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Review Article

Comparison of Clinical Outcomes After Different Surgical Approaches for Lateral Epicondylitis

A Systematic Review and Meta-analysis

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Background: Lateral epicondylitis (LE) is one of the most common causes of lateral elbow pain. When nonoperative treatment fails, 1 of the 3 surgical approaches—open, percutaneous, or arthroscopic—is used. However, determining which approach has the superior clinical outcome remains controversial.

Purpose: To review the outcomes of different operative modalities for LE qualitatively and quantitatively.

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

Methods: This review was performed and reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Studies published in PubMed, Medline (via EBSCO), and ScienceDirect databases that treated LE with open, percutaneous, or arthroscopic approaches with at least 12 months of follow-up were included. Study quality was assessed using the Cochrane Risk of Bias 2 tool and the Methodological Index for Non-Randomized Studies score. The primary outcome was the success rate of each operative treatment approach—open, percutaneous, and arthroscopic.

Results: From an initial search result of 603 studies, 43 studies (n = 1941 elbows) were ultimately included. The arthroscopic approach had the highest success rate (91.9% [95% CI, 89.2%-94.7%]) compared with the percutaneous (91% [95% CI, 87.3%-94.6%]) and open (82.7% [95% CI, 75.6%-89.8%]) approaches for LE surgery with changes in the mean visual analog scale pain score of 5.54, 4.90, and 3.63, respectively. According to the Disabilities of the Arm, Shoulder and Hand score, the functional outcome improved in the arthroscopic group (from 54.11 to 15.47), the percutaneous group (from 44.90 to 10.47), and the open group (from 53.55 to 16.13). The overall improvement was also found in the Mayo Elbow Performance Score, the arthroscopic group (from 55.12 to 90.97), the percutaneous group (from 56.31 to 87.65), and the open group (from 64 to 93.37).

Conclusion: Arthroscopic surgery had the highest rate of success and the best improvement in functional outcomes among the 3 approaches of LE surgery.

Keywords: arthroscopic; lateral epicondylitis; surgical approach; tennis elbow

Lateral epicondylitis (LE)—commonly known as tennis elbow—is one of the most common causes of lateral elbow pain. It is primarily caused by the repetitive strain that leads to the extensor carpi radialis brevis (ECRB) tendon overload. LE can be found in 1% to 3% of the general population and increases in older people, smokers, people who are obese, and those with heavy repetitive activities.[8]

Most LE cases can resolve spontaneously or with conservative treatment. However, up to 10% of patients do not respond to conservative treatment.[6] Different surgical approaches have been developed for LE. Three approaches are widely used when conservative treatment fails—open, arthroscopic, and percutaneous. However, determining which approach has the superior clinical outcome remains controversial, leaving the option to the individual

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surgeon's experience and ease of the approach.[33,39,40,55] Therefore, there is a need to investigate the functional outcomes between these 3 different approaches.

This study aimed to perform a systematic review and meta-analysis to determine whether there is a more successful surgical approach to LE. We hypothesized that among the 3 treatment approaches, arthroscopic surgery would lead to better functional outcomes.

METHODS

Search Strategy

This study was performed and reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[52] References of included studies were also reviewed to find those not found in the original search. The study protocol was registered on the PROSPERO International Prospective Register of Systematic Reviews. Using the PICO (population, intervention, comparison, and outcomes) model, the study population included patients with chronic LE (persistent lateral elbow pain for >6 months despite conservative treatment); the intervention was any of the 3 surgical treatments (open, percutaneous, or arthroscopic); there was no comparison group; and the outcomes were the success rate and functional outcomes.

A detailed literature search was performed on PubMed, Medline (via EBSCO), and ScienceDirect databases in June 2022 with a Boolean search string consisting of a combination of "lateral epicondylitis," "tennis elbow," "open surgery," "Nirschl procedure," "percutaneous surgery," and "arthroscopic surgery."

Study Selection

All included studies contained original data published in English, treating LE with open, percutaneous, or arthroscopic approaches, with at least 12 months of follow-up. The success rate of LE surgery was defined as the increment in patient satisfaction, significant improvement in pain, or no need for reintervention. Studies that used adjuvant surgery and additional surgical methods and included patients with previous LE surgery were excluded from the review. Narrative reports, articles on surgical techniques, and animal and cadaveric studies were also excluded.

