

Progression to Osteoarthritis After the Surgical Treatment of Anterior Shoulder Instability

A Systematic Review and Meta-analysis

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Background: Traumatic anterior shoulder instability (ASI) is common among young, active patients, with a progression to glenohumeral osteoarthritis (OA) in up to 55% of patients. Surgical stabilization procedures are routinely offered to patients; however, the long-term risk of the development and severity of OA after these interventions remains unclear because of the overlap with injury mechanics.

Purpose: To evaluate the incidence and severity of radiographic OA after surgical treatment for traumatic ASI.

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

Methods: This PROSPERO-registered systematic review and meta-analysis was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A literature search was performed on February 12, 2025, in MEDLINE via PubMed, CINAHL, Embase, CENTRAL and SPORTDiscus, covering publications from 2004 to 2025. Data extracted included the rate of progression to OA (graded in accordance with the Samilson-Prieto or Buscayret classification), incidence of recurrent dislocations, and Rowe score at final follow-up. Cohort characteristics were summarized with weighted means, and data were presented as pooled proportion estimates with 95% confidence intervals (CIs), calculated via meta-analysis of binomial (OA progression, recurrent dislocation) and continuous (Rowe score) variables.

Results: A total of 34 studies with a minimum 5-year follow-up comprising 2375 patients and 2403 shoulders were included, and 1962 of these shoulders had follow-up radiographs at a mean follow-up time of 139.0 months. The overall pooled rate of progression to radiographically diagnosed OA was 40.7% (95% CI, 32.6%-49.2%); rates of progression to grade $\geq$ II and grade III OA were estimated to be 10.5% (95% CI, 6.9%-15.6%) and 2.3% (95% CI, 1.1%-4.7%), respectively. The pooled rate of OA at final follow-up based on a surgical intervention was 47.2% (95% CI, 32.0%-63.0%) for arthroscopic Bankart repair, 46.8% (95% CI, 36.6%-57.2%) for open Bankart repair, and 30.3% (95% CI, 20.0%-43.0%) for the Latarjet procedure. The overall pooled rate of recurrent instability was 10.4% (95% CI, 7.7%-13.9%), and the overall pooled Rowe score at final follow-up was 88.2 (95% CI, 86.1-90.3).

Conclusion: The progression to radiographic OA occurred in a significant number of patients after surgical treatment for traumatic ASI at long-term follow-up. Although radiographic OA was common, severe degeneration was relatively rare, and functional outcomes remained favorable. These findings provide clinicians with pooled long-term data that can support evidence-based patient counseling, inform surgical planning, and guide future interventional trials.

Keywords: anterior shoulder instability; osteoarthritis; surgical stabilization; arthroscopy; Latarjet; Bankart

a resolution of pain and symptoms, recurrent ASI has been linked to structural damage and an increased risk of developing glenohumeral osteoarthritis (OA).^{14,33} Studies have demonstrated that ASI with multiple dislocations at an early age, or insufficient and delayed surgical stabilization, can often progress to glenohumeral OA.^{8,24,31} Additionally, it has been established that earlier age at the time of the primary dislocation, extensive bone loss, and multiple incidents of recurrent instability contribute to the development of OA in nonoperatively managed ASI.^{8,25,47}

Although surgical stabilization of the glenohumeral joint can improve joint functionality and return to pre-ASI activities, its impact on the progression to OA remains insufficiently characterized because of the heterogeneous results found in the literature.^{3,8,23,24,38} The reported rates of progressive OA after surgical treatment in the literature vary widely, ranging from as low as 5% to upward of 80%.^{3,57} It is important to note that older procedures, such as the Putti-Platt procedure, are associated with higher OA rates because of the restrictive techniques used, whereas the rates of OA in procedures focused on anatomic alignment are less characterized in the literature.²⁹ Similarly, the rates of OA for nonoperative treatment have ranged significantly, with studies reporting ranges from 11% to 55% after the initial instability event.^{9,25,40} Multiple factors have been evaluated to determine their impact on OA progression, including procedure performed, recurrence of instability, and follow-up duration. Therefore, this study aimed to summarize the rate of OA after the surgical management of ASI and to explore the occurrence of glenohumeral OA based on surgical technique.

METHODS

This PROSPERO-registered systematic review (CRD 420250656096) and meta-analysis was performed in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and Cochrane guidelines.^{13,43}

Literature Search

MEDLINE via PubMed, CINAHL, Embase, CENTRAL, and SPORTDiscus were queried for relevant articles on

February 12, 2025 using terms related to shoulder instability and OA. The detailed search algorithm for each database can be found in the Appendix.

Eligibility Criteria

Inclusion criteria were studies that were peer reviewed, involved human participants, and included clinical outcomes of patients who underwent Bankart (arthroscopic or open) repair or the Latarjet procedure for primary traumatic ASI. These 3 types of procedures were chosen to limit heterogeneity that would be introduced by the inclusion of a small subset of studies that have reported on outdated and alternative techniques. Exclusion criteria were (1) studies that did not report rates of progression to OA, (2) studies on atraumatic ASI, (3) studies with a mean follow-up <5 years, (4) studies that used OA classification systems other than the Samilson-Prieto or Buscayret classification to categorize the progression to OA, and (5) studies that included other procedures for ASI. Reviews, case reports, animal studies, cadaveric studies, conference abstracts, editorial commentaries, and study protocols were excluded.

Article Screening and Selection

References were imported into Covidence (Veritas Health Innovation), where duplicates were removed. There were 2 independent reviewers (C.B.C. and B.J.L.) who performed title/abstract screening and a full-text review. If there were disagreements between the 2 reviewers, a third reviewer (J.M.C.) was consulted to assess for final inclusion in the study.

Data Collection

The following data were extracted from each article by 2 independent reviewers (C.B.C. and B.J.L.): treatment type, follow-up period, cohort characteristics, time between dislocation and surgery, and grade of preoperative and postoperative OA according to the Samilson-Prieto or Buscayret classification. The grade of OA was classified as either 0, I, II, or III.^{8,48} Secondary outcomes included the

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Ethical approval was not sought for the present study.

number of recurrent instability events and postoperative Rowe score.

Quality Assessment

The Methodological Index for Non-Randomized Studies (MINORS) was used to assess the quality of nonrandomized studies.⁵² The adjusted Oxford Centre for Evidence-Based Medicine criteria were used to quantify the level of evidence of each study.⁷

Classification of OA and Rowe Score

The Samilson-Prieto classification stratifies OA into 4 categories based on proper anteroposterior radiographic imaging: grade 0, no OA; grade I, inferior humeral or glenoid exostosis measuring <3 mm; grade II, inferior humeral or glenoid exostosis measuring between 3 and 7 mm with subtle glenohumeral irregularity; and grade III, inferior humeral or glenoid exostosis measuring >7 mm with narrowing of the glenohumeral joint and sclerosis.⁴⁸ The Buscayret classification of OA is a modified version of the Samilson-Prieto classification, further separating grade III into 2 categories. In the Buscayret classification, grade III includes inferior humeral or glenoid exostosis measuring >7 mm with narrowing and sclerosis of the glenohumeral joint, and grade IV is complete obliteration of the glenohumeral joint.⁸ Similar to other studies reporting on glenohumeral OA, grades III and IV were merged to standardize outcomes across the studies.⁵⁴ The Rowe score is a tool used for the postoperative assessment of Bankart repair, which takes into account stability (50 points), mobility (20 points), and functionality (30 points) for a maximum score of 100. Rowe scores are considered excellent (90-100), good (75-89), fair (51-74), or poor (≤ 50).³⁴

Statistical Analysis

Descriptive statistics were reported as frequencies, ranges, and percentages. Meta-analyses were performed in R (Version 4.4.1; R Foundation for Statistical Computing) utilizing the “meta” and “metafor” packages. A proportional meta-analysis of pooled data was performed for the overall cohort to assess the rate of progression to OA, grade $\geq$ II OA, and grade III OA as well as the rate of postoperative dislocations. A pooled meta-analysis was performed using mean Rowe scores. Alternative measures of central tendency and variance were translated to means and standard deviations using the method of Hozo et al.²⁶ Subgroup analyses for the rate of progression to OA, recurrent dislocation rate, and Rowe score were performed by treatment modality. The results were presented as proportion estimates with 95% confidence intervals (CIs) on forest plots. Heterogeneity was measured with the I^2 statistic. Random-effects models were used for all meta-analyses. Publication bias was evaluated with funnel plots (Appendix Figure A1).

