Systematic Review of the Surgical Outcomes of Elbow Plicae

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Background: Surgical resection is usually required for symptomatic elbow plicae that have failed nonoperative therapy. However, evidence of surgical outcomes has not been presented.

Purpose: To review the surgical outcomes for the treatment of synovial plicae in the radiocapitellar joint.

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

Methods: We searched the PubMed, Ovid/MEDLINE, Cochrane Library, Google Scholar, and Embase databases using keywords as well as Medical Subject Headings terms and Emtree ([(elbow OR humeroradial joint OR radiohumeral joint) AND (meniscus OR plica)] OR snapping elbow OR snapping triceps OR synovial fold syndrome OR synovial fringe) for English-language studies. We conducted a systematic review using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Results: A total of 14 articles comprising four level 5 and ten level 4 studies were identified, including 279 patients (284 elbows). The triggering factors reported for 58 patients were heavy labor (29 patients; 50.0%), sporting activities (17 patients; 29.3%), and nonspecific trauma (12 patients; 20.7%). Overall, 92 patients (33.0%) were administered a steroid injection before surgery. Arthroscopic plica resection was performed in 266 patients (95.3%). Intraoperatively, plicae were mostly found in the posterior (44.0%) and posterolateral (28.6%) sites, and chondromalacia of the radial head was observed in 25 patients (9.2%). Of the reported surgical outcomes, 67.7% showed a resolution of symptoms. However, 9.3% of patients had residual symptoms, which were likely associated with preexisting radial head chondromalacia. The complication rate was reported as 1.8%.

Conclusion: Symptomatic elbow plicae were mostly treated arthroscopically, with most of the results being favorable. Pre-existing chondromalacia and the underestimation of concomitant intra-articular abnormalities may yield an inferior outcome.

Keywords: elbow plicae; synovial plicae; systematic review; surgical outcome

The synovial plica represents an asymptomatic remnant of the synovial membrane from embryological development.[13,18] It has been shown to cover 28% of the radiocapitellar joint of the adult radial head.[16] The plica is well established and reported in the knee joint rather than in the elbow joint. Normally, the synovial plica is without a function and is asymptomatic.[13] The plica becomes symptomatic when it suffers from chronic inflammation secondary to repetitive trauma (sports); it later turns into a thickened fibrotic tissue fold.[13,15] Moreover, the plica has been indicated as one of the sources of radiocapitellar joint snapping.[6] Radiocapitellar snapping is not a common condition, and owing to its rarity, it is frequently misdiagnosed.[2,3,14,24,25] Symptomatic synovial plicae are infrequently encountered as a cause of lateral elbow pain, and this condition has been variously termed as "plica,"[2,17,25] "plica syndrome,"[5] "synovial fold,"[9,14] "synovial fringe,"[6] and "elbow synovial fold syndrome."[3,21]

Surgical treatment is indicated when nonoperative treatment fails to relieve symptoms. The use of surgical treatment for symptomatic synovial plicae has been reported for over 30 years. Although surgical treatment is generally associated with favorable outcomes, studies continue to report on the incomplete resolution of symptoms.[2,14,17,24,29] This systematic review primarily aimed to define the functional outcomes of surgical treatment for symptomatic synovial plicae. Secondary objectives included defining intraoperative findings and abnormalities that may be associated with inferior results.

METHODS

Search Strategy and Study Selection

This systematic review was performed according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[19,20] guidelines. The PubMed, Embase,

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Cochrane Library, Ovid/MEDLINE, and Google Scholar databases were electronically searched using keywords conforming to Medical Subject Headings to find relevant articles. Natural keywords were chosen to increase sensitivity: ([(elbow OR humeroradial joint OR radiohumeral joint) AND (meniscus OR plica)] OR snapping elbow OR snapping triceps OR synovial fold syndrome OR synovial fringe). The number of studies was limited; thus, there were no restrictions on specific surgical procedures, publication status, or study periods. After eliminating duplicate articles, 2 independent reviewers (E.K., A.N.) examined the titles and abstracts to select the first candidates; they then selected the final articles through a full-text review. We also conducted citation tracking in the reference lists of the retrieved studies to identify additional related articles. Any disagreement that arose in the selection process was resolved by a group discussion or intervention by a third reviewer (H.K.). Figure 1 displays the flow of study selection.

Inclusion and Exclusion Criteria

All included studies contained original data published in the English language on patients undergoing surgical procedures for symptomatic synovial plicae. Included studies reported on the type of surgery, intraoperative findings, and outcomes and complications of surgery. Studies on imaging techniques, skeletally immature patients, and cadaveric specimens were excluded.

Quality Appraisal and Risk of Bias

There were 5 reviewers (E.K., H.L., A.N., H.K., and D.M.K.) who independently reviewed each article and decided whether to include or exclude any study based on a discussion and consensus. The level of evidence of each study was determined according to the criteria set by the Oxford Centre for Evidence-Based Medicine.[12] The inclusion or exclusion decisions were discussed with 2 expert orthopaedic surgeons (K.H.K. and I.-H.J.) specializing in elbow surgery. The Methodological Index for Non-Randomized Studies (MINORS) tool[28] was used to assess the risk of bias of each study. This tool comprises 8 items for both comparative and noncomparative studies, plus 4 additional items for studies with $\geq$2 comparative groups. Each item is scored as 0, 1, or 2, with maximum scores of 16 or 24 points. A high total indicates a low risk of bias. In the current study, a score of >60% of the total (14/24 points or 9/16 points) was considered high quality.

