007. Although satisfactory outcomes have recently been reported and benefits have been advocated for this technique, such as decreased stiffness, quicker rehabilitation and return to sport activities [13, 14], the high complexity of this operation and the required dexterity still make it a path to be trod with great care as each step is strewn with pitfalls and potentially serious complications [14, 15].

Recently, a number of clinical trials with a minimum 12-month follow-up have compared the clinical, functional and radiographic outcomes of the open and the arthroscopic Latarjet procedures. Our aim was to answer to the following questions: (1) Do the clinical, functional and radiographic outcomes of arthroscopic Latarjet procedure significantly differ from the open procedure? (2) What is the quality of the evidence of the already published studies which compared the arthroscopic Latarjet technique with the open procedure? Our hypothesis was that the arthroscopic Latarjet would be proved at least not inferior to the open procedure.

Methods

Two reviewers independently conducted a systematic search according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) using the MEDLINE/PubMed database and the Cochrane Database of Systematic Reviews [16]. These databases were queried with the terms “shoulder” AND “anterior” AND “instability” AND “Latarjet”. To maximize the search, backward chaining of reference lists from retrieved papers was also undertaken. A preliminary assessment of only the titles and abstracts of the search results was initially performed. The second stage involved a careful review of the full-text publications.

Inclusion criteria were controlled clinical studies comparing the clinical and/or functional and/or radiographic outcome of arthroscopic and open Latarjet. The clinical trials should have contained at least a 12-month follow-up evaluation, with at least one clinical and/or functional subjective score or radiographic evaluation reported, while all of the studies included must have been written in English as full-text manuscript. Furthermore, they should have been published from January 1, 2007 (the year when arthroscopic Latarjet was firstly reported in the literature) till January 14, 2018 (end of our search).

Exclusion criteria were non-comparative studies, trials dealing with other bone block procedures or studies comparing arthroscopic Bankart and/or remplissage with the Latarjet procedure, irrelevant studies, preclinical, cadaveric or animal studies, abstracts, literature reviews, case reports, technical notes, editorial comments, expert opinions, studies with less than 12-month follow-up, studies without any clinical and/or functional and/or radiographic outcomes, articles not written in English, papers published after January 14, 2018 or before 2007 (the year when arthroscopic Latarjet was firstly reported in the literature).

Differences between reviewers were discussed until agreement was achieved. (When disagreement still existed, the senior author made the determination.) They independently extracted data from each study and assessed variable reporting of outcome data. Descriptive statistics were calculated for each study and parameters were analysed. The methodological quality of each study and the different types of detected bias were assessed independently by each reviewer with the use of modified Coleman methodology score [17], and the mean score amongst reviewers was calculated. In addition, the overall quality of the studies was graded according to the GRADE Working Group guidelines [18]. Selective reporting bias like publication bias was not included in the assessment. The primary outcome measures were the recurrence rate, osteolysis rate, non-union rate, rate of inadequate position of the graft and graft healing rate. Secondary outcomes were the postoperative clinical and functional subjective scores, early pain reduction, duration of surgery, postoperative glenohumeral osteoarthritis, postoperative subscapularis fatty infiltration and postoperative positive subjective apprehension test.

Results

From the 259 initial papers, we finally chose five clinical studies (but six papers, because the study of Kordasiewicz et al. [12, 19] was divided into two articles entitled as “Part 1” and “Part 2”) which were eligible to our inclusion–exclusion criteria [2, 4, 12, 19–21]. We excluded from our review all studies that were not comparative (70), studies published before 2007 (40), irrelevant studies (31), literature reviews (29), preclinical studies (20), trials involving other bone block procedures (14), surveys comparing Latarjet with arthroscopic Bankart and/or remplissage procedure (10), duplicated studies (9), technical notes (7), case reports (7), studies without outcomes (6), articles not written in English (2 in French, 2 in Czech, 1 in Spanish, 1 in Chinese), relative studies with mean follow-up less than 12 months (1), overlapping articles (1) and editorial comments (2). A summary flow chart of our literature search according to PRISMA guidelines is shown in Fig. 1.

Level of evidence and study's design

Three out of the five studies of this review (60%) had a level of evidence II [4, 20, 21], while two out of the five studies (40%) had a level of evidence III [2, 12, 19]. There was one retrospective study (20%) [12, 19] and four prospective studies [2, 4, 20, 21]. All studies (100%) included in this review were non-randomized [2, 4, 12, 19–21], and they were published between 2016 and 2018 (Table 1).

Quality of the studies and possible risk of bias

The overall quality of the studies included in this review, as it was evaluated according to the GRADE Working Group guidelines [18], ranged from low [2, 12, 19] to moderate [4, 20, 21].

The mean modified Coleman score for methodological deficiencies of the studies was 65.4/100, whereas it ranged from 53/100 [4] to 77/100 [2] (Table 1).

