Research paper

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# Ultrasonography of the ulnar nerve loop in relation to the flexor carpi ulnaris tendon

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**Abstract**

**Aim:** The purpose of this study is to present the ultrasound appearance of a previously undescribed-at-imaging variant of the ulnar nerve near the Guyon's canal. **Material and methods:** The ultrasound database of one of the authors, who has more than 10 years of experience in peripheral nerve ultrasound, was searched for the phrases "UN variant" or "UN loop." The other two authors, with more than 10 years of experience in nerve imaging, retrospectively reviewed the static sonograms as well as the videoclips stored, to confirm the findings. **Results:** Between October 2019 and October 2023, six cases were found in five patients, where ultrasound demonstrated previously undescribed-at-imaging anatomical variations of the distal ulnar nerve on six distal forearms. The variant was symptomatic in three cases in which possible distal compression was clinically suspected. A branch of the ulnar nerve made a loop around the flexor carpi ulnaris, which also presented with a variation of normal anatomy. In symptomatic patients, the diameter of the aberrant branch (retrospectively measured) was significantly enlarged. **Conclusions:** High-resolution ultrasound can accurately demonstrate ulnar nerve variants even when only small nerve fascicles are involved, which may be clinically relevant and misinterpreted. Loops of the ulnar nerve are rare, but likely under-recognized. We think that symptoms are generally tolerated by patients if the motor branch of the ulnar nerve is not affected, as in our cases.

## Introduction

Entrapment of the ulnar nerve (UN) most commonly occurs at the elbow, at the level of the so-called cubital tunnel[1]. Less frequent locations include the Guyon's canal at the wrist[2].

With ultrasound (US), it is possible to study the normal and pathological UN as well as its relationship with contiguous structures, such as muscles and tendons[3,4]. Moreover, high-frequency transducers can exquisitely demonstrate the small branches of the UN, since their course is usually superficial[5–10].

Among rare compression syndromes related to variants, loops of the UN have been described at the distal forearm and at the Guyon's canal. These variants are usually associated with flexor carpi ulnaris (FCU) variations, and have been identified during surgery or anatomical dissection[11–13]. However, to the best of our knowledge, these variants have never been reported in the radiological literature so far.

We present a series of six cases in which we demonstrated at US variations of the UN at the distal forearm/wrist, where a branch of the nerve had an anomalous course in relation to the FCU.

## Materials and methods

Approval for this study was obtained from the ethical board of our institution. The requirement for informed patient consent was waived because of the retrospective nature of the study.

Sonographic reports from the same institution were searched from October 2019 to October 2023 for the key phrases "UN variant" or "UN loop". Static images and video clips were retrieved from the PACS system and reviewed.

Sonographic examinations were performed by the same clinician (M.B.) with more than 10 years of experience in musculoskeletal

and nerve US. Two different US machines were used based on availability, both equipped with two transducers: one linear (respectively 5–14 MHz for the first machine and 6–15 MHz for the second), and one hockey stick with a smaller footprint and higher frequency (7–18 MHz for the first US system, 6–24 MHz for the second).

Color and/or Power Doppler were used to differentiate nerve fascicles from vessels. Nerves and branches were followed using the elevator technique in the axial planes; long-axis sonograms were acquired to confirm the course of the nerve in the case of a variant, especially when abnormal thickening was present. Images of the intrinsic muscles of the hand supplied by the motor branch of the UN were also obtained to demonstrate possible alterations.

The maximum transverse diameter of the aberrant branches was measured in the axial planes, as well as the normal diameter proximally; the ratio between the two measurements was then calculated.

After the first demonstrated case, it became easier to depict a similar variation in patients who were referred for US wrist evaluation, even without any clinical sign of UN pathology.

The two other authors (C.P., G.R.), each with more than 10 years of experience in peripheral nerve imaging, reviewed the static sonograms as well as the video clips.

## Results

We identified six upper limbs with an anomalous course of the UN at the distal forearm-wrist, in five patients. In these cases, nerve fascicles formed a loop with respect to the FCU, which also exhibited a variation of the usual anatomy. The data are summarized in Tab. 1.

