Review

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Persistent lateral elbow pain from overlooked posterolateral impingement of the elbow: a literature review and guidance for treatment

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Posterolateral impingement is sometimes diagnosed as a cause of refractory elbow pain, often after other treatments have been tried for common conditions such as lateral epicondylitis (tennis elbow) or subtly different conditions common in throwing athletes, such as valgus extension overload syndrome. Arthroscopic surgical treatment is effective when targeting abnormal anatomy such as plicae folds. Partial excision of the olecranon must be undertaken with caution because it can lead to instability. This systematic review of the current literature uses a narrative synthesis to identify anatomical morphological variations of the olecranon, humeral and capitellar geometry, and overloading of the lateral part of the elbow as causative factors for this condition and discusses how arthroscopic techniques can resolve symptoms. Further understanding of the static and dynamic anatomy of the lateral part of the elbow will help to develop future treatment and preventive strategies.

Keywords: Posterolateral impingement; Epicondylitis; Lateral epicondylitis; Instability; Arthroscopy

INTRODUCTION

Our understanding of the complex anatomy of the elbow has come a long way since Peterson and Jones described the elbow as "merely a connecting joint between the hand and trunk, and restricted motion can be compensated for in other joints" in 1971 [1,2]. Although the need to treat rheumatoid arthritis has waned with the advent of biological treatment, further understanding has been driven by the need to reconstruct damaged elbow joints following trauma and the development of arthroscopic assessments and treatments for elbow conditions [3-6].

Posterolateral impingement of the elbow is an uncommon disorder that presents with lateral elbow pain that is often attributed to epicondylitis or "tennis elbow." Thus, it is frequently missed clinically and treated with surgical techniques intended for a different injury [5-8]. Typically, patients describe overuse of the elbow, often related to sporting activities such as overhead throwing or manual work, which leads to repetitive hyperextension trauma within the lateral part of the elbow [2,5]. The hyperextension part of this movement forces the olecranon tip into the olec-

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ranon fossa. This impingement leads to osteophyte production on the olecranon tip, especially at the lateral side, which is poorly recognized as an issue. Our aim in this study was to systematically review the best evidence available in surgical and anatomical journals to better understand why this condition develops in some individuals and not others and learn how best to recognize, treat, and prevent it.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

The research question for our review was refined using the Population, Intervention, Comparison, Outcome, and Study design (PICOS) framework [9]. We did not, however, include "Comparison" in our eligibility criteria.

Studies were considered eligible for inclusion if they met the following criteria: (1) anatomical population: anatomy of lateral elbow/capitellum/olecranon; (2) clinical population: lateral elbow pain or structure, elbow valgus extension overload syndrome, refractory epicondylitis, posterolateral impingement of the elbow; (3) intervention: reported for participants who received treatment, assessment, or imaging for posterolateral impingement/lateral elbow structures; (4) outcomes: recovery from surgery/physiotherapy or other modalities of treatment for lateral epicondylitis; and (5) study design: both randomized and non-randomized controlled trials, single-group design studies, case reports, and cadaveric dissection studies.

Studies were excluded based on the following criteria: (1) population: other causes of lateral elbow pain/epicondylitis, plicae, radial tunnel syndrome, capitellar osteochondral lesions, or radiocapitellar osteoarthritis; (2) intervention: lacked a clinically relevant surgical or anatomical component; (3) outcomes: described only assessment or definitions of posterolateral impingement; (4) study design: did not report empirical data; and (5) not published in the English language.

SEARCH STRATEGY

We searched for eligible studies in the following databases: Medline, Embase, and PsycINFO. All databases were searched from 1990 to January 2020. The following search algorithm was adapted for our chosen databases: ("elbow") AND ("posterolateral") AND ("Elbow Valgus Extension Overload Syndrome") AND ("impingement) *" OR "anatomy" OR "surgical" OR "surgery." The searches were conducted by a specialist librarian (within the hospital trust of the lead author) who is skilled at database searches, and the lists were amalgamated. Several search iterations were used to maximize sensitivity [10].

In addition to the electronic databases, we searched the reference lists of the included studies and relevant reviews to identify missed eligible studies. The snowballing method was adopted to include the whole breadth of the available literature, including making contact with study authors to identify additional studies [11]. The British Elbow and Shoulder Surgery and Clinical Anatomy websites were also searched for relevant articles.

