Ultrasonographic differential diagnosis of medial elbow pain

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Medial elbow pain is a common musculoskeletal problem among individuals engaging in repetitive activities. Medial epicondylitis is the predominant cause of this pain. However, other potential causes must be considered as part of the differential diagnosis. This article discusses several etiologies of medial elbow pain, including medial epicondylitis, ulnar neuropathy, snapping triceps syndrome, ulnar collateral ligament injury, medial antebrachial cutaneous neuropathy, and diseases of the elbow joint, with an emphasis on ultrasound (US) findings. Awareness of possible diagnoses and their US features can assist radiologists in establishing a comprehensive diagnosis for medial elbow pain.

Keywords: Elbow; Pain; Ultrasound; Sonography; Epicondylitis; Neuropathy

Key points: Medial epicondylitis is the most common cause of medial elbow pain, displaying swelling and hypoechoic change of the common flexor tendon on ultrasound (US). Neovascularization, calcifications, or tendon tears may also be present. The ulnar nerve should be assessed for signs of entrapment or dynamic instability on US. A cross-sectional area of 10 mm\(^2\) or higher is recommended as indicative of a pathological nerve. Injuries to the ulnar collateral ligament, medial antebrachial cutaneous neuropathy, and elbow joint pathologies can be evaluated using US as part of a differential diagnosis.

Introduction

Medial elbow pain is a musculoskeletal issue that is frequently encountered in individuals engaged in repetitive activities, although it is less prevalent than lateral elbow pain [1,2]. Medial epicondylitis, a pathological condition involving the common flexor tendon, is recognized as the most common cause of medial elbow pain. However, other anatomical structures within the medial elbow region can also contribute to the pain, and these should be considered in the differential diagnosis. Such structures include the ulnar nerve, the medial head of the triceps, the ulnar collateral ligament (UCL), the medial antebrachial cutaneous nerve (MACN), and the elbow joint.

Ultrasonography (US) plays a key role in identifying the causes of medial elbow pain due to the superficial location of potential pain sources. Additionally, US represents a practical tool for screening other structures that may harbor coexisting pathologies or represent alternative diagnoses, even when positive findings are already apparent in one structure. Moreover, US offers the benefit of...
dynamic evaluation, which is essential for assessing the instability of a structure or joint laxity. Alongside US, incorporating the patient’s characteristic history, symptoms, and physical examination findings aids in refining potential diagnoses and conducting a more targeted US assessment. Table 1 presents common causes of medial elbow pain, their clinical features, and checklists for US evaluation.

This review article will discuss several etiologies of medial elbow pain, including medial epicondylitis, ulnar entrapment neuropathy, ulnar nerve instability, snapping triceps syndrome, UCL injury, MACN neuropathy, and elbow joint diseases, with a focus on US findings. Familiarity with potential diagnoses and their US features can assist radiologists in formulating a comprehensive diagnosis for medial elbow pain.

### Scanning Technique

US examination of the medial elbow can be performed with the patient either seated or lying in the supine position on an examination table (Fig. 1). For a more expedient setup, the patient should sit facing the examiner and rest their arm on a table or

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US, ultrasound.

### Fig. 1. Two common positions for evaluating the medial elbow with ultrasonography.

A. The seated position and probe placement enable a rapid and straightforward examination of the medial elbow in the long axis. B. The supine position and probe placement provide greater comfort for dynamic assessment.
Medial Epicondylitis

Medial epicondylitis, commonly known as “golfer’s elbow,” is a frequent source of medial elbow pain [2]. Patients may present with a history of repetitive actions that entail valgus stress and flexion of the elbow, involve wrist flexion and pronation, or are associated with activities such as golf, overhead throwing, and racket sports [2,9,10]. Chronic overuse and repetitive microtears to the common flexor tendon result in tendon degeneration and angiofibroblastic changes, which in turn can lead to tendinosis and tearing [10].

Typical symptoms include medial elbow pain, often with an insidious onset and sometimes accompanied by grip strength weakness [2]. The most tender point is usually found 5 to 10 mm distal and anterior to the medial epicondyle, and pain is elicited during resisted wrist flexion and forearm pronation [10].