One patient presented the variant bilaterally (Cases 3, 4). In the other four patients, the variant was unilateral.

In three cases (Cases 1, 3, 4), a small branch detached from the proximal dorsal cutaneous branch of the UN (DCBUN) to proceed parallel to the UN. Just proximal to the pisiform bone, the aberrant branch passed between a variant of the FCU, composed of two tendons, both inserting at the pisiform, one medially and one laterally. Then, the branch made a loop over the radial FCU tendon to pierce the palmar carpal ligament and re-join the UN at the proximal Guyon's canal (Fig. 1, Fig. 2, Video 1). The branch was distally followed, ending in the superficial branch of the UN (SBUN).

One patient (Case 2) was similar to the previous cases, except for the absence of the DCBUN (the aberrant branch originated at the level where the DCBUN usually detaches from the UN).

In another patient (Case 5), the DCBUN was normal, and the aberrant branch originated from the UN just proximal to the pisiform, then followed a course similar to the previous cases.

In the last patient (Case 6), it was the DCBUN that made a loop at a small accessory FCU tendon, located deep to the normal FCU (Fig. 3). Later, it continued its normal course to the dorsal-ulnar side of the hand.

UN-related sensitive symptoms were present in two patients, one of whom had bilateral symptoms (Cases 1, 3, 4): paresthesia of the little finger and the fourth finger, mainly present during repetitive wrist movements. In these patients, the sonographic Tinel sign, achieved by pressing with the transducer at the level of the branch compression, elicited the patient's symptoms. No one presented with clinical signs of UN motor palsy, and there were no alterations when evaluating the intrinsic muscles of the hand supplied by the deep motor branch of the UN.

Patients with symptoms demonstrated aberrant branch swelling, whereas there was only mild nerve thickening in the asymptomatic cases. Measurements of the branches, as well as the ratio between the maximal branch enlargement and the normal proximal diameter, are reported in Tab. 1.

**Tab. 1.** Demographic characteristics, description of the variant found, whether it was associated with nerve entrapment-related symptoms

| Case side | Age | Sex | UN variation | Symptoms | Bmax / Bprox ratio |
|---|---|---|---|---|---|
| 1 Right | 55 | M | A small branch detaches from the DCBUN to proceed parallel to the UN, and just proximal to the pisiform passes through a bifid FCU, rejoining the UN at the proximal Guyon's canal | Yes | 2.7 / 0.5 mm 5.4 |
| 2 Right | 70 | F | The aberrant branch detaches from the UN at the level of the usual DCBUN origin to follow a course similar to that of case 1. DCBUN is absent | No | 0.9 / 0.6 mm 1.5 |
| 3 (bilateral) Left | 48 | M | Similar to case 1 | Yes | 2.6 / 0.7 mm 3.7 |
| 4 (bilateral) Right | 48 | M | Similar to case 1 | Yes | 3/ 0.7 mm 4.3 |
| 5 Left | 37 | M | A small branch detaches from the UN just before the pisiform to pass through a bifid FCU, and then rejoins the UN at the proximal Guyon's canal | No | 0.9 / 0.7 mm 1.3 |
| 6 Right | 51 | F | DCBUN forming a loop around an accessory, deeply located small FCU tendon | No | 0.6 / 0.3 mm 2 |

Patients presented the variant only on one side, except for a 48-year-old male (Cases 3, 4), in whom the variant was bilateral. Bmax / Bprox refers to the measurement of the branch transverse diameter, respectively, at the point of maximal enlargement (Bmax) and proximally, where it was normal (Bprox). Ratio refers to the ratio of these measurements. DCBUN indicates the dorsal cutaneous branch of the ulnar nerve; FCU – flexor carpi ulnaris; UN – ulnar nerve