Data Extraction and Analysis

Data were extracted from the text, figures, tables, and supplementary material of each of the included studies. These data included (1) article and demographic characteristics, (2) preoperative characteristics (symptoms, range of motion [ROM], radiological findings, and steroid injection use), (3) intraoperative characteristics (type of surgery, intraoperative findings, histological findings, and location of plica), and (4) postoperative outcomes (functional outcomes and complications of surgery). We conducted a qualitative assessment of all studies and produced a narrative report. Where possible, data were combined, although this was not always possible because of the low level of evidence and heterogeneity of the studies.

RESULTS

In the first step, 243 articles were retrieved for initial screening; the titles and abstracts of these articles were examined for duplication. Conference abstracts were excluded from the review. Full-text reviews of 50 articles helped in identifying 14 articles (4 with evidence level 5 and 10 with evidence level 4 studies) for the systematic review.

Study Quality Assessment

The mean MINORS score was 9.9 ± 1.2. There were no comparative studies. Figure 2 shows the distribution of MINORS scores and the range considered high-quality articles. There were 7 articles that were considered high-quality studies with a low risk of bias, exceeding 60% of the total score.[4,14,17,23-25,29]

Article and Demographic Characteristics

The 14 chosen studies included 279 patients (284 elbows) who had undergone surgery for elbow synovial plicae (Table 1). The study populations included 175 men (62.7%) and 104 women (37.3%). Furthermore, 10 of 14 studies had over 12 months of mean follow-up time.[2-4,9,14,17,23,25,29,30]

The initial diagnoses were lateral epicondylitis (157 patients; 56.3%)[14,23-25] and loose bodies (12 patients;

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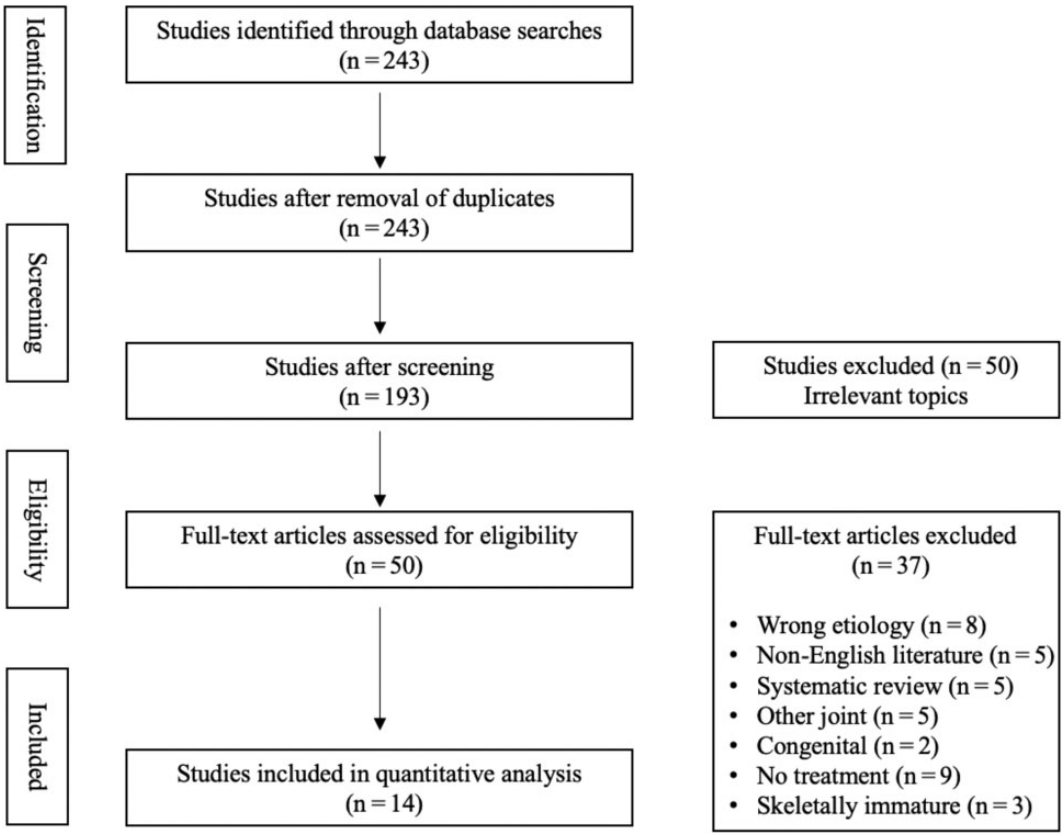

Figure 1. PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) guidelines used for article selection.

4.3%).[2,3,23] Painless snapping was reported in 1 patient.[1] Triggering factors were documented before symptoms for 58 patients; the triggering factors were heavy labor (29 patients; 50.0%), sporting activities (17 patients; 29.3%), and nonspecific trauma (12 patients; 20.7%). Lateral epicondylitis was reported as a comorbidity for 6 patients (2.2%).

The dominant extremity was reported as affected in 67.1% (51/76) of the patients. The mean symptom duration was reported in 12 studies for 98 patients: symptom duration was >6 months for 83 (84.7%) patients and <6 months for 15 (15.3%) patients.

