Systematic Review of Elbow Instability in Association With Refractory Lateral Epicondylitis

Myth or Fact?

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Background: Elbow instability, particularly posterolateral rotatory instability (PLRI), has been reported in patients with refractory lateral epicondylitis (LE). However, evidence of diagnostic approach and surgical outcomes is lacking.

Purpose: To identify (1) the risk factors, clinical and radiologic-diagnostic characteristics, and (2) the treatment options and clinical outcome of LE with PLRI.

Study design: Systematic review.

Methods: We searched the PubMed, Ovid/MEDLINE, Cochrane Library, Google Scholar, Scopus, and EMBASE databases using keywords as well as Medical Subject Headings terms and Emtree using ''(lateral epicondylitis OR tennis elbow) AND (instability OR posterolateral rotatory instability)'' for English-language studies. We conducted a systematic review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Results: In total, 8 articles comprising 6 level 4 and 2 level 3 studies were identified, including 249 patients (254 elbows). The main triggering factor was heavy labor activity (74/172; 43%). A total of 184 patients (73.9%) received either single (4/184; 2.2%) or multiple (180/184; 97.8%) steroid injections. Clinically, instability was always accompanied by pain in 9% of study individuals. Magnetic resonance imaging (MRI) revealed that radial collateral ligament (RCL) and lateral ulnar collateral ligament (LUCL) lesions were most common (18/79; 23%). The most common surgical procedure performed was arthroscopic RCL plication (62/120; 52%) followed by LUCL reconstruction (30/120; 25%). A ligament patholaxity sign was shown intraoperatively for 64% (44/69). Clinical outcomes ranged from good to excellent in all studies. The most common residual symptom was limited range of motion (11/18; 61%).

Conclusion: Instability can coexist and may be associated with refractory LE. The risk factors of instability associated with refractory LE are heavy labor and multiple steroid injections. A systematic approach to identify the clinical and MRI presentation of the condition followed by examination under anesthesia are necessary for affirmative diagnosis, as independent presentations may be misleading.

Keywords: lateral epicondylitis; elbow tendinopathy; joint instability; systematic review; treatment outcome

The main lesion in lateral epicondylitis (LE) is at the origin of the extensor carpi radialis brevis (ECRB) and is thought to arise after microtrauma and repetitive injury.[20] Generally, symptoms will resolve within a year using nonoperative measures as the first line of treatment.[5] However, 25% of the patients develop refractory symptoms.[6] LE may exist either as a singular entity or coexist with radial tunnel syndrome, elbow instability, or intra-articular lesions such as plica.[4,13,20,22,25]

Elbow instability, particularly posterolateral rotatory instability (PLRI), has been reported as a concurrent finding in refractory LE.[1,2,8,10,13-15,27] Associated ligament insufficiency has been shown to induce elbow instability, and PLRI has been reported after a traumatic event,[10] corticosteroid injections,[1,2,8,13-15,27] and iatrogenic injury during LE surgery.[19] These conditions may coexist, and when they do, it may be difficult to identify the main triggering factor. This situation makes the recording of patient history, physical examination, and diagnostic imaging important to establish a relevant diagnosis. In the case of PLRI after a traumatic event, patients have reported a change in pain characteristics along with elbow instability.[10] Corticosteroid injections are effective for eliminating pain in patients with LE; however, the effect is usually only

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transitory. Basic science studies have shown that corticosteroid injection into the tendon and ligament origins may contribute to weakening these structures, ultimately resulting in mechanical failure.[12,30] Apparently, even minor traumas can provoke PLRI in the ligament-deficient joint. Therefore, PLRI of the elbow joint should always be considered in the differential diagnosis of either refractory or recurrent symptoms of LE.

Despite the studies describing the combination of LE and PLRI of the elbow, up until now, there have been inconsistencies in data regarding both the diagnosis of instability and the clinical outcome. The purposes of this systematic review were to describe (1) the risk factors, clinical and radiologic diagnostic characteristics, and (2) the treatment options and clinical outcome for patients with LE with PLRI.

METHODS

Search Strategy and Study Selection

This systematic review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[17] guidelines. The PubMed, Ovid/MEDLINE, EMBASE, Cochrane Library, Scopus, and Google Scholar databases were searched using keywords conforming to Medical Subject Headings and Emtree to identify relevant articles. Natural keywords were chosen to increase sensitivity: "(lateral epicondylitis OR tennis elbow) AND (instability OR posterolateral rotatory instability)."

The number of studies was limited; thus, there were no restrictions with regard to specific surgical procedures, publication status, or study period. After eliminating duplicate documents, 2 independent reviewers (E.K. and H.L.) screened the titles and abstracts to select the first round of candidate articles; the final articles were identified through a full-text review. We also conducted citation tracking in the bibliographies of the retrieved studies to identify additional related articles. Any disagreement that arose in the selection process was resolved by group discussion or intervention by a third reviewer (H.K.). Figure 1 displays the flow of the study selection.

Inclusion and Exclusion Criteria

All included studies contained original data published in the English language. Studies on diagnosis, imaging, and treatment of patients undergoing surgical procedures for PLRI associated with LE were included. Studies describing imaging techniques and/or using cadavers were excluded.