Three out of the five studies of this review (60%) were characterized by selection, detection and performance bias [2, 4, 12, 19], while two out of the five studies (40%) were characterized by selection, detection, performance and attrition bias [20, 21]. Finally, two out of the five studies of this review (40%) reported a possible conflict of interest [2, 20] (Table 1).

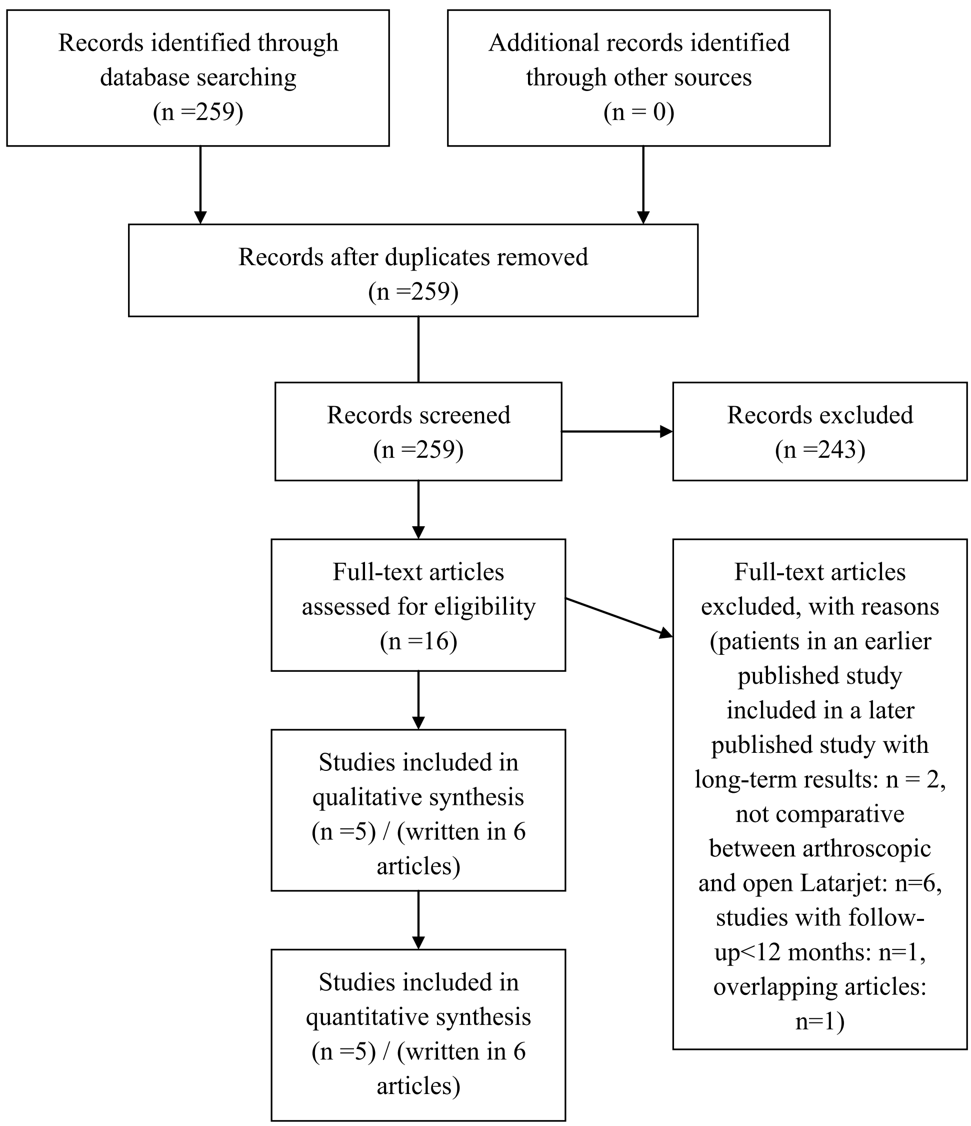

Fig. 1 PRISMA flow chart

Table 1 Main characteristics of the studies which were included in this review: authors, type of study, level of evidence, number of patients, sex, mean age, mean follow-up, modified Coleman score, possible high risk of bias, conflict of interest

Author(s)	Type of study	Level of evidence	Number of patients	Sex	Mean age	Mean FU (months)	Modified Coleman score	Possible high risk of bias	Conflict of interest
Kordasiewicz et al. (Part 1 and 2) [12, 19]	Retrospective comparative	III	110 (open: 48, arthro: 62)	101 M, 9 F (open: 46 M, 2 F; arthro: 55 M, 7 F)	Open: 28 Arthro: 26	54.2 (open) 23.4 (arthro) (sign. dif.)	67	Selection, detection and performance	Not rep.
Russo et al. [4]	Prospective comparative	II	46 (open: 21, arthro: 25)	43 M, 3 F	Not rep.	12 (min.)	53	Selection, detection and performance	Not rep.
Zhu et al. [2]	Prospective comparative	III	90 (open: 44, arthro: 46)	68 M, 22 F (open: 32 M, 12 F arthro: 36 M, 10 F)	Open: 34.8 Arthro: 32.1	37.4 (open) 26.9 (arthro) (sign. dif.)	77	Selection, detection and performance	Yes
Marion et al. [20]	Prospective comparative	II	58 (open: 22, arthro: 36)	45 M, 13 F (open: 16 M, 6 F; arthro: 29 M, 7 F)	Open: 27.3 Arthro: 26.7	29.8	74	Selection, detection, attrition and performance	Yes
Metais et al. [21]	Prospective comparative	II	390 (open: 104, arthro with screw: 222, arthro with endobutton: 64)	Not rep.	27.8	22.7	56	Selection, detection attrition and performance	No

