A detailed anatomical study of the muscles of the forearm and hand in the Anubis baboon (*Papio anubis*) in comparison with humans

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Abstract

The anatomy of the human forearm and hand has been described in great detail, including possible anatomical variations. For animals, this information is still not complete. The aim of this case study was to describe the anatomy of the muscles of the forearm and hand in one individual of the Anubis baboon and to compare this information with the available data on the subject and with the anatomical standard and possible variations in humans. The biggest differences were noted in the extensor digiti minimi, where two separate muscle bellies were dissected. We believe that in this individual it was the extensor digiti quarti proprius and extensor digiti quinti proprius muscles. Anatomical standard has not yet been established for the thenar, hypothenar, and contrahentes muscles in the deep layer of the muscles of the forearm of the baboon and literary sources differ notably in some information. Determining the anatomical standard and anatomical variability of individual structures in animals is an important contribution to the field of veterinary surgery and orthopaedics.

Primates, monkey anatomy, comparative anatomy, old world monkeys, thoracic limb

The anatomy of the muscles of the forearm and hand in humans has been studied in great detail. In addition to textbooks that describe the anatomical norm (e.g. Schünke et al. 2006; Dauber and Feneis 2007; Čihák 2011; Netter 2014; Drake et al. 2015), there is also a very detailed publication that describes possible anatomical variations in humans (Tubbs et al. 2016). Determining the percentage probability of occurrence of variation in the population and the detailed description of individual differences in anatomical structures is very beneficial knowledge for surgery. However, such detailed data on anatomical norms and variations in animals are still not available today. The presented study is therefore intended to partially contribute to improving this situation.

The Anubis baboon (*Papio anubis*) is a narrow-nosed primate living primarily on the African continent. Today, this species is found in zoos around the world. One of the most important factors contributing to a thriving life in captivity is high-quality veterinary care. An injured animal may need clinical treatment or surgery. In such case, sufficient available data on the detailed anatomy of a particular species is the basis for successful therapy. Due to the mechanics of baboon movement, injuries to the bones and muscles of the thoracic limb can easily occur. Several publications discuss these structures in baboons (Hill 1970; Swindler and Wood 1973; Yoshida and Fukuyama 1979; Homma and Sakai 1992; Tubbs et al. 2005; Diogo and Wood 2011; Kivell et al. 2016), however, several major differences can be found in their anatomical descriptions. In our case study, we describe the anatomy of the forearm and hand, with emphasis on the origin, insertion and innervation of the muscles in one individual baboon. These animals are not commonly found

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in Central Europe and only a few individuals are kept in two zoos in the Czech Republic – they are the hamadryas baboon (*Papio hamadryas*) and the yellow baboon (*Papio cynocephalus*).

The Anubis baboon (*Papio anubis*), which is the subject of this study, was the last individual of its species from the Brno Zoo breeding. The aim of this case study was to describe in great detail the anatomy of the forearm and hand muscles and to compare this information with available studies on this primate genus. Any work expanding knowledge on this issue can contribute notably in the future to the stabilisation of the anatomical standard in these exotic species and, at the same time, to the determination of anatomical varieties as is the case in human anatomy.

Materials and Methods

In this study, an anatomical dissection of the thoracic limbs in the area of the forearm and hand of the Anubis baboon (*Papio anubis*) was performed. This female was born on 13 April 1998 in the zoo in Brno in the Czech Republic and lived to be almost 24 years old. The Anubis baboon was euthanized for medical reasons unrelated to this study. Anatomical dissection was performed and the origin, insertion, and innervation of the muscles of the forearm and hand were described in detail (Plates VIII–X, Figs 1–3). The results were compared with available studies on baboon thoracic limb anatomy. The text was supplemented with a detailed table comparing the anatomical standard in humans given in basic textbooks of human anatomy (Čihák 2011; Drake et al. 2015) with our findings in the Anubis baboon.

Results

All dissected anatomical structures of the thoracic limb of the baboon are summarised in detail in Table 1 and compared with normal anatomical proportions in humans.

Discussion

In the below listed muscles, our findings differed significantly from those of other authors or they strongly resembled the anatomical variations described in humans.