RESULTS

Study Selection and Quality Assessment

A total of 4484 studies were found in the initial search, and 238 full texts were screened. A final 34 studies met inclusion criteria for the study (Appendix Figure A2).[#] There were 12 level 3 cohort or comparative studies,^{**} and 22 were level 4 case series or noncomparative studies.^{††} The mean MINORS score for noncomparative studies was 10.64 ± 1.12 (66.5% maximum score across the average of all the studies; 9-12), and for comparative studies, the mean MINORS score was 18.33 ± 1.21 (76.4%; 17-24) (Appendix Table A1).

Study Characteristics

The 34 included studies comprised 2375 patients and 2403 shoulders (Table 1). The mean age at the time of surgery was 28.1 years, and male patients accounted for 67.7% of the cohort. A total of 1962 shoulders had follow-up radiographs, with 784 shoulders displaying OA. The weighted mean follow-up time for the overall cohort was 150.9 months (range, 60-348 months). The Latarjet procedure was performed in 15 studies (44.1%)^{††} and demonstrated the presence of OA in 245 of the 748 shoulders (32.8%) with radiographs at a weighted mean follow-up of 145.1 months. Arthroscopic Bankart repair was performed in 15 studies (44.1%)^{§§} and demonstrated the presence of OA in 341 of the 713 shoulders (47.8%) with radiographs at a weighted mean follow-up of 128.9 months. Open Bankart repair was performed in 9 studies (26.5%)^{4,5,8,21,22,37,38,44,56} and showed the presence of OA in 198 of the 501 shoulders (39.5%) with radiographs at a weighted mean follow-up of 183.2 months. Preoperative OA was graded and reported in 4 studies.^{18,35,38,39}

Overall Cohort

A proportional meta-analysis of pooled data for the overall cohort revealed that the rate of progression to OA after the surgical treatment of ASI was 40.7% (95% CI, 32.6%-49.2%; $I^2 = 87.1\%$) (Figure 1). The rate of progression to grade $\geq$ II OA for the overall cohort was 10.5% (95% CI, 6.9%-15.6%; $I^2 = 80.0\%$), with the rate of progression to grade III OA being 2.3% (95% CI, 1.1%-4.7%; $I^2 = 51.9\%$) (Figures 2 and 3). The pooled Rowe score at final follow-up was 88.2 (95% CI, 86.1-90.3; $I^2 = 95.9\%$), and the pooled rate of recurrent instability was 10.4% (95% CI, 7.7%-13.9%; $I^2 = 80.0\%$) (Figures 4 and 5). Figure 6 depicts bubble plots for the progression to OA.

[#]References 3-6, 8, 10-12, 17-22, 27, 28, 30, 32, 35-39, 41, 44-47, 49, 50, 53, 55-57.

^{**}References 4, 5, 8, 12, 20, 22, 38, 46, 47, 50, 55, 56.

^{††}References 3, 6, 10, 11, 17-19, 21, 27, 28, 30, 32, 35-37, 39, 41, 44, 45, 49, 53, 57.

^{§§}References 3, 5, 8, 12, 17-20, 32, 35, 36, 39, 45, 49, 55.

^{§§}References 6, 8, 10, 11, 27, 28, 30, 41, 46, 47, 50, 53, 55-57.

TABLE 1
Study Characteristics^a

First Author (Year)	LOE	No. of Shoulders	No. of Male Shoulders	Age, ^b y	Time to Surgery, ^b mo	Follow-up, ^b mo	Treatment	No. of Shoulders With Radiographs	No. of Shoulders That Developed OA (Grade I/II/III)	Rowe Score ^b	No. of Recurrent Instability Events
Bauer ³ (2024)	4	20	17	22.9	21	79.2	Open Latarjet	20	1 (1/0/0)	90 ± 8.8	1
Berendes ⁴ (2007)	3	31	26	28	NR	132	Open Bankart	31	10 (9/0/1)	90 ± 8	16
Bonneville ⁵ (2023) (A)	3	32	32	21.2	25.2	82.8	Open Bankart	22	15 (10/5/0)	90.7 ± 14.1	6
Bonneville ⁵ (2023) (B)	3	31	30	21.7	42	76.8	Open Latarjet	21	8 (8/0/0)	89.7 ± 9.3	1
Brejuin ⁶ (2022)	4	51	41	26	NR	87	Arthroscopic Bankart	35	6 (5/1/0)	88 ± 12	8
Buscayret ⁸ (2004) (A)	3	253	186	28.7	46.8	75.6	Open Latarjet	253	52 (37/9/6)	NR	15
Buscayret ⁸ (2004) (B)	3	200	131	27.9	51.6	92.4	Open Bankart	200	46 (34/7/5)	NR	10
Buscayret ⁸ (2004) (C)	3	69	46	28.5	48	78	Arthroscopic Bankart	69	9 (6/3/0)	NR	9
Castagna ¹⁰ (2010)	4	31	26	26.3	45.6	130.8	Arthroscopic Bankart	31	12 (9/3/0)	80.1 ± 17.5	7
Chapus ¹¹ (2015)	4	18	15	20.5	NR	116.4	Arthroscopic Bankart	18	3 (3/0/0)	86 ± 22	5
Chillemi ¹² (2021)	3	40	33	26.5	26.4	307.2	Open Latarjet	40	21 (11/6/4)	84.5 ± 13.8	2
de l'Escalopier ²⁰ (2018)	3	20	20	26.5	NR	195.6	Open Latarjet	20	3 (2/1/0)	91.8 ± 9.9	0
Domos ¹⁸ (2019)	4	99	60	46	156	156	Open Latarjet	99	76 (35/28/13)	87 ± 7	6
Domos ¹⁷ (2020)	4	45	26	15.7	NR	79.2	Open Latarjet	45	4 (4/0/0)	95 ± 18.8	2
Emami ¹⁹ (2011)	4	30	NR	30.56	NR	60	Open Bristow	30	9 (9/0/0)	77.6	0
Fabre ²¹ (2010)	4	50	46	25	48	336	Open Bankart	44	29 (18/5/6)	82 ± 18	8
Gamulin ²² (2014)	3	35	25	27.2	60	154.8	Open Bankart	33	15 (12/3/0)	87.5 ± 15	5
Izquierdo-Fernández ²⁷ (2022)	4	26	20	28.05	71.16	211.8	Arthroscopic Bankart	26	26 (12/3/11)	81.4 ± 12.5	2
Kavaja ²⁸ (2012)	4	83	60	29	60	156	Arthroscopic Bankart	74	50 (40/9/1)	NR	28
Komnos ³⁰ (2019)	4	48	NR	24.8	NR	105.4	Arthroscopic Bankart	48	11 (9/2/0)	94.4 ± 15	6
Lalanne ³² (2023)	4	44	35	28	NR	264	Open Latarjet	44	22 (7/9/6)	NR	4
Marjanovic ³⁵ (2022)	4	140	123	29.5	NR	110	Open Latarjet	17	12 (5/6/1)	NR	9
Mizuno ³⁶ (2014)	4	68	49	29.4	NR	240	Open Latarjet	60	12 (6/2/4)	89.6	4
Moroder ³⁷ (2015)	4	40	30	26.7	52.8	264	Open Bankart	26	13 (6/3/4)	88.7 ± 12	7
Neviaser ³⁸ (2017)	3	127	102	31	NR	205.2	Open Bankart	91	43 (34/9/0)	91.4 ± 7.5	2
Neyton ³⁹ (2012)	4	37	34	23.4	40	144	Open Latarjet	37	11 (11/0/0)	93 ± 10	0
Ono ⁴¹ (2019)	4	51	44	27	63.6	121.2	Arthroscopic Bankart	38	14 (0/12/2)	76 ± 23	16
Pelet ⁴⁴ (2006)	4	30	24	26.6	49	348	Open Bankart	21	12 (0/5/7)	80 ± 16.3	3
Pelletier ⁴⁵ (2025)	4	40	33	26.6	56	71	Arthroscopic Latarjet	32	6 (3/2/1)	87 ± 20	3
Plancher ⁴⁶ (2024) (A)	3	38	33	26.8	1.2	75.6	Arthroscopic Bankart	34	17 (15/2/0)	96.9 ± 6.8	2
Plancher ⁴⁶ (2024) (B)	3	26	19	37.7	1.7	93.6	Arthroscopic Bankart	20	11 (9/2/0)	99.5 ± 1.6	3
Plath ⁴⁷ (2015)	3	100	NR	27.7	23.3	156.2	Arthroscopic Bankart	100	69 (41/16/12)	NR	21
Schroder ⁴⁹ (2006)	4	57	54	20.5	NR	216	Open Bristow	11	5 (1/0/4)	81.8 ± 23.8	8
Shim ⁵⁰ (2019)	3	133	111	25	29.75	64	Arthroscopic Bankart	73	33 (27/6/0)	90.7 ± 15.7	8
Van Gastel ⁵³ (2019)	4	73	51	30	NR	157.2	Arthroscopic Bankart	55	33 (27/4/2)	NR	30
Waltenspül ⁵⁵ (2022) (A)	3	35	19	16.4	18	165.6	Arthroscopic Bankart	15	4 (4/0/0)	NR	13
Waltenspül ⁵⁵ (2022) (B)	3	31	25	16.7	22.8	135.6	Open Latarjet	19	3 (3/0/0)	NR	1
Zaffagnini ⁵⁶ (2012) (A)	3	49	NR	35	NR	164.4	Arthroscopic Bankart	49	18 (12/4/2)	85 ± 22.6	6
Zaffagnini ⁵⁶ (2012) (B)	3	33	NR	38	NR	188.4	Open Bankart	33	15 (9/4/2)	83 ± 24.4	3
Zink ⁵⁷ (2022)	4	39	NR	28.4	NR	122.9	Arthroscopic Bankart	28	25 (12/10/3)	84.6 ± 24.2	7