Preoperative Characteristics

Nearly all patients (90.7%) had pain as the main symptom. Mechanical symptoms such as locking, clicking, catching, popping, and snapping were described for 157 patients (56.3%). However, the type of mechanical symptoms was not specified for 121 patients (77.1%). Preoperative ROM was reported in 149 patients (53.4%). Of the reported studies, ROM was found to be a deficit in 23 patients (15.4%). Standard plain elbow radiographs had been taken for most patients. However, only 70.6% (197/279) of patients had undergone magnetic resonance imaging (MRI); of the 197 patients who underwent MRI, 76 (38.6%) provided details on the MRI examination, including 66 patients (86.8%) with abnormal findings and 10 (13.2%) with normal findings. The abnormal findings were mostly described as thickened plicae, which had been measured in 56 patients (5 studies). A thickness greater than 3 mm was considered a considerable contribution.[17,23] A local steroid injection was documented in 92 patients (33.0%). Steroid was administered as a single shot in 93.4% of cases and repeated in 6.6% of cases. Table 2 summarizes the preoperative characteristics of these patients. In addition, 2 articles described the causes of failed nonoperative treatment, which were impingement of the plica structure[25] and possible chondral changes involving the adjacent cartilage.[14]

Intraoperative Characteristics

In total, 271 patients (97.1%) underwent surgical interventions. The most common type of surgery was arthroscopic plica resection in approximately 95.3% of cases. Only 1 patient underwent open plica resection.[30] Moreover, 4 patients (1.5%) with arthroscopic plica resection un95.3derwent additional procedures[25]; for 3 of them, the additional procedure was concurrently performed and unrelated to snapping plicae. However, 1 patient had a redundant plica despite resection. The redundant plica was then sutured back to the olecranon with a suture anchor. Thickened synovial plicae were described in 271 patients (97.1%). Associated intra-articular abnormalities were described as synovitis (35 patients; 12.9%) and chondromalacia of the radial head (25 patients; 9.2%) and capitellum (9 patients; 3.3%). Overall, 4 studies provided histological findings for 13 patients with

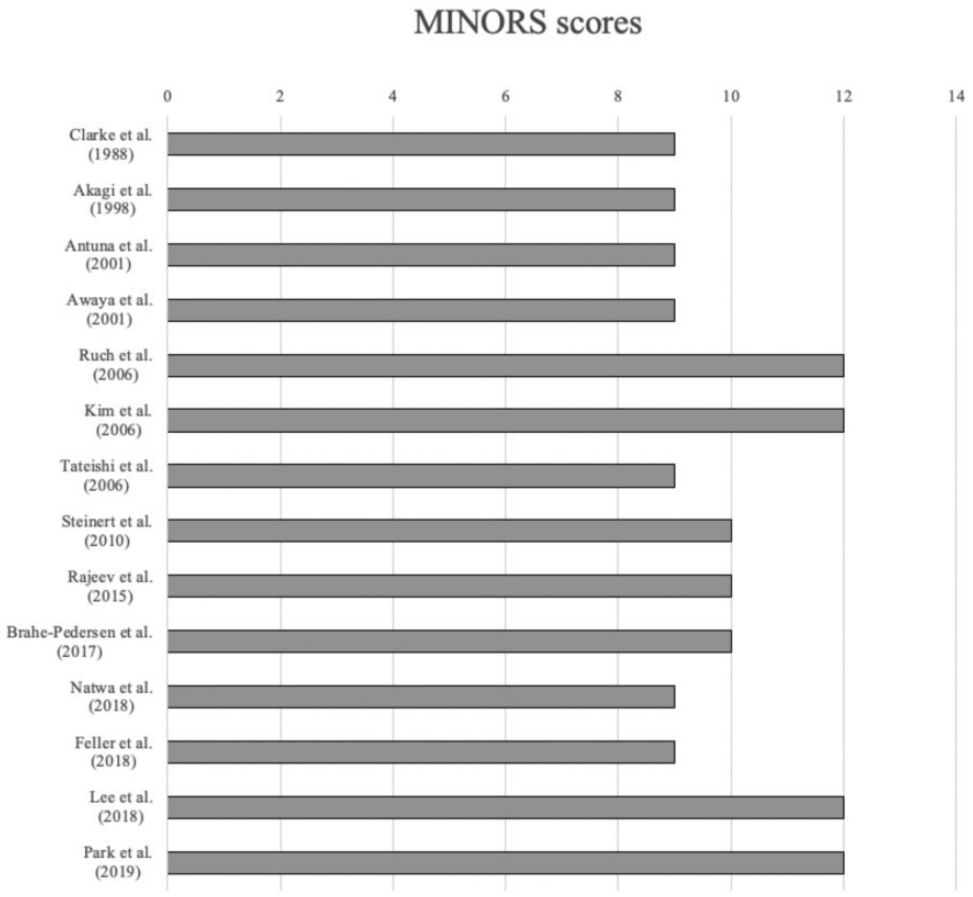

Figure 2. Distribution of Methodological Index for Non-Randomized Studies (MINORS) scores and the range considered as high-quality studies.

resected specimens, which were described as chondroid metaplasia of the synovial fold,[1] synovitis,[3,6] and fibrous tissue.[30] The intra-articular location of synovial plicae was specified in 84 patients. The locations of synovial plicae in respective order were posterior (44.0%), posterolateral (28.6%), anterolateral (4.8%), anteroposterior (4.8%), and anterior (1.2%). Table 3 summarizes the intraoperative characteristics of these patients.