STUDY SCREENING AND DATA COLLECTION PROCESS

The number of studies excluded at the title and abstract screening stage and the number of studies excluded at the full-text screening stage were recorded systematically with reasons (e.g., "not anatomical or surgically relevant" or "not lateral part of the elbow"). Three researchers (NA, GASS, NA) were involved in both the title and abstract and full-text screening stages, and where there was uncertainty in study eligibility, a consensus decision was made by at least two screeners.

Endnote was used to capture and manage the references at each stage of screening. Data extraction was undertaken using a table to facilitate the assessment of quality and eligibility when screening full articles; we used an inductive rather than deductive stance based on previously identified themes [12]. The same three researchers (NA, GASS, NA) extracted the study designs, participant characteristics (number of participants, surgical, imaging, dissections), intervention characteristics (location of intervention, method), details of outcomes assessed, and findings for each eligible outcome.

DATA SYNTHESIS

A thematic analysis with the constant comparison method was used to synthesize the findings. The literature encompassed qualitative and quantitative data of differing quality, so a narrative synthesis was chosen as the best way to interpret these articles cohesively [12].

SEARCH RESULTS

We screened 52 full-texts and excluded 31 of them for the following reasons: 20 were without description; 4 were letters or commentaries, and 5 were not relevant to the topic (Fig. 1).

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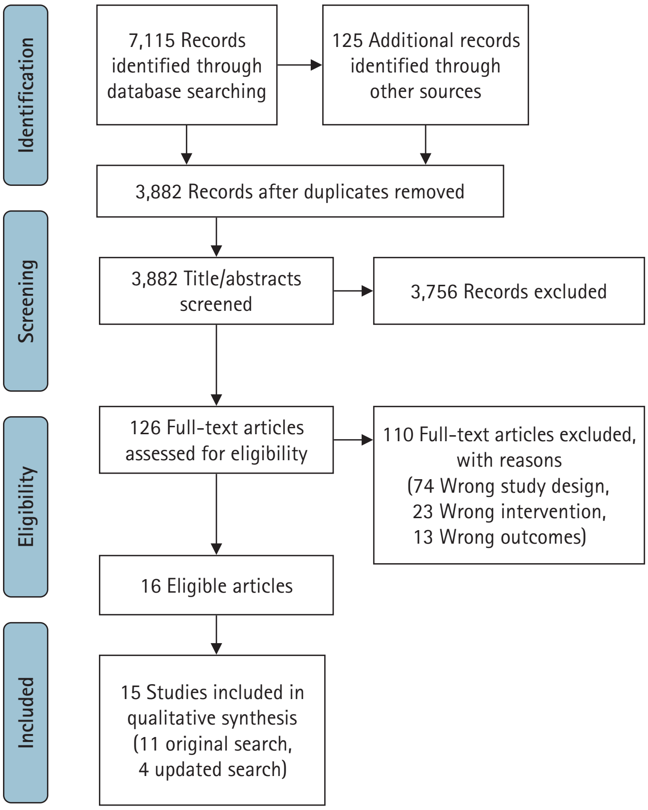

Fig. 1. Search strategy for our review.

RESULTS

Clinical Anatomy of the Elbow Joint

Most elbow joint stability is provided by the bony anatomy, particularly the ulnohumeral articulation, and a strong medial collateral ligament and lateral collateral ligament [13]. A primary stabilizer provides constraint, and its release causes laxity, and a secondary stabilizer is a constraint whose release alone is insufficient to cause laxity; however release of the secondary stabilizer after division of the primary stabilizer increases the laxity of the joint [13].

Medially ulnohumeral articulation behaves mechanically as a hinge joint [14]. Anatomically, the radiocapitellar articulation is a spheroidal (ball-and-socket) joint and has been described as a condyle-type joint constrained by the proximal radioulnar joint to allow only flexion/extension and pronation/supination [15]. The proximal radioulnar articulation itself constitutes a separate pivot joint [14]. The radiocapitellar joint has a much smaller surface area than the ulnohumeral joint, but it transmits higher loads, up to 60% higher when the elbow is extended and axially loaded [14,16]. Therefore, it is more prone to injury and degeneration than the ulnohumeral joint, as seen arthroscopically and