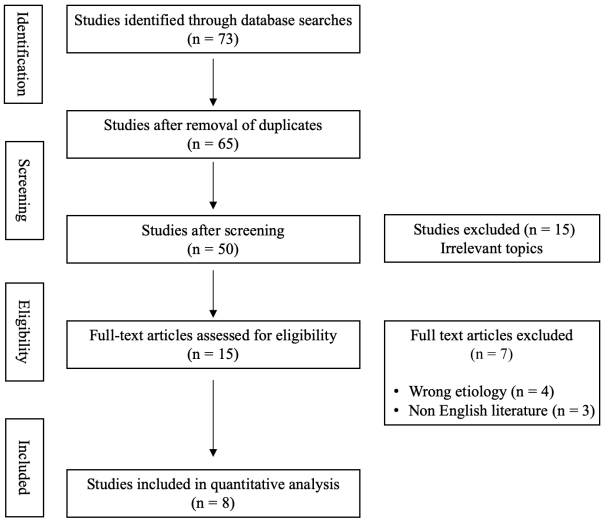

Figure 1. The flow of the article inclusion process adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[18]

Quality Appraisal and Risk of Bias

Four reviewers (E.K., H.L., H.K., and J.-M.K.) independently reviewed each of the articles that were finally included and decided whether to include or exclude any study based on discussion and consensus. The level of evidence of each study was determined according to the criteria stipulated by the Oxford Centre for Evidence-Based Medicine.[21] Decisions on inclusion or exclusion were discussed with 2 expert orthopaedic surgeons specializing in elbow surgery (K.-H.K. and I.-H.J.). The Methodological Index for Nonrandomized Studies (MINORS) was used to assess the risk of bias of each study.[28] The evaluation items of the MINORS tool comprised 8 common items and 4 additional items for studies with a comparative group. Each item was scored with 0, 1, or 2, giving maximum scores of 16 points for a noncomparative study and 24 points for a comparative study.[18] The higher the total score, the lower the risk of introduced bias. As there was no consensus regarding the cutoff point for MINORS assessment, in the current study a score >60% of the total score with the MINORS evaluation tool (14 of 24 points or 9 of 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

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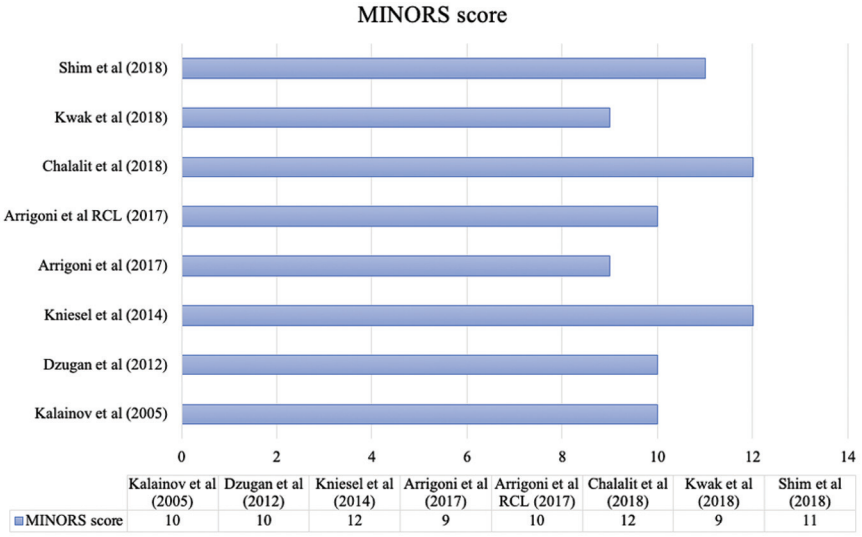

Figure 2. Distribution of the Methodological Index for Nonrandomized Studies (MINORS) scores and the range of studies considered high-quality. RCL, radial collateral ligament.

data included the following: (1) article and patient characteristics; (2) preoperative characteristics (symptoms, radiologic investigations and findings, and status of steroid injection and previous surgery); (3) intraoperative characteristics (type of surgery, intraoperative findings); and (4) postoperative outcomes (functional outcome assessment). We performed a qualitative assessment of all studies and produced a narrative report. The postoperative characteristics for the open and arthroscopic surgery were described. 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. Collated data were summarized in tables using Microsoft Office Excel (2013; Microsoft).

RESULTS

Article Inclusion

A total of 73 articles were retrieved for initial screening (Figure 1); the titles and abstracts of these articles were examined for duplication. Conference abstracts were excluded from the review. Full-text reviews of 15 articles resulted in the identification of 8 articles (6 level 4 and 2 level 3 studies) for the systematic review.

Study Quality Assessment

In the bias risk assessment, the mean score for all 8 studies was 10.3. There were no comparative studies. Figure 2 shows the distribution of MINORS scores and the range of studies considered high-quality. Six articles were considered high-quality studies with a low risk of bias, exceeding 60% of the total points.

Article and Patient Characteristics

The 8 included articles comprised 249 patients (254 elbows) with LE with associated elbow instability (Appendix Table A1, available in the online version of this article). The study population included 83 men (46.1%) and 97 women (53.9%), and the mean age was 48.3 years. The dominant extremity was affected in 65.8% (123/187).[2,3,13,15] The triggering factors were documented in 5 studies[10,13-15,27] and comprised heavy labor activity (74/172; 43%), a history of trauma (11/203; 5.4%), and sports activity (1/172; 0.6%). Not all studies described all measured parameters. A total of 97.1% (242/249) patients had experienced symptoms for at least 6 months before surgical treatment.