^aLOE, level of evidence; NR, not reported; OA, osteoarthritis.^bData are shown as mean or mean ± SD.

Subgroup Analyses

For studies reporting on arthroscopic Bankart repair (15 studies; 713 shoulders with radiographs), the pooled rate of progression to OA was 47.2% (95% CI, 32.0%-63.0%; $I^2 = 85.8\%$), with the rate of progression to grade $\geq$ II OA being 11.2% (95% CI, 6.2%-19.2%; $I^2 = 79.7\%$) and the rate of progression to grade III OA being 1.2% (95% CI, 0.3%-5.3%; $I^2 = 50.7\%$) (Figures 1-3). The pooled mean estimate of the Rowe score at final follow-up in 510 shoulders was 88.0 (95% CI, 83.5-92.5; $I^2 = 96.0\%$), with that of recurrent instability being 17.9% (95% CI, 13.0%-24.2%; $I^2 = 76.5\%$) in 870 shoulders (Figures 4 and 5).^{||||}

For studies reporting on open Bankart repair (9 studies; 501 shoulders with radiographs), the pooled rate of

progression to OA was 46.8% (95% CI, 36.6%-57.2%; $I^2 = 83.2\%$), with the rate of progression to grade $\geq$ II OA being 15.7% (95% CI, 8.8%-26.4%; $I^2 = 82.3\%$) and the rate of progression to grade III OA being 3.8% (95% CI, 1.1%-11.8%; $I^2 = 67.2\%$) (Figures 1-3). The pooled mean estimate of the Rowe score at final follow-up in 378 shoulders was 87.3 (95% CI, 84.4-90.3; $I^2 = 76.6\%$), with that of recurrent instability being 11.8% (95% CI, 7.7%-13.9%; $I^2 = 84.7\%$) in 578 shoulders (Figures 4 and 5).^{4,5,8,21,22,37,38,44,56}

For studies reporting on the Latarjet procedure (15 studies; 748 shoulders with radiographs), the pooled rate of progression to OA was 30.3% (95% CI, 20.0%-43.0%; $I^2 = 89.2\%$), with the rate of progression to grade $\geq$ II OA being 5.8% (95% CI, 1.8%-16.9%; $I^2 = 80.1\%$) and the rate of progression to grade III OA being 3.1% (95% CI, 1.2%-8.1%; $I^2 = 42.5\%$) (Figures 1-3). The pooled mean estimate of the Rowe score at final follow-up in 389 shoulders was

^{||||}References 6, 8, 10, 11, 27, 28, 30, 41, 46, 47, 50, 53, 55-57.