M males, *F* females, *arthro* arthroscopic, *FU* follow-up, *rep* reported, *min* minimum, *sign* significant, *dif* difference

Demographics

Totally, 694 patients were included in this review. From them, 239 patients underwent the open procedure and 455 patients underwent the arthroscopic procedure. The vast majority of the patients were males (84.5%) [2, 4, 12, 19, 20], while the mean age of the patients who underwent the arthroscopic technique ranged from 26 years [12, 19] to 32.1 years [2] and the mean age of the patients who were treated with the open technique ranged from 27.3 years [20] to 34.8 years [2]. The mean follow-up ranged from 12 [4] to 54.2 months [12, 19] (Table 1).

Duration of surgery

Three out of the five studies of this review (60%) compared the duration of surgery between the open and arthroscopic Latarjet procedures [2, 12, 19, 20]. According to two out of the three aforementioned studies (66%) [2, 20], the duration was significantly longer in the arthroscopic group than in the open one (122.8 and 89.3 min, respectively, in the study by Zhu et al. [2], and 76.8 min and 61.6 min, respectively, in the paper by Marion et al. [20]). However, Kordasiewicz et al. [19] found that the duration was significantly shorter in the arthroscopic group than in the open group (110 and 120 min, respectively).

Postoperative recurrence of instability

Postoperative recurrence was reported in three out of the five studies of this review (60%) [19–21]. Overall, the recurrence rate with the Latarjet procedure was very low, since only 2.2% of all patients experienced postoperative dislocation (five patients in the open group and 10 in the arthroscopic group). All studies (100%) illustrated that there were not any significant differences regarding the postoperative recurrence rate between the open and the arthroscopic Latarjet procedures. Kordasiewicz et al. found three cases of recurrence in each group (6.2% in the open one and 4.8% in the arthroscopic one—a difference statistically insignificant) [19]. Marion et al. [20] reported only one recurrence in the arthroscopic group. Metais et al. [21] noted recurrent instability in two patients of the open group, two patients of the arthroscopic group with screw fixation and four patients of the arthroscopic group with endobutton fixation.

Infection rates

Four out of the five studies (80%) did not report any postoperative infection leading to revision [2, 4, 12, 19, 20], while one study (20%) documented two cases of infection in the open group and four cases in the arthroscopic group [21].

Wound healing

None of the studies (0%) included in this review reported postoperative scar problems or other complications related to the healing of the surgical wound. One study (20%) documented two patients treated with the open procedure who developed postoperative haematoma requiring surgical irrigation [21].

Osteolysis and graft resorption

Osteolysis was reported in two out of the five (40%) studies, which were included in this review [2, 12]. Kordasiewicz et al. [12] found that there was not any total graft osteolysis in the arthroscopic group, while there were 32 cases of partial superior graft osteolysis and two cases of partial inferior graft osteolysis. As for the open group, there were five cases of total graft osteolysis, 10 cases of partial superior graft osteolysis and one case of partial inferior graft osteolysis [12]. Kordasiewicz et al. [12] depicted that both the differences in total and superior graft osteolysis between the open and the arthroscopic groups were significant. Zhu et al. [2] documented significantly less graft resorption in the arthroscopic group one year postoperatively.

Non-union of the coracoid autograft

Cases of non-union were reported in one out of the five studies (20%) of this review [12]. Kordasiewicz et al. [12] found that the non-union rate was significantly higher with the open procedure (five out of 24 cases) in comparison with the arthroscopic one (one out of 50 cases).

Fractures of the coracoid autograft

Three out of the five studies (60%) reported intra- or postoperative bone block fracture [12, 19–21]. Overall, there were 11 arthroscopically treated patients who had an intra- or postoperative fracture of the coracoid autograft and two patients who underwent an open Latarjet procedure.

Medial–lateral position of the graft

Three out of the five studies (60%) assessed the medial–lateral position of the graft [2, 12, 20]. According to Zhu et al. [2], the position of the graft in medial–lateral direction was optimal, in both the open and the arthroscopic groups. Marion et al. [20] documented that the position of the coracoid bone block was significantly more lateral with the arthroscopic Latarjet procedure. Kordasiewicz et al. [12] illustrated that much more patients of the arthroscopic Latarjet group than of the open Latarjet group had an inadequate medial positioning of the graft (14.6% of cases in the open group versus 41.7% in the arthroscopic one). On the other hand, the difference of the lateral graft overhanging was found insignificant between the two groups (16.7% of the patients in the arthroscopic one and 19.5% of the patients in the open one) [12].