Preoperative Characteristics

Data on preoperative characteristics are collated in Appendix Table A2 (available online). Physical examination revealed that pain was the most common symptom (187/249; 75%). Instability symptoms were always accompanied by pain in 9% of the study individuals (23/249). For 35 patients (14%), symptoms were not described.[2] The most common instability test performed in-office was the posterolateral drawer test (22/68; 32%), followed by the varus stress test (17/68; 25%), and the lateral pivot-shift test (15/68; 22%). The preoperative range of motion (ROM) and functional score were only documented in 171 patients.[1,8,10,15,27]

Standard plain elbow radiographs had been taken for most of the patients. However, only 177 of 254 elbows (70%) had undergone a magnetic resonance imaging (MRI) examination (Figure 3). There were no studies reporting unremarkable MRI findings. MRI findings were reported for 79 patients and revealed signs of instability with ligament lesion as the most common finding (49/79; 62%). The most common ligament lesion was injury to

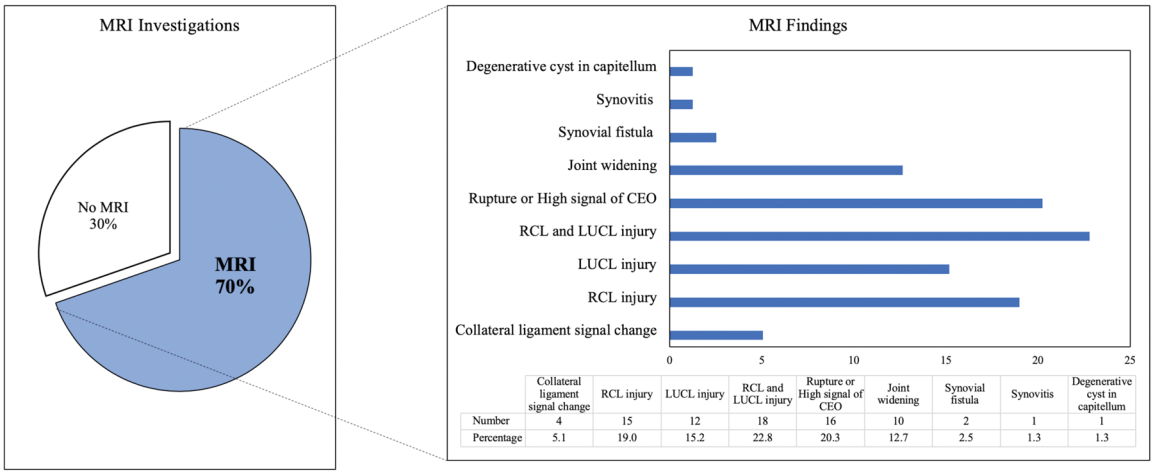

Figure 3. The distribution of magnetic resonance imaging (MRI) investigations and findings. The numbers in the horizontal axis in the bar plot reflect proportions (%). CEO, common extensor origin; LUCL, lateral ulnar collateral ligament; RCL, radial collateral ligament.

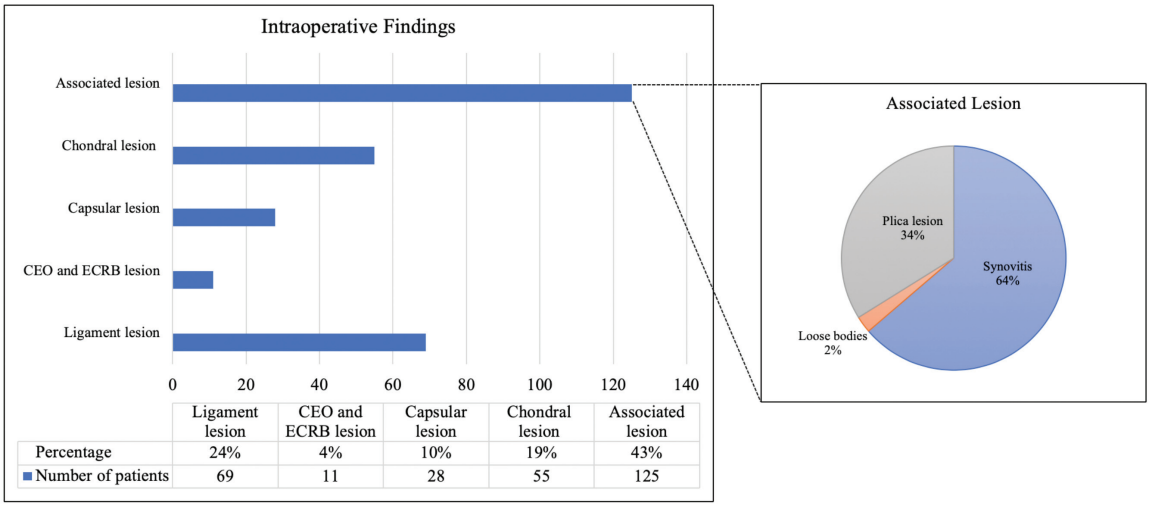

Figure 4. The distribution of intraoperative findings. The numbers in the horizontal axis in the bar plot reflect the number of patients. ECRB, extensor carpi radialis brevis; CEO, common extensor origin.

the radial collateral ligament (RCL) and the lateral ulnar collateral ligament (LUCL) (18/79; 23%).