Postoperative Outcomes

Of 265 patients with postoperative ROM descriptions, 36 (13.6%) reported improvements in ROM. Only 1 patient had a 20° flexion deficit due to pain. The remaining patients showed no changes in ROM after surgery. Overall, 6 studies (247 patients; 88.5%) provided functional outcome scores, ranging from good to excellent. Of 218 patients with descriptions of residual symptoms and recurrences, 26 (11.9%) had residual symptoms, and 1 (0.5%)[2] had a recurrence of symptoms. The residual symptoms were varied and were mainly described as pain and mechanical symptoms.[2,14,17,23,24,29] The status of return to activity (sports or work) was described in 140 patients. Most of the patients were able to return to activity (137 patients; 97.9%). Of 109 patients, 70 (64.2%) reported that they were satisfied after surgical treatment. However, 39 patients (35.8%) were dissatisfied after surgical treatment. There were 3 studies that provided the reasons for remaining symptoms: the presence of chondromalacia of the radial head,[17,29] the underestimation of intra-articular abnormalities during imaging with ultrasonography,[4] and scar formation after previous surgical interventions.[17] Complications were reported in 5 patients (1.8%) as revision surgery (1 patient),[2] posterolateral rotatory instability (1 patient),[2] medial elbow instability (1 patient),[14] and a superficial wound infection resolved by oral antibiotic administration (2 patients).[24] Table 4 summarizes the postoperative outcomes.

DISCUSSION

The most important finding of this study was that surgical resection of symptomatic synovial plicae showed favorable results. This systematic review included 3 components associated with the surgical outcome: misdiagnosis, investigation, and prognosis.

Thickened plicae have been linked to overuse injuries and trauma and introduced as a source of lateral elbow

TABLE 1
Article and Demographic Characteristics[a]

Author (Year)	Study Type (LOE)	No. of Patients (Elbows)	Age,[b] y	Sex, M/F, n (%)	Follow-up,[b] mo	Associated History	Sporting Activities/ Heavy Labor	Comorbidities	Trauma	Dominant Extremity Affected	Symptom Duration,[b] mo
Clarke[6] (1988)	Case series (4)	3	31.6 (18-48)	2 (66.7)/1 (33.3)	9.6 (4-13)	—	Basketball	—	Olecranon contusion 2 mo previously	No	>3
						—	Tennis	—	—	Yes	1
						—	Vigorous housework	Recalcitrant LE	—	Yes	3
Akagi[1] (1998)	Case report (5)	1	27	1 (100.0)/0 (0.0)	1.5	Painless snapping since childhood	Heavy lifting	—	—	No	3
Antuna[2] (2001)	Case series (4)	14	36 (27-48)	8 (57.1)/6 (42.9)	24 (6-66)	5 (35.7%) were initially diagnosed with intra-articular loose bodies	—	4 (28.6%) had recalcitrant LE	2 (14.3%) had undisplaced radial head fractures	10 (71.4%)	13 (8-36)
Awaya[3] (2001)	Case series (4)	8	28.3 (17-37)	8 (100.0)/0 (0.0)	24	6 (75.0%) presented with symptoms mimicking loose bodies	2 (25.0%) were professional athletes	—	—	—	≤1 after MRI (not specified)
Ruch[25] (2006)	Case series (4)	10	40 (18-60)	4 (40.0)/6 (60.0)	25 (6-68)	All were initially diagnosed with LE	—	—	—	—	6
Kim[14] (2006)	Case series (4)	12	21.6 (17-33)	9 (75.0)/3 (25.0)	33.8 (24-65.5)	6 (50.0%) were initially diagnosed with LE	7 baseball pitchers, 2 softball pitchers, 3 golfers	—	—	11 (91.7%)	9.25 (3-24.5)
Tateishi[30] (2006)	Case report (5)	1 (2)	64	0 (0.0)/1 (100.0)	24 (right elbow), 48 (left elbow)	—	Dumbbell exercise (left elbow), farming (right elbow)	—	—	Yes	3 (left elbow), 4 (right elbow)
Steinert[29] (2010)	Case series (4)	3	48.6 (27-65)	3 (100.0)/0 (0.0)	30 (6-48)	—	—	—	1 (33.3%) had nonspecific trauma	—	7.7 (5-9)
Rajeev[24] (2015)	Case series (4)	121	38 (24-56)	92 (76.0)/29 (24.0)	12	All were initially diagnosed with LE	—	—	—	—	—
Brahe Pedersen[4] (2017)	Case series (4)	60 (64)	44 (18-66)	17 (28.3)/43 (71.7)	22 (12-31)	—	25 (41.7%) were manual workers	—	—	—	—
Natwa[21] (2018)	Case report (5)	1	NA	1 (100.0)/0 (0.0)	3	—	Baseball pitcher	—	—	Yes	4
Feller[9] (2018)	Case report (5)	1	59	1 (100.0)/0 (0.0)	24	—	Heavy labor (shipyard welder)	LE	—	—	3 after index surgery
Lee[17] (2018)	Case series (4)	20	42 (18-63)	11 (55.0)/9 (45.0)	34.8 (24-74.4)	—	—	—	5 (25.0%) had nonspecific trauma	13 (65.0%)	15.7 (4-60)
Park[23] (2019)	Case series (4)	24	44 (15-62)	18 (75.0)/6 (25.0)	24 (minimum)	Initial diagnosis: 20 (83.3%) with LE, 1 (4.2%) with OCD of capitellum, 1 (4.2%) with loose bodies, 1 (4.2%) with synovitis, 1 (4.2%) with synovitis and loose bodies	—	—	2 (8.3%) had direct trauma to elbow, 1 (4.2%) had a		
						hyperextension injury	13 (54.2%)	19.8 (2-52)			

[a]F, female; LE, lateral epicondylitis; LOE, level of evidence; M, male; MRI, magnetic resonance imaging; NA, not available; OCD, osteochondritis dissecans.