US is considered a practical and accurate modality for detecting medial epicondylitis, exhibiting good diagnostic performance with a sensitivity of 95.2%, specificity of 92%, and an accuracy of 93.5% [11]. On the long-axis view in the coronal plane, the normal tendon appears as a continuous band of longitudinal fibers with uniform high echogenicity, extending distally to the myotendinous junction and the hypoechoic musculature. US findings characteristic of medial epicondylitis include tendinosis features such as focal or diffuse hypoechogenic changes, heterogeneous echotexture, and tendon swelling, as well as outward bowing, ill-defined margins, or subjacent fluid collection (Fig. 4) [4,10–12]. Intradigital hypoechogenic calcifications, adjacent enthesal irregularity, or traction spurs may also be present and can be confirmed on elbow radiographs, which supports the diagnosis [6,13,14].

The calcifications found in degenerated tendons are typically dystrophic, characterized by well-defined margins, a solid appearance, and strong posterior acoustic shadowing. This contrasts with the amorphous, nodular, punctate, and even cystic calcific deposits seen in calcific tendinitis, which exhibit variable posterior acoustic shadowing (Fig. 5) [15]. Neovascularization of the tendon, which can be detected using color or power Doppler US, varies and is more commonly observed in patients with a longer duration of symptoms [11]. When performing a Doppler examination, it is important not to apply excessive pressure with the probe, as the vessels in the pathological tendon are compressible and can be easily collapsed by probe pressure, which may result in missed detection of abnormal vascularity on Doppler US [16]. A partial-thickness tear is indicated by an anechoic cleft or incomplete fiber discontinuity. Although rare in medial epicondylitis, a full-thickness tear is characterized by complete discontinuity and retraction of the tendon, if present [6].

Medial epicondylitis often coexists with other pathologies, including ulnar neuropathy and UCL injury. Up to 60% of patients with medial epicondylitis experience concomitant ulnar neuropathy [17–20], which is associated with increased pain and worse surgical outcomes [18,21]. In these cases, the surgical approach for ulnar neuropathy may need to be adjusted, as anterior transposition of the nerve might be preferable to an isolated release of the cubital tunnel. This helps prevent the nerve from remaining in the inflammatory bed after surgery. Consequently, when medial epicondylitis is diagnosed using US, other medial elbow structures should also be examined.
Ulnar neuropathy, or neuritis anywhere around the elbow [22,23]. Ulnar neuropathy typically results in paresthesia or numbness in the fourth and fifth digits, and patients may also experience elbow pain that radiates to the forearm and hand [24]. As the disease progresses to more severe stages, motor nerve impairment can develop, leading to weakness in the intrinsic hand muscles. This may manifest as an inability to adduct the fifth finger, known as the Wartenberg sign, or as a claw-hand deformity that primarily affects the fourth and fifth fingers [2,24–26].

**Ulnar Neuropathy**

Ulnar neuropathy at the elbow, also known as cubital tunnel syndrome, is the second most common compressive neuropathy affecting the upper extremity [2]. Although it was first introduced as ulnar entrapment neuropathy at the fibro-osseous passageway between the medial epicondyle and the olecranon, the term “cubital tunnel syndrome” is now more commonly used to describe a wide range of conditions, encompassing ulnar nerve compression, neuropathy, or neuritis anywhere around the elbow [22,23].

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**Fig. 4. Ultrasound (US) findings of medial epicondylitis.**

**Fig. 5. Radiograph and ultrasound (US) images of a 61-year-old woman with calcific tendinitis of the common flexor tendon.**
A. Oblique radiograph of the elbow reveals fluffy and cloudy calcifications (arrows) at the insertion of the common flexor tendon near the medial epicondyle (ME) of the humerus. B. Long-axis US image of the medial elbow displays an amorphous calcific deposit within the common flexor tendon, exhibiting minimal posterior acoustic shadowing. U, ulna; R, radius.
Ulnar neuropathy or neuritis can develop due to compression or irritation of the nerve. This irritation may stem from nerve instability or the spread of local inflammation at the elbow, such as that seen with medial epicondylitis. Additionally, the superficial location of the ulnar nerve and its proximity to the bone make it particularly susceptible to traumatic injury [27]. Clinicians must be well-informed about these conditions, as the treatment approach for each can vary. This article will discuss the two main entities of ulnar nerve entrapment and instability, while also addressing snapping triceps syndrome, a similar pathology associated with ulnar nerve instability.