Superior–inferior position of the graft

Four out of the five studies (80%) dealt with the superior–inferior position of the graft [2, 4, 12, 20]. According to two of them (50%) [2, 4], the open procedure was characterized by significantly better subequatorial positioning of the graft than the arthroscopic procedure. More specifically, Russo et al. [4] found that the positioning of the graft was correct (flush and subequatorial) in 76% of the arthroscopic cases and in 100% of the open cases. Zhu et al. [2] noticed that 100% of the grafts were subequatorial in the open group and 91.3% in the arthroscopic group. However, according to one out of the four papers (25%), the arthroscopic procedure was accompanied by significantly better equatorial position (more inferior) than the open procedure [20]. The authors of that study [20] noted that the equatorial position was below 5 o'clock in 43.7% of patients of the open group and in 80.8% of those of the arthroscopic group. Finally, according to one out of the four studies (25%) statistically significant differences were noted in the graft's height position between 2 and 4 o'clock (30% of the grafts in the arthroscopic versus 2.4% in the open group) and between 3 and 5 o'clock (56.7% in the arthroscopic versus 87.8% in the open group) [12].

Screw orientation

Four out of the five studies (80%) dealt with the orientation of the screws [2, 4, 12, 20]. Two of them (50%) showed significant differences between the open and the arthroscopic groups [12, 20]. Particularly, Kordasiewicz et al. [12] noted that the screws were more parallel to the glenoid in the arthroscopic group: The mean angles were 12.6° for the superior screw and 12.3° for the inferior one, while these angles in the open group were 17° and 15°, respectively. The difference was significant as for the superior screws [12]. Marion et al. [20] found that the mean convergence angle (formed by the tangent to the glenoid and the line which joins the centres of the heads of the screws) of the arthroscopic group was 28.6°, which was significantly bigger than the mean angle (16.5°) of the open group. However, according to Zhu et al. [2], the orientation of the screw had a mean angle of 18.1° between the axis of the screw and the glenoid fossa in the open group and a mean angle of 21.7° in the arthroscopic group. This difference was insignificant [2]. Also, Russo et al. [4] reported that the median divergence angle of the arthroscopic group was 19.4° and the screws were parallel to the glenoid surface in 56% of the arthroscopically treated patients and divergent in 44% of them. The median divergence angle of the open group was 11.2°, and the screws were parallel to the glenoid surface in 76% of the open treated patients and divergent in 24% of them [4]. Insignificant difference was noted amongst groups in terms of screw divergence [4].

Posterior protrusion of the screw

Two out of the five studies (40%) compared the posterior protrusion of the screw between the open and the arthroscopic groups [4, 12]. Both studies did not demonstrate any significant difference amongst groups as for this imaging variable. According to Kordasiewicz et al. [12], the posterior protrusion was 7.75 mm for the arthroscopic group and 6.34 mm for the open one, in terms of the superior screw. As far as the inferior screw is concerned, the posterior protrusion was 5.66 mm for the arthroscopic group and 4.55 mm for the open group [12]. Russo et al. [4] documented a posterior protrusion of the screw in 76% of the patients, who were arthroscopically treated and 71.4% of the patients of the open Latarjet group.

Postoperative osteoarthritis

One out of the five studies (20%) compared the rate of postoperative osteoarthritis (OA) between the open and the arthroscopic groups [4]. Russo et al. [4] used the Samilson and Prieto classification and found that, in the arthroscopic group, OA was absent in 88% of cases, grade 1 in 8% of cases and grade 2 in 4% of cases. In the open group, OA was absent in 71% of cases, grade 1 in 24% of cases and grade 2 in 5% of cases [4]. Mild OA was noted in 12% of cases in the arthroscopic group and in 28.6% of cases in the open group [4]. No significant differences were found amongst groups [4].

Clinical and functional subjective scores

Two out of the five studies of this review (40%) used the Walch–Duplay score [19, 21]. Kordasiewicz et al. [19] showed insignificant difference of this score between the groups which underwent an open Latarjet procedure and the group which was treated with an arthroscopic Latarjet procedure. Three out of the five studies of this review (60%) used the Rowe score [2, 19, 21]. While Kordasiewicz et al. [19] demonstrated a significant superiority of the open group to the arthroscopic one in terms of the mean postoperative Rowe score, Zhu et al. [2] found that there was not any significant difference between the two groups. One out of the five studies of this review (20%) made use of the Western Ontario Shoulder Instability Index (WOSI) [20]. According to Marion et al. [20], the total postoperative WOSI score and its emotional component were significantly better in the arthroscopic group. One out of the five studies of this review (20%) used the Constant–Murley score and the American Shoulder and Elbow Surgeons (ASES) score [2]. Zhu et al. [2] reported that there was not any significant difference as for the mean group ASES and Constant–Murley scores (Table 2).