Steroid injection was documented in 184 of 249 patients (73.9%). Steroids were given as a single shot in 4 of 184 patients (2.2%) and multiple shots in 180 of 184 patients (97.8%). Four studies (155 of 184 patients; 84.2%) described that their patients received >3 steroid injections.[1,2,13,15]

Intraoperative Characteristics

Data on intraoperative characteristics are listed in Table 1. Examination under anesthesia (EUA) was performed for 60 of 249 patients (24%). The type of EUA performed did not differ for those undergoing lateral pivot-shift test (21/60; 35%), the varus stress test (20/60; 33%), and the posterolateral drawer test (29/60; 48%). The intraoperative findings were classified as main lesions (ligament, extensor, capsular, and chondral lesions) and associated lesions (synovitis, plica, and loose bodies) (Figure 4). Ligament lesions were the most common intraoperative findings and comprised the lateral ligament patholaxity sign (44/69; 64%), LUCL injury (18/69; 26%), RCL and LUCL injury (6/69; 9%), and RCL injury (1/69; 1%).

Surgical intervention for instability was performed for 120 of 254 elbows (47%), and consisted of a main and additional procedure. Two studies included a control group without instability surgery.[14,15] The most common type of surgery was arthroscopic RCL plication (62/120; 52%), followed by LUCL reconstruction (30/120; 25%), LUCL and RCL reconstruction (8/120; 7%) and arthroscopic RCL repair with capsular plication (7/120; 6%). The additional procedures were common extensor origin repair (15/120;

TABLE 1
Intraoperative Characteristics of the Study Population[a]

No.	Article (year)	Intraoperative Findings	Lateral Epicondylitis Procedure	Instability Procedure	Additional Procedure
1	Kalainov and Cohen (2005)[13]	(1) EUA: posterolateral and varus instability (2) CEO lesion: large defect (3) Capsule lesion: attenuation of the posterior tissue; thin and expanded capsular tissue (4) Bare anterior aspect of the epicondyle	NA	(1) LUCL reconstruction (palmaris longus autograft) (2) Anconeus muscle flap	—
		(1) EUA: posterolateral rotatory instability (2) LUCL lesion: partial tear and attenuation (3) CEO lesion: torn and retracted (4) Chondral lesion: chondral defects at radial head and capitellum	Open debridement of extensor origin	(1) LUCL reconstruction (palmaris longus autograft) (2) Augmentation with remnant LUCL (3) Repair of extensor origin (4) Anconeus muscle advancement	—
		(1) EUA: posterolateral rotatory instability (2) ECRB lesion: amorphous tissue	Open debridement of extensor origin	(1) LUCL reconstruction (palmaris longus autograft) (2) Repair of extensor origin	—
2	Dzugan et al (2012)[10]	(1) EUA: posterolateral rotatory instability (2) Ligament lesion: RCL and/or LUCL tear (6 of 7) and RCL avulsion (1 of 7) (3) ECRB lesion: avulsion (2 of 7) and tear (5 of 7)	Arthroscopic debridement of ECRB	(1) Arthroscopic RCL repair (2) Capsular plication	—
3	Arrigoni et al (2017)[2]	(1) EUA: anterior drawer test (15 of 35) (2) Ligament lesion: lateral ligamentous patholaxity (17 of 35) (3) Intra-articular finding: synovitis (27 of 35), capitellar chondropathy (14 of 35)	Arthroscopy (not specified)	Arthroscopic RCL plication	Synovectomy (27 of 35)
4	Arrigoni et al (RCL) (2017)[1]	(1) Laxity signs: annular drive through sign, loose collar sign, R-LCL pull-up sign (2) Intra-articular lesions: synovitis, capsular tear, chondropathy of radial head and capitellum	NA	Arthroscopic RCL plication	Synovectomy and chondroplasty
5	Kniesel et al (2014)[14]	(1) EUA: lateral pivot-shift and posterolateral tests (2) Joint dehiscence: <3 mm (no instability): 25 of 40; 3-6 mm (slight instability): 13 of 40; >6 mm (severe instability): 2 of 40 (3) Chondral lesion: chondromalacia of lateral compartment (13 of 40) (4) Loose bodies (3 of 40) (5) Synovitis (25 of 40) (6) Plica lesion	NA	— Open debridement of extensor complex and refixation LUCL complex stabilization with triceps graft augmentation	Partial synovectomy (25 of 40) and Plica resection
6	Chanlalit and Dilokhuttakarn (2018)[8]	Plica lesion (2 of 6)	Arthroscopic debridement of ECRB	LUCL reconstruction (palmaris longus autograft)	Arthroscopic plica resection
7	Kwak et al (2018)[15]	(1) EUA: radiocapitellar joint widening with varus test (2.5-4.1 mm), posterolateral instability (2) Ligament lesion: LUCL tear (complete: 8 of 17 and partial: 9 of 17) (3) Capsular lesion: capsule attenuation	Open debridement of ECRB	LUCL reconstruction (13 of 17) (tibialis anterior graft)	—
		NA (control group)		NA (control group)	—
8	Shim et al (2018)[27]	EUA: lateral pivot-shift test, posterolateral drawer test, varus stress test	Open debridement of ECRB	(1) LUCL reconstruction (6 of 14) (palmaris longus or flexor carpi radialis) (2) Dual LUCL and RCL reconstruction (8 of 14)	—

[a]CEO; common extensor origin; ECRB, extensor carpi radialis brevis; EUA, examination under anesthesia; LUCL, lateral ulnar collateral ligament; NA, not available; RCL, radial collateral ligament; R-LCL, radial component of the lateral collateral ligament.