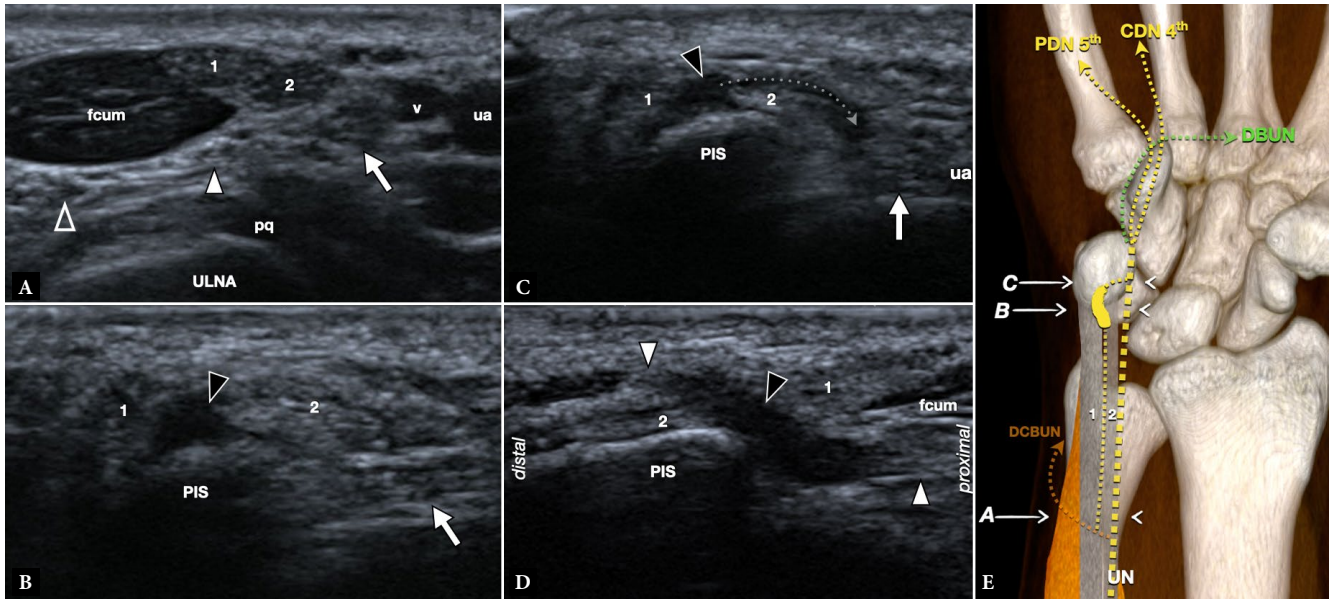


**Fig. 1.** *Case 1.* **A–C.** *Axial sonograms from proximal (***A***) to distal (***C***) at the distal third of the forearm and wrist in a patient with paresthesia of the 4th and 5th fingers. In* **A**, *the UN is indicated by the white arrow. An aberrant branch (white arrowhead) had detached from the DCBUN (open arrowhead). The FCU is composed of two tendons (1, 2).* **B.** *At the entrance of the Guyon's canal, the aberrant branch (black arrowhead) is thickened between the proximal pole of the pisiform bone (PIS) and the two tendons of the FCU. In* **C**, *slightly distal, the branch forms a loop (curved dotted arrow) over the radial tendon of the FCU (2) to rejoin the UN.* **D.** *Correspondent long-axis of the aberrant branch, clearly confirming its thickening.* **E.** *Schematic CT-3D drawing of the variant. Probe position of the axial images is indicated. CDN 4th indicates the common digital nerve of the 4th space; DBUN – deep branch of the ulnar nerve; fcum – flexor carpi ulnaris muscle; PDN 5th – proper digital nerve of the little finger; pq – pronator quadratus; ua – ulnar artery; v – vein*