Muscles of the forearm

Pronator teres (ventral group, superficial layer)

In the baboon, the muscle begins with only one head arising from the medial epicondyle of the humerus. This finding agrees with the description of Miller (1932), Hill (1970), Swindler and Wood (1973) and Diogo and Wood (2011). In humans, the aforementioned muscle has two heads – humeral and ulnar. The humeral head begins at the medial epicondyle of the humerus and the ulnar head at the coronoid process of the ulna. Inoue (1934) describes that in about 3% of people, the ulnar head of the pronator teres may be absent and in 6% of cases it is rudimentary.

Palmaris longus (ventral group, superficial layer)

The palmaris longus was well-developed in the baboon. Similarly, the existence of a muscle in this species is described by Macalister (1871), Michaëlis (1903), Hill (1970), Kikuchi (2010) and Diogo and Wood (2011). In humans, this muscle is variable and is not developed in approximately 20% of the population (Adachi 1909–1910). In gorillas and chimpanzees, authors did not find this muscle in about 5% of individuals (Sarmiento 1994; Gibbs et al. 2002); similar statistics do not yet exist for baboons.

The innervation of the palmaris longus muscle was notably different. In humans, this muscle is innervated by the median nerve (Drake et al. 2015). In the baboon, fibres from the ulnaris nerve entered the muscle.

Table 1. Comparison of muscles of the forearm and hand in the human and baboon.

Muscle	Species	Origin	Insertion	Innervation
M. flexor carpi radialis	Human	Medial epicondyle of humerus	Base of metacarpal bones II and III (palmar side)	Median nerve
	Baboon	Medial epicondyle of humerus	Base of metacarpal bones II and III (palmar side)	Median nerve
M. flexor carpi ulnaris	Human	Medial epicondyle of humerus, posterior border of ulna and olecranon	Pisiform	Ulnar nerve
	Baboon	Medial epicondyle of humerus, posterior border of ulna and olecranon	Accessory carpal bone (pisiform)	Ulnar nerve
M. pronator teres	Human	Medial epicondyle of humerus, medial side of coronoid process of ulna	Pronator tuberosity of radius	Median nerve
	Baboon	Medial epicondyle of humerus	Pronator tuberosity of radius	Median nerve
M. palmaris longus	Human	Medial epicondyle of humerus	Palmar aponeurosis of the hand	Median nerve
	Baboon	Medial epicondyle of humerus	Palmar aponeurosis of the hand	Ulnar nerve
M. flexor digitorum superficialis	Human	Medial epicondyle of humerus, coronoid process of ulna, proximal anterior part of radius	Margins of the middle phalanx of the 2nd–5th finger (palmar surface)	Median nerve
	Baboon	Medial epicondyle of humerus, proximal part of ulna	Margins of the middle phalanx of the 2nd–5th finger (palmar surface)	Median nerve Ulnar nerve
M. flexor digitorum profundus	Human	Medial and anterior surfaces of ulna, part of interosseous membrane	Margins of the distal phalanx of the 2nd–5th finger (palmar surface)	Median nerve Ulnar nerve
	Baboon	Anterior surface of the body of radius and ulna, interosseous membrane	Margins of the distal phalanx of the 1st–5th finger (palmar surface)	Median nerve Ulnar nerve
M. flexor pollicis longus	Human	Anterior surface of the body of radius, radial part of interosseous membrane	Base of distal phalanx of the thumb (palmar surface)	Median nerve
	Baboon	Rudimentary muscle – part of the flexor digitorum profundus	Rudimentary muscle – part of the flexor digitorum profundus	Median nerve
M. pronator quadratus	Human	Anterior surface of the distal part of ulna	Anterior surface of the distal part of radius	Median nerve
	Baboon	Anterior surface of the distal part of ulna	Anterior surface of the distal part of radius	Median nerve
M. brachioradialis	Human	Lateral supracondylar ridge of humerus	Styloid process of radius	Radial nerve
	Baboon	Lateral supracondylar ridge of humerus	Styloid process of radius	Radial nerve
M. extensor carpi radialis longus	Human	Distal part of lateral supraepicondylar ridge of humerus	Dorsal surface of base of the metacarpal bone II	Radial nerve
	Baboon	Common origin with extensor carpi radialis brevis on the distal part of lateral supraepicondylar ridge and lateral epicondyle of humerus	Common insertion with extensor carpi radialis brevis on the metacarpal bone II and III	Radial nerve

Table 1 (continued).