12.5%), anconeus muscle advancement flap (2/120; 2%), and LUCL remnant augmentation (2/120; 2%).

Postoperative Characteristics

Data on postoperative characteristics are displayed in Table 2. One study did not provide data on postoperative characteristics because the study solely investigated the preoperative characteristics.[15] The most common functional outcome tool used was the Disabilities of the Arm, Shoulder and Hand score. Of the 5 studies providing data on functional outcome, 3 studies (48 patients)[1,10,27] reported excellent results, 1 study[8] (6 patients) reported good to excellent results, and 1 study[14] (40 patients) indicated "no functional impairment" after surgical procedure. Data on postoperative ROM was reported for 57 patients, 49% (28/57) of whom described a loss of ROM. Of the 85 patients with data on symptoms resolution, 54 (63.5%) exhibited symptom resolution. Residual symptoms were described for 18 patients (25%). The most common residual symptom was a limitation in ROM (11/18;

TABLE 2
Postoperative Characteristics of the Study Population[a]

		Quantitative Assessment			Qualitative Assessment				
No.	Article (Year)	Outcome Measurement Tool	Reported Functional Score	Postoperative ROM	Resolution of Symptoms	Recurrence/ Residual Symptoms	Return to Work/Sports	Satisfaction Rate	Reason for Partial Improvement
1	Kalainov and Cohen (2005)[13]	ROM	NA	Terminal extension loss (5°)	Yes	No	NA	NA	NA
		ROM	NA	Full	Yes	No	NA	NA	NA
		ROM	NA	Full	Yes	Palpable crepitus over radiohumeral joint with stress test	NA	NA	None
2	Dzugan et al (2012)[10]	ROM ACES MEPS	MEPS: 93.6 Objective ACES: 100 Subjective ACES: 93.6	Full (0-140)	Yes	No	6 of 7 return to preinjury level, 1 of 7 return to lower than preinjury level	NA	None
3	Arrigoni et al (2017)[2]	NA	NA	NA	NA	NA	NA	NA	NA
4	Arrigoni et al (RCL) (2017)[1]	ROM SANE DASH OES	SANE: 90 DASH: 9.1 OES: 42	Extension-flexion: 0-145	16 of 27 (59%)	11 of 27 (ROM restriction)	NA	26 of 27 (satisfied)	None
5	Kniesel et al (2014)[14]	DASH	18 ± 18.9	NA	23 of 25 (92%)	1 of 40 (new onset of pain) 1 of 40 (stiffness)	NA	37 of 40 (satisfied)	None
			29.6 ± 20.1		10 of 15 (66.7%)				
			19		1 of 2 (50%)				
6	Chanlalit and Dilokhuttakarn (2018)[8]	ROM MEPI QuickDASH	MEPI: 97.5 (range, 95-100) QuickDASH: 9 (range, 3.3-33)	Extension-flexion: 1-136	Yes	No	NA	NA	NA
7	Kwak et al (2018)[15]	NA	NA	NA	NA	NA	NA	NA	NA
		NA	NA	NA	NA	NA	NA	NA	NA
8	Shim et al (2018)[27]	ROM DASH MEPS VAS	MEPS: 91 DASH: 13.5 VAS: 0.9	Full ROM	10 of 14 (71.4%)	3 of 14 (mild instability); 1 of 14 (sensitivity with palpation of the stitches)	NA	NA	None

[a]ACES, Andrew Carson Elbow Score; DASH, Disability of the Arm, Shoulder and Hand; MEPI, Mayo Elbow Performance Index; MEPS, Mayo Elbow Performance Score; NA, not applicable; OES, Oxford Elbow Score; QuickDASH, shortened version of DASH; ROM, range of motion; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

61%), followed by mild instability (3/18; 17%). The open procedure (LUCL with and without RCL reconstruction) had lower residual symptoms and more patients with longer follow-up times (≥24 months) compared with those having the arthroscopic procedure (RCL with and without capsular plication) (Figure 5, A and B). Only 1 study reported data on the extent to which patients were able to return to their activities and revealed that 1 of 7 patients failed to return to the preinjury level of activity.[10] Only 2 studies[1,14] described the satisfaction rate, which revealed that 94% (63/67) were satisfied after surgical treatment. The reason for dissatisfaction and the existence of residual symptoms were not described in any of the studies.

DISCUSSION

This systematic review describes the existence of elbow instability associated with refractory LE, focusing particularly on diagnostic approaches and surgical measures.

