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Ultrasound Imaging of Normal Displacement of the Extensor Carpi Ulnaris Tendon Within the Ulnar Groove in 12 Forearm–Wrist Positions

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Abstract

OBJECTIVE—Instability of the extensor carpi ulnaris (ECU) tendon can be a difficult clinical diagnosis because of normal changes in tendon position during wrist motion. Our goal was to determine the normal variation of ECU tendon displacement in 12 forearm–wrist positions.

SUBJECTS AND METHODS—Ultrasound imaging of the ECU tendons of 40 symptom-free wrists of healthy volunteers (13 women, seven men; mean age, 22.3 years; range, 20–25 years) was performed. Each ECU tendon was examined in 12 positions: four wrist positions (ulnar deviation, radial deviation, flexion, and extension) in each of three forearm positions (pronation, supination, and neutral).

RESULTS—ECU tendon displacement in the right hand was not significantly different from that in the left, and displacement in men did not differ significantly from that in women. There was a small but significant difference between displacement in the dominant and that in the nondominant hand ($p < 0.02$). Mean ECU tendon displacement was greatest in the supinated forearm position ($p < 0.001$) followed by the neutral position ($p < 0.001$) and was least in the pronated position ($p < 0.001$). Both ulnar deviation ($p < 0.001$) and flexion ($p < 0.002$) were associated with greater ECU tendon displacement than were radial deviation ($p < 0.001$) and extension ($p < 0.002$). Maximum percentage displacement volar to the ulnar border of the groove was 50% in flexed supination and ulnar deviation. The maximum displaced distance volar to the ulnar border of the groove was 5 mm.

CONCLUSION—Sonographic evaluation of the ECU tendon is simple and practical. Knowledge of normal ECU displacement relative to the ulnar groove may help in evaluation of ulnar-sided wrist pain.

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Keywords

extensor carpi ulnaris tendon; ultrasound; wrist

Ulnar-sided wrist pain is often a diagnostic challenge because of the complex anatomic configuration and biomechanical properties of the wrist. An important differential consideration in ulnar-sided wrist pain is instability of the extensor carpi ulnaris (ECU) tendon due to abnormal subluxation or dislocation [1]. The diagnosis is usually made on the basis of the clinical history and physical examination findings. However, advanced imaging may also be considered in the diagnostic paradigm.

MRI is effective in the detection of subtle bone marrow changes and soft-tissue abnormalities in addition to pathologic changes in the ECU tendon [2]. However, musculoskeletal ultrasound may be a cost-effective alternative to MRI in evaluation of the ECU tendon. In addition, high-resolution real-time ultrasound imaging may have an important role not only in the diagnosis of ECU abnormalities but also in the dynamic assessment of instability. In one previous study [3] investigators evaluated normal movement of the ECU tendon within the dorsal wrist compartment, but only in two wrist positions in a limited number of symptom-free subjects. The goal of our study was to determine the normal variation in ECU tendon displacement in 12 forearm–wrist positions. Establishing the normal range of ECU displacement in symptom-free healthy persons may help in evaluations of patients with pain in the ECU tendon.

Subjects and Methods

Institutional review board approval for this study protocol and informed consent from each volunteer were obtained. Exclusion criteria included the presence of wrist pain, previous hand or wrist trauma, previous surgery, and a history of inflammatory arthritis. From August 2005 to February 2006, 20 consecutively enrolled healthy volunteers (13 women, seven men; mean age, 22.3 years; range, 20–25 years) prospectively underwent musculoskeletal ultrasound examinations of the ECU tendons of the left and right wrists. The examinations were performed by one musculoskeletal radiologist with more than 5 years of ultrasound experience.

The ultrasound examinations (iU22 ultrasound system, Philips Healthcare) were performed with a variable high-frequency high-resolution 12-5–MHz linear-array transducer. Volunteers were seated in a chair across from the sonographer with forearm, wrist, and flexed elbow resting on a small adjustable table. Sonographic images of the ECU tendon were obtained in the following order: forearm pronation with wrist in radial deviation, ulnar deviation, flexion, and extension; forearm supination with wrist in radial deviation, ulnar deviation, flexion, and extension; and forearm in neutral position with wrist in radial deviation, ulnar deviation, flexion, and extension. The forearm neutral position was defined as a handshake position with thumb pointing upward.

A total of 12 sonographic images (three forearm and four wrist positions) of the ECU tendon relative to the osseous ulnar groove were obtained for each wrist. Each high-resolution

sonographic image was captured at the maximum of each combined wrist–forearm position in high-definition zoom mode with the 2× magnification setting. The position of the ECU tendon within the sixth dorsal compartment of each wrist was measured in relation to the osseous ulnar groove based on an established standardized ultrasound measurement [3]. The 480 data results obtained were also expressed as a percentage of displacement relative to the apex of the ulnar border of the ulnar groove.

Percentage displacement, or measured physiologic movement of the ECU tendon within the ulnar groove, was calculated with the measurement tool on a radiology workstation (Horizon Rad Station, version 11.0 service package 6, McKesson) and DICOM viewer (eFilm Lite software, Merge Healthcare). For each wrist, the osseous ulnar groove width was measured in millimeters, and the volar edge of the ECU tendon was identified (Figs. 1A and 1B). The distance between the apex of the ulnar border of the groove and the volar edge of the ECU tendon was determined and divided by the entire width of the ulnar groove to yield percentage displacement (Fig. 1C). Both percentage displacement and absolute displaced distance were recorded.

In a previous study, Pratt et al. [3] measured percentage displacement of the ECU tendon in only the forearm neutral position with the wrist in flexion and extension. Those authors stated that a limitation of the study was partial acoustic shadowing of the ulnar groove because the groove was obscured by the medial distal radial cortex during forearm rotation (Fig. 2). They therefore believed that adequate measurements could not be made in wrist–forearm positions, such as supination and pronation, that might have been important in evaluation of instability of the ECU tendon. We, however, believed that because the osseous structure of the ulnar groove did not change with changes in wrist position, the measured width of the ulnar groove in the neutral position can be a constant denominator. This supposition allowed measurement of ECU tendon displacement in the 12 wrist positions, which may be a more comprehensive standard for the diagnosis of instability.

Percentage displacement was expressed as positive when the volar edge of the ECU tendon subluxed over the apex of the ulnar border of the groove and as negative when the volar edge of the ECU tendon remained in the ulnar groove. This standardized approach established by the Australian Melbourne Orthopedic Group in the study by Pratt et al. [3] was expanded to include additional measurements of the four wrist positions while the forearm was pronated and while it was supinated.