Muscle	Species	Origin	Insertion	Innervation
M. extensor carpi radialis brevis	Human	Lateral epicondyle of humerus	Dorsal surface of base of metacarpal bone III	Radial nerve
	Baboon	Common origin with extensor carpi radialis longus on the distal part of lateral supraepicondylar ridge and lateral epicondyle of humerus	Common insertion with extensor carpi radialis longus on the metacarpal bone II and III	Radial nerve
M. extensor digitorum	Human	Lateral epicondyle of humerus	Dorsal surface of the bases of middle and distal phalanges of the 2nd–5th finger	Radial nerve
	Baboon	Lateral epicondyle of humerus	The dorsal aponeurosis of the 2nd–5th finger in the level of basis phalangis proximalis	Radial nerve
M. extensor digiti minimi	Human	Lateral epicondyle of humerus	The dorsal aponeurosis of the little finger	Radial nerve
	Baboon	Lateral epicondyle of humerus, posterior surface of ulna	Two muscle bellies connected at the level of the wrist, insertion in dorsal aponeurosis of the little finger	Radial nerve
M. extensor carpi ulnaris	Human	Lateral epicondyle of humerus	Tubercle on the base of the medial side of the metacarpal bone V	Radial nerve
	Baboon	Lateral epicondyle of humerus	Base of the metacarpal bone V	Radial nerve
M. supinator	Human	Lateral epicondyle of humerus, radial collateral ligament of the elbow joint, supinator crest of ulna	Anterolateral surface of the radius, laterally to the pronator tuberosity of radius	Radial nerve
	Baboon	Lateral epicondyle of humerus, posterolateral proximal part of ulna, radial collateral ligament of the elbow joint	Anterolateral surface of radius, laterally to the pronator tuberosity of radius	Radial nerve
M. abductor pollicis longus	Human	Posterior surface of radius, ulna and interosseous membrane	Lateral side of base of the metacarpal bone I	Radial nerve
	Baboon	Posterior surface of radius, ulna and interosseous membrane	Lateral side of base of the metacarpal bone I, Os sesamoideum radiale	Radial nerve
M. extensor pollicis brevis	Human	Posterior surface of radius and interosseous membrane	Dorsal surface of the base of proximal phalanx of the thumb	Radial nerve
	Baboon	Not developed	Not developed	-
M. extensor pollicis longus	Human	Posterior surface of ulna and interosseous membrane	Dorsal surface of the base of proximal phalanx of the thumb	Radial nerve
	Baboon	Common origin with the extensor indicis – distal half of the posterior part of ulna, interosseous membrane	Distal part of the proximal phalanx of the 1st finger	Radial nerve
M. extensor indicis	Human	Posterior surface of ulna	The dorsal aponeurosis of the index finger	Radial nerve
	Baboon	Common origin with the extensor pollicis longus – distal half of the posterior part of ulna, interosseous membrane	Connects with the tendon of extensor digitorum muscle and inserts on the 2nd finger at the level of the metacarpophalangeal joint II	Radial nerve

Table 1 (continued).