Pain

Two out of the five studies of this review (40%) used the visual analogue scale (VAS) pain score [19, 20]. According to Kordasiewicz et al. [19], there was insignificant difference between the groups postoperatively (mean VAS: 0.77 in the open group and 1.38 in the arthroscopic group), while Marion et al. [20] found a significant superiority of the arthroscopic group to the open one on the seventh postoperative day (mean VAS: 2.5 in the open group and 1.2 in the arthroscopic group) (Table 2).

Postoperative positive apprehension test

Three out of the five studies of this review (60%) assessed the subjective apprehension of the patients who underwent the Latarjet procedure [2, 19, 21]. Two out of the three studies (66.6%) did not report any significant difference between the open and the arthroscopic methods [2, 21], while one study (33.3%) illustrated the opposite [19]. More specifically, Kordasiewicz et al. [19] showed that the arthroscopic group demonstrated significantly higher rate of positive subjective apprehension test than the open group. According to Zhu et al. [2], the apprehension test was negative for all the patients in both groups postoperatively, although it was positive in all of them preoperatively. Finally, Metais et al. [21] depicted that all three groups included in their study (open procedure, arthroscopic Latarjet with screw fixation and arthroscopic Latarjet with endobutton fixation) did not demonstrate any significant differences as for the rate of positive postoperative apprehension test.

Postoperative fatty infiltration of the subscapularis muscle

One out of the five studies (20%) compared the fatty infiltration of the subscapularis muscle between the open and the arthroscopic groups [12]. Kordasiewicz et al. [12] found that

Table 2 Type of clinical and functional subjective scores assessed, mean preoperative and postoperative values and significant difference

Author(s)	Clinical scores	Preoperative clinical score	Postoperative clinical score	Significant difference
Kordasiewicz et al. [19]	Rowe, Walch–Duplay, VAS pain	Rowe: 25 (open) 27 (arthroscopic) Walch–Duplay: 15 (open): 20 (arthroscopic)	Rowe: 87.8 (open) 78.9 (arthroscopic) Walch–Duplay: 83.9 (open): 76.7 (arthroscopic) VAS pain: 0.77 (open): 1.38 (arthroscopic)	Rowe score: significantly higher with the open technique
Zhu et al. [2]	ASES, Constant–Murley, Rowe	ASES: 77.6 (open) 86.4 (arthroscopic) Constant–Murley: 89.5 (open): 93.1 (arthroscopic) Rowe: 39.8 (open): 43.9 (arthroscopic)	ASES: 93.3 (open): 93.0 (arthroscopic) Constant–Murley: 96.5 (open): 95.0 (arthroscopic) Rowe: 97.1 (open): 95.4 (arthroscopic)	Insignificant difference between the open group and the arthroscopic group regarding any of the clinical scores
Marion et al. [20]	WOSI, VAS pain	–	WOSI (total): 78.5%(open): 82.3%(arthroscopic) WOSI (symptoms): 80.5% (open): 83.6% (arthroscopic) WOSI (sports): 79% (open): 80.7% (arthroscopic) WOSI (daily life): 82.2% (open): 85.8%(arthroscopic) WOSI (emotional): 66.2%(open): 75.2%(arthroscopic) VAS pain: 2.5 (open): 1.2 (arthroscopic)	Total WOSI score and its emotional component: significantly better in the arthroscopic group VAS pain score: significantly better in the arthroscopic group (7 days postoperatively)
Metais et al. [21]	Walch–Duplay score Modified Rowe	Walch–Duplay score: 46 (open: 36.4 arthroscopic with screw: 49.3) Modified Rowe score: 46 (open: 40.5 arthroscopic with screw: 47.9)	Walch–Duplay score: 90.6 (open: 85.9, arthroscopic with screw: 91, arthroscopic with endobutton: 97.5) Modified Rowe score: 91.1 (open: 83.9, arthroscopic with screw: 92.8, arthroscopic with endobutton: 95.3)	Significant difference across groups

VAS visual analogue scale; *ASES* American Shoulder and Elbow Surgeons; *WOSI*: Western Ontario Shoulder Instability Index

there were not any significant differences amongst groups as for the postoperative fatty infiltration of subscapularis muscle. Grade I infiltration was noted in 11.7% of cases in the arthroscopic group and in 9.8% of cases in the open group. Grade 2 infiltration was found only in 2.4% of cases in the open group [12].

Discussion

The most important finding of our review was that both the open and the arthroscopic Latarjet procedures led to satisfactory radiographic and clinical outcomes for the treatment of patients with recurrent anterior shoulder instability and significant glenoid bone loss. The arthroscopic technique illustrated comparable results to the open technique regarding the postoperative recurrence rate [19–21], which is the primary criterion for the success of treatment of the aforementioned patients. In addition, most studies assessing the postoperative apprehension test as a subjective sign of remaining instability reported no significant differences between the arthroscopic and the open procedures [2, 21].