[b]Data are shown as mean or mean (range).

pain.[14,17,21,30] This systematic review showed that sports activities[6,14,21] and heavy labor[1,4,6,9] may serve as triggering factors. Although nonspecific, traumatic events may be responsible for triggering factors.[2,3,17,23,29] This suggests that an injury, including repetitive microtrauma from overuse, can cause symptomatic synovial plica syndrome. As a result of repetitive microtrauma, the plica may became inflamed, which explains thickening of the structure. Thickened plicae are most likely compressed between adjacent articular surfaces (capitellum and radial head); these illustrate pain and snapping as symptoms, which are more provoking in the dominant extremity, as shown in this review. Therefore, it is not advisable to ignore a history of overuse injuries in this clinical condition. Symptomatic synovial plicae can easily be misdiagnosed as lateral epicondylitis because of the similar pain location at the lateral aspect of the elbow. However, tenderness at the posterolateral soft spot may serve as a hint to differentiate plica syndrome from lateral epicondylitis.[14] In cases where lateral epicondylitis coexists with symptomatic synovial plicae, the source of lateral elbow pain will be difficult to establish. An anatomic study has shown that the synovial plica is a continuation of the anatomic structure of the radiocapitellar joint capsule with a common extensor origin.[31] This means that the source of lateral elbow pain can be generated from the shared single enthesis.[31]

Nonoperative treatment has always been the preferred method of treatment of symptomatic synovial plicae. Some studies suggest nonoperative therapy for at least 2 or 3 months before trying surgical interventions.[21] However, the exact cutoff period of nonoperative treatment remains inconclusive. This systematic review showed that most studies tend to proceed with operative treatment when

TABLE 2
Preoperative Characteristics[a]

Author (Year)	Pain	Mechanical Symptoms	Description of Mechanical Symptoms	Preoperative ROM	Radiological Examination	Radiological Findings	Previous Steroid Injection or Surgery
Clarke[6] (1988)	Yes	Yes	Locking	Full	Radiography	Normal	Single steroid injection
			Clicking, reproducible locking	10° extension deficit	Radiography	Loose body in anterior compartment	Repeated steroid injection
			Catching, popping	NA	Radiography	Normal	Repeated steroid injection
Akagi[1] (1998)	Yes	Yes	Catching, snapping	Full	Radiography, pneumoarthrography	Radiography: normal; pneumoarthrography: intra-articular cord in radiohumeral joint	None
Antuna[2] (2001)	Yes	Yes	Snapping (7 [50.0%] were reproducible)	Within normal limits	Radiography, MRI (6 [42.9%])	Radiography: normal; MRI: normal in 5 patients and mild edema of annular ligament in 1 patient	4 (28.6%) received local corticoid injections, 4 (28.6%) underwent previous surgery (LE, loose bodies, PIN entrapment, elbow instability)
Awaya[3] (2001)	No	Yes	Locking	NA	MRI	Synovial plicae with thickness of 3.1 mm (range, 2-5 mm), projecting focal fat pad superoposterior to olecranon recess	None
Ruch[25] (2006)	Yes	9 (90.0%)	Snapping	7 (70.0%) had full, 3 (30.0%) had extension deficit of 7°-20°	NA	NA	All patients received local steroid injections (to exclude LE)
Kim[14] (2006)	Yes	7 (58.3%)	Snapping, clicking, catching	Extension-flexion: 6°-136°; pronation-supination: 85°-80°	Radiography, MRI, MRA (5 [41.7%])	Radiography: NA; MRI: 9 (75.0%) with abnormal plicae (>3 mm in thickness, irregular or nodular in appearance)	8 (66.7%) received single steroid injection
Tateishi[30] (2006)	Yes	Yes	Snapping	Extension-flexion: 0°-135°; pronation-supination: 90°-90°	Right elbow: radiography, MRI, MRA; left elbow: NA	Radiography: normal; MRI: triangular tissue extruding from articular capsule at anterior portion of radiohumeral joint; MRA: protruding shadow whose location matched with MRI result	None
Steinert[29] (2010)	Yes	Yes	Snapping	Full	Radiography, MRI	Radiography: normal; MRI: thickened synovial plicae (>3 mm in thickness) in 2 patients	None
Rajeev[24] (2015)	Yes	Not described	NA	NA	MRI (No. of patients not specified)	NA	None
Brahe Pedersen[4] (2017)	Yes	Yes	Catching, snapping	7 (11.7%) had decreased ROM (not specified)	US	Hypoechoic rims between radial head and capitellum	At least 1 steroid injection
Natwa[21] (2018)	Yes	No	NA	Full	Radiography, MRI, MRA	Radiography, MRI: normal; MRA: posterolateral joint capsular tear and adjacent synovial hypertrophy	None
Feller[9] (2018)	Yes	Yes	Snapping	Full	MRI, US	MRI: common extensor tendinopathy, thickened RCL; US: entrapment of synovial fold to radiohumeral joint during elbow flexion	Arthroscopic debridement of ECRB and resection of synovial plicae
Lee[17] (2018)	Yes	10 (50.0%)	Catching, snapping	6 (30.0%) had mild extension deficit of 5°-20°	Radiography, MRI	Radiography: NA; MRI: meniscus-like synovial plicae (mean thickness, 3.7 ± 1.0 mm; mean mediolateral length, 9.4 ± 1.6 mm; mean anteroposterior length, 8.2 ± 1.7 mm)	7 (35.0%) received single steroid injection
Park[23] (2019)	6 (25.0%)	9 (37.5%)	Catching, snapping	6 (25.0%) had extension deficit of 12°-20°	MRI	17 (70.8%) with thickened plicae (>3 mm), 7 (29.2%) with synovial proliferation	—