Level of Evidence and Quality Assessment

Three independent authors (L.C.S., M.A., F.L.) performed identification, selection, data extraction, and level of evidence assessment for each included study. The level of evidence was determined using the 2011 guidelines of the Oxford Centre for Evidence-Based Medicine.[23] The different opinions between the 3 authors were resolved by reassessment and discussion with a fourth author (E.K.). A fifth author (J.M.K.) performed a quality assessment of the studies with the Methodological Index for Non-Randomized Studies (MINORS) score for nonrandomized studies and the Cochrane Risk of Bias 2 assessment tool for randomized studies.[2,57] The MINORS score allows a maximum of 16 points for noncomparative studies and 24 points for comparative studies. High-quality studies are defined as those with scores of >60%—9 of 16 for noncomparative studies and 14 of 24 for comparative studies.[31,57] Risk of bias, according to the Cochrane assessment, was judged as high, low, or unclear.[2,23,57]

Data Extraction and Analysis

All data were extracted from the text, figures, tables, and associated supplementary files from each included study. These data included (1) study and patient characteristics; (2) mean follow-up times; (3) mean LE onset; (4) pain visual analog scale (VAS) scores; (5) functional scores, namely, the Disabilities of the Arm, Shoulder and Hand (DASH) score and the Mayo Elbow Performance Score (MEPS); and (6) the mean duration of return to work. The primary clinical outcome was the success rate of surgery. The secondary outcome was the functional outcome of the patients.

Statistical analysis was performed using the OpenMeta-Analyst (*Tufts Medical Center*). The I^2 value was used to identify the heterogeneity between studies. The random-effects model was used for all meta-analyses. Forest plots were used to describe the data on surgical success rates. Statistical significance was determined as $P < .05$.

RESULTS

Study Selection

After the initial screening, 603 studies were retrieved. Of these studies, 43 met the inclusion and exclusion criteria and were ultimately included in this review (Figure 1).

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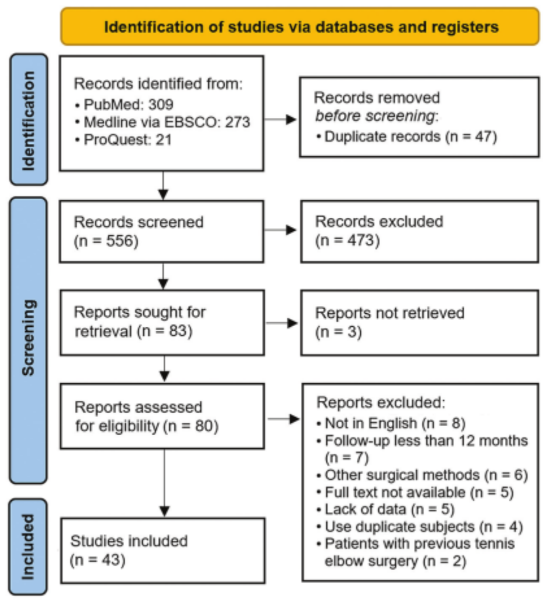

Figure 1. PRISMA flowchart of study inclusion in the review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Study Quality Assessment

The level of evidence analysis indicated that there were 4 randomized controlled trials,[11,16,36,38] all with level 2 evidence, and 3 studies[49,56,59] with level 3 evidence; the remaining 36 studies had level 4 evidence. The 39 nonrandomized studies consisted of 35 noncomparative and 4 comparative studies, which, according to the MINORS criteria, were considered to be of high quality (Figure 2). The 4 randomized controlled trials were considered as having a low risk of bias according to the Cochrane Risk of Bias 2 tool.

Characteristics of the Studies and Patients

All studies were published from 2001 to 2022 and included a total of 1941 elbows—609 elbows that underwent open surgery (11 studies** were included in the analysis) (Table 1), 423 elbows that underwent percutaneous surgery (13 studies††) (Table 2), and 909 elbows that underwent arthroscopic surgery (22 studies‡‡) (Table 3). The mean age of the patients varied among the open (range, 41-54.2 years), percutaneous (range, 39-55.3 years), and arthroscopic (range, 33.7-54 years) groups. The duration of LE also varied among the open (range, 13.3-26.4 months), percutaneous (range, >6-40 months), and arthroscopic (range, 6-34 months) groups. The mean follow-up was 7.73 years (range, 1-12.6 years) for the open group, 2.26 years (range, 1-7.5 years) for the percutaneous group, and 3.78 years (range, 1-10.3 years) for the arthroscopic group. The patients in the open group returned to work in 3 weeks to 3 months, the percutaneous group returned in 2 to 3 weeks, and those in the arthroscopic group returned in 6 days to 4.3 months.

