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Case Series

Anatomy Section

Anatomical Variations of the Extrinsic Musculature of Thumb

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ABSTRACT

Anatomical variations are commonly encountered during human cadaver dissections. Some of these variations are never discovered unless there is an underlying injury that requires attention. For conceivable clinical and rehabilitation treatments, anatomical modifications may have implications on function therefore it is imperative to report them. This case series depicts the anatomical inconsistency in the muscles and tendons of the extrinsic musculature of the thumb in three human specimens. During a cadaver dissection in physical therapy anatomy course, various anatomical variations were found in three human cadaveric specimens. Cadaver 1 (91-year-old Caucasian female) exhibited a new muscle with a split tendon near the distal posterolateral radius. The author uncovered the supplementary muscle between the Extensor Pollicis Longus (EPL) and Extensor Pollicis Brevis muscles. Cadaver 2 (56-year-old Caucasian male) had two other extrinsic tendons inserted at the thumb. The Extensor Digitorum provided an extra tendon to the pollicis; a similar insertion as the EPL was recognised. In Cadaver 3 (77-year-old Caucasian male) an extra muscle belly was observed within the tendon of the abductor pollicis longus. The other muscle variation was near the distolateral attachment at the base of the first metacarpal joint, between the abductor pollicis brevis and extensor carpi radialis muscles. Understanding the diverse anatomical arrangements could prove beneficial for surgeons and those involved in rehabilitating upper extremities. A detailed understanding of the forearm structural anatomy and anomalies is essential to comprehend the function and movements when lesions affect the normal biomechanics within teaching and clinical environments.

Keywords: Extra thumb tendon, Forearm anatomical variations, Forearm extra muscles

INTRODUCTION

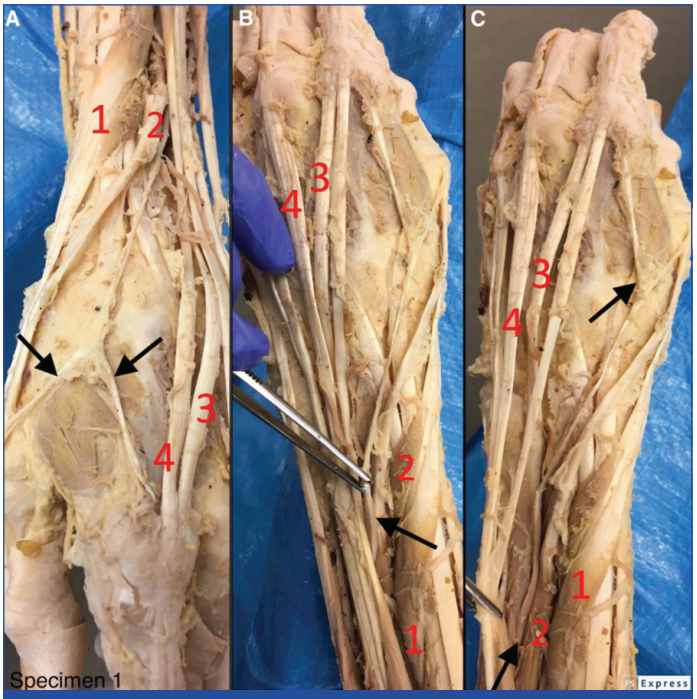
Human gross anatomy is an introductory course in health-related programs, such as physical therapy [1]. One technique for teaching human anatomy is cadaver dissections and prosections [2]. The most typical anatomy and anatomical architecture are described in anatomy textbooks such as Moore KL et al., [3]. Often during dissection, deviations from the established pattern are observed in forearm region, these variances are essential to document because of the potential ramifications of the region's movement [4].

Therefore, this case series aimed to report three anatomical differences in the forearm and thumb musculature. In 2018-2019, first-year physical therapy students supervised by the human anatomy laboratory coordinator at Texas Woman's University School of Physical Therapy, Dallas, recognised the architectural variation of thumb musculature on three cadavers. The author received the specimens through the University of UT Southwestern Medical School's body donation program.