No significant difference was found amongst groups in relation to the postoperative osteoarthritis, infection rates, soft tissue healing, postoperative mean ASES, mean Walch–Duplay score, fatty infiltration of the subscapularis muscle and posterior protrusion of the screw. The arthroscopic technique yielded significantly superior results as for the non-union rate of the graft, the total graft osteolysis and graft resorption, the mean WOSI score and the early (first week) postoperative pain. Most of the studies investigating the medial–lateral positioning of the graft in our review depicted that the open procedure was superior to the arthroscopic one. On the other hand, the results were conflicting concerning the superior–inferior position of the graft, screw orientation, duration of surgery, mean Rowe score and mean VAS score for pain.

Proper coracoid bone graft position and its fusion seem to be two key stabilizing factors [22, 23]. Graft positioning over 2 mm laterally or 4 mm medially from the glenoid border was defined as proud or too medial, respectively [24]. Reports have indicated that the lateral overhang of the coracoid graft is significantly associated with postoperative arthritis and that a medialized position of the coracoid is associated with recurrent instability [2]. The optimum superior–inferior position of the coracoid graft is controversial and different authors suggest various "optimal" positions [25–28]. Our review showed conflicting results regarding the superiority of the open to the arthroscopic procedure as for the graft positioning [2, 4, 12, 20]. Further comparative clinical trials are required to confirm the superiority of the open procedure to the arthroscopic one as for the medial–lateral positioning of the graft, while no definite conclusions can be made concerning the superior–inferior positioning of the graft.

On the other hand, it was shown that the graft fusion was improved with the arthroscopic procedure, when compared with the open technique. The total graft osteolysis, graft resorption and non-union rate were significantly lower with the use of arthroscopic Latarjet [2, 12]. Nevertheless, the number of comparative trials reporting osteolysis and non-union rate was small, so that definite conclusions as for the superiority of the arthroscopic procedure cannot be extracted.

The posterior screw protrusion was measured in two studies, which evaluated its penetration into infraspinatus fossa [4, 12]. The arthroscopic technique depicted comparable results with the gold standard open technique in both studies [4, 12]. As for the screw orientation, the results of the studies which were included in this review were conflicting [2, 4, 12, 20]. Therefore, more comparative trials are required to be conducted in the future in order to lead to definite conclusions.

Maynou et al. [29] have proved that the subscapularis split led to significantly lower rate of subscapularis fatty infiltration in comparison with the L-shaped incision ($p=0.001$). The postoperative fatty infiltration of the subscapularis muscle according to Goutallier et al. [30] classification was reported in one study of our review [12]. All five comparative studies which were included in our review used subscapularis split, while no study made use of subscapularis detachment and reattachment with suture anchors. Interestingly, the different techniques of subscapularis split in the open and arthroscopic procedure led to similar results [12].

Regarding the postoperative osteoarthritis, it would be expected that the open procedure would result in higher rate of degenerative changes in comparison with a minimally invasive procedure. However, the only study which investigated this variable reported no significant differences between the open and the arthroscopic procedures [4].

As expected, it was shown that the early postoperative pain was diminished with the use of a minimally invasive approach like the arthroscopic Latarjet [20]. Nevertheless, these results referred only to the first postoperative week [20] and not later in the follow-up, where the difference was insignificant amongst groups [19]. As for the clinical and functional subjective scores, the results of the studies which were included in this review varied widely. While the use of mean ASES [2], Constant–Murley [2] and Walch–Duplay [19, 21] scores depicted no significant differences amongst groups, the mean WOSI score was significantly improved in the arthroscopically treated group in comparison with the open Latarjet group [20], and the mean Rowe score led to conflicting results [2, 19, 21]. Accordingly, no clinical and functional superiority of the open procedure to the arthroscopic one can be established.

Two out of the three studies of our review, which documented the duration of surgery illustrated that the arthroscopic procedure was more time-consuming than the open Latarjet [2, 20]. Furthermore, Cunningham et al. [24] also reported a longer operative time in the arthroscopic group compared with the open group with a difference of 65 min. A learning curve of 10 arthroscopic Latarjet procedures has been shown to be needed to reduce the need for conversion from arthroscopic to open surgery and 20 procedures to have the same operating time as the open technique [20, 31].

According to a relative systematic review by Griesser et al. [32], 73% of recurrence occurred within the first 12 months after the Latarjet surgery. So, we included in our review only those comparative clinical studies which reported a minimum follow-up of 12 months.