Primary Outcome: Surgical Success Rate

The success rate for all 3 surgical approaches was high. The success rate for the open approach was 82.7% (95% CI, 75.6%-89.8%; I^2 = 86.78%; $P < .001$) (Figure 3A). The success rate for the percutaneous approach was 91% (95% CI, 87.3%-94.6%; I^2 = 49.41%; $P = .022$) (Figure 3B), and the success rate for the arthroscopic approach was 91.9% (95% CI, 89.2%-94.7%; I^2 = 56.22%; $P < .001$) (Figure 3C).

Secondary Outcome: Functional Scores

Improvement in the DASH score was shown on all 3 surgical approaches for LE. The arthroscopic approach was found to be superior in improving the pre- to postoperative weighted mean of the DASH score (from 54.51 to 15.47) compared with the percutaneous approach (from 44.90 to 10.47) and the open approach (from 53.55 to 16.13). (Figure 4A). The MEPS also improved on all 3 surgical approaches. It was found that the arthroscopic approach had the most superior pre- to postoperative improvement (from 55.12 to 90.97) compared with the percutaneous (from 56.31 to 87.65) and open approaches (from 64 to 93.37) (Figure 4B).

DISCUSSION

The major finding of our systematic review and meta-analysis of 1941 elbows showed that patients with LE had higher success rates and functional outcomes when treated with an arthroscopic approach than open or percutaneous approaches (91.9% vs 82.7% vs 91%).

Open surgery remains a traditional but preferred method that has lasted almost half a decade. It was first introduced by Nirschl and Pettrone[46] in 1979 and involved debriding the damaged parts in the insertion of the ECRB muscle by exposing the ECRB, excision of the identified lesion, and repair. Improvement after open surgery has been found in 97.7% of patients and 85.2% of patients returning to full activity. The results in the pilot study by Nirschl and Pettrone[46] are slightly different from those in our study, where the success rate was 82.7%. The high heterogeneity among the included studies (I^2 = 86.78%) could have influenced the difference in the success rate, considering that the difference in the technique and duration of the follow-up can affect the result. Khashaba[28] used

**References 11, 13, 16-18, 37, 38, 58, 59, 63, 66.

††References 1, 6, 10, 16, 22, 36, 41, 45, 54, 56, 60, 65, 69.

‡‡References 3, 4, 7, 11, 14, 19-21, 24, 27, 35, 36, 43, 44, 48-50, 53, 61, 62, 64, 68.