**Ulnar Nerve Entrapment**

Several anatomical sites around the elbow are vulnerable to ulnar nerve compression. From proximal to distal, these include the intermuscular septum, encompassing the arcade of Struthers; the medial epicondylopecty at the entrance of the cubital tunnel; the area within the cubital tunnel; and the region between the two heads of the flexor carpi ulnaris, below the Osborne band (fascia) (Fig. 6) [7,28,29]. Of these, the cubital tunnel is the most frequent site of ulnar nerve compression [7,28].

The thickened cubital tunnel retinaculum or a shallow epicondylar groove can limit the space available for the ulnar nerve within the cubital tunnel. Additionally, space-occupying soft tissue lesions, such as anatomic variants including anconeus epitrochlearis, ganglion cysts, or various types of tumors, may contribute to ulnar nerve compression in cubital tunnel syndrome [30,31]. Osseous abnormalities of the elbow joint, such as those resulting from trauma, surgery, arthritis, osteophytes, and cubitus valgus, may also compress the nerve or disrupt its course [4,32,33].

The normal nerve on US typically exhibits a characteristic fascicular pattern, consisting of hypoechoic neural bundles with hyperechoic interfaces. However, at the cubital tunnel, the ulnar nerve frequently presents as entirely hypoechoic and lacking discrete fascicles, even when not pathological [34]. Consequently, the absence of a fascicular pattern should not be solely relied upon as evidence of ulnar neuropathy on US.

In contrast, the pathological nerve tends to be substantially enlarged in addition to the less fascicular appearance [6,8,35]. Swelling is often segmental and located proximal to the site of compression, sometimes accompanied by an abrupt change in caliber [4,8]. The size of the ulnar nerve is usually assessed at the proximal cubital tunnel using the cross-sectional area (CSA) (Fig. 7). Since the CSA may decrease when the elbow is flexed compared to when it is extended, measurements should be taken with the elbow extended [4,27,36]. In the previous literature, the cut-off value of the CSA indicating abnormal findings ranges from 7.5 to 10 mm$^2$ [37–39]. A recent meta-analysis recommends a threshold of 10 mm$^2$ for diagnosing cubital tunnel syndrome. This recommendation is based on the observation that the CSA of the ulnar nerve at various elbow locations rarely exceeds 10 mm$^2$ in the healthy population. Additionally, the sensitivity, specificity, and diagnostic odds ratio values pooled from five studies using this cut-off were 85%, 91%, and 53.96, respectively [39]. Considering sex-related differences in normal nerve size [34,40], a side-to-side comparison may offer additional diagnostic value in borderline cases.

Some studies have examined the differences in CSA values measured at the cubital tunnel compared to other locations. This approach may be particularly beneficial for evaluating patients with diffuse nerve enlargement due to obesity or polyneuropathy. Yoon et al. proposed a diagnostic criterion based on a ratio of 1.5:1, comparing the CSA at the site of maximal swelling around the elbow to that of the nerve either proximally or distally. This criterion demonstrated a sensitivity of 100% and a specificity of 96.7% [41].

**Ulnar Nerve Instability**

Ulnar nerve instability is another cause of chronic ulnar neuropathy. An unstable ulnar nerve exhibits transient medial displacement from the cubital tunnel over the medial epicondyle when the elbow is flexed, then returns to its original position during elbow extension. This repetitive movement of the nerve can lead to damage and induce friction neuritis [42]. Patients may experience a snapping sensation over the medial epicondyle during elbow flexion and extension. Several factors can contribute to ulnar nerve instability, including congenital partial or complete absence of the cubital tunnel retinaculum, hypertrophic triceps muscles, or a shallow