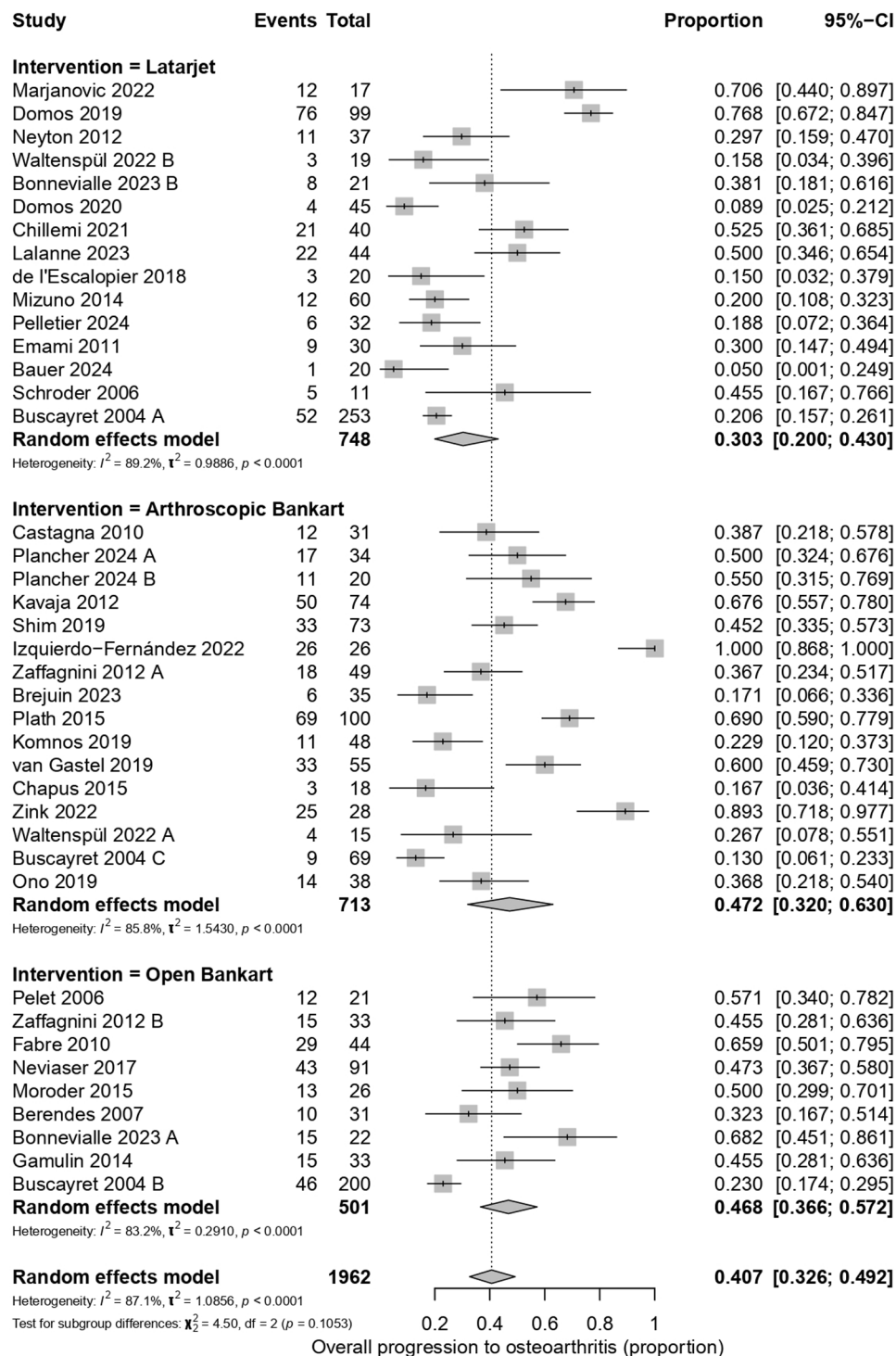


Figure 1. Progression to osteoarthritis following each surgical procedure.

89.0 (95% CI, 86.6-91.5; $I^2 = 72.2\%$), with that of recurrent instability being 5.9% (95% CI, 4.5%-7.5%; $I^2 = 0.0\%$) in 955 shoulders (Figures 4 and 5).¹¹

¹¹References 3, 5, 8, 12, 17-20, 32, 35, 36, 39, 45, 49, 55.

DISCUSSION

This study synthesized data from over 2400 shoulders across 34 studies with long-term follow-up to provide robust evidence on the radiographic progression of glenohumeral OA after surgical treatment for traumatic ASI.

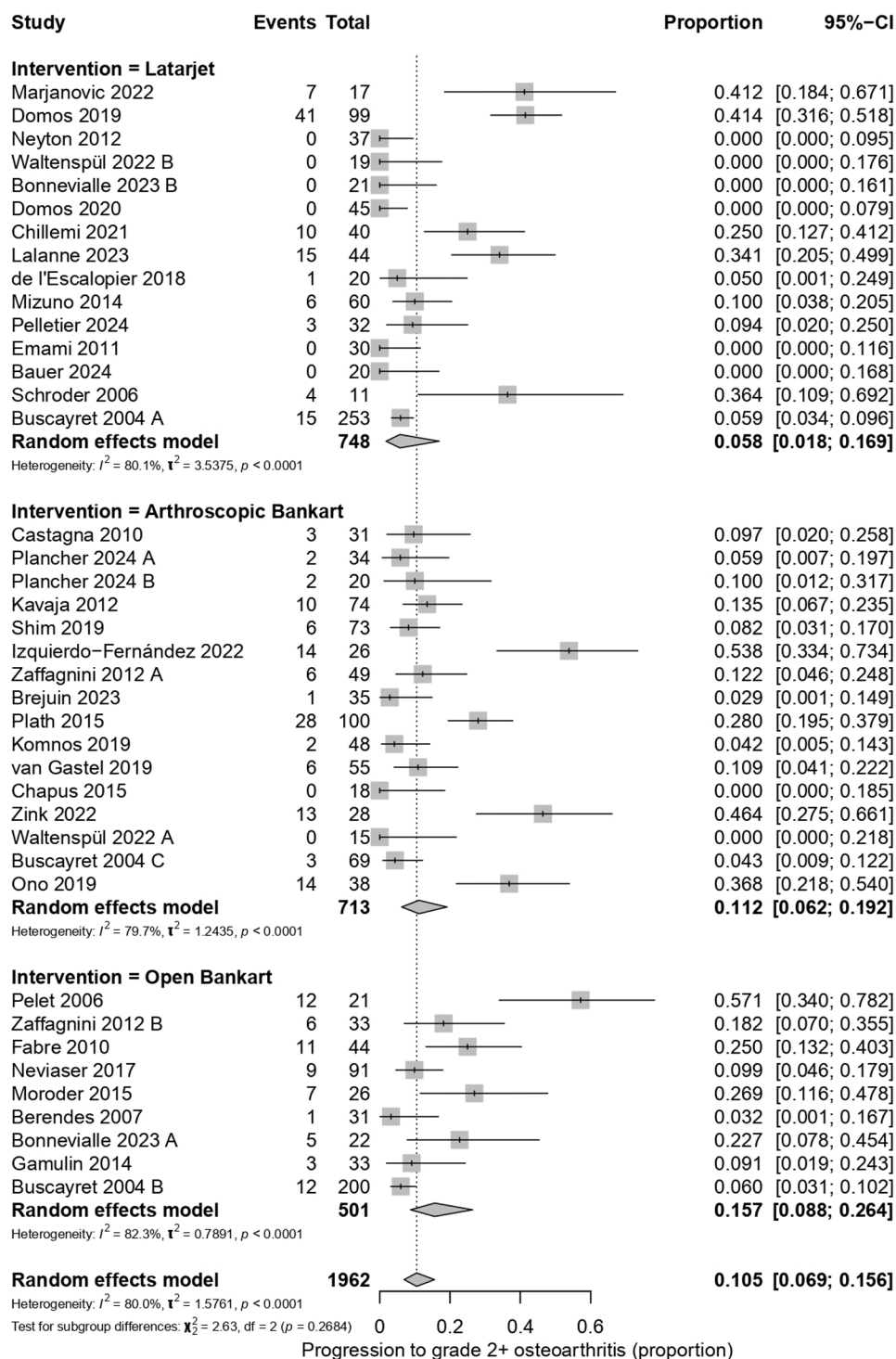


Figure 2. Progression to grade $\geq$ II osteoarthritis broken down by procedure.

The principal finding of this study was that radiographic OA developed in 40.7% of patients at long-term follow-up (mean, 11.6 years). However, 10.5% progressed to moderate OA (grade $\geq$ II), and only 2.3% developed severe OA (grade III) within the follow-up period. Furthermore, the development of OA did not appear to compromise

functional outcomes in most patients after the surgical treatment of ASI. The pooled mean Rowe score of 88.2 across all surgical techniques reflects good to excellent functional outcomes and patient satisfaction. Similarly, the low pooled rate of recurrent instability events of 10.4% indicates the effective long-term durability of