[a]ECRB, extensor carpi radialis brevis; LE, lateral epicondylitis; MRA, magnetic resonance arthrography; MRI, magnetic resonance imaging; NA, not available; PIN, posterior interosseous nerve; RCL, radial collateral ligament; ROM, range of motion; US, ultrasonography.

nonoperative methods fail to show an improvement in 6 months. A history of steroid injections is perhaps the most interesting issue to be discussed. Although most studies did not clarify the protocol for steroid injection use, it was indicated as a diagnostic tool for the treatment of lateral epicondylitis by Ruch et al[25] and as nonoperative treatment of lateral epicondylitis by Antuna and O'Driscoll.[2] A steroid injection was reported to offer no direct benefit to irritated medial plicae in the knee joint because it aims to alleviate internal derangement of the knee so that the patient can participate in an exercise program to suppress the symptoms.[10] In the elbow joint, a steroid injection was reported to provide temporary relief[14] for inflammation; therefore, it may have an impact as part of a nonoperative measure alongside guided physical therapy.

Snapping synovial plicae can be misdiagnosed as lateral epicondylitis, intra-articular loose bodies, and snapping of the triceps tendon.[21] This review showed that 3 main symptoms describe snapping synovial plicae: (1) lateral elbow pain; (2) mechanical symptoms; and (3) ROM deficit, particularly extension. The first 2 symptoms are motion dependent. Lateral elbow pain presented in all cases can be explained by the presence of nerve fibers[7] in the folds as well as the release of cytokines and other inflammatory mediators.[6] Therefore, the term "elbow synovial fold syndrome" or "plica syndrome of the elbow" may be appropriate to describe this condition because of the existence of a spectrum of symptoms.[3,21] Preoperative imaging has shown that plain radiographs are not very helpful in diagnosing snapping synovial plicae, except that they are used to exclude intra-articular loose bodies.[1,2,6,14,17,21,29,30] Snapping synovial plicae can be considered internal derangement of the elbow joint; therefore, MRI will be very helpful as a diagnostic tool.¶ MRI is an excellent tool to detect the structure of synovial plicae; however, it cannot distinguish pathological plicae from normal plicae. In their

¶References 2, 3, 9, 14, 17, 21, 23, 24, 29, 30.

TABLE 3
Intraoperative Characteristics[a]

Author (Year)	Surgery Type	Intraoperative Findings	Histological Findings	Plica Location
Clarke[6] (1988)	Arthroscopic synovial band excision and synovectomy	(1) Synovial band that fell between radial head and capitellum during pronation and extension, (2) diffuse synovitis, (3) radial head chondromalacia	Synovitis with acute and chronic fibrotic changes	Anterolateral
	Arthroscopic synovial fringe excision and synovectomy	(1) Synovial fringe, (2) mild synovitis, (3) radial head chondromalacia		Anterolateral
	Arthroscopic synovial fringe excision and synovectomy	(1) Inflamed synovial fringe, (2) synovitis, (3) radial head chondromalacia		Anterolateral
Akagi[1] (1998)	Arthroscopic assisted synovial cord resection	(1) Synovial cord that disappeared from radiohumeral joint when elbow was flexed >100°, (2) degenerative changes in anterolateral aspect of radial head	Dense collagen fiber bundles of matrix with chondroid metaplasia of synovial fold	Anterolateral
Antuna[2] (2001)	Arthroscopic synovial plica resection and synovectomy	(1) Synovial plica that was thickened and inflamed and appeared as extension of annular ligament, (2) local synovitis adjacent to plica, (3) 13 (92.9%) with chondromalacia of anterolateral aspect of radial head, (4) 3 (21.4%) with capitellar erosion	—	Lateral
Awaya[3] (2001)	Synovial plica resection (not specified for arthroscopic or open surgery)	NR	Chronic synovitis	Posterior
Ruch[25] (2006)	6 (60.0%) underwent arthroscopic synovial plica resection, 4 (40.0%) underwent additional procedures (transposition of ulnar nerve, ulnar nerve decompression, loose body removal, posterolateral ligamentous complex repair)	Inflamed synovial fold that occupied one-third of posterior aspect of radial head	—	Posterior
Kim[14] (2006)	Arthroscopic synovial plica resection	(1) Thickened and hypertrophic synovial plica, (2) synovitis and inflammation of capsular tissue in 8 (66.7%), (3) chondromalacia of capitellum in 5 (41.7%) and of radial head in 2 (16.7%)	—	NR
Tateishi[30] (2006)	Open resection of synovial fold	Elastic hard tissue located at superior edge of annular ligament that interposed between radial head and capitellum of humerus	Fibrous and fatty connective tissue	NR (left elbow), posterior (right elbow)
Steinert[29] (2010)	Arthroscopic synovial plica resection	(1) Hypertrophic synovial plica, (2) synovitis in 1 (33.3%), (3) chondromalacia of anterior part of radial head in 1 (33.3%)	—	Posterior
Rajeev[24] (2015)	Arthroscopic synovial plica resection	Thickened and inflamed humeroradial synovial plica	—	NR
Brahe Pedersen[4] (2017)	Arthroscopic synovial plica resection	Cartilage injury (ICRS grade 1) at radial head associated with synovial plica	—	NR
Natwa[21] (2018)	Arthroscopic synovial plica resection	Redundant tissue and scar formation at radiocapitellar joint	—	NR
Feller[9] (2018)	Arthroscopic resection of proximal portion of annular ligament	(1) First surgery: hypertrophic synovial plicae interposed between radiohumeral joint, (2) second surgery: thickened and partially torn annular ligament that subluxed over radial head during elbow extension-flexion	—	NR
Lee[17] (2018)	Arthroscopic synovial plica resection	Enfolded synovial mass that extended over one-third of posterior aspect of radial head	—	Posterior in 15 (75.0%), anterior in 1 (5.0%), both posterior and anterior in 4 (20.0%)
Park[23] (2019)	Arthroscopic synovial plica resection	(1) Synovitis in 9 (37.5%); (2) chondromalacia of radial head in 3 (12.5%), capitellum in 1 (4.2%), and both radial head and capitellum in 3 (12.5%)	—	Posterolateral