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*Fig. 6. Schematic drawing depicting common sites of ulnar nerve entrapment. The Osborne band (fascia) is shown as the fascia that covers the humeral and ulnar heads of the flexor carpi ulnaris, as originally described. The cubital tunnel retinaculum, which is distinct from the Osborne fascia, forms the roof of the cubital tunnel.*
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US is a unique imaging modality that enables the visualization of the real-time dynamic movement of the ulnar nerve. To observe this movement, the US probe should be positioned transversely over the medial epicondyle, taking care not to apply excessive pressure, which can inhibit nerve movement. Slow flexing of the elbow while monitoring the US can reveal the transient movement of the nerve (Fig. 8, Video clip 1). If capturing the nerve’s movement in real time proves challenging, instability can still be assessed by determining whether the nerve remains within the cubital tunnel after elbow flexion. The extent of ulnar nerve displacement during elbow flexion can be classified as either subluxation, where the nerve is displaced over the apex of the medial epicondyle but does not move further upon full flexion, or dislocation, where the nerve shifts medially and moves completely past the medial epicondyle (Fig. 8) [47].

However, ulnar nerve instability does not invariably lead to ulnar neuropathy. Studies have indicated that ulnar nerve instability can be found in up to 20%–49% of the asymptomatic healthy population [6,47]; as such, it is considered a normal variant. Consequently, the diagnosis of ulnar neuropathy should be approached with caution in asymptomatic patients.

Snapping Triceps Syndrome
Snapping triceps syndrome is a pathological condition that causes irritation and instability of the ulnar nerve due to medial subluxation of the triceps muscle during elbow flexion. Patients may experience medial elbow pain, a snapping sensation, and/or symptoms of ulnar neuropathy [48,49]. Characteristic features include two distinct snaps on the medial elbow, often palpable, with the first corresponding to the dislocation of the ulnar nerve and the second to the subluxation of the triceps muscle [48,50]. Snapping triceps syndrome tends to affect men, manual laborers, athletes, and individuals with varus elbow deformity [51]. Several predisposing factors have been identified, including varus malalignment of the humerus, hypoplastic medial epicondyle, hypertrophic distal triceps muscle, and accessory slips of the triceps muscle [49,52,53].

Subluxation of the medial head of the triceps muscle can be observed crossing over the apex of the medial epicondyle during elbow flexion, along with the ulnar nerve (Fig. 9). Dynamic US of the medial elbow is advantageous for visually capturing the snapping triceps and concomitant ulnar nerve dislocation in real time (Video clip 2) [50]. The snapping sensation may be conveyed through the transducer. However, accompanying structural changes in the ulnar nerve, such as increased CSA, may not be apparent on US even in patients with ulnar nerve symptoms [50].

UCL Injury

The UCL, also known as the medial collateral ligament of the elbow, is a critical stabilizer of the elbow joint, comprising anterior, posterior, and transverse bands. The anterior band of the UCL serves as the primary restraint against valgus stress on the elbow and is the focal point for assessing ligament injuries using US [54]. UCL injuries are particularly prevalent among overhead athletes,
especially baseball pitchers, but they also affect participants in football, tennis, golf, and various other sports [55,56]. Overhead throwing activities subject the elbow to considerable valgus stress. This repetitive stress, combined with inadequate muscle stabilization, can result in ligament damage and subsequent valgus instability of the elbow [55,57,58]. Patients may experience chronic medial elbow pain during the late cocking and early acceleration phases of throwing. Alternatively, in the case of an acute injury, they may describe a sudden popping sensation followed by immediate pain and an inability to continue throwing [1,2].

The anterior band of the UCL originates from the inferior surface of the medial epicondyle, beneath the common flexor tendon, and extends to the sublime tubercle of the ulna. On US, it appears compact, hyperechoic, and fibrillar with a fan-like or cord-like