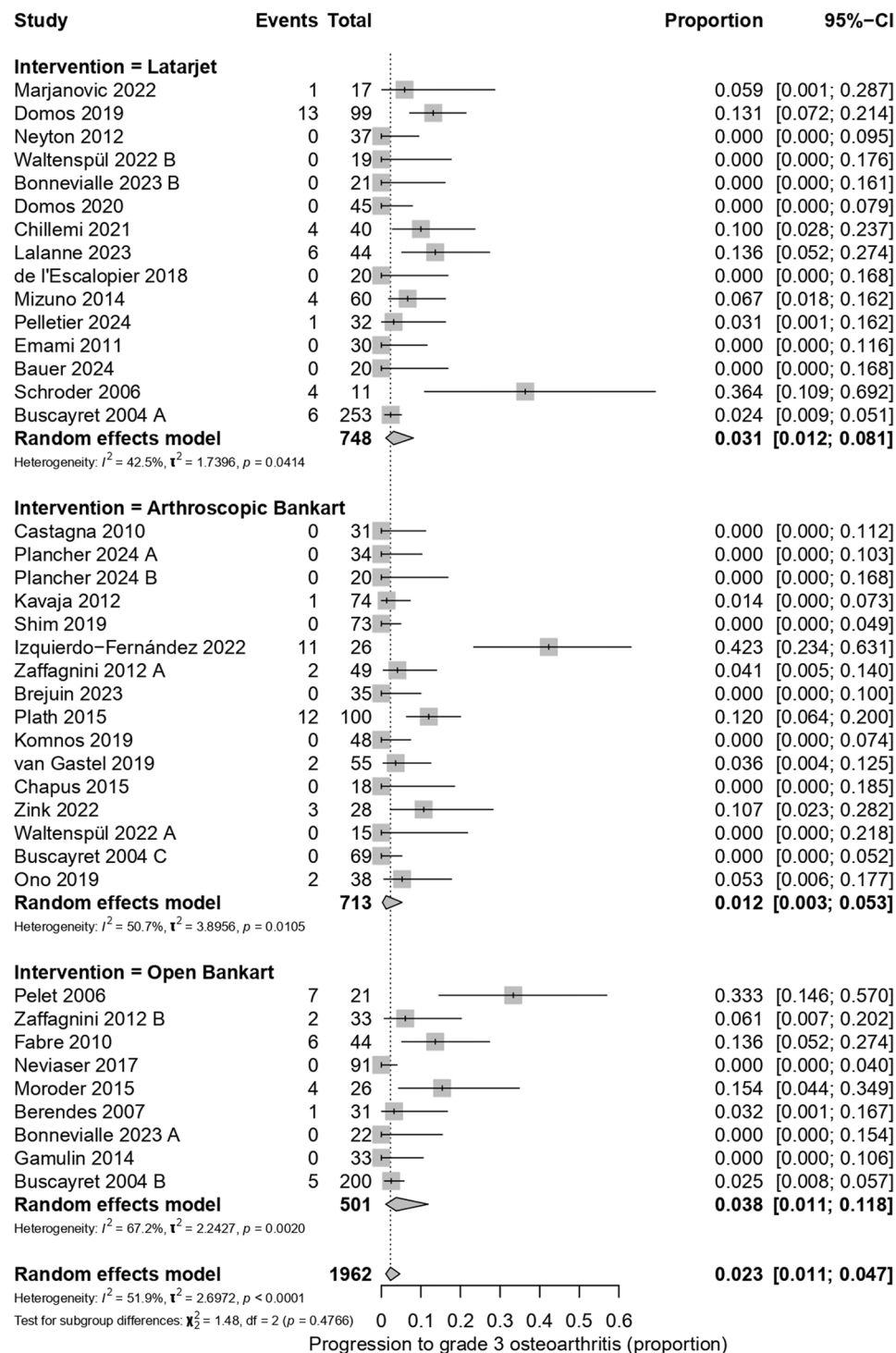


Figure 3. Progression to grade III osteoarthritis broken down by procedure.

surgical stabilization. While these findings suggest that structural changes after traumatic ASI are common, clinically significant joint degeneration remains relatively infrequent. Radiographic OA has long been recognized as a potential complication after surgical stabilization for ASI, but prior studies have reported a wide range of

prevalence largely because of heterogeneous follow-up durations and surgical techniques. The findings of this meta-analysis provide a standardized estimate of this risk and help to contextualize radiographic OA as a relatively frequent but often subclinical finding in the long-term postoperative period.

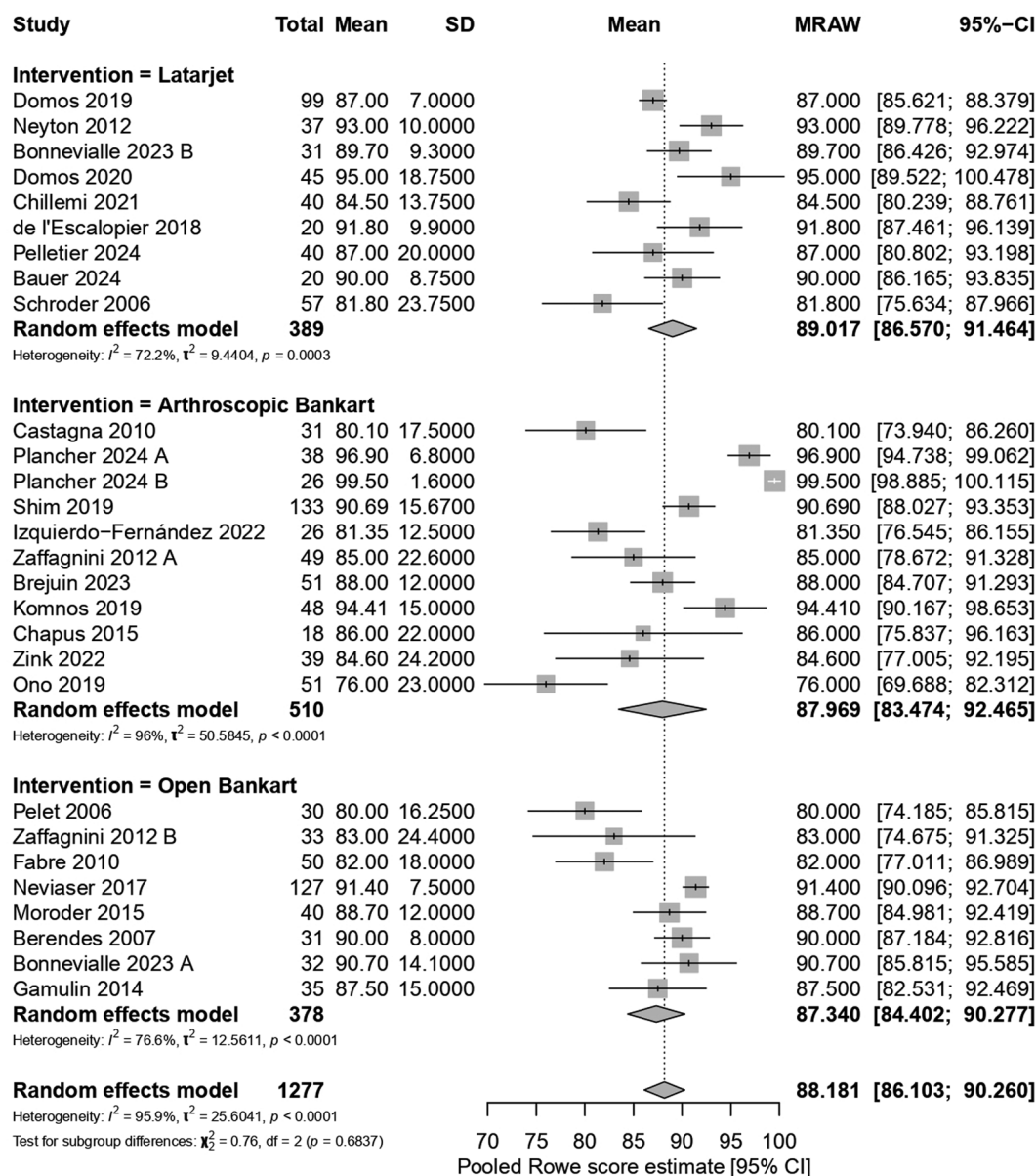


Figure 4. Measurement of shoulder function calculated with Rowe score.