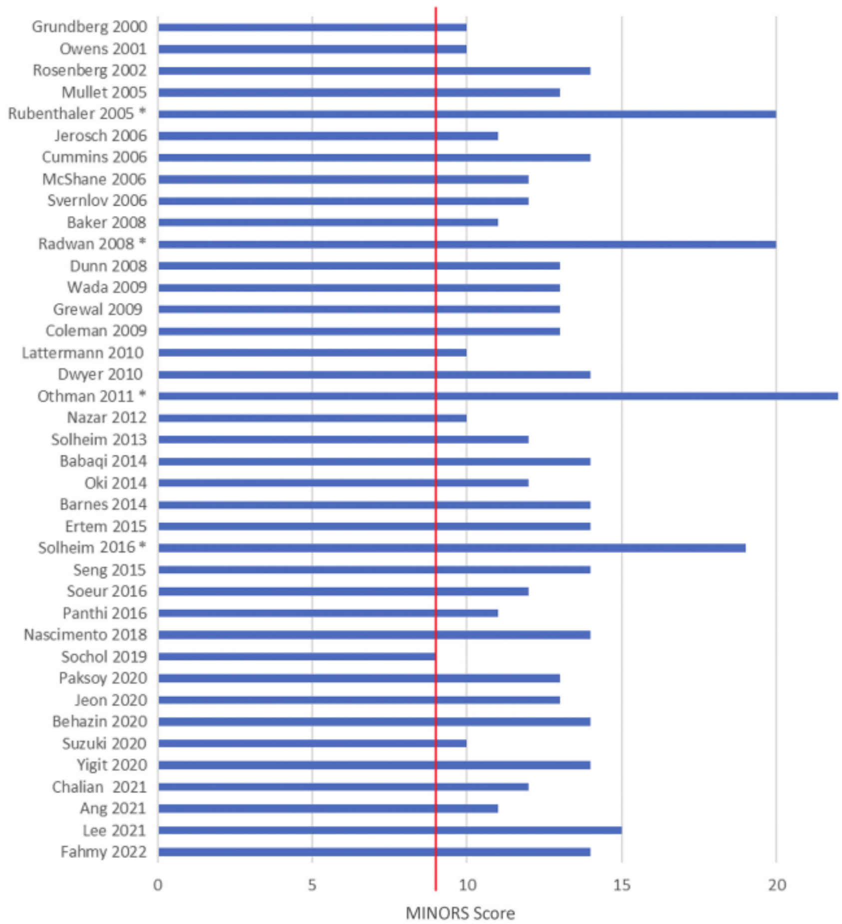

Figure 2. MINORS Quality Assessment of the 39 nonrandomized studies; 35 studies were noncomparative and 4 studies (indicated with asterisks) were comparative. The vertical red line represents the cutoff point for noncomparative studies to be considered high quality.[41] MINORS, Methodological Index for Non-Randomized Studies.

the standard Nirschl technique without drilling or decortication and reported that at 6 months, the mean extension power was less than that of most unaffected elbows in most patients. On the other hand, Lee et al[37] found that the clinical results at a minimum 5-year follow-up revealed statistically significant improved functional scores compared with the preoperative state and muscle strength compared with unaffected elbows.

In the present study, the percutaneous approach, reviewed in 13 studies, was found to have a high success rate (91%). Several surgical techniques regarding the percutaneous approach have been described. The release of extensor tendon origin percutaneously was stated by Cutts et al in their manuscript.[15] A local anesthetic was used in the lateral elbow, and a percutaneous release was performed through a skin incision. The release can be extended by performing the Mill manipulation—full extension with the pronation arm while the wrist and fingers are held in flexion.[45,51] Ang et al[1] found that using ultrasound to modify percutaneous surgery resulted in significant pain relief up to 90 months after the surgery. Even with a 3-year follow-up, patients with LE experienced considerably improved function and symptoms after an ultrasound-guided percutaneous needle tenotomy. Arthroscopic debridement in LE was first introduced by Baker et al[5] in 2000 to treat 40 patients. To evaluate intra-articular pathology, Baker et al[5] classified capsular lesions into 3 types—intact, linear capsular tear, and complete capsular tear. They found that arthroscopic tennis elbow debridement was a reliable treatment, in which 29 of 30 (96.7%) cases were successful.

There is still a lack of evidence to conclude which surgical approach can provide the most superior functional score regarding pain reduction and satisfaction rate. A systematic review by Burn et al[9] found no significant differences between the 3 surgical techniques (open, arthroscopic,

TABLE 1
Characteristics of Studies Using the Open Approach for Lateral Epicondylitis (n = 11 Studies)[a]

First Author (Year)	Study Design; LOE	MINORS or Cochrane RoB Score	Patients/ Elbows, n	Age, Years	Sex, M/F, n	Onset, Months	Follow-up, Years	Success Rate	RTW, Months	Score, Preop/Postop		
										VAS Pain	DASH	MEPS
Lee[37] (2021)	CS; 4	15	99/99	44.8 ± 9.8	39/60	22	8.5	95/99	2.4 ± 0.6	4.9/1.1	50/13	64/90
Clark[11] (2018)	RCT; 2	Low	29/29	46.9 ± 7.04	19/18	—	1	18/29	—	6.13/3.06	46.5/22.2	—
Solheim[63] (2013)	RCC; 4	12	80/80	46	38/42	19	4.1	77/80	—	—	60.5/17.80	—
Dwyer[18] (2010)	CS; 4	14	22/22	49	12/10	21	2	20/22	3	—	—	—
Coleman[13] (2010)	CS; 4	13	137/149	42	72/65	25	9.8	117/137	1.5	—	—	—/95.8
Dunn[17] (2008)	CS; 4	13	83/92	46	45/38	26.4	12.6	77/92	—	—	—	—
Svernlöv[66] (2006)	PCS; 4	12	53/55	46	25/28	33	7.5	46/53	—	—	—	—
Rubenthaler[59] (2005)	RC; 3	20[b]	10/10	54.2	7/3	13.3	7.625	7/10	0.75	—	—	—
Dunkow[16] (2004)	RCT; 2	Low	24/24	43	11/13	—	1	22/24	5[c]	—	70[c]/53[c]	—
Rosenberg[58] (2002)	CS; 4	14	22/22	47	16/6	21	1	15/19	—	—	—	—
Leppilahti[38] (2001)[d]	RCT; 2	Low	(a) 13/14	(a) 42	(a) 6/7	(a) 23	(a) 2.6	(a) 9/13	(a) 2	—	—	—
			(b) 14/14	(b) 41	(b) 7/7	(b) 23	(b) 2.6	(b) 11/14	(b) 2.5			