Fig. 8. Patient positioning and probe placement for ulnar nerve instability testing, along with corresponding ultrasound images. A. By placing the transducer at the cubital tunnel with minimal pressure, the examiner can observe whether the ulnar nerve displaces from the cubital tunnel upon elbow flexion. B–D. Short-axis ultrasound images obtained at the posteromedial elbow demonstrate the ulnar nerve in various positions during elbow flexion. B. In a 28-year-old man, the ulnar nerve (asterisk) is located posterior to the medial epicondyle (ME), which is its typical position during elbow flexion. C. In a 29-year-old woman, the ulnar nerve (asterisk) is subluxated at the apex of the ME during elbow flexion. D. In a 58-year-old man, the ulnar nerve (asterisk) is completely dislocated and positioned anterior to the ME during elbow flexion. Tri, triceps brachii.
structure. Applying valgus stress to the elbow can improve the visualization of the anterior band of the UCL, as the fibers tighten and become homogenously visible from the proximal to distal ends with the reduction of anisotropy. Partial tears of the anterior band of the UCL are characterized by hypoechoic changes, thickening, or focal anechoic defects involving discontinuity of the ligament. In cases of remote ligament injuries, intact fibers may appear lax. In skeletally immature adolescents, avulsion bone fragments from the medial epicondyle may be present. Complete tears of the ligament are indicated by the non-visualization or focal complete discontinuity of the fibers, accompanied by surrounding fluid or hemorrhage of variable echogenicity [4,6,59].

Dynamic US with valgus stress applied to the elbow joint can be used to demonstrate joint space widening, indicative of ligamentous laxity. To apply valgus stress to the elbow, the examiner externally rotates the shoulder while the arm is abducted and the elbow is flexed. Normally, the medial elbow joint space opens less than 3 mm with a firm endpoint [2,60]. However, abnormal medial joint space widening can be observed under valgus stress in the presence of a UCL injury (Fig. 10). The recommended diagnostic criterion is a change in joint space exceeding 1 mm between unstressed and stressed conditions, with a sensitivity of 96% and specificity of 81% according to previous research [61,62]. Nonetheless, a caveat exists when diagnosing a UCL injury based solely on widened joint space; asymptomatic professional athletes may exhibit a joint space gap of up to 3–4 mm or display asymmetry between their throwing and non-throwing arms [63].

**Medial Antebrachial Cutaneous Neuropathy**

The MACN is a purely sensory nerve that provides cutaneous sensation to the medial forearm. It originates from the medial cord of the brachial plexus and runs medially and posteriorly to the axillary artery before piercing the deep fascia in conjunction with the basilic vein, with which it runs distally. The MACN typically divides into anterior and posterior branches at the mid-arm level [64,65].
Fig. 10. A 27-year-old man who presented with right medial elbow pain that arose while he was doing push-ups. The patient had a history of right medial elbow injury sustained during gymnastics in middle school. A. Dynamic ultrasound (US) with valgus stress can be performed with the patient’s arm abducted and the elbow flexed. The US probe should visualize the ulnar collateral ligament and medial joint space while the examiner applies a valgus force by pressing down on the patient’s forearm or hand to expand the medial joint space of the elbow. B–E. Dynamic US images with valgus stress on the bilateral elbow are presented for comparison. B. Long-axis image of the normal left medial elbow shows the ulnar collateral ligament (arrows) with a low-echoic appearance due to anisotropy artifact. C. When valgus stress is applied, the ulnar collateral ligament (arrows) straightens, appears hyperechoic, and demonstrates a normal fibrillar appearance. Note that the medial joint space shows little change with valgus stress. D. Long-axis image obtained from the injured right medial elbow reveals thickening and a low-echoic change in the ulnar collateral ligament (arrows). E. With valgus stress applied, the medial joint space expands, with a joint space difference of more than 2 mm. Note the focal sagging (arrowhead) of the overlying flexor muscle into the widened joint space, indicating discontinuity of the ulnar collateral ligament. ME, medial epicondyle; U, ulna.
Accordingly, the nerve can be identified on US by following the basilic vein and positioning the probe medial to the biceps brachii muscle in the subcutaneous tissue at the anteromedial elbow (Fig. 11) [66]. MACN injury is most commonly caused by iatrogenic events, including complications from venous puncture, injection for medial epicondylitis, and cubital tunnel release [66]. Patients generally present with pain and numbness over the medial elbow and forearm. While the nerve may not display overt changes on US, a positive Tinel sign elicited by compressing the probe over the nerve can aid in diagnosis [66]. Additionally, reports describe symptomatic snapping of the MACN over the medial epicondyle during elbow flexion and extension [66,67]. Consequently, dynamic US of the MACN should be considered in cases of suspected neuropathy.