The diagnosis of elbow instability associated with refractory LE is not straightforward due to the multifactorial etiology and potentially interfering conditions.[1,2,8,10,13-15,27] Therefore, a systematic approach involving the identification of risk factors, clinical presentation, and radiologic findings is required. This systematic review showed that heavy labor activity serves as a major risk factor for triggering the instability in refractory LE. Patients reported a deterioration of symptoms after heavy labor activity, which not only reflected an increase in pain intensity but also a change in pain characteristics, accompanied by an associated feeling of instability.[10]

A history of steroid injection is perhaps the most interesting issue to be discussed. Nearly all patients received steroid injections as part of the nonoperative therapy, with the majority of patients receiving multiple injections. A national database study analyzing 3863 patients showed that recieving 3 or more preoperative injections is the most significant risk factor for revision surgery in LE.[9] Taken together, previous studies have tended to identify steroid injections as the cause of instability in refractory LE. Steroid injections have been administered typically for the immediate alleviation of pain, but with only temporary effects.[29] Furthermore, evidence from animal studies has

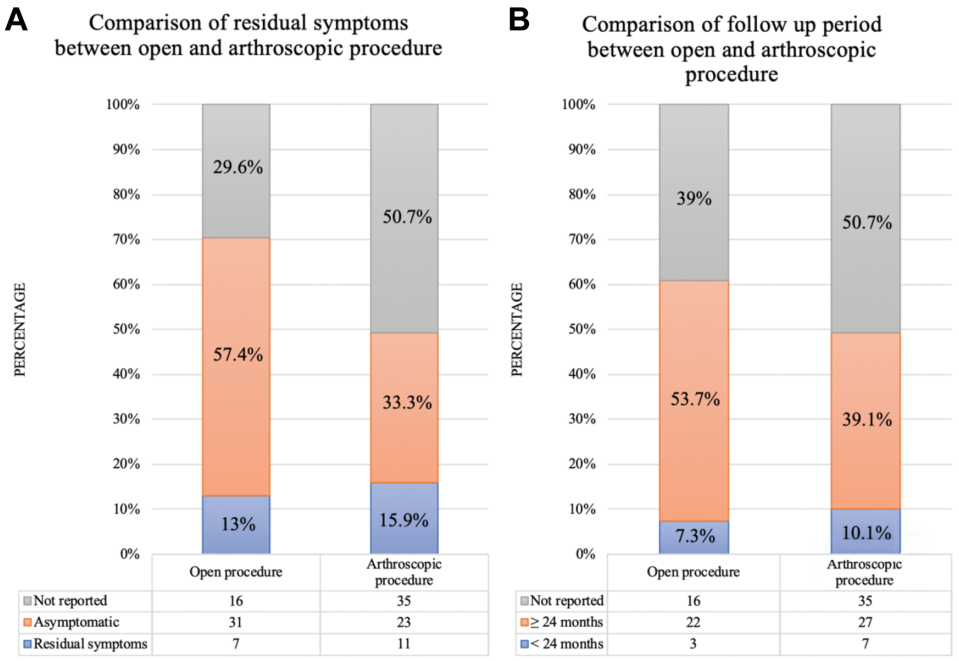

Figure 5. Comparison of the (A) existence of residual symptoms and (B) follow-up period after arthroscopic (radial collateral ligament [RCL] plication with and without capsular plication) and open procedure (lateral ulnar collateral ligament with and without RCL reconstruction).

shown that intratendinous steroid injections result in a reduction of collagen tensile strength, suggesting caution for expedient use of local steroid therapy.[12] We speculate that the negative effect from repeated corticosteroid injections may compromise the lateral stabilizing soft tissue elements in this narrow region, where some of the structures converge (Figure 6). However, the amount and duration of the corticosteroid injections correlated with instability is inconclusive.

It is important to recognize the dominant symptoms for instability associated with refractory LE. Instability symptoms are always followed by pain, but instability is not always present clinically. Instability can be confirmed by performing special tests such as the posterolateral drawer, varus stress, and lateral pivot-shift tests. The ROM is usually in the normal range. Plain radiography is not helpful for imaging investigation despite being commonly used. MRI is helpful for detecting ligament lesions as signs suggestive of instability; however, MRI cannot distinguish the definite ligament lesion, as the RCL and LUCL share confluent structures in their epicondylar attachments. This is supported by the current systematic review, which identified LUCL and RCL injury as the most common lesions found by MRI. The diagnostic gold standard of LE and ligament instability are essentially clinical assessment. However, when symptoms are refractory, it is necessary to perform MRI, which can provide additional information corresponding with the clinical assessment.[7,23] Besides, high-resolution MRI with contrast has the ability to detect subtle changes.[24] Considering its noninvasive nature, MRI is helpful as a substantial adjunct examination to support clinical findings.[7,23,24]

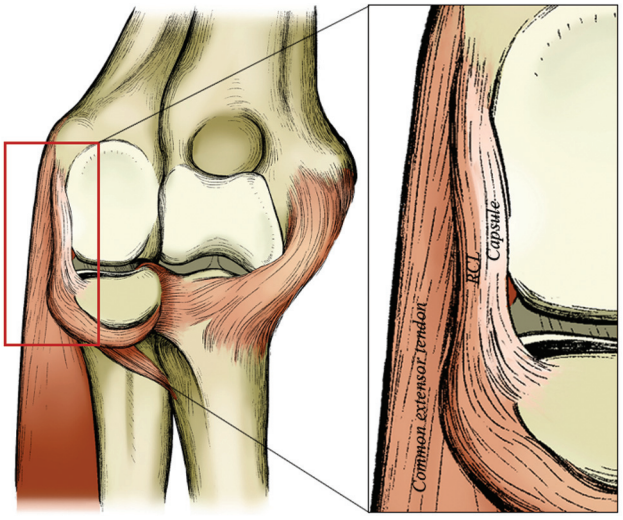

Figure 6. The epicondylar attachment of the lateral stabilizing soft tissues of the elbow joint comprising the common extensor tendon, radial collateral ligament (RCL) and joint capsule, all occupying a relatively narrow space.