[a]Data are reported as the mean or mean ± SD unless otherwise indicated. Dashes indicate data not reported. CS, case series; DASH, Disabilities of the Arm, Shoulder and Hand; F, female; LOE, level of evidence; M, male; MEPS, Mayo Elbow Performance Score; PCS, prospective case series; Postop, postoperative; Preop, preoperative; RC, retrospective cohort; RCC, retrospective case control; RCT, randomized controlled trial; RoB, risk of bias; RTW, return to work; VAS, visual analog scale.

[b]Comparative study.

[c]Median.

[d]Group (a) underwent decompression of the posterior interosseous nerve; group (b) underwent lengthening of the tendon of the distal tendon of the extensor carpi radialis brevis.

TABLE 2
Characteristics of Studies Using the Percutaneous Approach for Lateral Epicondylitis (n = 13 Studies)[a]

First Author (Year)	Study Design; LOE	MINORS or Cochrane RoB Score	Patients/ Elbows, n	Age, Years	Sex, M/F, n	Onset, Months	Follow-up, Years	Success Rate	RTW, Months	Score, Preop/Postop		
										VAS Pain	VAS Pain	VAS Pain
Ang[1] (2021)	CS; 4	11	19/19	46	7/12	—	7.5	19/19	—	5.5/0	24.2/0.8	—
Yigit[69] (2020)	CS; 4	14	41/47	46	19/22	—	4.3	36/41	0.5	—/2.6	—	—/82
Suzuki[65] (2020)	CS; 4	10	36/36	55	19/17	10	1	31/36	—	7/3	—	—
Seng[60] (2016)	CS; 4	14	20/20	45.5	7/13	12.5	3	20/20	—	5.4/0.4	27.8/0.4	—
Barnes[6] (2015)	CS; 4	14	19/19	55.3	10/9	—	1	15/19	—	6.4/0.7	44.1/8.6	59.1/90.5
Nazar[45] (2012)	CS; 4	10	24/30	55	7/17	40	3	20/24	0.75	—	—/8.47	—
McShane[41] (2006)	CS; 4	12	55/61	49	30/25	9	2.3	44/55	—	—	—	—
Grundberg[22] (2000)	CS; 4	10	30/32	43	13/17	18	2.17	27/30	—	—	—	—
Chalian[10] (2021)	CS; 4	12	37/37	51.3	15/22	>6	1.45	33/37	—	—	56.2/14.5	—
Lee[36] (2018)	RCT; 2	Low	22/22	51.59 ± 5.75	8/14	23.91	2	21/22	—	7.27/1.5	60/25	53.9/95.7
Panthi[54] (2017)	CS; 4	11	50/50	42.2	18/32	9.3	1	40/50	—	—	—	—
Radwan[56] (2008)	PC; 3	20[b]	27/27	39	18/9	18.26	1	21/27	—	3.5/0.6	—	—
Dunkow[16] (2004)	RCT; 2	Low	23/23	46	11/12	—	1	24/24	0.5	—	70[c]/49[c]	—

[a]Data are reported as the mean or mean ± SD unless otherwise indicated. Dashes indicate data not reported. CS, case series; F, female; LOE, level of evidence; M, male; PC, prospective cohort; Postop, postoperative; Preop, preoperative; RCC, retrospective case control; RCT, randomized controlled trial; RoB, risk of bias; RTW, return to work; VAS, visual analog scale.

[b]Comparative study.

[c]Median.

and percutaneous) in terms of functional outcome (DASH), pain intensity (VAS), and patient satisfaction at 1-year follow-up. A retrospective study by Szabo et al[67] that compared functional outcomes in patients treated with open, arthroscopic, and percutaneous release reported similar functional outcomes and VAS scores after 48 months of follow-up in the 3 different groups. A systematic review by Moradi et al[42] comparing open and arthroscopic surgery in LE found no significant differences in VAS and DASH scores, time to return to work, and patient satisfaction, although the arthroscopic approach had a lower complication rate. Paksoy et al[53] reported lower overall complication rates, shorter rehabilitation, faster wound healing, less postoperative pain, and earlier return to work and sports activities with the arthroscopic technique. Othman[49] showed no significant difference in functional outcomes in patients treated with the arthroscopic and percutaneous release (DASH score: 24 vs 20, respectively