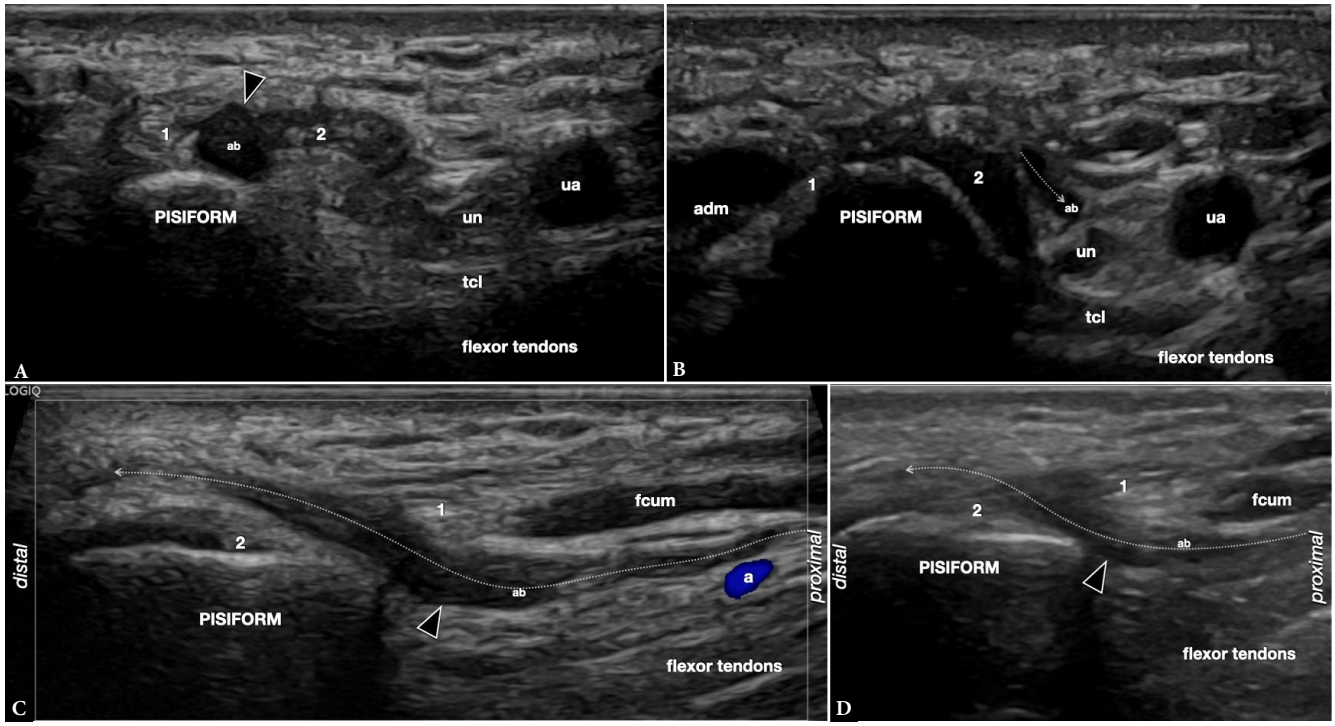


**Fig. 2.** *Case 3. Patient with bilateral symptomatic variant, similar to Case 1. Note the details with a 6–24 MHz hockey-stick transducer (***A–C***) and latest-generation US machine.* **A–B.** *Axial sonograms from proximal (***A***) to distal (***B***) at the entrance of the Guyon's canal. In* **A**, *the aberrant branch (ab, indicated also by the black arrowhead) is thickened between the proximal pisiform bone and the two tendons (1,2) of the FCU. In* **B**, *slightly distal the aberrant branch rejoins the UN. Note anisotropy of the radial FCU tendon (2), which appears hypoechoic.* **C.** *Longitudinal Color Doppler sonogram confirms the non-vascular nature of the aberrant branch, thickened and hypoechoic, which distinguishes it from a small vessel (a). The course of the branch is indicated by the curved dotted arrow.* **D.** *Corresponding longitudinal sonogram obtained with a 6–15 MHz transducer. The variant is clearly easier to visualize in* **C** *than in* **D** *due to the superior quality of the hockey stick when evaluating superficial structures, related to its higher frequency. Fcum indicates the flexor carpi ulnaris muscle; tcl, transverse carpal ligament; ua, ulnar artery*