Statistical software (R, version 2.6.1, R Foundation for Statistical Computing) was used for statistical analysis of ECU tendon displacement in the 12 positions of the 40 symptom-free wrists of volunteers. Differences between left and right wrists, dominant hands, and the sexes were tested with Student's paired t tests and one-way and two-way repeated measures analysis of variance.

Results

For each of the 12 positions, there was no statistically significant difference in ECU tendon displacement between right and left hands ($p < 0.45$) or with sex ($p < 0.88$). There was a

statistically significant difference, however, in mean ECU tendon displacement between dominant and nondominant hands. The displacement of the tendon in the dominant hand was 0.55 mm greater on average than that in the nondominant hand ($p < 0.02$).

Mean displacement, in millimeters, of the ECU tendon relative to the apex of the ulnar border of the groove in the three forearm positions across all four wrist positions was −1.19 mm (SD, 1.67 mm) in pronation, −0.57 mm (SD, 1.72 mm) in neutral position, and 1.46 mm (SD, 2.03 mm) in supination. We found that the mean ECU tendon displacement was greatest for the supinated forearm position ($p < 0.001$) followed by the neutral position ($p < 0.001$) and was least in the pronated position ($p < 0.001$). Thus, from pronation to neutral to supination, the degree of ECU tendon displacement increased progressively from completely within the ulnar groove to a mean of 1.46 mm (SD, 2.03) beyond the apex of the ulnar border of the ulnar groove. The maximum percentage displacement was 50% volar to the ulnar border of the groove, and the maximum absolute displaced distance was 5 mm.

The mean displacement of the ECU tendon in the four wrist positions (across all three forearm positions) was −0.72 mm (SD, 1.81) with radial deviation, 0.42 mm (SD, 0.35) with ulnar deviation, 0.35 mm (SD, 2.33) with flexion, and −0.45 mm (SD, 2.06) with extension. In comparisons of the four wrist positions, both ulnar deviation ($p < 0.001$) and flexion ($p < 0.002$) were associated with greater ECU tendon displacement beyond the ulnar border apex of the groove than were radial deviation ($p < 0.001$) and wrist extension ($p < 0.002$). The maximum percentage displacement volar to the ulnar border of the groove was 50% for ulnar deviation and 45% for flexion with forearm supination. The maximum absolute displaced distance beyond the apex of the ulnar border was 5 mm.

Two-way repeated measures analysis of variance showed that the combination of the four wrist positions and the three forearm positions was additive rather than interactive. For example, the supinated position had the greatest mean ECU tendon displacement relative to the ulnar border apex of the ulnar groove (1.46 mm). This mean displacement increased to 1.95 mm (SD, 1.78 mm) beyond the apex of the ulnar border when supination was combined with ulnar deviation (Fig. 3) and increased to 1.98 mm (SD, 1.98 mm) when supination was combined with wrist flexion.

In forearm pronation, the ECU remained entirely within the ulnar groove in all four wrist positions; therefore, forearm pronation is presumably the most stable forearm position for the ECU tendon. The mean displacement with the forearm in neutral position was within the ulnar groove in three of the four wrist positions (radial deviation, flexion, extension). Figure 4 shows the number of the 40 wrists that had ECU displacement beyond the apex of the ulnar border of the groove in the 12 forearm–wrist combinations. Across all 12 forearm-wrist combinations, the dorsal edge of the ECU tendon never dislocated over the ulnar border of the groove. The volar edge of the tendon also did not dislocate beyond the radial border of the groove in any of the forearm–wrist positions.

Discussion

Ulnar-sided wrist pain is often a diagnostic challenge similar to that encountered with shoulder pain and low back pain, which can have multiple causes with similar symptoms. An important diagnostic consideration of ulnar-sided wrist pain is ECU tendon instability, that is, symptomatic subluxation or dislocation [1, 4]. Causes of ECU tendon instability include sports-related injuries common among tennis players and golfers [5, 6], chronic inflammatory processes such as rheumatoid arthritis [7], stenosing tenosynovitis [8], and wrist trauma, usually due to hypersupination and ulnar deviation [9, 10].

Understanding the complex anatomic and biomechanical properties of the distal radioulnar joint and their effect on the sixth dorsal compartment and ECU tendon is important for accurate diagnosis. With forearm rotation, the distal radioulnar joint moves in three planes: rotation along the long axis of the forearm (average of 150° around the ulnar head from maximal pronation to maximal supination), dorsal–volar translation, and proximal–distal translation [11, 12]. In pronation, the ulnar head contacts the dorsal margin of the sigmoid notch and becomes palpable [13]. With supination, the ulnar head contacts only the volar margin of the sigmoid notch, and the ECU compartment and extensor digiti quinti compartments nearly touch each other [13]. Pronation increases ulnar variance, and supination decreases it [14]. It is important to understand that the ECU tendon, held by its subsheath within the ulnar groove, makes various movements within a dynamic, complex system.

Inoue and Tamura [15] described the clinical findings of symptomatic ECU subluxation and dislocation in all patients undergoing forearm supination and wrist flexion, with or without ulnar deviation, accompanied by an audible click. On forearm pronation, the ECU tendon reduced into its groove as found at physical examination. However, there was no imaging correlation. Pfirrmann and colleagues [11] observed that at both CT and MRI, the ECU tendon appeared to be in physiologic subluxation during forearm supination in patients without symptoms, but this displacement was not studied further (Fig. 5). MRI is well established for evaluation of tendon abnormalities and subtle bone marrow changes [2]. MRI is a static technique, however, and not optimal for evaluation of the dynamic component of ECU tendon instability. High-resolution ultrasound is safe and cost-effective. Patients often prefer ultrasound over MRI [16], and ultrasound is well suited for evaluation of tendons. We believe our study is the first prospective dynamic ultrasound evaluation of normal ECU displacement reflecting all aspects of wrist movement.

Before the start of our study, we found only one previous study in which ultrasound was used to evaluate the normal ECU tendon. Pratt et al. in 2004 [3] studied normal ECU tendon movement within the groove in 10 volunteers (20 wrists). They found that the volar edge of the tendon was not displaced more than 40% (percentage width of groove) beyond the ulnar border of the groove in healthy subjects. However, ECU tendon movement was described in only the neutral forearm position (handshake position) with wrist flexion and extension. The authors stated that evaluation of the ECU in other forearm–wrist positions was limited by partial acoustic shadowing of the ulnar groove by the medial–distal radial cortex during forearm supination and pronation. We believed that studying ECU tendon movement in 12

forearm–wrist positions would reflect the complex biomechanical properties of the tendon and provide a comprehensive standard for evaluation of ECU tendon instability.