TABLE 3
Characteristics of Studies Using the Arthroscopic Approach for Lateral Epicondylitis (n = 22 Studies)[a]

										Score, Preop/ Postop		
First Author (Year)	Study Design; LOE	MINORS or Cochrane RoB Score	Patients/ Elbows, n	Age, Years	Sex, M/F, n	Onset, Months	Follow-up, Years	Success Rate	RTW, Months	VAS Pain	DASH	MEPS
Fahmy[20] (2022)	PCS; 4	14	22/22	34.6	17/5	10.8	5	22/22	3.9	7.86/0.79	—	57.1/95.6
Behazin[7] (2021)	PCS; 4	14	11/11	42 ± 6.8	3/8	18	1	10/11	—	7/2.2	56/15	56/90
Jeon[24] (2020)	CS; 4	13	22/22	51.2	15/7	16.2	2.45	22/22	2.33	7.5/2.5	54.5/3.6	51.9/84.3
Paksoy[53] (2021)[c]	CS; 4	13	(a) 18/18	(a) 46	(a) 46%	(a) 20	(a) 5.16	(a) 17/18	(a) 1.63	(a) 7.3/1.5	(a) 61/13	—
			(b) 20/20	(b) 43	(b) 48%	(b) 20	(b) 5	(b) 19/20	(b) 1.63	(b) 7.2/1.5	(b) 62/12	
Sochol[61] (2019)	Technical report; 4	9	35/35	46.2 ± 9.9	25/10	—	9.2	25/35	—	—	—	—
Nascimento[44] (2017)	PCS; 4	14	104/104	46.9	71/33	25	2.86	99/104	—	7.6/3.3	48.9/21.24	—
Clark[11] (2018)	RCT; 2	Low	32/32	45.6 ± 9.8	22/16	—	1	20/30	—	6.42/2.69	52.6/23.5	—
Lee[36] (2018)	RCT; 2	Low	24/24	51.25	11/13	26.17	2	19/24	—	7.33/1.41	55/20	55.2/95.4
Soeur[62] (2016)	PCS; 4	12	35/39	48 ± 8.4	20/15	18	Median: 4	28/39	1.25	—	—/15.9	—
Solheim[64] (2016)[d]	RCC; 4	19[b]	(c) 204/204	(c) 46	(c) 23/23	(c) 24	(c) 4.58	(c) 188/204	(c) 1.63	(c) 7.4/1.5	(c) 60/11	—
			(d) 79/79	(d) 47	(d) 23/24	(d) 24	(d) 4.67	(d) 71/79	(d) 1.167	(d) 7.2/1.5	(d) 60/12	
Ertem[19] (2015)	PCS; 4	14	29/29	46	14/15	—	1.7	21/28	—	—	81.1/34.7	48.5/101.2
Oki[48] (2014)	PCS; 4	12	23/23	49	5/18	34	2	21/22	2	4.7/1.35	32/15	—
Babaqi[3] (2014)	CS; 4	14	31/33	33.7	20/11	16.3	1.2	29/31	0.267	8.64/1.48	24.46/4.81	61.82/94.1
Othman[49] (2011)	PC; 3	22[b]	14/14	42	8/6	>6	1	13/14	0.5-1	9.1/2	72/48	—
Lattermann[35] (2010)	CS; 4	10	36/36	42	24/12	19	3.5	28/32	1.133	8.5/1.9	—	—/11.1
Grewal[21] (2009)	CS; 4	13	36/36	45.3	20/16	30	3.5	30/36	4.3	—	—	—/78.6
Wada[68] (2009)	CS; 4	13	18/18	54	9/9	6	2.3	15/18	0.8	5.95/0.6	—/10.6	—
Baker[4] (2008)	PCS; 4	11	30/30	43	19/11	14.4	10.83	29/30	—	—/0.9835	—	—/11.7
Cummins[14] (2006)	PCS; 4	14	18/18	43.2	13/5	13.6	1.8	16/18	—	8.6/2.2	—	—
Jerosch[27] (2006)	CS; 4	11	20/20	45.3	13/7	>6	1.8	17/20	0.733	6.267/0.9	—	—/10.9
Mullett[43] (2005)	CS; 4	13	30/30	46	16/14	>9	2	28/30	0.25	—	—	—
Owens[50] (2001)	CS; 4	10	12/12	49.9	12/4	31.7	2	12/12	0.2	—/1.8	—	—

[a]Data are reported as the mean or mean ± SD unless otherwise indicated. Dashes indicate data not reported. CS, case series; DASH, Disabilities of the Arm, Shoulder and Hand; F, female; LOE, level of evidence; M, male; MEPS, Mayo Elbow Performance Score; PC, prospective cohort; PCS, prospective case series; Postop, postoperative; Preop, preoperative; RC, retrospective cohort; RCC, retrospective case control; RCT, randomized controlled trial; RoB, risk of bias; RTW, return to work; VAS, visual analog scale.