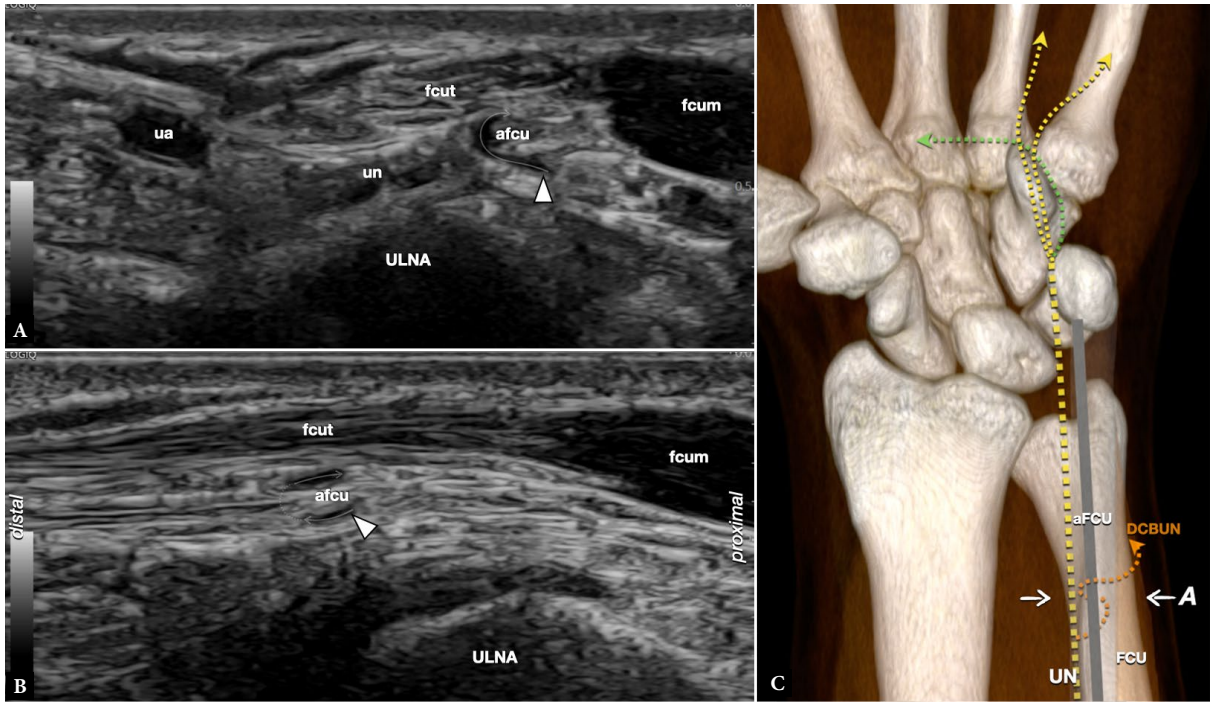


**Fig. 3.** *Case 6. Incidental asymptomatic variant.* **A.** *Axial sonogram at the distal forearm. The DCBUN (white arrowhead) forms a loop (small gray arrow) around an accessory tendon of the FCU (afcu).* **B.** *Sagittal sonogram demonstrates the small branch passing deep and over to the small accessory tendon due to its loop course.* **C.** *Schematic CT-3D drawing of the variant. The FCU is transparent to better show the relationship of the DCBUN with the accessory tendon. Position of the transducer in A is indicated. Fcum indicates the flexor carpi ulnaris muscle; fcut – flexor carpi ulnaris tendon; ua – ulnar artery*

In all of the cases, the variant was clearly depicted using the hockey stick transducer and a frequency of at least 18 MHz. Details were finer with the latest-generation US machine and a probe with a frequency of up to 24 MHz (Fig. 2, Video 1). It was more difficult to demonstrate the variants using the transducers with intermediate frequency, up to 14 MHz for the first US system and 15 MHz for the second system, respectively (Fig. 2D).

## Discussion

In our cases, a branch of the UN formed a loop around a variant of the FCU.