At the time of this writing, MacLennan et al. [17] were conducting a study that included 21 patients with painful snapping ECU tendons. All 21 patients underwent preoperative dynamic ultrasound evaluation in only the forearm pronated and forearm supinated positions without wrist deviation. At ultrasound examination, all patients were described as having painful ECU tendon subluxation. At surgery, all patients had intact tendon sheaths, and the injuries were diagnosed as type C in the classification proposed by Inoue and Tamura [15]. However, there was no control group, and all patients underwent surgery.

We used ultrasound to measure displacement of the ECU tendon relative to the apex of the ulnar border and to calculate percentage displacement using the ulnar groove width as the constant denominator in 12 forearm–wrist positions. In accordance with the findings of Pratt et al. [3], mean displacement remained within the ulnar groove in three of the four wrist positions (radial deviation, flexion, extension) while the forearm was in neutral position. However, we also found that the normal ECU tendon was displaced up to a maximum of 50% with either forearm supination or wrist ulnar deviation and up to 45% with wrist flexion. This maximum displacement was greater than that the 40% previously reported by Pratt et al. and was likely due to the additional forearm and wrist movements, which may have offered more provocative maneuvers in displacing the ECU.

We found a small but statistically significant difference between dominant and nondominant hands. On average, the dominant hand had 0.55-mm greater mean displacement relative to the nondominant hand, perhaps because of increased laxity of the ECU subsheath from repetitive use of the dominant hand. There was no significant difference in ECU tendon displacement between right and left hands or according to sex.

Although an advantage of ultrasound is its utility in dynamic evaluation, we did not assess the normal dynamic range of motion of the ECU tendon. However, dynamic real-time evaluation with ultrasound may help in the diagnosis of painful snapping ECU tendon and should be further studied in a cohort of abnormal cases.

A limitation of our study was lack of a case group of abnormal ECU tendons to determine whether unstable tendons differ in displacement compared with our findings in healthy subjects. A further limitation was the small number of volunteers and their young age. It is possible that in a study with a larger number of volunteers we might have identified volunteers without symptoms who had greater degrees of displacement in certain forearm and wrist positions, as in the small group of persons with a congenitally shallow ulnar groove for the ECU [18]. It is unlikely, however, that average displacement and patterns of tendon excursion would change markedly in a larger study. Further investigation with subjects with symptomatic abnormalities and correlation with operative findings is needed.

Ultrasound evaluation of the ECU tendon is simple and practical. Establishing a comprehensive standard of normal ECU tendon movement in the ulnar groove, especially in positions such as supination, ulnar deviation, and flexion, may help in evaluation for ECU tendon instability as a cause of ulnar-sided wrist pain.

References

1. Allende C, Le Viet D. Extensor carpi ulnaris problems at the wrist: classification, surgical treatment and results. J Hand Surg Br. 2005; 30:265–272. [PubMed: 15862366]
2. Mack MG, Keim S, Balzer JO, et al. Clinical impact of MRI in acute wrist fractures. Eur Radiol. 2003; 13:612–617. [PubMed: 12594566]
3. Pratt RK, Hoy GA, Bass Franzcr C. Extensor carpi ulnaris subluxation or dislocation? Ultrasound measurement of tendon excursion and normal values. Hand Surg. 2004; 9:137–143. [PubMed: 15810097]
4. Paley D, McMurtry RY, Murray JF. Dorsal dislocation of the ulnar styloid and extensor carpi ulnaris tendon into the distal radioulnar joint: the empty sulcus sign. J Hand Surg Am. 1987; 12:1029–1032. [PubMed: 3693829]
5. Montalvan B, Parier J, Brasseur JL, Le Viet D, Drape JL. Extensor carpi ulnaris injuries in tennis players: a study of 28 cases. Br J Sports Med. 2006; 40:424–429. [PubMed: 16632573]
6. Rettig AC. Athletic injuries of the wrist and hand. Part II. Overuse injuries of the wrist and traumatic injuries to the hand. Am J Sports Med. 2004; 32:262–273. [PubMed: 14754754]
7. McQueen F, Beckley V, Crabbe J, Robinson E, Yeoman S, Stewart N. Magnetic resonance imaging evidence of tendinopathy in early rheumatoid arthritis predicts tendon rupture at six years. Arthritis Rheum. 2005; 52:744–751. [PubMed: 15751075]
8. Hajj AA, Wood MB. Stenosing tenosynovitis of the extensor carpi ulnaris. J Hand Surg Am. 1986; 11:519–520. [PubMed: 3722761]
9. Inoue G, Tamura Y. Surgical treatment for recurrent dislocation of the extensor carpi ulnaris tendon. J Hand Surg Br. 2001; 26:556–559. [PubMed: 11884112]
10. Burkhart SS, Wood MB, Linscheid RL. Posttraumatic recurrent subluxation of the extensor carpi ulnaris tendon. J Hand Surg Am. 1982; 7:1–3. [PubMed: 7082460]
11. Pfirrmann CW, Theumann NH, Chung CB, Botte MJ, Trudell DJ, Resnick D. What happens to the triangular fibrocartilage complex during pronation and supination of the forearm? Analysis of its morphology and diagnostic assessment with MR arthrography. Skeletal Radiol. 2001; 30:677–685. [PubMed: 11810165]
12. Shin AY, Deitch MA, Sachar K, Boyer MI. Ulnar-sided wrist pain: diagnosis and treatment. Instr Course Lect. 2005; 54:115–128. [PubMed: 15948439]
13. Spinner M, Kaplan EB. Extensor carpi ulnaris. Its relationship to the stability of the distal radio-ulnar joint. Clin Orthop Relat Res. 1970; 68:124–129. [PubMed: 5414710]
14. Epner RA, Bowers WH, Guilford WB. Ulnar variance: the effect of wrist positioning and roentgen filming technique. J Hand Surg Am. 1982; 7:298–305. [PubMed: 7086100]
15. Inoue G, Tamura Y. Recurrent dislocation of the extensor carpi ulnaris tendon. Br J Sports Med. 1998; 32:172–174. [PubMed: 9631228]
16. Middleton WD, Payne WT, Teefey SA, Hildebolt CF, Rubin DA, Yamaguchi K. Sonography and MRI of the shoulder: comparison of patient satisfaction. AJR. 2004; 183:1449–1452. [PubMed: 15505319]
17. MacLennan AJ, Nemechek NM, Waitayawinyu T, Trumble TE. Diagnosis and anatomic reconstruction of extensor carpi ulnaris subluxation. J Hand Surg Am. 2008; 33:59–64. [PubMed: 18261666]
18. Nakashima T, Hojo T, Furukawa H. Deep and shallow forms of the sulcus for extensor carpi ulnaris. J Anat. 1993; 183:635–638. [PubMed: 8300441]