One study showed that an elbow with chronic PLRI may have normal MRI findings[11]; hence, EUA may confirm the presence of instability suspected by clinical examination and radiologic investigation. Radiocapitellar joint widening over 1.5 mm seen by magnetic resonance arthrography with traction was associated with subtle varus instability.[16] When performing the EUA, researchers have shown a "no

endpoint" feeling while performing the varus stress test[27] and that radiocapitellar joint widening of at least 2.5 mm[15] may indicate instability. The current study was unable to show any evidence of a direct relationship between instability presentation as evidenced by clinical workup, imaging modalities, and EUA because of a lack of supporting evidence. However, based on the descriptive data available, we suggest that one should consider the presence of instability in patients with refractory LE with a history of multiple steroid injections and a positive instability test that corresponds with MRI findings.

Nonoperative treatment is the preferred treatment of symptomatic instability associated with refractory LE. However, the exact duration of nonoperative treatment remains uncertain. Most studies tend to proceed with operative treatment when the nonoperative method fails to show any improvement over a period of 6 months. Our systematic review showed that half of the surgical treatments were performed using an arthroscopic approach, namely, arthroscopic RCL plication. It is possible that the benefits of the arthroscopic approach include the opportunity to diagnose intra-articular pathology, identifying elements of pathology that could be missed by imaging or open technique, and performing dynamic evaluation for instability.[2,3,4,14] The reason for performing RCL plication is the theory of pathological cascade,[1,2] which initiates from the elongated RCL failing in its role as a static stabilizer to the varus pronation stress performed repetitively on a daily basis. ECRB overloading (tendinopathy) could be a consequence of RCL elongation with time. As the RCL plication aims to reduce capsular volume, this can also be achieved in an open manner as a part of an LUCL reconstruction. We observed a tendency for authors of the included studies to perform LUCL reconstruction in cases of major instability and arthroscopic RCL in cases with only subtle instability.

This systematic review revealed the interesting fact that regardless of a favorable outcome after operative treatment, limited ROM is the most common residual symptom. However, the loss of ROM can be considered a "trade" for a stable, painless elbow joint, as shown for the shoulder joint after capsular plication.[26] Due to the lack of conclusive evidence from controlled treatment studies in favor of any technique, patients are generally treated according to the surgeon's preferred approach without concern for the possible existence of instability in association with refractory LE. Hence, the outcomes of surgical treatment for instability associated with refractory LE are left unanswered by this systematic review due to the lack of comparative studies with control groups. This systematic review showed, however, that there is a requirement to conduct preoperative patient selection to tailor an individualized treatment regimen for each patient.

Limitations

This review has some limitations. First, only 2 of the studies had a control group for the comparison of patients with and without instability. What is more, there was a lack of complete data in the mentioned studies. Second, data from the included studies were collected retrospectively. Third, the outcome measurement tools of the studies were heterogeneously reported, preventing direct comparison of outcomes and highlighting the need for standardized methods. Fourth, the subgroup analysis for postoperative clinical outcome may limit the extrapolation to a bigger population as there were only few articles with large number of cases. Fifth, only a few articles showed the common extensor origin and ECRB lesion as intraoperative findings indicating that instability remained the focus of the included articles, which may mislead as a misdiagnosis. Last, only 6 studies were classified as high-quality studies based on the MINORS criteria.

CONCLUSION

The current systematic review confirmed the fact that instability may coexist with refractory LE. The risk factors of instability associated with refractory LE include heavy labor background and multiple steroid injections. A systematic approach to identifying the clinical and imaging presentation of the condition followed by EUA are critical for affirmative diagnosis, as independent presentations may be misleading. The variation in outcome assessment tools used in the published literature warrant a consensus on reporting functional outcomes after surgical treatment for instability associated with refractory LE.

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REFERENCES

1. Arrigoni P, Cucchi D, D'Ambrosi R, et al. Arthroscopic R-LCL plication for symptomatic minor instability of the lateral elbow (SMILE). *Knee Surg Sports Traumatol Arthrosc*. 2017;25(7):2264-2270.