At the level of the wrist, three zones of possible UN compression are usually described in the literature[14]. Zone I refers to entrapment at the level of the Guyon's canal or proximally; since the UN has not yet divided, patients present with motor and sensory deficits. Zone II affects only the deep motor branch of the UN. Zone III compressions involve the superficial branch, primarily a sensory nerve, distal to the division of the UN. In our symptomatic patients, the entrapment was challenging to locate clinically, as it could be suspected distally (Zone III), whereas it was actually proximal to the entrance of the Guyon's canal (Zone I).

Reviewing the literature, similar variants have been reported during surgery.

O'Hara, Zook, and Kang described intraoperative cases of UN neuropathy, without motor deficits, aggravated by wrist movement, related to some fascicles penetrating a split of the FCU tendon[11–13].

Janmohammadi reported UN neuropathy, associated with a motor deficit, in a pregnant woman without a history of trauma; at surgery, the UN was demonstrated dividing into two branches six centimeters proximal to the pisiform, with one of the branches forming an arch and passing through the FCU[15]. Brunet recently reported a similar case, demonstrated at surgery, in which MRI could not clearly define the anatomical abnormality[16]. These variant cases seem similar to our findings except for Case 6.

Around 6 cm proximal to the ulna styloid, the DCBUN originates from the UN to innervate the sensitivity of the dorsal ulnar region of the hand[10].

We found no cases of a DCBUN loop, similar to our Case 6, described in the anatomical and radiological literature.

Regarding imaging reports, in a recent retrospective review a rare variant of the motor branch of the UN passing through the carpal tunnel was demonstrated at US and MRI[17]; however, this variant appears different from the loop observed in our study.

The capabilities of US in demonstrating even small nerves, especially when their course is superficial, are currently mostly well known[8,18]. Moreover, US can show dynamic changes of nerves during specific movements[19]. Nerves can be followed in the axial plane by the elevator technique, with their typical fascicular "honeycomb"-like appearance. Using high-frequency transducers (at least 18 MHz is suggested), small branches can also be visualized, appearing as small non-vascular fascicle(s). The aberrant branches described in this article were particularly thin (normal anteroposterior diameter less than 1 millimeter) and could be depicted as a hypoechoic "dot"

in the axial plane, or as a tubular non-vascular structure in the long-axis, more easily demonstrated in case of entrapment (diameter up to around 2.5 mm). Similar to other compressive neuropathies like carpal tunnel syndrome, we found that the aberrant branches were enlarged just proximal to the compression region[20,21]. US is an excellent tool to correlate anatomical and clinical findings. The patient's clinical symptoms can be evaluated directly during the examination, for example by using the Tinel sign. At the side of potential compression or visible enlargement, the nerve will be compressed by pressing the transducer (easier with small-footprint hockey sticks) toward the nerve. A positive Tinel sign is represented by paresthesia or pain that can be provoked during compression.

We believe that loops like the ones described in the present series are rare, but likely under-diagnosed at imaging due to the very small size of the involved branches, and because these variations may be asymptomatic.

Our case series has some limitations. Firstly, symptoms were present in only three cases, and the number of patients was too low to determine a cut-off for pathology. However, it seems that a ratio in the transverse diameter larger than 3 may be more likely associated with symptoms, whereas minimal nerve thickening can be interpreted as paraphysiological due to its anomalous path.

Moreover, none of our patients underwent surgery; the patients were asymptomatic in half the cases. Symptomatic patients preferred to avoid surgery because of the absence of motor palsy.

An electrodiagnostic test was suggested in symptomatic cases, but we do not have the results of the test.

## Conclusions

We believe that loops of the UN are rare, but likely under-recognized. Moreover, symptoms may not be severe and are tolerated by the patient, particularly if the fascicles involved do not form part of the motor branch of the UN, as in our cases. US, particularly with high-frequency transducers and in experienced hands, can exquisitely show the anatomy and variants of the UN and its small branches. Therefore, it should be regarded as the first and possibly conclusive imaging diagnostic method in cases of UN palsy.

### Conflict of interest

*The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.*

### Author contributions

*Original concept of study: MB. Writing of manuscript: MB, GR. Analysis and interpretation of data: GR. Final acceptation of manuscript: MB, CP, GR. Collection, recording and/or compilation of data: MB. Critical review of manuscript: CP, GR.*

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