Muscle	Species	Origin	Insertion	Innervation
M. adductor pollicis brevis	Human	Scaphoid, trapezium, flexor retinaculum of the hand	Proximal phalanx and dorsal aponeurosis of the thumb, radial sesamoid bone	Median nerve
	Baboon	Scaphoid (radial carpal bone), trapezium (first carpal bone), flexor retinaculum of the hand	Base of proximal phalanx of the 1st finger	Median nerve
M. opponens pollics	Human	Trapezium, flexor retinaculum of the hand	Lateral margin of the metacarpal bone I	Median nerve
	Baboon	Scaphoid (radial carpal bone), trapezium (first carpal bone)	Lateral margin of the metacarpal bone I, articular capsule of the metacarpophalangeal joint I	Median nerve
M. flexor pollicis brevis	Human (superficial and deep head)	Tubercle of trapezium, trapezoid, capitate and flexor retinaculum of the hand	Proximal phalanx of the thumb, radial sesamoid bone	Median nerve – superficial head Ulnar nerve – deep head
	Baboon	Flexor retinaculum of the hand	Basis of the proximal phalanx of the thumb – radial side	Median nerve
M. flexor digiti secundi profundus	Human	Developed in foetal stage only	-	-
	Baboon	Scaphoid (radial carpal bone), trapezium (first carpal bone)	Basis of the proximal phalanx of the thumb – ulnar side	Ulnar nerve
M. adductor pollicis – caput transversum	Human	Body of the metacarpal bone III	Base of proximal phalanx and the dorsal aponeurosis– caput transversum of the thumb	Ulnar nerve
	Baboon	Body of the metacarpal bone III	Medial side of the articular capsule of the 1st metacarpophalangeal joint	Ulnar nerve
M. adductor pollicis – caput obliquum	Human	Capitate, bases of metacarpal bones II – III	Base of proximal phalanx and the dorsal aponeurosis of the thumb	Ulnar nerve
	Baboon	Scaphoid (radial carpal bone), trapezium (first carpal bone)	Medial side of the articular capsule of the 1st metacarpophalangeal joint	Ulnar nerve
Mm. contrahentes	Human	Not developed	Not developed	-
	Baboon	Metacarpal bone III	Radial side of the base of proximal phalanx IV, Radial side of the base of proximal phalanx V	Ulnar nerve
M. abductor digiti minimi	Human	Pisiform, flexor retinaculum of the hand, the pisohamate ligament	Proximal phalanx of the little finger	Ulnar nerve
	Baboon	Accessory carpal bone (pisiform)	Articular capsule of the metacarpophalangeal joint V	Ulnar nerve
M. flexor digiti minimi brevis	Human	Hook of the hamate, flexor retinaculum of the hand	Proximal phalanx of the little finger	Ulnar nerve
	Baboon	Flexor retinaculum of the hand	Ulnar side of articular capsule of the metacarpophalangeal joint V	Ulnar nerve

Table 1 (continued).

Muscle	Species	Origin	Insertion	Innervation
M. opponens digiti minimi	Human	Hook of the hamate, flexor retinaculum of the hand	Medial surface of the body and head of metacarpal bone V	Ulnar nerve
	Baboon (superficial and deep part)	Carpal bone IV (hamate)	Medial surface of the body and head of metacarpal bone V	Ulnar nerve
M. palmaris brevis	Human	Palmar aponeurosis and flexor retinaculum of the hand	Dermis of skin on the medial side of the hand	Ulnar nerve
	Baboon	Palmar aponeurosis and flexor retinaculum of the hand	Dermis of skin on the medial side of the hand	Ulnar nerve
Mm. interossei palmares	Human	Medial margin of the proximal part of the metacarpal bones II, IV, V	Base of the proximal phalanx of the 2nd, 4th and 5th finger, dorsal aponeurosis of the hand	Ulnar nerve
	Baboon	Not developed	-	-
Mm. interossei dorsales	Human	Adjacent sides if metacarpal bones I – V	Proximal phalanx of the 2nd–5th finger	Ulnar nerve
	Baboon	Not developed	-	-
Mm. flexores breves profundi	Human	Developed in foetal stage only	-	-
	Baboon	Metacarpal bones	Radial and ulnar side of proximal phalanx of digits	Ulnar nerve
Mm. intermetacarpales	Human	Developed in foetal stage only	-	-
	Baboon	Metacarpal bones	Radial and ulnar side of proximal phalanx of fingers	Ulnar nerve
Mm. lumbricales	Human	Flexor digitorum profundus tendons	Lateral side of the base of proximal phalanx II – V, dorsal aponeurosis	Median nerve Ulnar nerve
	Baboon	Flexor digitorum profundus tendons	Lateral side of the base of proximal phalanx II – V, dorsal aponeurosis	Median nerve Ulnar nerve

Flexor digitorum superficialis (ventral group, intermediate layer)