None of the studies documented the mean group time for return to sports and/or the preoperative level of activity which could be different between an open and a minimally invasive, arthroscopic surgeries. Moreover, only one study investigated the possible differences in the detection and treatment of concomitant injuries between the two groups, without finding any significant differences amongst them [19]. However, Kordasiewicz et al. [19] found out that, especially for the detection and treatment of intra-articular lesions, the open procedure was inferior to the arthroscopic one. Finally, from the total number of 694 patients of this review, only four patients (0.6%) experienced an iatrogenic nerve damage (one medial cutaneous antebrachial nerve

[19], two suprascapular nerves and one musculocutaneous nerve [21]). Although all four of them were treated with the arthroscopic procedure, this number was very small to lead to statistically significant conclusions.

Weak points of the study which was conducted by Zhu et al. [2] were that it included significantly different mean final follow-ups between the two groups, while there were different indications for surgery (primary and revision cases). On the other hand, Kordasiewicz et al. [12, 19] excluded all revision cases, but the groups were significantly different regarding the number of patients and the mean follow-up. In addition, no preoperative radiographic data were reported [12, 19]. Russo et al. [4] described imaging variable outcomes but no clinical results, recurrence rate or complications' rates. The study conducted by Metais et al. was a multicentre study of the French Arthroscopic Society which had the drawback that compared two different techniques performed by various surgeons [21]. Another weak point of that study was that only 36% of the eligible patients were available to be re-evaluated at the last follow-up [21]. Finally, the study of Marion et al. [20] assessed the results of two different surgeons coming from two different centres.

Although all studies were comparative, none amongst them was randomized. As a result, there was a complete lack of level I randomized controlled trials. The "quality assessment" of the studies for methodological deficiencies, as a common alternative to "risk of bias" [33], was examined by the modified Coleman methodology Score [17]. The mean modified Coleman score was not high, while we found high risk of possible selection, detection and performance bias in the majority of the studies [2, 4, 12, 19].

Conclusions

There was low to moderate clinical evidence to support that the arthroscopic Latarjet procedure was not inferior to the open procedure regarding the recurrence rate, infection rates, soft tissue healing, the positive postoperative apprehension test, the postoperative mean ASES and mean Walch–Duplay scores, the fatty infiltration of the subscapularis muscle and the posterior protrusion of the screw. While the arthroscopic technique led to superior results concerning the non-union rate of the graft, the total graft osteolysis and graft resorption, the mean WOSI score and the early (first week) postoperative pain when compared with the open Latarjet, the outcomes were conflicting concerning the superior–inferior position of the graft, screw orientation, duration of surgery, mean Rowe and VAS scores.

Funding This study has not received any kind of funding.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Latarjet M (1958) Technic of coracoid preglenoid arthroereisis in the treatment of recurrent dislocation of the shoulder. Lyon Chir 54(04):604–607
2. Zhu Y, Jiang C, Song G (2017) 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 45(7):1645–1653. https://doi.org/10.1177/0363546517693845
3. Patte D, Bernageau J, Rodineau J, Gardes JC (1980) Unstable painful shoulders (authors' translation). Rev Chir Orthop Reparatrice Appar Mot 66(3):157–165
4. Russo A, Grasso A, Arrighi A, Pistorio A, Molfetta L (2017) Accuracy of coracoid bone graft placement: open versus arthroscopic Latarjet. Joints 5(2):85–88. https://doi.org/10.1055/s-0037-1603934
5. Bhatia S, Frank RM, Ghodara NS et al (2014) The outcomes and surgical techniques of the Latarjet procedure. Arthroscopy 30:227–235. https://doi.org/10.1016/j.arthro.2013.10.013
6. Allain J, Goutallier D, Glorion C, Surgery J (1998) Long-term results of the Latarjet procedure for the treatment of anterior instability of the shoulder. J Bone Joint Surg Am 80:841–8526
7. Ladermann A, Lubbeke A, Stern R et al (2013) Risk factors for dislocation arthropathy after Latarjet procedure: a long-term study. Int Orthop 37:1093–1098. https://doi.org/10.1007/s00264-013-1848-y
8. Walch G, Boileau P (2000) Latarjet–Bristow procedure for recurrent anterior instability. Tech Shoulder Elbow Surg 1:256–261
9. Patte D, Debeyre J (1980) Luxations rıcidivantes de l'ıpaule. EMC Tech Chir Orthop 44265:44–52
10. Hovelius L, Eriksson K, Fredin H et al (1983) Recurrences after initial dislocation of the shoulder. Results of a prospective study of treatment. J Bone Joint Surg Am 65:343–349
11. Hovelius L, Sandstrom B, Saebo M (2006) 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 Elb Surg 15:279–289. https://doi.org/10.1016/j.jse.2005.09.014
12. Kordasiewicz B, Kicinski M, Małachowsetki K, Wieczorek J, Chaberek S, Pomianowski S (2018) Comparative study of open and arthroscopic coracoid transfer for shoulder anterior instability (Latarjet)-computed tomography evaluation at a short term follow-up. Part II. Int Orthop. https://doi.org/10.1007/s00264-017-3739-0
13. Lafosse L, Lejeune E, Bouchard A, Kakuda C, Gobezie R, Kochhar T (2007) The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability. Arthroscopy 23(11):1242 **e1241-1245**
14. Lafosse L, Boyle S (2010) Arthroscopic Latarjet procedure. J Shoulder Elbow Surg 19:2–12
15. Boileau P, Thilu CE, Mercier N et al (2014) Arthroscopic Bristow–Latarjet combined with bankart repair restores shoulder stability in patients with glenoid bone loss. Clin Orthop Relat Res 472:2413–2424