[b]Comparative study.

[c]Group (a) underwent arthroscopic lateral capsular resection with extensor carpi radialis brevis debridement; group (b) underwent arthroscopic lateral capsular resection alone.

[d]Group (c) underwent arthroscopic tenotomy; group (d) underwent arthroscopic debridement.

[P = .5]; reduction in VAS pain: 2 vs 2.1 points, respectively [P = .16]). These findings are comparable to our results, which showed a slight difference in the success rate of percutaneous and arthroscopic approaches (91% vs 91.9%).

Several studies failed to find the superiority of the arthroscopic approach to the open approach which were found in the current study.[32,34] Kwon et al[34] also found that the Nirschl technique provided superior pain relief when compared with arthroscopic surgery despite a small effect size. Kim et al[32] showed that the open surgery group had better grip strength and VAS score when compared with the arthroscopic group. We believe that the smaller effect size and sample size were the reasons for having a different conclusion from the present meta-analysis.[34]

Traditionally, the aim of surgery for a refractory case of LE is to resect or release the degenerative tissue. Incomplete identification of the targeted area may cause incomplete resection of the degenerative tissue.[12,25] Identifying the origin of ECRB as the targeted pathologic tissue is essential to achieve adequate resection. Arthroscopic surgery is advantageous because it allows surgeons to resect capsular pathology[4] and proceed with the debridement of pathologic ECRB. Moreover, the arthroscopic approach may facilitate the evaluation of elbow instability, which may coexist with LE.[29,47] Ultimately, the arthroscopic approach also allows the surgeon to evaluate concomitant intra-articular pathology, which is not uncommon in refractory LE.[24,25,26,30,31]

Strengths and Limitations

The present meta-analysis involved an extensive search, which was followed by the quantitative analysis of large number of participants (n = 1941 elbows) from 43 high-quality studies. The results of the present meta-analysis can be generalized to the larger population because of the longer follow-up duration compared with that of the body of the published literature. Despite these strengths, the present meta-analysis reported variations in study outcomes between studies that showed moderate (arthroscopic and percutaneous surgery) to high heterogeneity (open surgery). Secondary data showed differences in surgical technique, duration of follow-up, and the variation in outcome measurement tools, which might contribute to the