CASE SERIES

Specimen 1

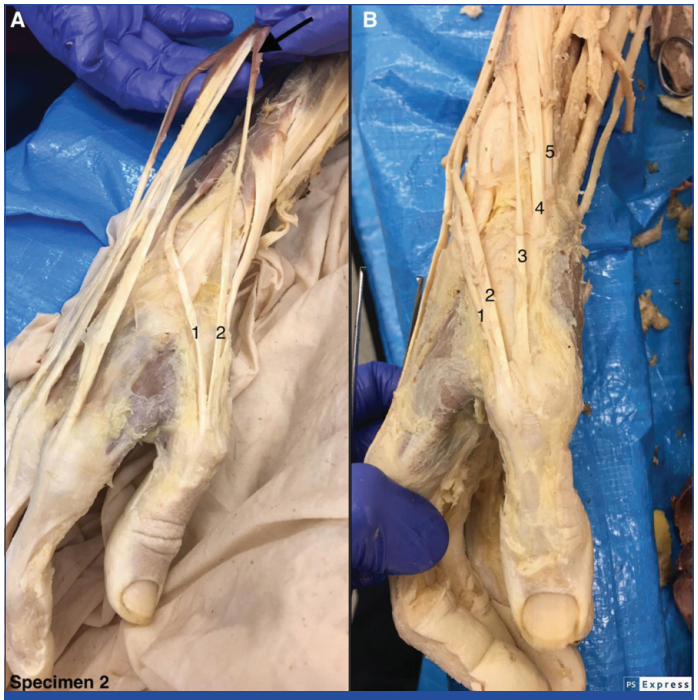
The first case was of a 91-year-old Caucasian female. During dissection, an additional muscle was located on the posterior forearm, between the EPL and extensor pollicis brevis muscles. The tendon was identified near the distal posterolateral radius and could be followed proximally to the muscle belly; the tendon was divided before the insertion at the base of the proximal phalange of the first and second digit. The muscle originated from the middle posterior surface of the ulna and the interosseous membrane. The thumb muscle inserted into the base metacarpophalangeal joints of the first (like the tendon of the EPL) and second digits [Table/Fig-1]. The function of this newfound muscle appears as an extensor of the pollex.



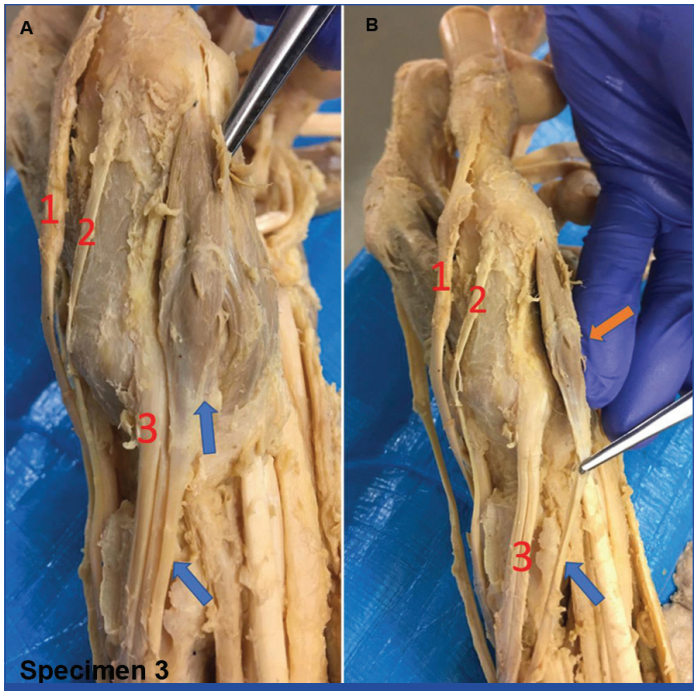
[Table/Fig-1]: Variations of the tendon is depicted by arrows. 1) Extensor Pollicis Brevis; 2) Abductor Pollicis Longus; 3) Extensor Indicis; 4) Extensor Digitorum for A, B and C. Placement A shows the splits of the tendon into the first and second digit depicted by black arrows. Placement B shows the extra muscle distal on the forearm region. Placement C shows a proximal to distal extensor view of the split tendons.

Specimen 2

The second case was of a 56-year-old Caucasian male. The second specimen had two extra extrinsic tendons, consisting of five, inserted at the thumb. The author observed the extensor digitorum yielded a different tendon to the pollicis, comparable to the insertion of the EPL. The tendon of the abductor pollicis longus was split in two and was inserted at the first metacarpal base [Table/Fig-2].



[Table/Fig-2]: Variations of the extra tendons is portrayed by numbers. Placement A shows the split tendon from the extensor digitorum insertion onto the thumb; 1) the EPL; 2) the extra EPL tendon (2). Placement B shows: 1) the EPL; 2) the extra EPL tendon; 3) the extensor pollicis brevis; and 4-5) the abductor pollicis longus with split tendon.



[Table/Fig-3]: Variations of the extra muscle belly is represented by arrows. Placement A and B shows: 1) EPL; 2) Extensor Pollicis Brevis; 3) Abductor Pollicis Longus, and the extra muscle belly found embedded within the tendon of the abductor pollicis longus (arrow). Placement B also, shows the location near the distolateral attachment site at the base of the first metacarpal joint, between the abductor pollicis brevis and extensor carpi radialis muscles.