In the examined baboon, the muscle arose from the medial epicondyle of the humerus and the proximal end of the anterior surface of the ulna. Michaëlis (1903) and Hill (1970) report a very similar finding. However, most authors (Macalister 1871; Champneys 1871; MacDowell 1910; Swindler and Wood 1973; Diogo and Wood 2011) are inclined to the opinion that, in the baboon, the origin of the muscle from the humerus is the norm and the additional radial or ulnar head is an anatomical variation. The flexor digitorum superficialis in humans, in addition to the humerus and ulna, also originates from the anterior surface of the radius. However, Mori (1964) describes that the radial head is a very variable part of the muscle in humans and can be completely absent in about 7.5% of people; in 12.5% of people it is rudimentary. In humans, the innervation of the flexor digitorum superficialis is provided by the median nerve (Drake et al. 2015); in the baboon, branches of the median nerve and ulnar nerve entering the muscle were found.

Flexor digitorum profundus (ventral group, deep layer)

In the baboon, the flexor digitorum profundus begins on the anteromedial surface of the ulna, partly on the antebrachial interosseous membrane and on the anterior surface of the radius. Diogo and Wood (2011) state that in the Anubis baboon, it was also possible to describe a part of the muscle clearly arising from the medial epicondyle of the humerus. The origin of the muscle determined by us is identical to the description by Hill (1970) and Swindler and Wood (1973), who also do not describe the beginning from the humerus. In humans, the muscle begins on the anteromedial surface of the ulna and on the antebrachial interosseous membrane. According to the norm, the origin from the radius is not recorded. However, Ishimi (1951) and Inoue (1934) mention a variable beginning of the flexor digitorum profundus on the proximal part of the body of the radius in approximately 16–33% of humans.

Flexor digitorum profundus attaches to the distal phalanx of the 2nd to 5th fingers in humans, and also to the 1st finger in baboons. This attachment tendon is the remnant of the flexor pollicis longus.

Flexor digitorum profundus in humans is innervated from two sources –the median nerve and the ulnar nerve. The finding at the dissection of the examined baboon corresponded to the description of the innervation by Swindler and Wood (1973) who state that in the baboon, this muscle is innervated only by the median nerve and its branches.

Flexor pollicis longus (ventral group, deep layer)

This muscle is considered rudimentary in the baboon, it is mostly part of the flexor digitorum profundus. Groves (1995) and Shoshani et al. (1996), however, state that the flexor pollicis longus is a separate muscle in the baboon. Our finding agrees with the description of the muscle by Day and Napier (1963) who describe this muscle as a part of the flexor digitorum profundus attaching to the 1st finger. A similar situation is also possible in humans as a variation. The belly of the flexor pollicis longus may be partially fused with the flexor digitorum profundus (Ishimi 1951), or this muscle may not be developed at all (Wagstaffe 1872; Hall 1903; Usami 1987).

Extensor carpi radialis longus et brevis (lateral group)

In the baboon, these two muscles have a common origin in the distal part of the lateral supraepicondylar crest and on the lateral epicondyle of the humerus and are partially fused in the proximal section. A similar situation can occur in humans within the variability. Ishimi (1951) states that the muscles can be partially or completely fused and can have two or three common tendons, which then attach to the metacarpal bones. By default, the extensor carpi radialis longus and brevis are two independently developed muscles.

Extensor digiti minimi (dorsal group, superficial layer)

Straus (1941), Swindler and Wood (1973), and Diogo and Wood (2011) uniformly describe the origin of the extensor digiti minimi in the baboon only from the humerus. Champneys (1871) and Hill (1970) state that the beginning of the extensor digiti minimi in the baboon is always on the lateral epicondyle of the humerus, less often also on the ulna and only rarely on the radius. In the examined baboon, this muscle arose from the lateral epicondyle of the humerus and, in a small section, from the back surface of the ulna. It had two bellies that joined into a single tendon and their common attachment disappeared in the dorsal aponeurosis of the 4th and 5th fingers. In this case, it is possible that there were two muscles – extensor digiti quarti proprius and extensor digiti quinti proprius, as described in the baboon by Kimura and Tazai (1970). These authors stated that both separate muscles fused into one common muscle belly, which had two separate tendons of attachment and together formed the extensor digiti minimi. The question therefore remains what can be considered as an anatomical norm and what as a variation in the above cases. In humans, the extensor digiti minimi is a thin single muscle starting at the lateral epicondyle of the humerus. It attaches to the dorsal aponeurosis of the 5th finger. In 4% of cases, the second belly of this muscle may be present, which is called the extensor digiti minimi accessorius (Mori 1964).