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1. O'Connor PJ, Campbell R, Bharath AK, Campbell D, Hawkes R, Robinson P. Pictorial review of wrist injuries in the elite golfer. British Journal of Sports Medicine. 2016; 50(17):1053–1063. [PubMed: 27343240]
2. Nacey, Nicholas C.; Pierce, Jennifer L. Ultrasound Imaging of the Hand and Wrist: Fundamentals and New Perspectives. Current Radiology Reports. 2016; 4(8)

3. Starr, Harlan M.; Sedgley, Matthew D.; Means, Kenneth R.; Murphy, Michael S. Ultrasonography for Hand and Wrist Conditions. Journal of the American Academy of Orthopaedic Surgeons. 2016; 24(8):544–554. [PubMed: 27355280]

4. Petchprapa, Catherine N.; Meraj, Seema; Jain, Nidhi. ECU tendon “dislocation” in asymptomatic volunteers. Skeletal Radiology. 2016; 45(6):805–812. [PubMed: 26980226]

5. Conroy, Christine; Ruchelsman, David E.; Vitale, Mark A. Extensor Carpi Ulnaris Instability in Athletes - Diagnosis and Treatment. Operative Techniques in Sports Medicine. 2016; 24(2):139–147.

6. Stone, Taylor J.; Rosenberg, Zehava S.; Velez, Zoraida Restrepo; Ciavarra, Gina; Prost, Roberto; Bencardino, Jenny T. Subluxation of the peroneus long tendon in the cuboid tunnel: is it normal or pathologic? An ultrasound and magnetic resonance imaging study. Skeletal Radiology. 2016; 45:357–365. [PubMed: 26659451]

7. Ghatan, Andrew C.; Puri, Sameer G.; Morse, Kyle W.; Hearns, Krystle A.; von Althann, Caroline; Carlson, Michelle G. Relative Contribution of the Subsheath to Extensor Carpi Ulnaris Tendon Stability: Implications for Surgical Reconstruction and Rehabilitation. The Journal of Hand Surgery. 2016; 41:225–232. [PubMed: 26691954]

8. Islam, Anamul; Sundaraj, Kenneth; Badlishah Ahmad, R.; Sundaraj, Sebastian; Ahamed, Nizam Uddin; Ali, Md. Asraf Analysis of crosstalk in the mechanomyographic signals generated by forearm muscles during different wrist postures. Muscle & Nerve. 2015; 51:899–906. 10.1002/mus.v51.6. [PubMed: 25204740]

9. Sole, Joshua S.; Wisniewski, Steve J.; Newcomer, Karen L.; Maida, Eugene; Smith, Jay. Sonographic Evaluation of the Extensor Carpi Ulnaris in Asymptomatic Tennis Players. PM&R. 2015; 7:255–263. [PubMed: 25217825]

10. Chiavaras, Mary M.; Jacobson, Jon A.; Yablon, Corrie M.; Brigido, Monica Kalume; Girish, Gandikota. Pitfalls in Wrist and Hand Ultrasound. American Journal of Roentgenology. 2014; 203(3):531–540. [PubMed: 25148155]

11. Sofka, Carolyn M. Ultrasound of the Hand and Wrist. Ultrasound Quarterly. 2014; 30:184–192. [PubMed: 25148487]

12. Chang, Connie Y.; Huang, Ambrose J.; Bredella, Miriam A.; Kattapuram, Susan V.; Torriani, Martin. Association between distal ulnar morphology and extensor carpi ulnaris tendon pathology. Skeletal Radiology. 2014; 43:793–800. [PubMed: 24595441]

13. Massaki, Alexandre Norio; Tan, Jeffrey; Huang, Brady K.; Chang, Eric Y.; Trudell, Debra J.; Resnick, Donald L. Extensor retinaculum of the wrist: gross anatomical correlation with MR imaging after ultrasound-guided tenography with emphasis on anatomical features in wrist dorsiflexion responsible for tendon impingement. Skeletal Radiology. 2013; 42:1727–1737. [PubMed: 24085470]

14. Yung M, Wells RP. Changes in muscle geometry during forearm pronation and supination and their relationships to EMG cross-correlation measures. Journal of Electromyography and Kinesiology. 2013; 23:664–672. [PubMed: 23369877]

15. Campbell D, Campbell R, O'Connor P, Hawkes R. Sports-related extensor carpi ulnaris pathology: a review of functional anatomy, sports injury and management. British Journal of Sports Medicine. 2013; 47(17):1105. [PubMed: 24096897]

16. Kim, Byung-Sung; Yoon, Hong-Gi; Kim, Hyung-Tae; Park, Kang-Hee; Kim, Chang-Geun; Song, Hyun-Seok. Subluxation of the Extensor Carpi Ulnaris Tendon Associated with the Extensor Digitorum Tendon Subluxation of the Long Finger. Clinics in Orthopedic Surgery. 2013; 5:82. [PubMed: 23467477]

17. Soubeyrand M, Begin M, Pierrart J, Gagey O, Dumontier C, Guerini H. L’échographie pour le chirurgien de la main (conférence d’enseignement XLVe congrès de la Société française de chirurgie de la main). Chirurgie de la Main. 2011; 30:368–384. [PubMed: 22047745]