Subgroup analyses revealed variability in the rate and severity of progression to radiographic OA across surgical techniques. Prior studies have reported a wide range of OA prevalence after the Latarjet procedure, with some cohorts demonstrating rates $>50\%$.^{12,18,32,35} These variations are likely attributable to multiple factors, including younger age at the time of the primary dislocation, longer delay between the initial dislocation and surgical stabilization, higher number of recurrent instability events, and longer follow-up duration.^{18,32,35} Additionally, surgical techniques, including lateral overhang of the coracoid graft, are thought to alter joint biomechanics, including limitations in external rotation, which may influence

contact forces at the glenohumeral joint, increasing the risk of glenohumeral OA over time.^{2,18,32,39,51}

Similar to the Latarjet procedure, the reported rates of OA after both arthroscopic and open Bankart repair vary widely in the literature.^{4,8,15,22} Shared patient-related factors, such as high-risk activity level, male sex, and number of instability events, may predispose these patients to long-term degenerative changes. Furthermore, extensive tightening of the glenohumeral joint and surrounding structures after Bankart repair has been implicated in altered joint mechanics, which may contribute to OA development over time.^{1,8,22,37} These findings reinforce the multifactorial nature of glenohumeral OA after surgical stabilization,

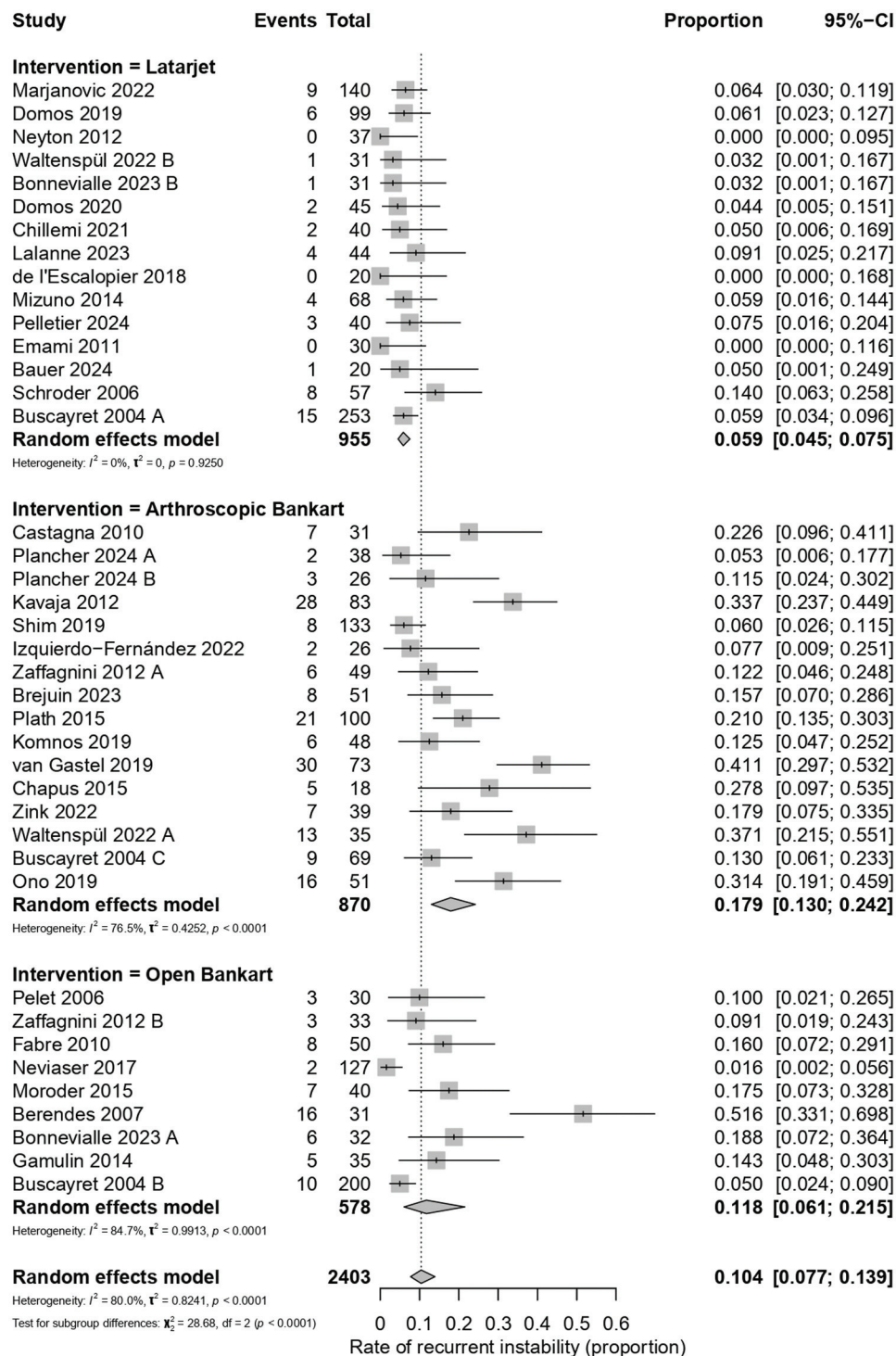


Figure 5. Rate of recurrent instability.

with variability influenced by both patient characteristics and surgical aspects. The results presented here offer a descriptive summary of the current evidence but do not support the direct comparison or superiority of any single surgical approach.

It is important to note that OA rates observed after surgical stabilization in this analysis should be interpreted in the context of the natural history of traumatic ASI. Long-term prospective studies of nonoperatively managed ASI have demonstrated radiographic OA rates ranging from

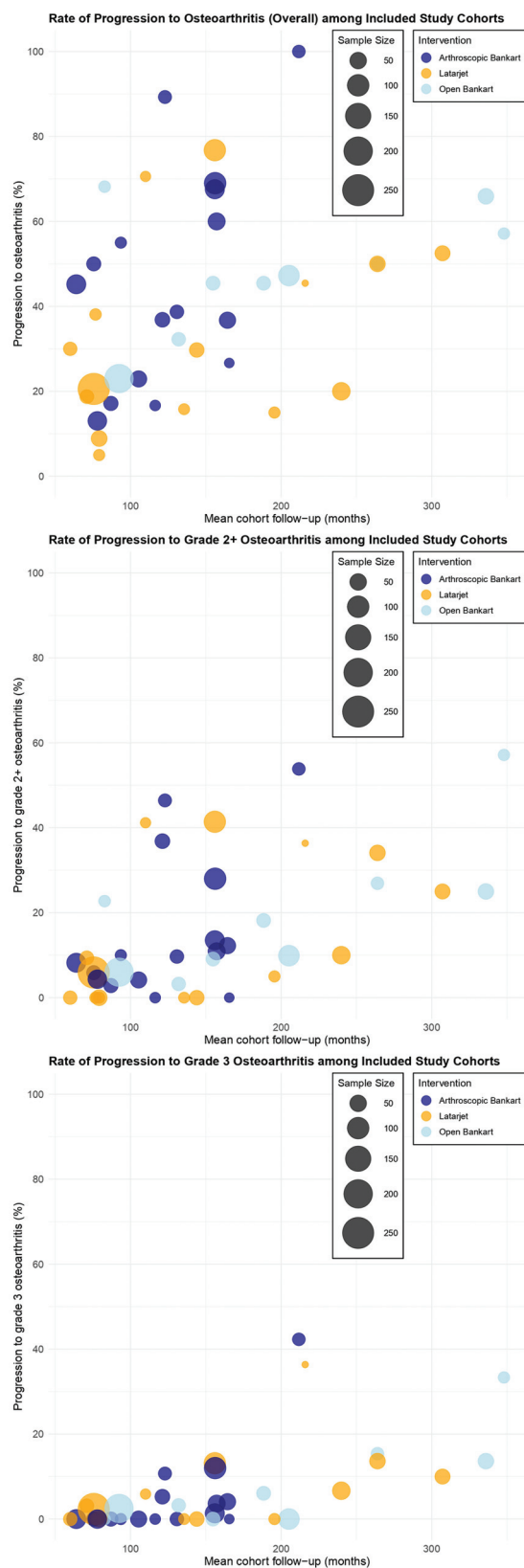


Figure 6. Bubble plots of (A) progression to osteoarthritis, (B) progression to grade $\geq$ II osteoarthritis, and (C) progression to grade III osteoarthritis.

11% to 55%.^{9,24} This range of OA demonstrates that arthropathy can develop in the absence of a surgical intervention, suggesting that the initial traumatic insult and subsequent instability episodes play a role in the degenerative cascade. Historically, surgical stabilization has often been reserved for patients experiencing recurrent instability, while certain patients with a first-time dislocation, particularly those with lower demand activity profiles, may never experience recurrence and therefore avoid operative interventions altogether. This may predispose surgical cohorts to a greater cumulative “traumatic burden” before stabilization, thereby inflating the apparent association between surgery and the subsequent development of OA. Consequently, the progression to radiographic OA cannot be attributed solely to surgical technique; rather, it likely reflects a multifactorial process involving the index injury, recurrent instability events, timing of the intervention, and patient-specific risk factors.