Specimen 3

The third case was of a 77-year-old Caucasian male. The third specimen had an additional muscle on the posterior forearm, embedded within the tendon of the abductor pollicis longus. The modification was detected near the distolateral attachment site at the base of the first metacarpal joint. The distinct muscle belly was located between the abductor pollicis brevis and the tendon of the extensor carpi radialis muscles. The abductor pollicis longus have a proximal belly that travels towards the posterior one half of the ulna and radius to the distal attachment were there share a common distal attachment on the base of the first metacarpal. A muscle was discovered in this cadaver in the middle of abductor pollicis brevis and extensor tendons of the extensor carpi radialis muscle. The tendon of abductor pollicis longus extended further distally revealing an additional muscle belly within the distolateral one-third of the tendon with an attachment point on the commonly seen lateral aspect of the first metacarpal bone [Table/Fig-3]. Differing from typical arrangements, this cadaver revealed an extra muscle belly inserting upon the distal excess portion of the tendon. An extra muscle belly was located embedded in the distal portion of the tendon, making the variation in this cadaver unique [Table/Fig-3].

DISCUSSION

Anatomical variations are the results of benign changes during embryonic stages of development [5]. Within multiple anatomy references embedded in anatomy courses, only the most common human architecture variations are reported [3].

Various reports have revealed extrinsic anatomical musculature modifications of the forearm in human specimens [6-9]. The most typical anatomy descriptions depict the forearm's extensor compartment as having five muscles that intersect the wrist joint, giving tendons to all five digits [3]. These tendons include the EPL, the abductor pollicis longus (APL), and the extensor pollicis brevis (EPB) muscles, all of which originate from the posterior forearm and insert on the first digit [3].

Additionally, the extensor digitorum (ED) emerges on the posterior forearm and inserts on digits 2 through 5 [6]. In distinction, the extensor indicis (EI) inserts onto the tendon of the extensor digitorum at the second metacarpal level [6]. The EPL originates from the ulna and interosseous membrane's posterior surface and attaches to the base of the thumb's distal phalanx [3]. In comparison, the EPB stems from the radius and interosseous membrane's posterior surface and embeds into the base of the proximal phalanx of the thumb. Lastly, the proximal attachment of the abductor pollicis longus is at the posterior surface of the radius, ulna, and the interosseous membrane, and inserts into the base of the first metacarpal. Commonly, the wrist musculature extensors are innervated by the radial nerve and irrigated by the posterior interosseous artery [6].

Since forearm and wrist function disorders, interventions, and surgery are unique to the anatomical configuration, it is imperative to report any discrepancies from the typical standard arrangement [10,11]. Therefore, this work intends to illustrate the anatomical variations discovered in the upper extremity's forearm musculature in three adult cadavers.

However, as reported by Suwannakhan A et al., the occurrence and incidence rates were low out of 100 cadavers, exclusively four varieties (4%) of the extensor digitorum proprius were reported, in comparison only one (1%, 1/100) out of those four variations had a split EI tendon [12].

While examining 147 cadavers, Georgiev GP et al., discovered that 84% had normal EI anatomy, ascribing a low 16% of the assessed upper limbs as having unusual EI architecture [13]. The rates and occurrences are of minimum equivalence to the standard EI structure; nevertheless, these modifications call for reporting and disclosing the newfound mutation in the literature.

Abu-Hijleh MF documented modifications of the extensor pollicis muscle, an additional independent tendon attaching to the base of the thumb's proximal phalanx and as an extra EPL and APL tendon [14]. Likewise, another report has alluded to the ED providing an extra tendon connected to EPL and the APL tendon splitting to the first digit base [15]. Comparable to this report's first specimen Nishijo K et al., identified EPL and APL deviations on an adult female's right wrist. These muscle variations were discovered during surgery after the patient had recurrent pain during wrist extension [11]. Additionally, specimen 3 showed uniqueness by containing two separate muscle bellies within the APL tendon. One muscle belly at

the traditional origin of the ulna's proximal half and the middle one-third of the radius. The second was located at the first metacarpal's distolateral attachment site.

Comparable to the EPL and APL placement and specimen 1, the two extra tendons were embedded on the bases of both the first phalanx and metacarpal, respectively. Kim YJ et al., discovered a similar variant of the EPL during a wrist surgery, which comprised an additional tendon emerging from the forearm/wrist's extensor compartment with regular insertion [16]. Alike the second specimen, Melo C et al., published an unusual branch of the ED to the thumb in a human cadaver, analogous to the insertion and function of the split EPL tendon [15]. However, contrary to specimen 2, the four-digit tendon splits further and contributes a tendon to the fifth finger as well. A literature review regarding anatomical variations of the extensor musculature in the forearm are depicted in [Table/Fig-4] [6,11-18].