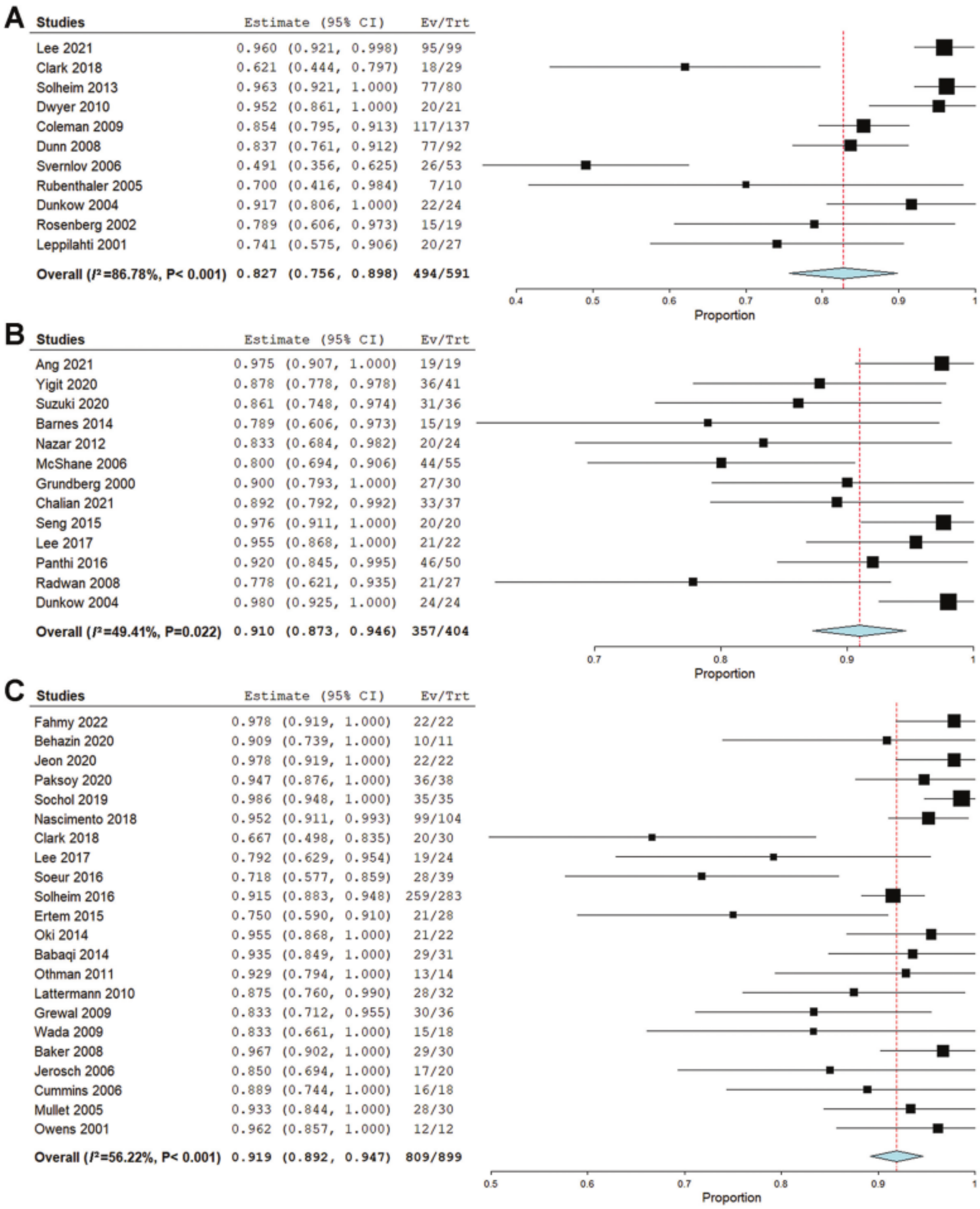

Figure 3. Forest plots of the success rates for the (A) open approach, (B) percutaneous approach, and (C) arthroscopic approach. Ev/Trt, event/treated.

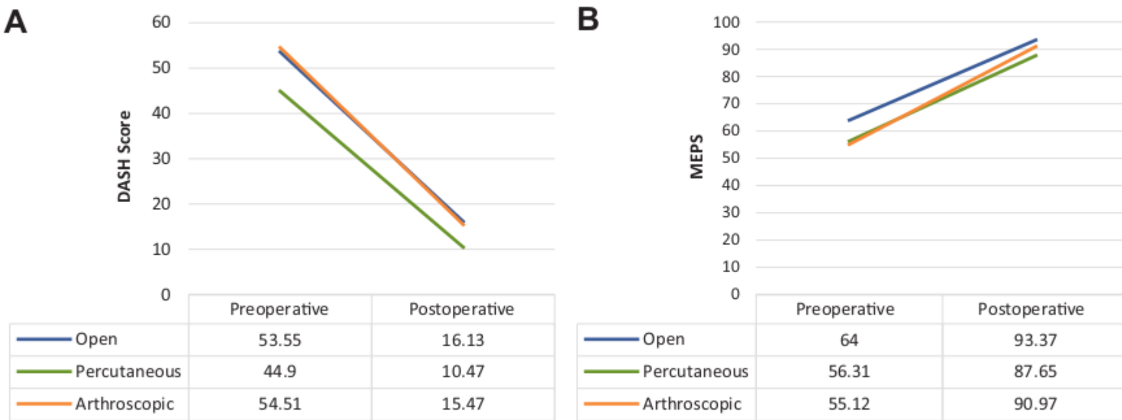

Figure 4. Graphs showing results of pre- versus postoperative functional scores according to surgical approach: (A) the DASH score and (B) the MEPS. DASH, Disabilities of the Arm, Shoulder and Hand; MEPS, Mayo Elbow Performance Score.

high heterogeneity of the open surgery group. In addition, we were unable to account for the variations regarding the perioperative protocol, such as physical therapy within each group, that may be present.

CONCLUSION

Open, percutaneous, and arthroscopic surgeries resulted in favorable outcomes in managing refractory LE. Arthroscopic surgery had a slightly higher success rate and functional outcome when compared with open and percutaneous surgeries, based on our systematic review here; however, higher-level studies are needed to draw strong conclusions.

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