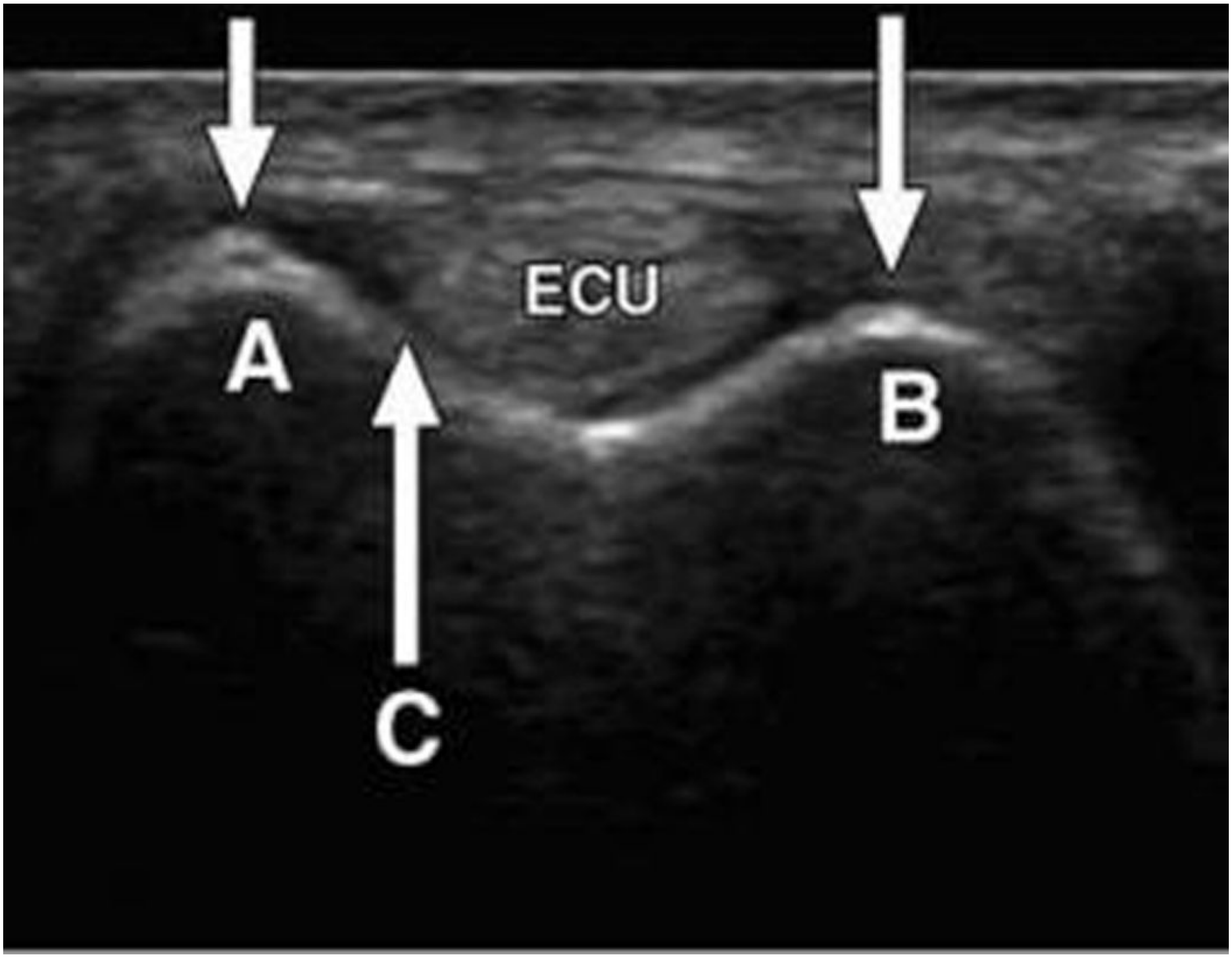
18. Imagerie du poignet et de la main. :133–183.

19. Jeantroux, Jeremy; Becce, Fabio; Guerini, Henri; Montalvan, Bernard; Viet, Dominique; Drapé, Jean-Luc. Athletic injuries of the extensor carpi ulnaris subsheath: MRI findings and utility of gadolinium-enhanced fat-saturated T1-weighted sequences with wrist pronation and supination. European Radiology. 2011; 21:160–166. [PubMed: 20680292]

20. Watanabe, Atsuya; Souza, Felipe; Vezeridis, Peter S.; Blazar, Philip; Yoshioka, Hiroshi. Ulnar-sided wrist pain. II. Clinical imaging and treatment. Skeletal Radiology. 2010; 39:837–857. [PubMed: 20012039]

21. Davis, Kirkland W.; Blankenbaker, Donna G. Imaging the Ligaments and Tendons of the Wrist. Seminars in Roentgenology. 2010; 45:194–217. [PubMed: 20483115]

22. Parier J, Montalvan B. Conflit de L'extensor Carpi Ulnaris dans sa Gouttière. :231–240.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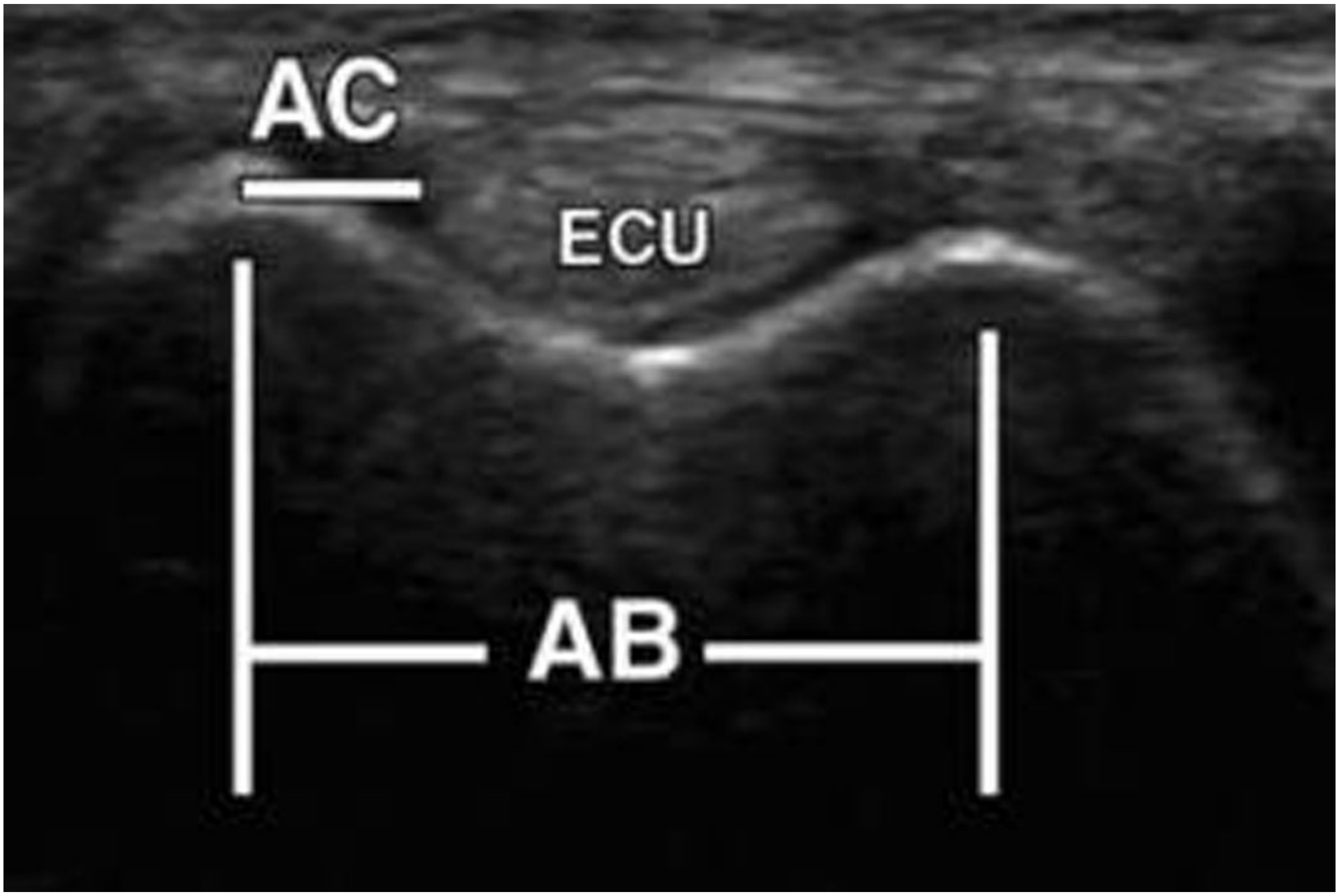