2. Arrigoni P, Cucchi D, D'Ambrosi R, et al. Intra-articular findings in symptomatic minor instability of the lateral elbow (SMILE). *Knee Surg Sports Traumatol Arthrosc*, 2017;25(7):2255-2263.
3. Arrigoni P, Fossati C, Zottarelli L, et al. 70 degrees frontal visualization of lateral compartment of the elbow allows extensor carpi radialis brevis tendon release with preservation of the radial lateral collateral ligament. *Arthroscopy*. 2014;30(1):29-35.
4. Baker CL Jr, Murphy KP, Gottlob CA, Curd DT. Arthroscopic classification and treatment of lateral epicondylitis: two-year clinical results. *J Shoulder Elbow Surg*. 2000;9(6):475-482.
5. Binder AI, Hazleman BL. Lateral humeral epicondylitis—a study of natural history and the effect of conservative therapy. *Br J Rheumatol*. 1983;22(2):73-76.
6. Bowen RE, Dorey FJ, Shapiro MS. Efficacy of nonoperative treatment for lateral epicondylitis. *Am J Orthop (Belle Mead, NJ)*. 2001;30(8): 642-646.
7. Bredella MA, Tirman PF, Fritz RC, et al. MR imaging findings of lateral ulnar collateral ligament abnormalities in patients with lateral epicondylitis. *AJR Am J Roentgenol*. 1999;173(5):1379-1382.
8. Chanlalit C, Dilokhuttakarn T. Lateral collateral ligament reconstruction in atraumatic posterolateral rotatory instability. *JSES Open Access*. 2018;2(2):121-125.
9. Degen RM, Cancienne JM, Camp CL, et al. Three or more preoperative injections is the most significant risk factor for revision surgery after operative treatment of lateral epicondylitis: an analysis of 3863 patients. *J Shoulder Elbow Surg*. 2017;26(4):704-709.
10. Dzugan SS, Savoie FH 3rd, Field LD, O'Brien MJ, You Z. Acute radial ulno-humeral ligament injury in patients with chronic lateral epicondylitis: an observational report. *J Shoulder Elbow Surg*. 2012; 21(12):1651-1655.
11. Grafe MW, McAdams TR, Beaulieu CF, Ladd AL. Magnetic resonance imaging in diagnosis of chronic posterolateral rotatory instability of the elbow. *Am J Orthop (Belle Mead, NJ)*. 2003;32(10):501-504.
12. Hugate R, Pennypacker J, Saunders M, Juliano P. The effects of intratendinous and retrocalcaneal intrabursal injections of corticosteroid on the biomechanical properties of rabbit Achilles tendons. *J Bone Joint Surg Am*. 2004;86(4):794-801.
13. Kalainov DM, Cohen MS. Posterolateral rotatory instability of the elbow in association with lateral epicondylitis. A report of three cases. *J Bone Joint Surg Am*. 2005;87(5):1120-1125.
14. Kniesel B, Huth J, Bauer G, Mauch F. Systematic diagnosis and therapy of lateral elbow pain with emphasis on elbow instability. *Arch Orthop Trauma Surg*. 2014;134(12):1641-1647.
15. Kwak SH, Lee SJ, Jeong HS, Do MU, Suh KT. Subtle elbow instability associated with lateral epicondylitis. *BMC Musculoskel Dis*. 2018; 19(1):136.
16. Lee RK, Griffith JF, Yuen BT, Ng AW, Yeung DK. Elbow MR arthrography with traction. *Br J Radiol*. 2016;89(1064):20160378.
17. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *Ann Intern Med*. 2009;151(4):264-269.
18. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097.
19. Morrey BF. Reoperation for failed surgical treatment of refractory lateral epicondylitis. *J Shoulder Elbow Surg*. 1992;1(1):47-55.
20. Nirschl RP, Pettrone FA. Tennis elbow. The surgical treatment of lateral epicondylitis. *J Bone Joint Surg Am*. 1979;61(6A):832-839.
21. OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence. Oxford Centre for Evidence-Based Medicine. Accessed December 28, 2019. https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence
22. Owens BD, Murphy KP, Kuklo TR. Arthroscopic release for lateral epicondylitis. *Arthroscopy*. 2001;17(6):582-587.
23. Potter HG, Weiland AJ, Schatz JA, Paletta GA, Hotchkiss RN. Posterolateral rotatory instability of the elbow: usefulness of MR imaging in diagnosis. *Radiology*. 1997;204(1):185-189.
24. Qi L, Zhu ZF, Li F, Wang RF. MR imaging of patients with lateral epicondylitis of the elbow: is the common extensor tendon an isolated lesion? *PLoS One*. 2013;8(11):e79498.
25. Ruch DS, Papadonikolakis A, Campolattaro RM. The posterolateral plica: a cause of refractory lateral elbow pain. *J Shoulder Elbow Surg*. 2006;15(3):367-370.
26. Shafer BL, Mihata T, McGarry MH, Tibone JE, Lee TQ. Effects of capsular plication and rotator interval closure in simulated multidirectional shoulder instability. *J Bone Joint Surg Am*. 2008;90(1):136-144.
27. Shim JW, Yoo SH, Park MJ. Surgical management of lateral epicondylitis combined with ligament insufficiency. *J Shoulder Elbow Surg*. 2018;27(10):1907-1912.
28. Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (MINORS): development and validation of a new instrument. *ANZ J Surg*. 2003;73(9):712-716.
29. Solveborn SA, Buch F, Mallmin H, Adalberth G. Cortisone injection with anesthetic additives for radial epicondylalgia (tennis elbow). *Clin Orthop Relat Res*. 1995;316:99-105.
30. Wiggins ME, Fadale PD, Barrach H, Ehrlich MG, Walsh WR. Healing characteristics of a type I collagenous structure treated with corticosteroids. *Am J Sports Med*. 1994;22(2):279-288.