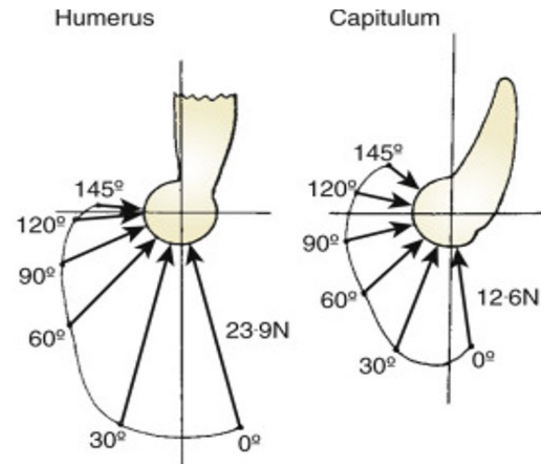

Fig. 2. Demonstrating contact stresses at distal humerus and capitellum

in cadavers [17,18]. Indeed, the cartilage loss in the lateral part of the joint can be extensive, even when the ulnohumeral joint is preserved [19].

The transmission of forces through the radiocapitellar joint also depends on the alignment in the coronal plane because in the valgus position, only 12% of forces are transmitted through the ulnohumeral articulation, whereas in varus positions, 92% of the force passes through the humeroulnar articulation [16]. This suggests that most of the forces in the elbow joint pass through the radiocapitellar joint in both the valgus position and pronation [20]. In full extension, the muscles at the elbow are biomechanically disadvantaged, and they generate great forces across the elbow joint in extension to achieve flexion. Fig. 2 shows how simple rotational movements lead to stretching of the collateral ligaments [21,22]. Damage and stretching of the medial collateral ligament transmits most of the forces through the radiocapitellar joint, which eventually causes impingement and its consequences in the posterolateral aspect of the elbow [16].

Ring and Jupiter [23] conceptualized instability at the elbow in terms of deficiencies in the four columns of anatomical structures (anterior, medial, lateral, and posterior). Lateral arm pain at the elbow can be due to posterolateral instability and might have a bearing on the development of degenerative changes and impingement (Fig. 3) [24].

Etiopathology of Posterolateral Impingement Syndrome

The elbow joint is formed by mesenchymal cavitation and divided by synovial septa into its three main articulations [25]. Elbow synovial plicae, or folds, are septal remnants of this process that can hypertrophy, causing mechanical symptoms and impingement from soft tissues within the lateral part of the joint [26].

Fig. 3. Ring concept of stability by Ring and Jupiter [23].