Fig. 1.

21-year-old healthy male volunteer.

A, Transverse ultrasound image of extensor carpi ulnaris (ECU) tendon at deepest part of groove shows ulnar border of groove (A), radial border of groove (B), and volar edge of ECU tendon (C).

B, Axial T1-weighted MR image corresponding to **A** shows conventional anatomic features and landmarks of sixth dorsal compartment containing ECU tendon in ulnar groove. A = ulnar border of groove, B = radial border of groove, C = volar edge of ECU tendon.

C, Transverse ultrasound image shows standard ECU measurement. Percentage displacement = AC/AB × 100. AC = absolute displacement [3].

Fig. 2.

23-year-old healthy male volunteer. Transverse sonographic image with wrist in supination and ulnar deviation. Extensor carpi ulnaris measurement is modified for supination and pronation. In each forearm and wrist position, apex of ulnar border (A) was consistently identified. Although radial border is shadowed (*asterisk*), ulnar groove length remains constant. Arrow indicates extensor carpi ulnaris tendon.

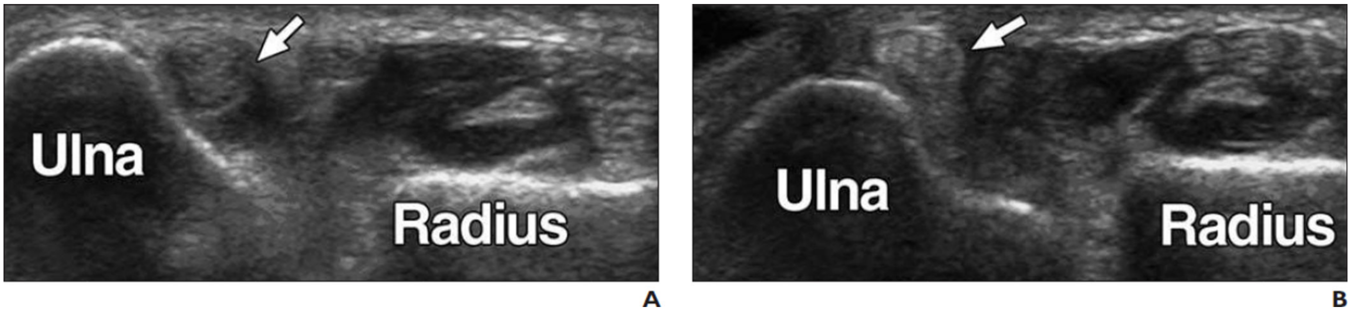

Fig. 3.
25-year-old healthy female volunteer.
A and **B**, Transverse ultrasound images show normal displacement of extensor carpi ulnaris tendon from supinated radial (**A**) to supinated ulnar (**B**) forearm–wrist position. Arrow indicates extensor carpi ulnaris tendon.

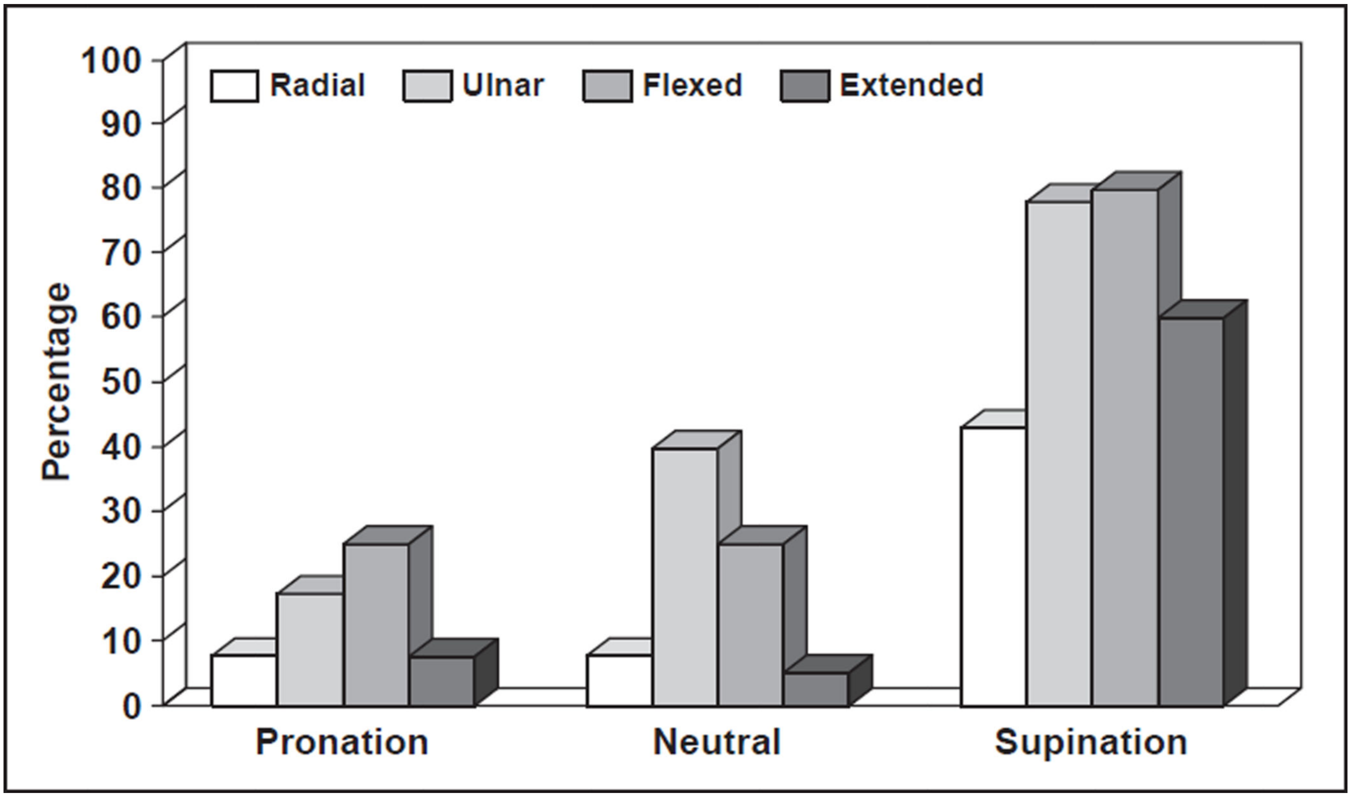

Fig. 4.

