# Accessory Flexor Carpi Ulnaris Muscle in Humans: A Rare Anatomical Case with Clinical Considerations

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**Abstract:** Anatomical variations of the forearm flexor muscles are occasionally encountered. Though usually observed incidentally during autopsies or imaging studies, they may at times cause concern due to associated clinical symptoms. This report presents a case of unilateral accessory flexor carpi ulnaris (AFCU) muscle observed in a human male cadaver aged 78 years. During routine cadaveric dissection, an anomalous AFCU muscle was observed in the left forearm of a human male cadaver aged 78 years. Standard institutional guidelines pertaining to the use of human cadaver for teaching and research were followed. A thorough literature review about the flexor carpi ulnaris (FCU) through the PubMed, Embase and Google scholar databases was undertaken, using the keywords – accessory flexor carpi ulnaris muscle, aberrant flexor carpi ulnaris muscle and anatomical variation of flexor carpi ulnaris muscle. Relevant gross anatomical findings were recorded and photographed. AFCU was identified on the medial aspect of the distal third of the left forearm. The AFCU was found originating from the ante-brachial fascia and the fascia covering the FCU on the left forearm, forming a small separate belly deep to the main muscle. It terminated as a thin tendon running alongside the hypothenar muscles and attached distally to the base of the proximal phalanx of the little finger. The AFCU was found to be innervated by a branch of the ulnar nerve. Awareness about the rare AFCU muscle is clinically important as a possible cause of ulnar nerve compression but also as a possible graft in reconstruction surgeries.

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## Introduction

The flexor carpi ulnaris (FCU), the most medial of the superficial forearm flexors, arises from two heads, humeral and ulnar, connected by a tendinous arch called the arcuate ligament of Osborne (Tubbs et al., 2016). The smaller *humeral head* originates from the medial epicondyle through the common flexor origin together with other superficial forearm flexors. The *ulnar head* has an extensive origin from the medial aspect of the olecranon process, an aponeurotic origin from the proximal two-thirds of the posterior border of ulna, and a minor origin from the intermuscular septum separating it from the flexor digitorum superficialis. The thick tendon forming along its anterolateral border in its distal half, descends on the medial aspect of the forearm to insert initially to the pisiform bone. From the pisiform, it is prolonged to the hook of the hamate and the fifth metacarpal bone by pisohamate and pisometacarpal ligaments (Sookur et al., 2008; Watts, 2021). The ulnar nerve innervates the two heads separately (Sookur et al., 2008).

The FCU functions as a palmar flexor of the wrist, and as an ulnar deviator in combination with extensor carpi ulnaris. Additionally, the FCU also supports the medial collateral ligament of the elbow joint. The FCU may be used as a free vascularised flap, if its unique surgical anatomy is taken under consideration. The muscle is also commonly utilized for tendon transfer to extensors of the wrist, particularly in cases of radial nerve palsy (Niumsawatt et al., 2013).

Aberrant and accessory muscles, often detected as incidental findings during surgeries and imaging studies, may confuse clinicians and surgeons (Sookur et al., 2008). Sometimes they become clinically important owing to their potential for

**Table 1 – A brief literature review to summarize observations about the accessory flexor carpi ulnaris (AFCU) and other related variations of the flexor carpi ulnaris (FCU) muscle**

| Authors | Population and study type | Cohort size (number of probands) | Notable findings |
|---|---|---|---|
| López Milena et al. (2001) | Spanish, clinical case | single case | Symptomatic unilateral AFCU (side not mentioned in the report) in a 25-year-old fisherman, causing ulnar nerve compression, treated by partial resection of the muscle. |
| Campos et al. (2010) | Brazilian, cadaveric case | single case | Incidental AFCU on the left forearm, observed in a 59-year-old male cadaver. |
| Ang et al. (2010) | Australasian, clinical case | single case | Incidental AFCU at the left wrist, observed in a 29-year-old man during ulnar nerve repair. |