This meta-analysis provides further understanding of long-term glenohumeral OA development after surgical stabilization for ASI. By reporting updated pooled rates of OA progression from studies with medium- to long-term follow-up, this analysis offers a benchmark against which to assess new and modified techniques for treating ASI. Future studies must prioritize prospective trials with long-term radiographic follow-up that include stratification by bone loss severity, surgical method, patient age, and activity level. These studies will be essential to clarify how surgical biomechanics and patient-specific factors influence the trajectory of OA development and to optimize long-term outcomes through evidence-based care.

This study is not without limitations. First, it is important to note that the progression to OA after ASI repair can be influenced by the initial dislocation event and the subsequent number of instability events before the procedure. Therefore, the data must be interpreted with the initial injury mechanism in mind. Another limitation is that the Rowe score does not account for pain, which is a major factor in determining satisfaction after surgical repair. The lack of pain likely overestimates patient satisfaction after repair. Likewise, this study also included both retrospective and prospective studies, resulting in substantial heterogeneity among the data. Because most of the studies included were retrospective, there is an increased possibility of reporting bias. Funnel plots confirmed the presence of a moderate degree of publication bias in reported outcome measures. Given the heterogeneity present, random-effects models were employed for all meta-analyses. Because of the reported limitations, it was decided to assess a proportion estimate of OA progression for each surgical subgroup rather than comparing subgroups. Furthermore, nuanced differences in the various studies’ reporting of OA could not be controlled. Funnel plots revealed that the highest concern of potential publication bias lay within the reporting of grade III OA; given the heterogeneity in this reporting, conclusions should be cautiously attributed to the effect of differential treatment methods. Although the random-effects model mitigates some heterogeneity, follow-up duration, OA reporting, and patient population remain significant limitations.

Lastly, the difference in follow-up times among the studies may influence the progression to more advanced stages of OA in each of our subgroups. Despite these limitations, this is the most extensive systematic review reporting on the rate of OA in traumatic ASI treated with the Latarjet procedure or Bankart repair in the literature. Our comprehensive inclusion of studies on treatment modalities may be valuable in improving outcomes associated with traumatic ASI stabilization.

CONCLUSION

The progression to radiographic OA occurred in a significant number of patients after surgical treatment for traumatic ASI at long-term follow-up. Although radiographic OA was common, severe degeneration was relatively rare, and functional outcomes remained favorable and clinically acceptable. These findings provide clinicians with pooled long-term data that can support evidence-based patient counseling, inform surgical planning, and guide future interventional trials.

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APPENDIX

SEARCH STRATEGIES BY DATABASE

MEDLINE Via PubMed

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Citations retrieved: 1964

(((((“Shoulder Dislocation”[MeSH Terms] OR “Bankart Lesions”[MeSH Terms] OR (“Shoulder”[MeSH Terms] OR “Shoulder Joint”[MeSH Terms]) AND “Joint Instability”[-MeSH Terms]) OR (“shoulder instability”[Title/Abstract] OR “glenohumeral instability”[Title/Abstract] OR “anterior instability”[Title/Abstract]) AND (“instab*”[Title/Abstract] OR “dislocat*”[Title/Abstract] OR “luxat*”[Title/Abstract]))) AND (“Orthopedic Procedures”[MeSH Terms] OR “surgery”[MeSH Subheading] OR “surg*”[Title/Abstract] OR “repair*”[Title/Abstract]) AND (“Arthritis”[MeSH Terms] OR “osteoarthr*”[Title/Abstract] OR “arthrosis”[Title/Abstract] OR “Arthritis”[Title/Abstract] OR “long term”[Title/Abstract] OR “follow up”[Title/Abstract] OR

((("osteo*" [Title/Abstract] AND "arthr*" [Title/Abstract]) OR "arthropath*" [Title/Abstract])) AND "english" [Language] NOT ("Editorial" [Publication Type] OR "Comment" [Publication Type] OR "Editorial" [Title] OR "Comment" [Title] OR "Systematic Review" [Title])) NOT ("Animals" [MeSH Terms] NOT "Humans" [MeSH Terms]) AND ((humans [Filter]) AND (english [Filter]))

Embase

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((('shoulder dislocation'/exp OR 'bankart lesion'/exp OR 'shoulder'/exp OR 'shoulder joint'/exp) AND 'joint instability'/exp OR 'shoulder instability':ti,ab OR 'glenohumeral instability':ti,ab OR 'anterior instability':ti,ab) AND ('instab*':ti,ab OR 'dislocat*':ti,ab OR 'luxat*':ti,ab OR 'luxation'/exp) AND ('orthopedic procedure' OR 'surgery'/exp OR surg*:ti,ab OR repair*:ti,ab) AND ('arthritis'/exp OR osteoarthr*:ti,ab OR arthrosis:ti,ab OR 'long term':ti,ab OR 'follow up':ti,ab OR ('osteo*':ti,ab AND 'arthr*':ti,ab) OR arthropath*:ti,ab) NOT ('editorial'/it OR 'comment'/it OR 'systematic review':ti) NOT ('animal'/exp NOT 'human'/exp) AND [humans]/lim AND [english]/lim

CINAHL

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AB (((("Shoulder Dislocation" OR "Bankart Lesion" OR "Shoulder Joint")) AND (("Joint Instability" OR

("shoulder instability" OR "glenohumeral instability" OR "anterior instability"))) AND (("instab*" OR "dislocat*" OR "luxat*") AND (("Orthopedic Surgery" OR "Surgical Procedures, Operative" OR ("surg*" OR "repair*")) AND (("Arthritis" OR ("osteoarthr*" OR "arthrosis" OR "long term" OR "follow up") OR ("osteo*" AND "arthr*") OR "arthropath*"))))