Graph shows percentage of normal wrists (n = 40) displaced beyond volar apex in each of three forearm positions.


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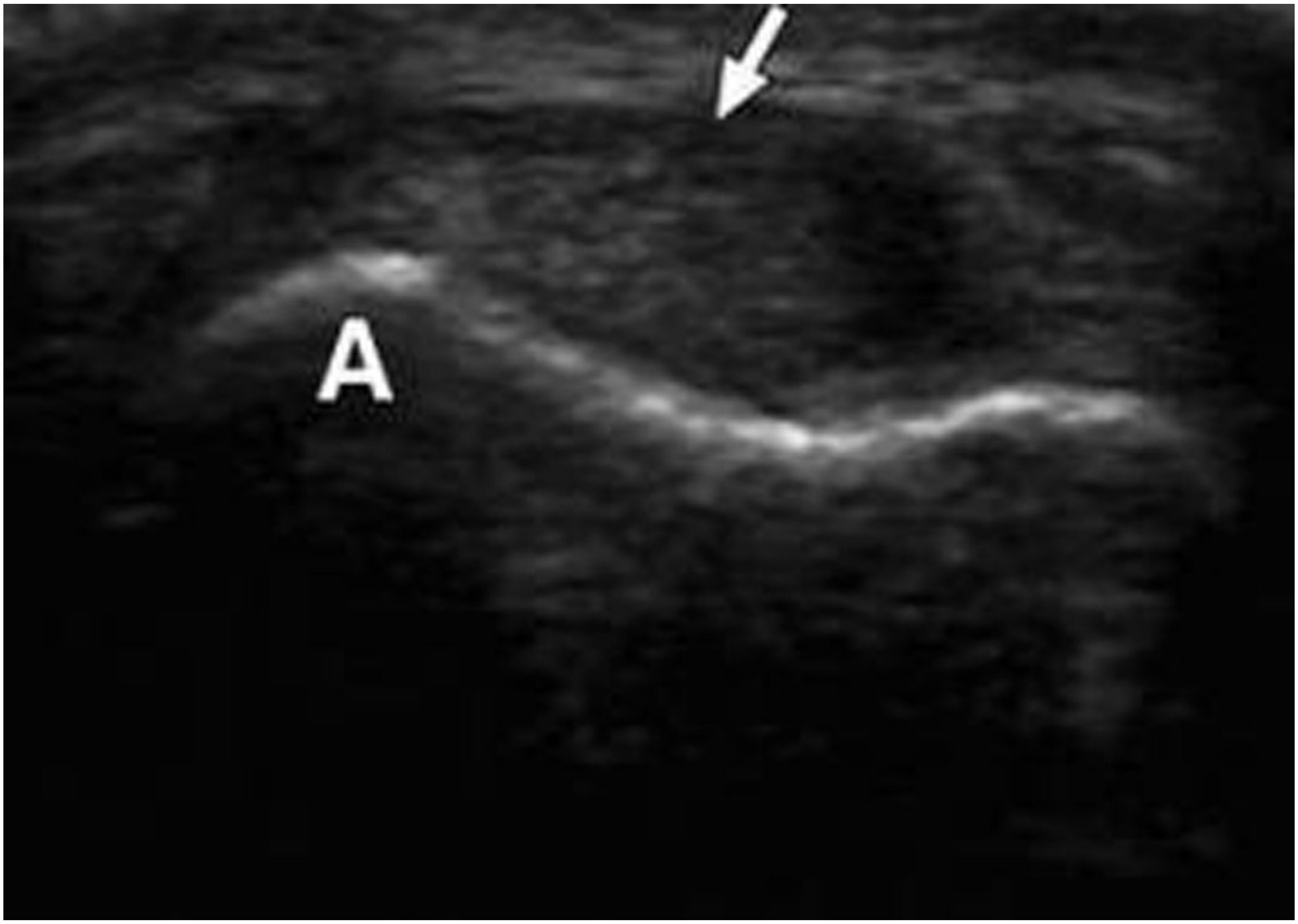
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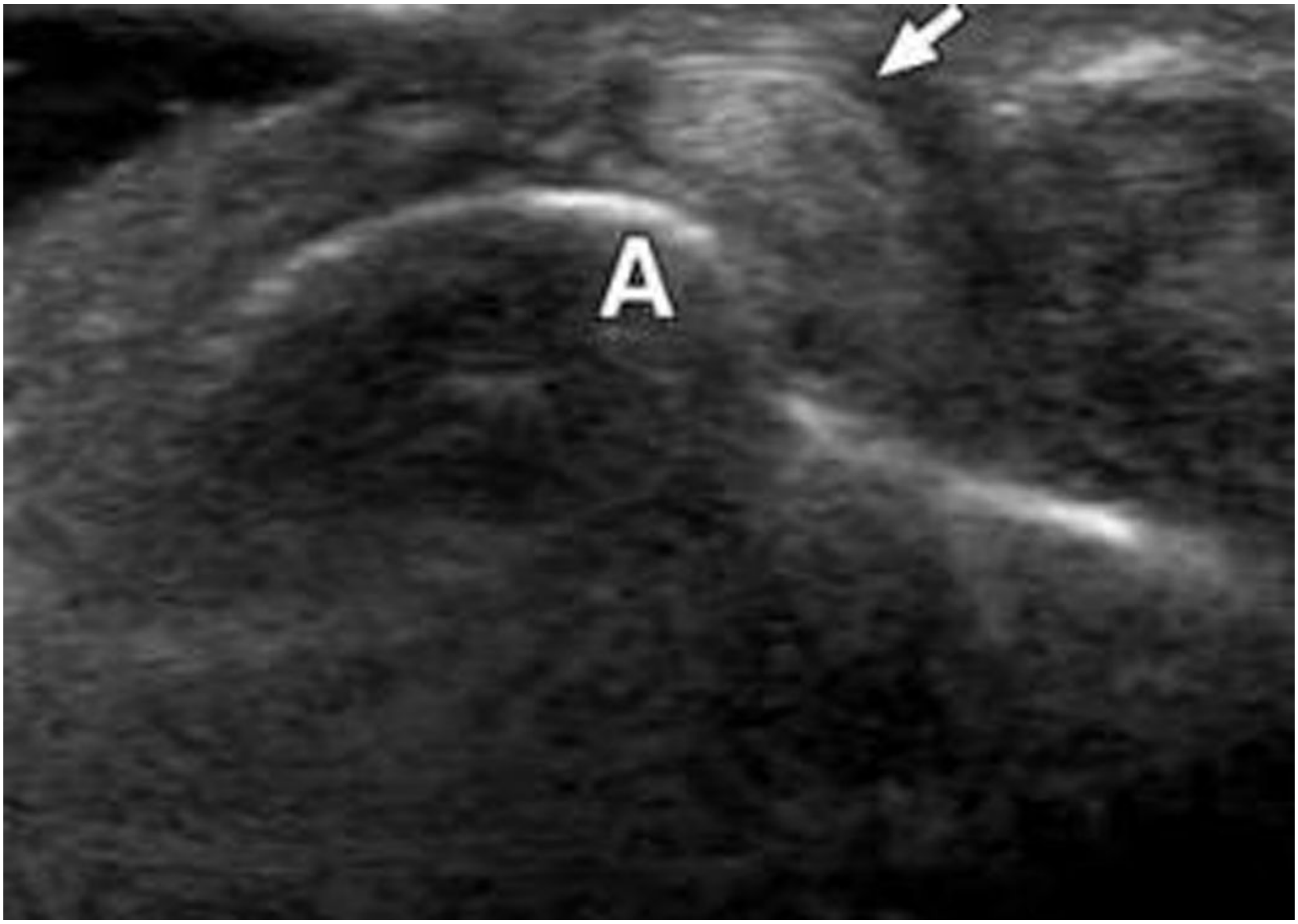
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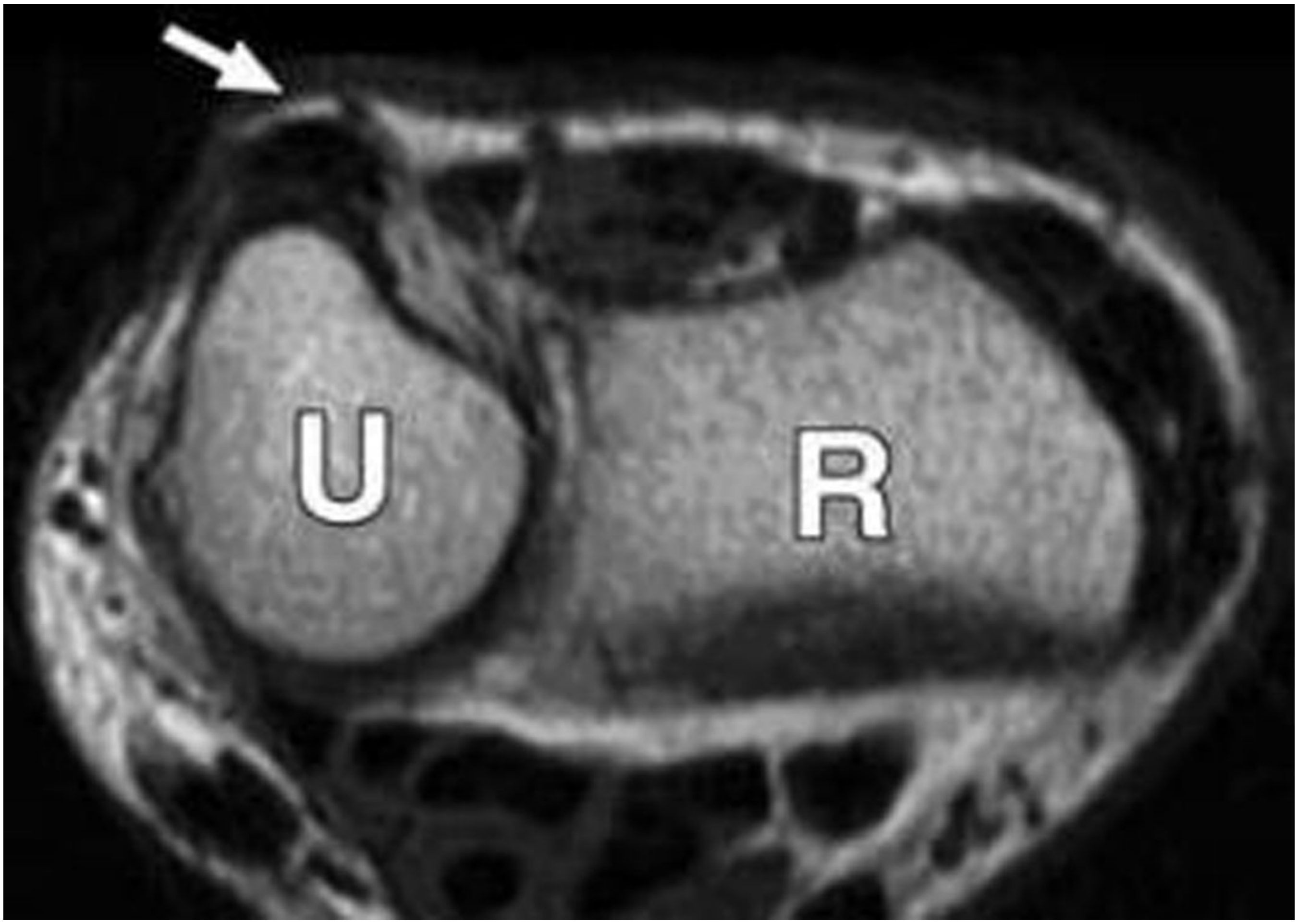

Fig. 5.
20-year-old healthy male volunteer with ultrasound findings of normal extensor carpi ulnaris tendon and 25-year-old healthy male volunteer with MRI findings of normal wrist. Arrow indicates extensor carpi ulnaris tendon. A = apex of ulnar border of groove, U = ulna, R = radius.

A and **B**, Transverse ultrasound image (**A**) and MR image (**B**) show wrist in pronation.

C and **D**, Transverse ultrasound image (**C**) and MR image (**D**) show wrist in neutral position.

E and **F**, Transverse ultrasound image (**E**) and MR image (**F**) show wrist in supination.