| Authors | Population and study type | Cohort size (number of probands) | Notable findings |
|---|---|---|---|
| Çıftçıoğlu et al. (2011) | Turkish, cadaveric case | single case | Incidental AFCU in the left forearm in a 65-year-old male cadaver. |
| Alvin et al. (2011) | American, cadaveric case | single case | Incidental AFCU in the left forearm in a 87-year-old male cadaver. |
| Niumsawatt et al. (2013) | – | review | Proposed an improved system of classification of the AFCU variants, different from the existing system earlier described by Testut and Latarjet. |
| Sakthivel and Verma (2017) | Indian, cadaveric case | single case | AFCU observed in the left forearm of a 61-year-old male cadaver, along with an absent palmaris longus muscle. |
| Wang and Ng (2021) | Malaysian, clinical cases | two cases | Distal ulnar nerve compression due to AFCU reported: one in the left wrist of a 29-year-old female and the other in the right wrist of a 58-year-old male patient. |
| Sawant (2013) | Indian, cadaveric case | single case | Additional slips of FCU (not convincing enough to be classified as AFCU) passing over the ulnar artery and ulnar nerve in the right wrist. |
| Vollala and Kumar (2006) | Indian, cadaveric study | 100 cases | 1% incidence of the AFCU on the left forearm among 100 dissected upper limbs was reported. |
| Bhardwaj et al. (2013) | Indian, clinical case | single case | Two heads of FCU observed (one regarded as AFCU) in a 31-year-old male patient, tendons of which were utilized for reconstruction procedures following Volkmann's ischemic contracture deficits. This case highlighted the clinical utility of the AFCU for the first time. |
| Iliev et al. (2016) | Bulgarian, cadaveric case | single case | Bilateral crescent-shaped fibro-muscular-tendinous structure arising from FCU muscle in a 69-year-old female cadaver. |
| Yonguç et al. (2018) | Turkish, cadaveric case | single case | Split AFCU on the left side in a male cadaver. |
| Kunc et al. (2019) | European, cadaveric case | single case | Incidental AFCU inserting on the flexor retinaculum in the right forearm of a 74-year-old male cadaver. |
| Pressney et al. (2020) | British, clinical case | single case | AFCU presenting as a symptomatic pseudo-tumour on the right wrist of a 13-year-old girl. |

causing neurovascular compression or limb deformity (López Milena et al., 2001; Niumsawatt et al., 2013). The accessory flexor carpi ulnaris (AFCU) is a very rare anatomical variation of FCU, with only a very few cases described in literature which are summarized in Table 1. In fact, as of today there are less than 20 reported cases of AFCU, with an approximate incidence ranging between 0.02–2.0% (Vollala and Kumar, 2006; Ang et al., 2010; Kunc et al., 2019). Table 1 summarizes observations about FCU variations reported earlier. The AFCUs exhibit great variation in origin, insertion, arrangement in relation to the main FCU, and in their innervation patterns.

An accidentally observed cadaveric case of AFCU on the left forearm is presented in this case report, together with an updated literature review.

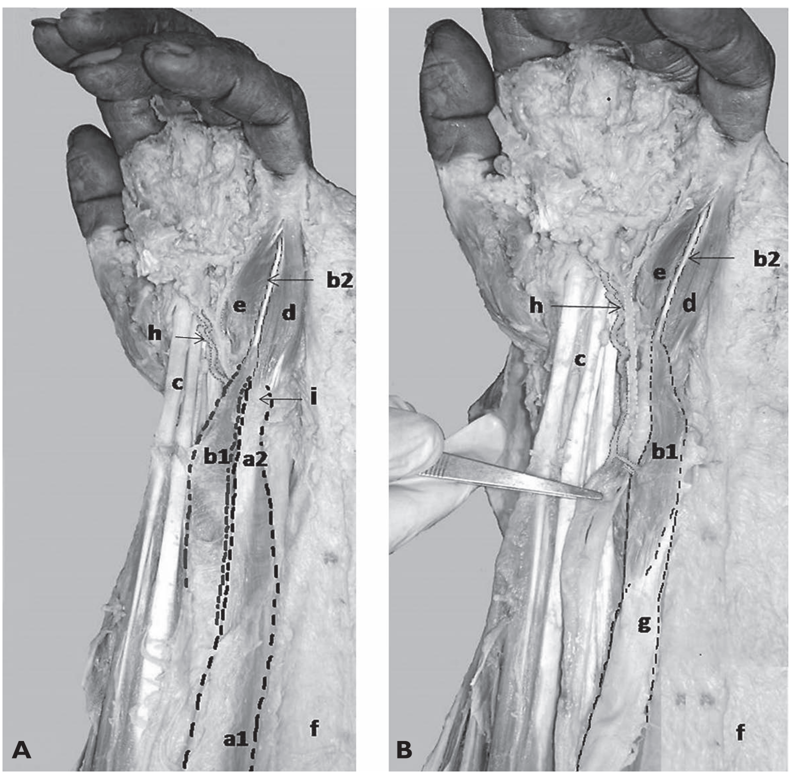


*Figure 1 – Left forearm, medial view (A), anterior view (B). A) Dissected accessory flexor carpi ulnaris muscle observed between the flexor digitorum superficialis and the flexor carpi ulnaris muscle tendons in the forearm. B) Accessory flexor carpi ulnaris muscle reflected medially showing the ulnar nerves and vessels (the flexor carpi ulnaris muscle is placed posterior to the accessory flexor carpi ulnaris muscle and not seen in this image). The structures labelled in the images are: a1 – flexor carpi ulnaris muscle belly; a2 – flexor carpi ulnaris tendon; b1 – accessory flexor carpi ulnaris muscle belly; b2 – accessory flexor carpi ulnaris tendon; c – flexor digitorum superficialis tendons; d – abductor digiti minimi muscle belly; e – flexor digiti minimi muscle belly; f – superficial fascia of the forearm; g – deep fascia of the forearm; h – ulnar vessels and nerves outlined in broken lines; i – pisiform bone.*