16. Liberati A, Altman DG, Tetzlaff J et al (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 339:b2700. https://doi.org/10.1136/bmj.b2700
17. Sambandam SN, Gul A, Priyanka P (2007) Analysis of methodological deficiencies of studies reporting surgical outcome following cemented total-joint arthroplasty of trapezio-metacarpal joint of the thumb. Int Orthop 31(5):639–645
18. Atkins D, Best D, Briss PA, GRADE Working Group (2004) Grading quality of evidence and strength of recommendations. BMJ 328(7454):1490
19. Kordasiewicz B, Małachowski K, Kicinski M, Chaberek S, Pomianowski S (2017) Comparative study of open and arthroscopic coracoid transfer for shoulder anterior instability (Latarjet)—clinical results at short term follow-up. Int Orthop 41(5):1023–1033. https://doi.org/10.1007/s00264-016-3372-3
20. Marion B, Klouche S, Deranlot J, Bauer T, Nourissat G, Hardy P (2017) A prospective comparative study of arthroscopic versus mini-open Latarjet procedure with a minimum 2-year follow-up. Arthroscopy 33(2):269–277. https://doi.org/10.1016/j.arthro.2016.06.046
21. Metais P, Clavert P, Barth J et al (2016) Preliminary clinical outcomes of Latarjet-Patte coracoid transfer by arthroscopy vs. open surgery: prospective multicentre study of 390 cases. Orthop Traumatol Surg Res 102(8S):S271–S276. https://doi.org/10.1016/j.otsr.2016.08.003
22. Wellmann M, PetersenW Zantop T et al (2009) Open shoulder repair of osseous glenoid defects: biomechanical effectiveness of the Latarjet procedure versus a contoured structural bone graft. Am J Sports Med 37:87–94. https://doi.org/10.1177/0363546508326714
23. Nourissat G, Neyton L, Metais P et al (2016) Functional outcomes after open versus arthroscopic Latarjet procedure: a prospective comparative study. Orthop Traumatol Surg Res 102(8S):S277–S279. https://doi.org/10.1016/j.otsr.2016.08.004
24. Cunningham G, Benchouk S, Kherad O, Lädermann A (2016) Comparison of arthroscopic and open Latarjet with a learning curve analysis. Knee Surg Sports Traumatol Arthrosc 24(2):540–545. https://doi.org/10.1007/s00167-015-3910-3
25. Boileau P, Mercier N, Roussanne Y, Thelu CE, Old J (2010) Arthroscopic Bankart–Bristow–Latarjet procedure: the development and early results of a safe and reproducible technique. Arthroscopy 26(11):1434–1450
26. Lafosse L, Boyle S, Gutierrez-Aramberri M, Shah A, Meller R (2010) Arthroscopic Latarjet procedure. Orthop Clin North Am 41(3):393–405
27. Saito H, Itoi E, Sugaya H, Minagawa H, Yamamoto N, Tuoheti Y (2005) Location of the glenoid defect in shoulders with recurrent anterior dislocation. Am J Sports Med 33(6):889–893
28. Nourissat G, Delaroche C, Bouillet B, Doursounian L, Aim F (2014) Optimization of bone-block positioning in the Bristow–Latarjet procedure: a biomechanical study. Orthop Traumatol Surg Res 100(5):509–513
29. Maynou C, Cassagnaud X, Mestdagh H (2005) Function of subscapularis after surgical treatment for recurrent instability of the shoulder using a bone-block procedure. J Bone Joint Surg Br 87(8):1096–1101
30. Goutallier D, Postel JM, Bernageau J et al (1995) Fatty infiltration of disrupted rotator cuff muscles. Rev Rhum Engl Ed 62:415–422
31. Ekhtiari S, Horner NS, Bedi A, Ayeni OR, Khan M (2018) The learning curve for the Latarjet procedure: a systematic review. Orthop J Sports Med 6(7):2325967118786930. https://doi.org/10.1177/2325967118786930
32. Griesser MJ, Harris JD, Mccoy BW et al (2013) Complications and reoperations after Bristow–Latarjet shoulder stabilization: a systematic review. J Shoulder Elb Surg 22(2):286–292. https://doi.org/10.1016/j.jse.2012.09.009
33. Viswanathan M, Ansari MT, Berkman ND et al Assessing the risk of bias of individual studies in systematic reviews of health care interventions. Methods guide for effectiveness and comparative effectiveness reviews. Agency for Healthcare Research and Quality (US), Rockville (MD), 2008–2012 March 8

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.