[a]ICRS, International Cartilage Repair Society; NR, not reported.

study on the value of MRI in establishing symptomatic plicae, Lee et al[17] found that the mean thickness of a pathological plica was 3.7 mm. However, Ruiz de Luzuriaga et al[26] reported that a plica would be considered pathological when it was thicker than 2.6 mm, which was compared with a control group with an average of 1.8 mm.[23] Hence, given the inconclusive findings, the cutoff thickness of a pathological plica is yet to be defined. MRI is also valuable to locate the position of plicae vis-à-vis the radial head quadrant. No consensus exists on the position of plicae and whether they can be considered symptomatic. However, considering the findings of this systematic review and the thickness of plicae, we can argue that plicae located in the posterior to lateral quadrant, which constituted up to 89.3% of the symptomatic plica, may be related to symptoms. MRI plays a major role in preoperative imaging, mainly because of its ability to detect the structures, dimensions, and positions of plicae in their relative coverage area to the radial head. It can also detect the secondary signs of concurrent abnormalities by assessing synovitis and possible chondral changes,[14] which may be suggestive of snapping synovial plicae. Considering its noninvasive nature, MRI is helpful as an initial examination vis-à-vis arthroscopic surgery as a gold standard of diagnostic tools.

Most of the surgical resection procedures of symptomatic plicae were arthroscopically performed owing to its for diagnosing intra-articular abnormalities. Histological descriptions of pathological plicae are rare, as reported by only 4 studies[1,3,6,30]; they resemble the medial plicae presented in the knee joint, which also showed the presence of synovitis, deep fibrosis, and metaplasia of plicae.[8,27] A history of blunt trauma may cause metaplasia of plicae,[8,27] which was reported by 5 studies.[2,6,17,23,29] We postulate that elastic synovial plicae turn into a thickened inelastic structure because of fibrotic and metaplastic changes; hence, these should be considered a precursor of plica syndrome, which is also shown in the knee joint.[27]

This systematic review illustrates the necessity of establishing a standard outcome measurement tool. Interestingly, although several outcome measurement tools were used, only the modified elbow scoring system included mechanical symptoms as one of the measured parameters.

TABLE 4
Postoperative Outcomes[a]