## Case report

Both upper limbs of a 78-year-old male cadaver were dissected following standard steps of dissection, and the findings recorded and photographed (Figure 1). The various dimensions of the FCU and AFCU (if present) muscles such as length, breadth and thickness of the muscle belly, length and breadth of the tendinous portion, were measured using a non-stretchable measuring tape and Vernier callipers.

On the left side, the entire FCU was found to measure 25.3 cm in total length, of which the muscle belly measured 22.5 cm and its tendon measured 2.8 cm. The lower third of the left forearm was found to exhibit an additional muscle which was identified as the AFCU. The AFCU was located between the FCU and the flexor digitorum superficialis (FDS) in the left forearm, and found to originate from the deep fascia of the forearm and from the fascia covering the FCU muscle.

The muscle belly of the AFCU was seen as fusiform in shape, measuring 7.3 cm in length, 2.1 cm in breadth and 0.4 cm in thickness. The tendon of the AFCU measured 5.4 cm in length, 0.3 cm in breadth and coursed lateral to the tendon of the FCU, passing superficial to the flexor retinaculum and giving a few tendinous slips to the pisiform bone. More distally, the tendon was seen to merge with tendons of the flexor digiti minimi and abductor digiti minimi muscles, eventually terminating at the ventrolateral aspect of the base of the proximal phalanx of the little finger (Figure 1B). The left AFCU muscle belly was observed to be much smaller than the left FCU muscle, transitioning into a slender tendon just proximal to the wrist joint, and passing distally superficial to the flexor retinaculum (Figure 1A). The ulnar nerve and artery were found to run between the AFCU and the FDS in the lower part of the forearm. The neurovascular supply of the AFCU muscle was seen to be derived from the ulnar nerve and vessels. The right forearm was not found to exhibit any accessory or aberrant muscle.

## Discussion

The upper limb bud is formed as an outgrowth of the somatic mesoderm on the ventrolateral aspect of the embryo at approximately 4 weeks of intrauterine life, under the master regulation of sonic hedgehog (SHH) gene expressed by the notochord. The mesodermal outgrowth is visible as an apical ectodermal ridge (AER). The embryological upper limb bud forms four zones; the *stylopod* or the future arm, the *zeugopod* or the future forearm, the *mesopod* or the future wrist and the *autopod* or the future hand (Al-Qattan and Kozin, 2013). Zeugopod cells express HOXA11 and HOXD9 during the period of establishment of these zones.

The central group of cells initially forms a blastema in the developing upper limb bud. Development of muscles starts with segmentation of the paraxial mesoderm into somites. Each somite has two parts: the *sclerotome* and the *dermo-myotome*. At about 5 weeks of gestation, the myoblasts originating from the myotomes migrate to specific sites in the upper limb bud to develop into the musculature of the upper limb. Myoblast cells aggregate into two muscle masses – the ventral and the dorsal muscle masses, which give rise to the flexor and the extensor group of muscles respectively (Pires et al., 2019). The skeletal muscle fibres may be identified in an embryo by approximately 7 weeks of intrauterine life. Proximal and superficial groups of muscles differentiate earlier than the distal and deeper groups of muscles with simultaneous nerve ingrowths. There are different proteins and transcription factors which regulate the spatial organization of the developing upper limb. Engrailed-1 (EN-1) expressed by the ventral ectoderm and WNT7 expressed by dorsal ectoderm mediate the dorsoventral axis. The proximo-distal axis is regulated by the FGF8, FGF4, FGF2 and WNT3A secreted by the AER (Al-Qattan and Kozin, 2013). Overall, signals from the neural tube, ectoderm and the lateral mesoderm provide signals for medio-lateral patterning so that the myogenic cells effectively migrate to form limb muscles.

The definite postnatal morphology of individual muscles is attained through complex interactions of several growth stimulators and apoptotic factors that influence the optimal differentiation of the myogenic cells during intrauterine life. The definitive form of a limb muscle is attained very early during embryonic development. It has been suggested that it is not the myogenic cells themselves, but the associated connective tissue which guides the myogenic precursor cells to differentiate into a specific muscle type and attain their final form. The myogenic precursor cells are morphogenetically neutral in behaviour (Carlson, 2014). Accessory muscles are formed in response to an imbalance in cell growth stimulating factors and factors controlling apoptosis (Buckingham et al., 2003). According to another theory, anomalies of the flexor muscles of the forearm have been attributed to a faulty separation of the flexor blastema (Bhardwaj et al., 2013).