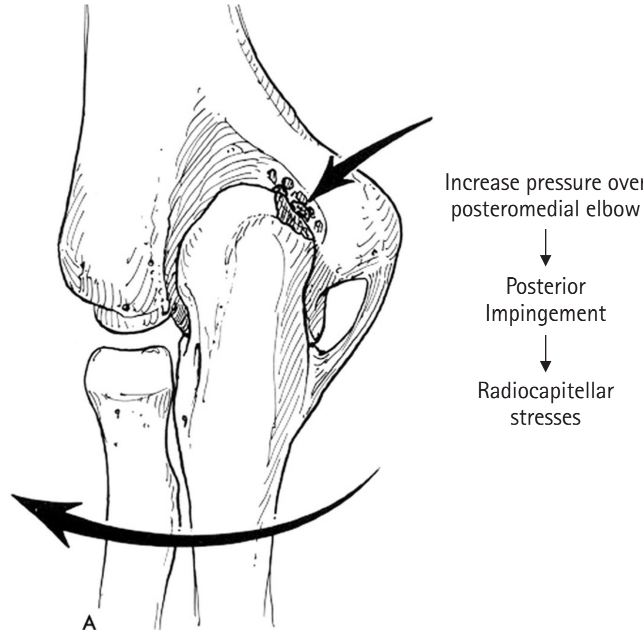

Fig. 4. Posterolateral impingement syndrome etiopathology

Joint congruence is also a factor because it can lead to the development of degenerative joint disease and impingement [27]. A biomechanical analysis of radiocapitellar arthroplasty showed significant capitellar morphological variation, making implant design difficult and also contributing to cartilage thickness variance. Congruence showed significant sexual dimorphism in the shape of the olecranon fossa and shape variance at the olecranon tip [28-30]. Congruent joints covered by thin articular cartilage have a low incidence of degenerative joint disease, whereas joints with thicker cartilage, such as the radiocapitellar joint, can be overworked during cyclic deformation under load and shear stresses [27]. Material fatigue with repetitive loading might initiate mechanical disruption of the cartilage and begin the process of degenerative disease. Throwing athletes and boxers are predisposed to posterolateral impingement. The act of throwing produces a combination of valgus forces and rapid extension that results in tensile forces along the medial side, compression on the lateral side of the elbow, and shear forces in the posterior compartment. Repetitive valgus overloading of the medial collateral ligament results in medial instability and abnormal valgus rotation of the elbow [31]. That has three consequences (Fig. 4): (1) Increased contact pressures over a decreased area in the posteromedial elbow, particularly between the medial tip of the olecranon and the medial crista of the humeral trochlea. (2) Posterior impingement of the elbow as the olecranon is wedged into the fossa during acceleration and the subsequent development of osteophytes and possible loose bodies within the elbow joint. (3) Increased compressive forces across the radiocapitellar joint, which leads to cartilage injury, osteochondritis dissecans lesions, and fragmentation.

Continued valgus and extension forces can produce olecranon tip osteophytes, loose bodies in the posterior or radiocapitellar compartment, and articular damage on the posteromedial trochlea caused by the olecranon osteophyte (the so-called kissing lesion), with chondromalacia on the posteromedial trochlea (olecranon fossa) [32]. The exact fit of the olecranon in the olecranon fossa of the humerus appears to be critical for maximal extension and therefore for the function of the elbow, and disturbances to this fit can lead to significant posterolateral impingement [17,33]. Partial resection of the olecranon in in vitro studies on cadavers increased valgus angulation and torque within the elbow with all levels of resection [34]. Statistically significant ulnar collateral ligament strain and instability developed after 9mm of resection [35]. Throwing athletes will perform badly with this increased strain on their medial collateral ligament. However, bone removal from the olecranon should be limited to osteophytes without the removal of normal bone because even small amounts of bone resection from the olecranon affect elbow stability [36]. Patients who overload their medial collateral ligament can develop olecranon osteophytes, so stability needs to be assessed clinically [37]. Posterolateral rotatory instability results from injury to the lateral ulnar collateral ligament complex, and patients experience mechanical symptoms such as clicking, popping, or grinding, particularly at forty degrees of flexion. The tests for this injury are the lateral pivot shift test and push-up chair test [38].

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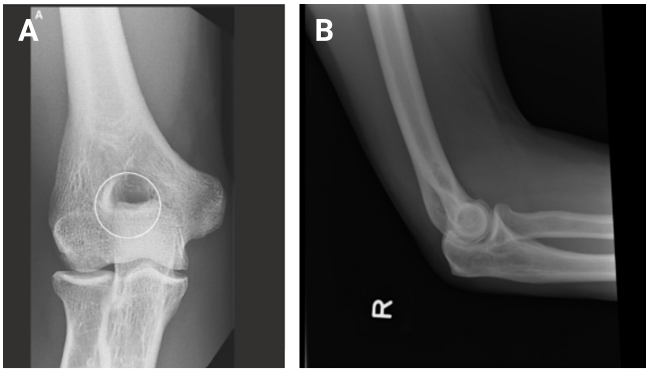

Fig. 5. Osteophyte formation on the posterolateral corner of the olecranon on anteroposterior (A) and lateral (B) radiographs.

IMAGING

Radiographs

Radiographs are helpful in detecting osteophytes on the olecranon or the borders of the posterior fossa, but the shape appears to be variable. Radiographs cannot detect mechanical impingement from soft tissues or plica [25,30]. The axial oblique view is helpful in detecting osteophytes and loose bodies on the olecranon or the borders of the posterior fossa. The elbow is flexed to 110° with the arm on the cassette and the beam angled at 45° toward the ulna (Fig. 5).

Ultrasound

Ultrasound can help to identify plica and assess the common extensor origin of lateral elbow pain in general [25,39]. A dynamic ultrasound allows a real-time evaluation of the moving elbow and can help to assess the stability of the ulnar collateral ligament [40]. It can also be used to evaluate the course of the posterior interosseous nerve and detect muscle tears, effusions, or osteophytes [39,41].

Computer Tomography

A computer Tomography (CT) scan defines the extent of wear within the elbow, which can be useful when planning surgery for arthritis, although some would argue that magnetic resonance arthrography is more useful in assessing intraarticular pathology and the extent of any loose bodies when x-rays are unclear [42,43]. When throwing athletes present with unusual posterior elbow pain and no significant findings on radiographs, a CT scan should be performed to exclude a stress fracture [44]. Some analysis has been performed on variations in olecranon shape, but more work is required to better understand them, especially posterolaterally (Fig. 6) [30].