**Arthritis**

Various etiologies of arthritis that affect the elbow joint can lead to medial elbow pain. Reviewing plain radiographs and the clinical history of patients prior to US examination can assist in forming an impression of the arthritic condition.

Primary osteoarthritis of the elbow joint is less common than post-traumatic arthritis and predominantly affects the ulnohumeral joint. The degenerative changes and osteophytes initially impact the tips of the olecranon and coronoid process, with the articular cartilage becoming involved in more advanced stages [68]. This leads to pain and a limited range of motion in elbow flexion and extension. Although it is challenging to directly identify narrowed joint spaces or cartilage lesions, US can detect the presence of osteophytes and intra-articular bodies, which can cause irritation and pain or may be accompanied by effusion [69]. A dynamic examination involving flexion and extension of the elbow may help to mobilize joint fluid and intra-articular bodies, thus differentiating loose bodies from fixed osteophytes [8]. Additionally, the examiner should assess for ulnar neuropathy, which can occur in patients with osteoarthritis due to nerve irritation or compression from osteophytes or ganglions near the cubital tunnel [70,71].

Inflammatory or crystal-induced arthritis can also involve the elbow joint, presenting with joint effusion, synovial hypertrophy, and destructive bone abnormalities. The posterior olecranon recess, when the elbow is flexed, is the most sensitive area for detecting small effusions. Here, US in the longitudinal plane can reveal the displacement of the hyperechoic fat pad due to joint distension [72]. A larger effusion can distend the coronoid and radial fossa in the anterior elbow. Unlike simple anechoic effusions, complex effusions may vary in echogenicity and are often challenging to differentiate from synovial hypertrophy. Compared to synovial hypertrophy, complex effusions exhibit compressibility of the recess, redistribution or movement of contents when pressure is applied, and an absence of blood flow on Doppler US [6]. Synovial hypertrophy associated with rheumatoid arthritis or other forms of inflammatory arthritis may display diffuse synovial proliferation, which is typically less echogenic than subcutaneous fat, as well as synovial hyperemia and joint distension (Fig. 12) [6]. Cortical irregularities and disruptions, often seen with synovitis, can indicate adjacent bone erosions due to inflammation [6,8]. In diseases characterized by crystal deposition, such as gout or pseudogout, hyperechoic foci of mineral deposition...
may be observed within the joint or periarticular soft tissue. Furthermore, olecranon bursitis, which is commonly associated with gout or rheumatoid arthritis, presents as a distended bursa with effusion and synovial proliferation.

Medial elbow pain has numerous potential causes beyond those previously discussed, such as lymphoproliferative disease (Fig. 13), occult tumors, and more. Without an active search for the underlying pathology, the true source of pain may be easily overlooked during US examination. Consequently, it is crucial for radiologists to scan the area of greatest pain to ensure that US is used for the efficient and thorough assessment of medial elbow pain.

**Conclusion**

In the evaluation of medial elbow pain, US provides an efficient and dynamic assessment of the medial elbow structures. Correlating characteristic clinical features can improve the accuracy of US by directing examiners to the suspected structures and aiding in the differentiation of the cause of pain. However, even when positive findings are identified in one structure, other structures should be screened for coexisting pathologies or alternative diagnoses. A thorough examination of the most painful site must be ensured. Adopting this comprehensive approach leads to a more accurate
evaluation of medial elbow pain.

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Supplementary Material
Video clip 1. A 28-year-old woman with ulnar nerve instability in the right elbow. The short-axis view of the cubital tunnel and medial epicondyle during elbow flexion reveals transient anterior displacement of the ulnar nerve over the medial epicondyle. The ulnar nerve returns to its original location with elbow extension (https://doi.org/10.14366/usg.24102).

Video clip 2. A 35-year-old man with snapping triceps syndrome in the left elbow. The short-axis view of the cubital tunnel and medial epicondyle during elbow flexion shows anterior displacement of the ulnar nerve, with the triceps muscle belly following shortly after in a similar fashion. Both the triceps muscle and ulnar nerve return to their original locations with elbow extension (https://doi.org/10.14366/usg.24102).

References
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