	Quantitative Assessment			Qualitative Assessment					
Author (Year)	Outcome Measurement Tool	Functional Score[b]	Postoperative ROM	Symptom Resolution	Recurrent/Residual Symptoms	Return to Work/Sports	Satisfaction	Complications or Revision Surgery	Reason for Partial Improvement
Clarke[6] (1988)	None	NA	NA	Yes	No	1 (33.3%), NR for 2 (66.7%)	NA	No	–
Akagi[1] (1998)	None	NA	NA	Yes	No	Yes (at 3 wk)	NA	No	–
Antuna[2] (2001)	None	NA	Same as preoperative (within normal limits)	10 (71.4%)	4 (28.6%): 2 with residual mild pain with strenuous use of elbow, 1 with mild PLRI, 1 with recurrence of symptoms	NA	9 (64.3%) much better, 3 (21.4%) better, 2 (14.3%) same	2 (14.3%) with revision: 1 for arthroscopic plica resection, 1 for residual PLRI	NR
Awaya[3] (2001)	None	NA	NA	Yes	No	NA	NA	No	–
Ruch[25] (2006)	DASH	9 (0-37)	Full	Yes	No	NA	NA	No	–
Kim[14] (2006)	MEPS	92.5 (75-100) = excellent	Extension-flexion: 2°-139°; pronation-supination: 80°-88°	6 (50.0%)	2 (16.7%) with residual snapping, 4 (33.3%) with residual pain	11 (91.7%)	All satisfied	1 (8.3%) with UCL reconstruction due to medial elbow instability	–
Tateishi[30] (2006)	None	NA	Full	Yes	No	Yes	NA	No	–
Steinert[29] (2010)	None	NA	Full	2 (66.7%)	1 (33.3%) with residual pain	NA	All satisfied	No	Chondromalacia of radial head
Rajeev[24] (2015)	Modified elbow scoring system	93.2 (72-100) = excellent	Extension-flexion: 3°-135° (130°); full pronation-supination	118 (97.5%)	3 (2.5%) with residual pain	Mostly	NA	2 (1.7%) with superficial wound infection resolved with oral antibiotics	NR
Brahe Pedersen[4] (2017)	OES	Preoperative: 19 (17-20), postoperative: 35 (32-38)	1 (1.7%) with 20° flexion deficit (due to pain)	NA	NA	NA	27 (45.0%)	No	Missing >1 abnormality in elbow because investigation was only with US
Natwa[21] (2018)	None	NA	NA	Yes	No	Yes (at 3 mo)	NA	No	–
Feller[9] (2018)	None	NA	NA	Yes	NA	Yes (at 3 mo)	NA	No	–
Lee[17] (2018)	MEPI, VAS, DASH	MEPI preoperative: 66, MEPI postoperative: 89 = good; DASH preoperative: 26, DASH postoperative: 14.1; VAS preoperative: 6.3, VAS postoperative: 1	Extension deficit improved (not specified)	8 (40.0%)	12 (60.0%)	NA	7 (35.0%) completely satisfied, 9 (45.0%) mostly satisfied, 4 (20.0%) neutral	No	Possibly pre-existing chondromalacia or scar formation after surgical trauma
Park[23] (2019)	DASH, MEPS	DASH preoperative: 36.6, DASH postoperative: 8.9; MEPS preoperative: 56.9, MEPS postoperative: 95.6	2 (8.3%) with improvement of extension deficit	20 (83.3%)	1 (4.2%) with intermittent snapping	NA	NA	No	–

[a]DASH, Disabilities of the Arm, Shoulder and Hand; MEPI, Mayo Elbow Performance Index; MEPS, Mayo Elbow Performance Score; NA, not available; NR, not reported; OES, Oxford Elbow Score; PLRI, posterolateral rotatory instability; ROM, range of motion; UCL, ulnar collateral ligament; US, ultrasonography; VAS, visual analog scale.

[b]Data are shown as mean or mean (range).

The mechanical symptom is a major presenting symptoms despite pain. Accordingly, we strongly recommend using the modified elbow scoring system for clinical assessments. Despite the heterogeneity of the outcome measurement tools used in the studies presented in this review, surgical resection of symptomatic synovial plicae showed good to excellent results. This review showed that removing plicae will most likely help with symptom resolution. In patients with partial resolution, pain and mechanical symptoms were reported as common residual symptoms.[2,14,17,23,24,29] The reason for partial resolution was rarely discussed, despite the potential implications of this decision. In this review, however, we postulate that having associated chondromalacia and failing to identify associated elbow abnormalities are reasons for partial resolution. This assumption is supported by other studies that argue that surgical resection of the medial plica of the knee joint yields better clinical outcomes without coexisting cartilage lesions.[22] Therefore, attempts to establish direct correlations between favorable results of surgical treatment are questionable mainly because many confounding factors are at play in associated intra-articular abnormalities, which may affect prognoses.[17,29] We also suggest that an assessment of the possible chondral changes on preoperative MRI might be worthwhile before surgical treatment. Another notable concern about surgical resection of plicae is whether they will grow back after incomplete resection (division), as reported for knee joints.[8,10] This systematic

review was unable to address this concern in the elbow joint.

This systematic review revealed an interesting point regarding the satisfaction rate and residual symptoms. Although only approximately 9.3% of patients had residual symptoms, 35.8% were dissatisfied after the surgical procedure. It is unclear how the satisfaction rate was associated with residual symptoms. For example, 1 study[14] described that a patient was satisfied with undergoing surgery. However, the patient also stated that if he could choose again, he would not have undergone the surgical procedure. Furthermore, not all studies provided details of each patient, which prevents a direct association between the satisfaction rate and residual symptoms. Moreover, the literature has reported that the satisfaction rate has been shown to be influenced by many factors, including clinical care, patient outcomes, and hospital/surgical experience. This could explain the reason for dissatisfaction in the absence of complications.[11]

Limitations

This review has some limitations. First, none of the studies had a control group to enable a comparison of the effects of nonoperative treatment of elbow plicae. Second, data from the included studies were collected retrospectively. Third, the studies' outcome measurement tools were heterogeneously reported, preventing a direct comparison of outcomes and undermining the need for standardized methods. Last, only 7 studies were classified as high-quality studies based on the MINORS criteria.

CONCLUSION

Plica resection yields favorable outcomes when a thorough diagnostic approach is used to exclude coinciding morbidity. Coexisting chondromalacia and the failure to identify concomitant intra-articular abnormalities may be associated with inferior results. The variability in outcomes assessed in previous studies necessitates the immediate requirement of a consensus on reporting functional outcomes after surgical resection of plicae.

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