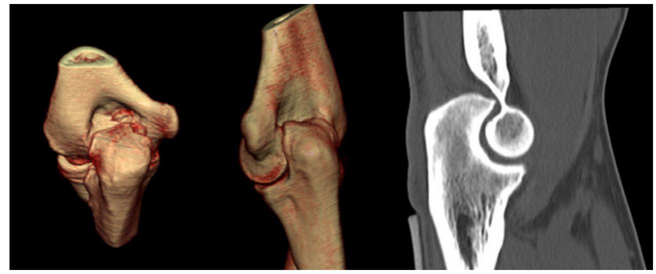

Fig. 6. Computer tomography scan showing impingement of the olecranon tip on the olecranon fossa.

Magnetic Resonance Imaging Scanning

Magnetic resonance imaging scans are extremely useful in defining intraarticular pathology, especially in equivocal cases when the diagnosis is uncertain [25,43,45]. They can rule out other causes of posterolateral elbow pain such as hypertrophied fat pads, olecranon stress fractures, subtle radiocapitellar osteoarthritis, osteochondritis dissecans, radiocapitellar synovitis, and extensor tendinopathy [46,47]. Stress fractures appear as linear decreases in signal intensity on T1W images, typically with marrow edema, and they are seen as increases in signal intensity on fat-suppressed T2W or short inversion-time inversion recovery images (Fig. 7).

TREATMENT

Initially, patients should be encouraged to rest and rehabilitate, with throwers avoiding triceps exercises that would continue to irritate the olecranon and exacerbate the impingement [47]. A gradual return to interval throwing supervised by a sports physiotherapist is allowed as symptoms resolve [47]. Persistent symptoms following active non-operative treatment were managed successfully by arthroscopic debridement of the elbow in 90% of 28 patients treated by this method in the literature; those patients returned to their preoperative levels, including sport [48,49]. During surgery, debridement of the posterior fossa of the elbow was performed until there was no further impingement of any soft tissue or visible bony osteophytes [49].

Open surgery was used with good results for the removal of loose bodies, resection of osteophytes and posterior spurs from the olecranon, synovectomy, and joint debridement [32]. However arthroscopic surgery gives comparable outcomes with faster rehabilitation and less hospitalization, which makes it more cost effective [50-54]. Arthroscopy also provides better joint visualization than open techniques, which require large surgical exposure and incisions to see the same area and thus increase the patient's potential morbidity [50].