Author	Number of cadavers	Anatomical variations
Abu-Hijleh MF 1993 [14]	1	Extra extensor muscle and tendon to the right thumb
Nishijo K et al., 2000 [11]	1	Duplicated APL tendon Duplicated EPL tendon with both tendons inserting into IP joint Absent EPB tendon
Roy S et al., 2010 [17]	1	APL splits at the base of first
Li J and Ren ZF 2013 [18]	1	EIP splits and inserts bilateral, ulnar and radial side ED gives a tendon to indicis that splits ulnar and radial side
Arora J et al., 2013 [6]	1	Extra belly and tendon for index finger
Melo C et al., 2013 [15]	1 1	ED splits: 2 tendons for the ring finger EI splits tendon to index and middle finger ED splits 1 Extensor Pollicis Longus (EPL) Ring finger tendon splits further and give a tendon to little finger EI splits for index and middle finger
Kim YJ et al., 2016 [16]	1	EPL tendon running over and crossing ECRL tendon in the second extensor compartment
Suwannakhan A et al., 2016 [12]	1 1 4	1 EDP with split tendons to volar and radial side 2 EDB EPI
Georgiev GP et al., 2018 [13]	1	One side: Extensor Digitorum No Extensor indicis propius Other Side: Extensor digitorum brevis Extensor indicis brevis
Present study, 2021	3	• An additional muscle was located on the posterior forearm, between the EPL and EPB muscles • Two extra extrinsic tendons, consisting of five, inserted at the thumb • An additional muscle on the posterior forearm, embedded within the tendon of the APL

[Table/Fig-4]: Represents modifications of the extensor digitorum found in different studies by various authors [6,11-18].
EIP: Extensor indicis propius; ED: Extensor digitorum; EDB: Extensor digitorium brevis; EPI: Extensor pollicis indicis; APL: Abductor pollicis longus; ECRL: Extensor carpi radialis longus; EPB: Extensor pollicis brevis; EPL: Extensor pollicis longus

Although the author can speculate, it is unclear why these specific anatomical variations transpired in the present three specimens, previous research outlines two different mechanisms for variants, genetics or environment [19, 20]. Regardless of the mechanism, the anatomical variances illustrated in this summary's specimens could be unique alterations during the embryological phases, notably cell differentiation [19]. The embryological opportunity for a deviation arrangement involving the period of the small bud precursors' development for the upper extremities is around the fourth week of embryonic growth. Conceivably, the buds withstand minor changes in the loose mesenchyme cells associated with the ectoderm and create anatomical deviations, including those illustrated in this report. During fourth and sixth weeks, the upper extremity buds' precursor will expand in length and change structure, forming a hand-plate by week six. After week six, cellular differentiation is finished, and the window for embryo deviations have closed [19, 21]. Without pathology or trauma, people can live their existence without ever realising these distinct types of configurations took place in their bodies. Due to their architecture and particularity of function, it is important to document anatomical cases, including these, that deviate from their normative mainstream counterparts [4]. A comprehensive insight into forearm anatomy is paramount to understanding the function and pathology when injured or impaired within teaching and clinical settings. Therefore, to contribute to the current published knowledge, this case series featured three distinct anatomical variations in the forearm's muscle and tendons' extrinsic musculature in the following three adult cadaver specimens.

CONCLUSION(S)

This case series ushers in recognising the extensors of these cadavers' forearm muscles vary from the established typical configurations. Though these muscles could promote the pollex's motor function, the muscles' modest proportion would provide minor improvements or weak movements. The knowledge of this newfound additional muscle may aid surgeons, physiotherapists, occupational therapists, and other health professionals in considering the possible functional characteristics among individuals with these anatomical distinctions.

Declaration: There is no full article submitted or published in any other journal related to this work. However, abstract of the following case series by Clare Hanrahan, Ashley Correa, Victoria Junious, Angela Norman , Kylee Guthrie, Thomas Slack, Martin G. Rosario. Human Cadaver Anatomical Variation of the Extrinsic Musculature of the Thumb was published in Volume 33, IssueS1 Experimental Biology 2019 Meeting Abstracts.

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And Abductor Pollicis Longus distal muscle belly variation in a male human cadaver by Carley Bowman and Martin Rosario. was published in Volume 34, Issue S1 Supplement: Experimental Biology 2020 Meeting Abstracts. https://doi.org/10.1096/fasebj.2020.34.s1.09085 First published: 20 April 2020 and was expected to be presented in San Diego California April 2020 (Cancelled due to COVID-19).

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