A rough estimate of incidence of anatomical variations in the forearm flexors varies between 5–25%, but the incidence of AFCU is approximately 0.16% (Ang et al., 2010). The approximate incidence of AFCU from existing reports ranges between 0.02–0.2% (Niumsawatt et al., 2013; Tubbs et al., 2016). A study on 100 upper limbs of cadavers of South Indian origin reported an incidence of 1% for the AFCU, which seems to be an overestimate (Vollala and Kumar, 2006).

Very few cases of the AFCU have been reported by different authors in the erstwhile literature, and there is inconsistent nomenclature for the variations. Different authors named the FCU variations differently: supernumerary belly of FCU, aberrant FCU, accessory FCU, digastric FCU, flexor carpi ulnaris palmaris muscle etc. (Arnold and Zech, 1977; Ang et al., 2010; Alvin et al., 2011). In their seminal multi-volume anatomical tome entitled “Traité d’anatomie humaine”, Testut and Latarjet described a classification system for FCU anomalies as early as 1928. More recently, Bhardwaj and co-workers (2013) suggested a new system of classification and nomenclature, mentioning the various subtypes of the variant FCU. They classified the FCU anomalies into three distinct groups: type I – single muscle belly with split or bifurcate tendons; type II – digastric or two muscle bellies with an intermediate tendon; type III – accessory FCU characterized by the presence of an additional muscle belly adjacent to the main muscle belly. The additional muscle belly and tendon may not have similar attachments as the main muscle or may share attachments with any of the other forearm flexor muscles in the vicinity.

The type III insertion of the AFCU on the pisiform bone has been reported (López Milena et al., 2001). A few reports described this AFCU attachment to pisiform further getting prolonged to merge with the hypothenar muscles, similar to that which has been observed in the present case (Mori, 1964). Such a prolonged distal tendinous slip may compress the ulnar neurovascular bundle and give rise to diverse clinical symptoms (O'Hara and Stone, 1988). There are reported cases of ulnar nerve compression in the Guyon's canal due to the AFCU or accessory abductor digiti minimi tendon (Kwak et al., 2011; Yasen, 2012; Paget et al., 2013). As the AFCU is very rare, it may be often overlooked as a possible cause of ulnar nerve entrapment. Furthermore, presence of such an accessory muscle may also be confused with a mass in the distal forearm. Newer imaging techniques can be effectively utilized to confirm the presence of a suspected AFCU muscle when presenting as a mass or causing neurovascular compression (López Milena et al., 2001). Presence of the AFCU seems to be easily diagnosable using magnetic resonance imaging (MRI) scans (Rau et al., 2014), and this modality may be a convenient means for elucidating further details about the morphology of this muscle.

The muscle presented here resembles a rare small muscle known as the ulno-carpeus brevis observed in 1.9% of cases (Tubbs et al., 2016), with a proximal attachment on the ulnar medial or anterior surface and a distal attachment variably on the pisiform bone, the hook of hamate, the proximal end of the fifth metacarpal bone or the abductor digiti minimi (Mori, 1964; Tubbs et al., 2016). A unilateral flexor carpi ulnaris brevis was recently described in a 19-year-old boy during repair surgery of forearm flexor tendons in the right wrist following an accidental cut injury. The presence of the additional muscle was later confirmed by an MRI study (Chong et al., 2009). We observed the small AFCU muscle belly in relation to the distal part of the left FCU which became tendinous distally and blended with the tendons of the hypothenar muscles. Thus the present case may be identified as of the type III variety, according to the classification system proposed by Bhardwaj and co-workers in 2013. Only a very few AFCU cases reported are of type III variety, though their precise incidence has not yet been estimated. Considering the extremely few reported cases, the proper identification and reporting of every single case is warranted. Table 1 presents a comprehensive summary of the AFCU anomalies reported so far. Although it is improper to comment on the predilection of AFCU variations for a particular side (left/right) considering the few reported cases, it may be observed from this table that these variations are more common on the left side.

## Conclusion

Although very rare in occurrence, the accessory flexor carpi ulnaris should be considered and ruled out in all cases of ulnar nerve entrapment. Awareness about this forearm variation is essential for hand surgeons to avoid misinterpretation of the muscle as a mass and to avoid iatrogenic injuries. Additionally, the AFCU may be used as a free vascularised muscle flap and utilized in tendon transfer surgeries.

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