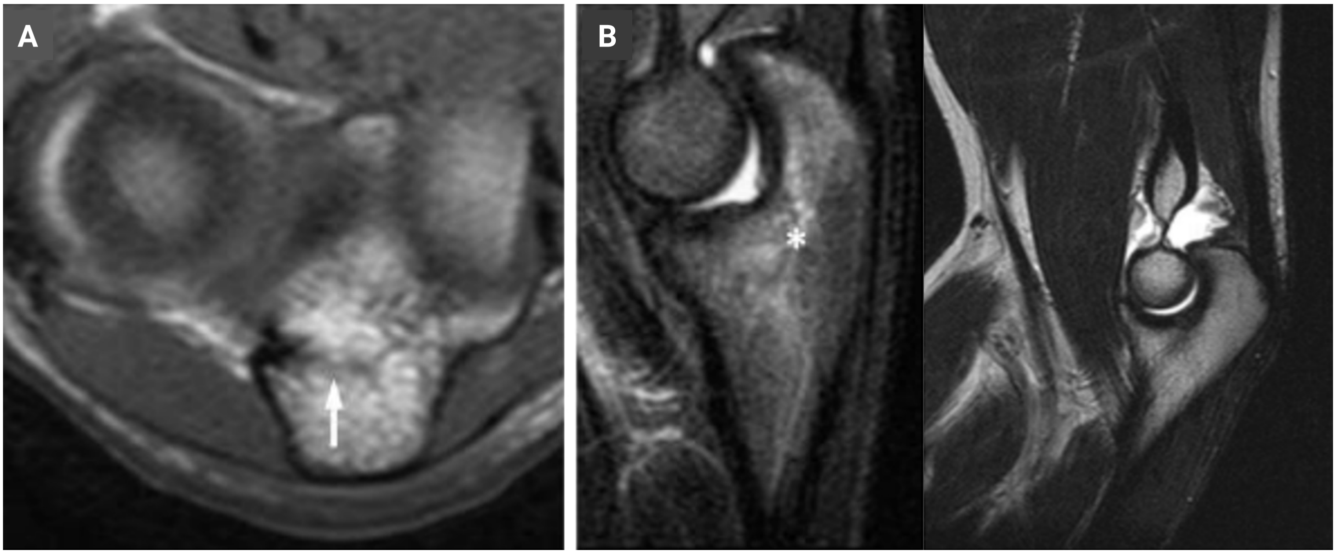

Fig. 7. Magnetic resonance imaging (MRI) scans are particularly useful for evaluating symptomatic posterolateral impingement of the elbow. (A) T1W axial MRI shows a linear low-signal fracture line (arrow) traversing the olecranon. (B) Short inversion-time inversion recovery sagittal MRI image shows increased signal (asterisk) corresponding to marrow edema in the olecranon.

Posterior impingement can also be part of a more widespread degenerative arthritis of the elbow, so preoperative evaluation is important to determine the extent of the disease, which can influence the treatment results and recovery [42]. A retrospective study by Adams et al. [50] analyzed 41 patients with primary osteoarthritis in 42 elbows. Preoperative pain, motion, and Mayo Elbow Performance Index scores were compared with those at the latest follow-up. The patients all underwent arthroscopic osteophyte resection and capsulectomy. At an average follow-up of more than 3 years, 81% of cases reported statistically significant improvements in mean flexion, extension, supination, and Mayo Elbow Performance Index [50]. In 1995, Ogilvie-Harris et al. [51] achieved good (n = 7) or excellent results (n = 14) in 21 patients treated with arthroscopic debridement for posterior impingement associated with degenerative elbow arthritis. Three criteria were used to determine the need for therapeutic arthroscopy: painful loss of extension of at least 10°, interference of function in sports or work-related duties, and radiographic evidence of posterior loose bodies or osteophytes of the olecranon fossa or posterior olecranon [51].

Arthroscopic elbow debridement surgery is undertaken in four stages: anterior elbow joint debridement followed by the posterior removal of loose bodies, olecranon osteophytes, and osteophytes in the olecranon fossa [51,52].

Elbow arthroscopy is also useful as a diagnostic adjunct when impingement is suspected but imaging has been equivocal. Selby and O'Brian [53] found impingement from soft tissues and the fat pad upon arthroscopy in five young pitchers who presented with complaints of dysfunction and pain on terminal elbow extension of their throwing arms. Debridement of the soft tissues and aberrant fat pad led to resolution of the pitchers' symptoms. Similar good outcomes have been achieved for posteromedial impingement, a related condition [54]. Table 1 consolidated the literature studies and outcomes with individual authors.

Table 1. Literature studies showing results of arthroscopic treatment for PLRI by different authors

Study	Level	Case	Follow-up	Result
Kim et al. (2006) [47]	IV	12	12 mo	Excellent
Valkering et al. (2008) [5]	IV	5	12 mo	Satisfactory to good
Rahusen et al. (2009) [49]	IV	16	38 mo	MAESS increased postoperatively ($P < 0.05$), VAS at rest decreased from 3 to 0 and, VAS after provocation decreased from 7 to 2.
Robinson et al. (2017) [52]	IV	7	15 mo	Mean DASH score, 2.7
Park et al. (2016) [31]	III	20	24 mo	MEPI improved from 66 to 89. DASH improved from 26 to 14.
Park et al. (2019) [26]	III	24	24 mo	MEPI improved from 56.9 to 95.6. DASH improved from 36.6 to 8.9.

PLRI: posterolateral rotatory instability, MAESS: Modified Andrews Elbow Scoring System, VAS: visual analog scale, DASH: Disabilities of Arm, Shoulder and Hand, MEPI: Mayo Elbow Performance Index.

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CONCLUSIONS

Posterolateral impingement syndrome of the elbow remains a difficult condition to diagnose clinically, and pain is often attributed to degeneration or pathology in the common extensor tendon. Currently, arthroscopic surgery is the preferable option for treatment because it has faster rehabilitation and less hospitalization than open surgery and is therefore more cost effective. Moreover, arthroscopy provides better joint visualization than open techniques. Further research into normal olecranon geometry is required because excision of the olecranon tip is advocated as part of the surgical procedure, and over-resection can lead to instability, as shown in previous cadaveric studies.

NOTES

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Conflict of interest

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Data availability

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