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SPORTDiscus

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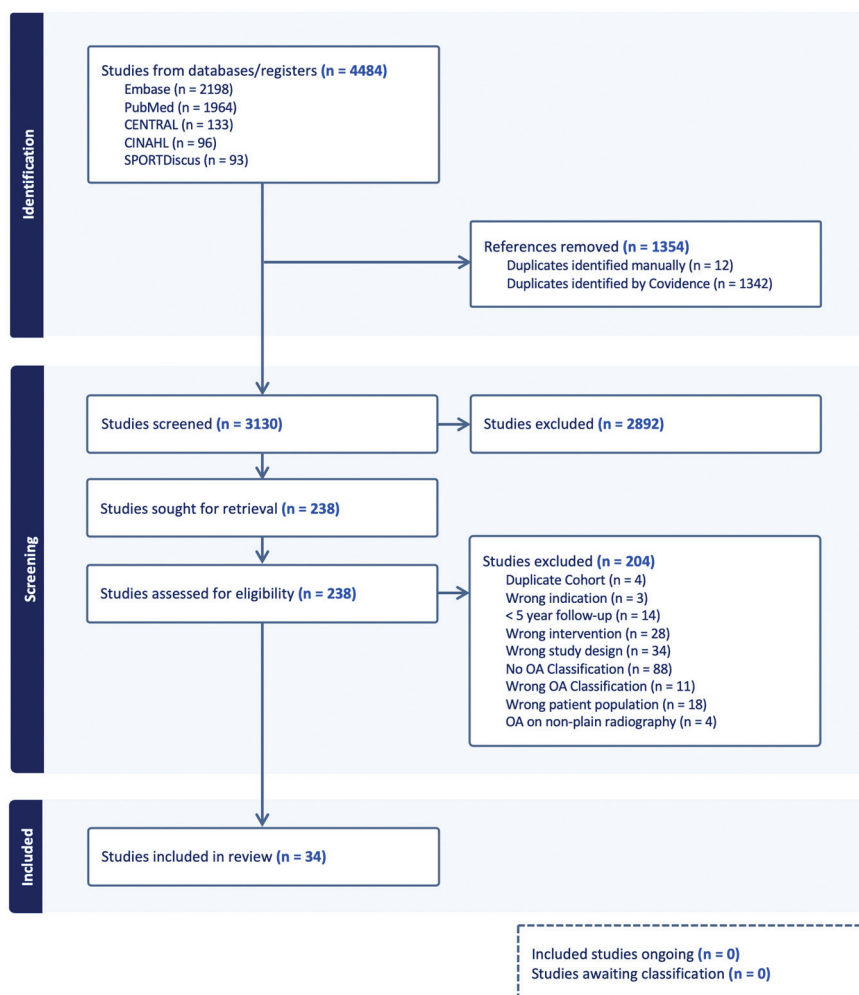
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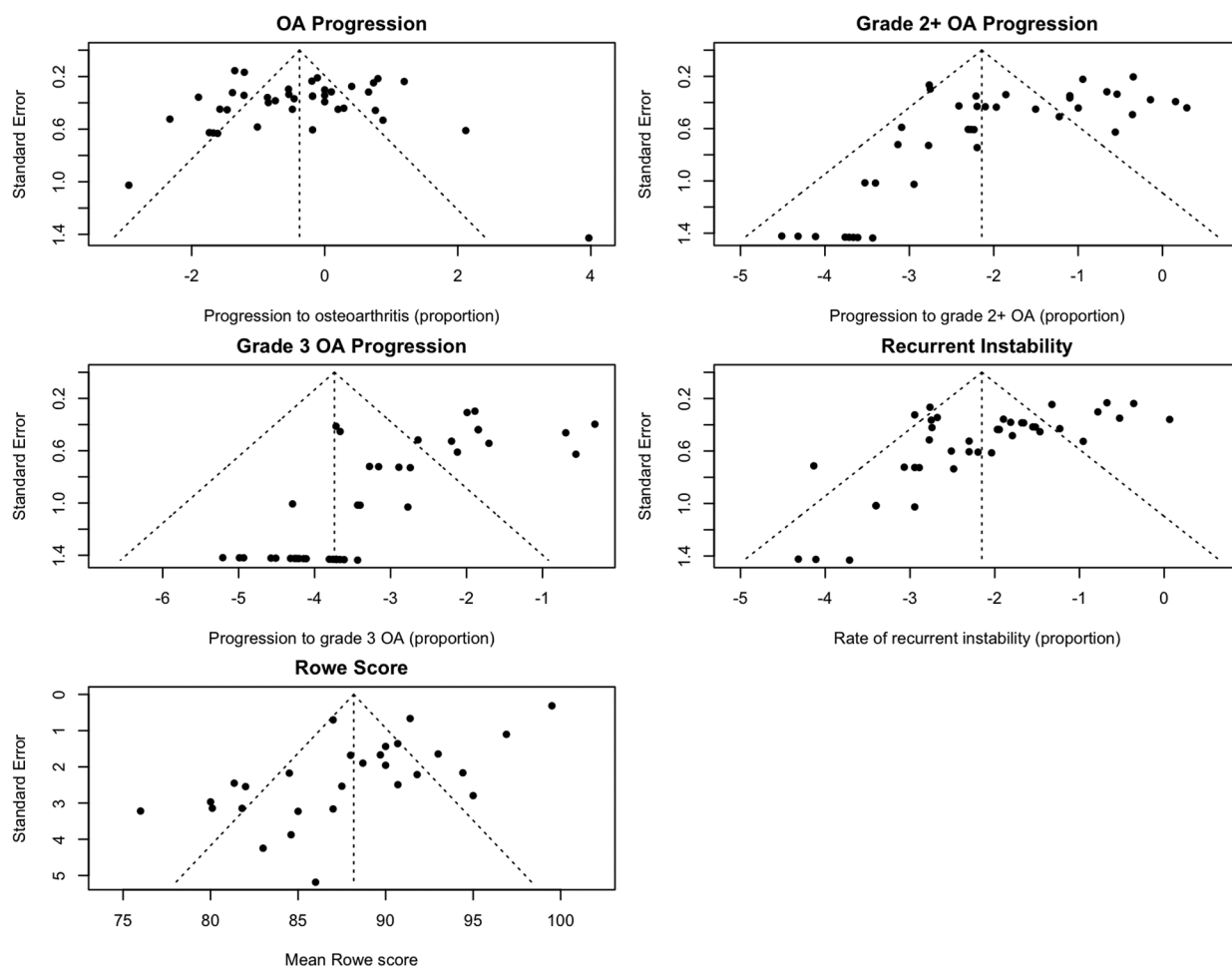
APPENDIX TABLE A1
MINORS Scores^a

First Author	Clearly Stated Aim	Consecutive Patients	Prospective Data Collection	Appropriate Endpoints	Unbiased Assessment	Appropriate Follow-up Period	<5% Loss to Follow-up	Prospective Calculation of Study Size	Adequate Control Group	Contemporary Groups	Baseline Equivalence of Groups	Adequate Statistical Analysis	Total Score ^b	Percentage of Maximum Score
Bauer ³	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Berendes ⁴	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Bonnevialle ⁵	2	2	1	2	2	2	1	0	2	2	1	2	19	79.2
Brejuin ⁶	2	2	0	2	1	2	1	0	NA	NA	NA	NA	10	62.5
Buscayret ⁸	2	2	0	2	1	2	1	0	1	2	2	2	17	70.8
Castagna ¹⁰	2	2	0	2	1	2	1	0	NA	NA	NA	NA	10	62.5
Chapus ¹¹	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Chillemi ¹²	2	2	0	2	1	2	1	0	NA	NA	NA	NA	10	62.5
de l'Escalopier ²⁰	2	2	0	2	1	2	1	0	NA	NA	NA	NA	10	62.5
Domos ¹⁸	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Domos ¹⁷	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Emami ¹⁹	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Fabre ²¹	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Gamulin ²²	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Izquierdo-Fernández ²⁷	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Kavaja ²⁸	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Komnos ³⁰	2	2	0	2	1	2	1	0	NA	NA	NA	NA	10	62.5
Lalanne ³²	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Marjanovic ³⁵	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Mizuno ³⁶	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Moroder ³⁷	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Neviaser ³⁸	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Neyton ³⁹	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Ono ⁴¹	2	1	0	2	1	2	2	0	NA	NA	NA	NA	10	62.5
Pelet ⁴⁴	2	1	0	2	1	2	1	0	NA	NA	NA	NA	9	56.3
Pelletier ⁴⁵	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Plancher ⁴⁶	2	2	0	2	1	2	2	0	0	2	2	2	17	70.8
Plath ⁴⁷	2	2	1	2	1	2	2	0	NA	NA	NA	NA	12	75.0
Schroder ⁴⁹	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Shim ⁵⁰	2	1	0	2	1	2	2	0	2	2	2	2	18	75.0
Van Gastel ⁵³	2	2	0	2	1	2	2	0	NA	NA	NA	NA	11	68.8
Waltenspül ⁵⁵	2	2	1	2	1	2	2	0	2	2	1	2	19	79.2
Zaffagnini ⁵⁶	2	2	1	2	1	2	2	0	2	2	2	2	20	83.3
Zink ⁵⁷	2	2	1	1	1	2	2	0	NA	NA	NA	NA	11	68.8

^aMINORS, Methodological Index for Non-Randomized Studies; NA, not applicable.^bThe total score for non-comparative studies is 16, so for example, 9/16 is 56.3%.



Appendix Figure A1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart. OA, osteoarthritis.



Appendix Figure A2. Funnel plots for meta-analysis outcome measures. OA, osteoarthritis.