Supinator (lateral group)

The supinator has two heads in the baboon – the humeral head and the ulnar head. These parts of the muscle are also described in the works of Champneys (1871), Straus (1941), Swindler and Wood (1973) and Diogo and Wood (2011). In the baboon, the magnitude of the supinator is remarkable, unlike in humans, where it is notably smaller.

Abductor pollicis longus (dorsal group, deep layer)

In the abductor pollicis longus, small differences in the attachment of the muscle were noted. According to our findings, the muscle ended at the basis of the 1st metacarpal bone and the radial sesamoid bone, which is also confirmed by the works of Swindler and Wood (1973) and Diogo and Wood (2011). According to Straus (1941), the abductor pollicis longus attaches to the 1st metacarpal bone and to the trapezium, and, according to Champneys (1871) and Hill (1970), to the 1st metacarpal bone and the trapezoideum. It therefore seems that the anatomical standard of attachment of the abductor pollicis longus in the baboon has not yet been definitively determined.

M. extensor pollicis brevis (dorsal group, deep layer)

The extensor pollicis brevis is not developed in the baboon. In humans, it begins on the posterior surface of the radius and antebrachial interosseous membrane and attaches dorsally to the base of the proximal phalanx of the thumb. Some authors (Wood 1867, 1868; Macalister 1875) describe that the extensor pollicis brevis may not be developed in humans or may be fused with the abductor pollicis longus (Yoshida and Fukuyama 1979; Kosugi et al. 1985; Homma and Sakai 1992).

Extensor indicis (dorsal group, deep layer)

In the baboon, the beginning of the muscle is common with the extensor pollicis longus. The muscles begin in the distal half of the back surface of the ulna and the antebrachial interosseous membrane. The extensor indicis subsequently connects with the tendon of the extensor digitorum for the 2nd finger and attaches at the level of the metacarpophalangeal joint of the 2nd finger. This course is also described in some baboons by Kaneff (1980). The attachment of the muscle exclusively to the 2nd finger seems to be more of an anatomical variation and the norm is the attachment to the 2nd and 3rd fingers as described by most authors (Macalister 1871; MacDowell 1910; Swindler and Wood 1973; Kaneff 1980).

Hand muscles

Thenar group

Opponens pollicis and adductor pollicis in the baboon attach mainly to the area of the joint capsule of the metacarpophalangeal joint. This finding of ours is also confirmed by the description of the attachment of the opponens pollicis to the distal part of the 1st metacarpal bone by Swindler and Wood (1973) and Diogo and Wood (2011).

Muscles of the middle space

The baboon has developed contrahentes muscles, which we do not find in humans. These muscles diverge with a common origin on the body of the 3rd metacarpal bone and were attached to the radial surface of the basis of the proximal phalanx of the 4th finger and the radial surface of the basis of the proximal phalanx of the 5th finger. Thus, two contrahentes muscles were developed in this baboon, whose innervation was provided by the ulnar nerve. Brooks (1886), Jouffroy (1962), Hill (1970), Lewis (1989) and Diogo and Wood (2011) describe the finding of three contrahentes muscles attaching to the 2nd, 4th and 5th fingers. Day and Napier (1963) reported that the contrahens muscle for the 2nd finger was not present in the baboon as a separate muscle. It is therefore possible that the contrahentes muscles for the 4th and 5th fingers are the anatomical norm for baboons, and the contrahens muscle for the 2nd finger is an anatomical variation. Yamamoto et al. (1988) describe that the adductor pollicis is a remnant of the contrahentes muscles in humans. Tubbs et al. (2005) report the finding of contrahentes muscles in humans, when these structures were also innervated by branches of the ulnar nerve, as is the case in the baboon.

Flexores breves profundi

Flexores breves profundi are a group of muscles that are present in baboons, similarly to lemurs, macaques or chimpanzees (Diogo 2009; Diogo and Abdala 2010). According to our findings, seven separate flexores breves profundi were found in the Anubis baboon. According to the literature, they are specifically the flexor brevis profundus III–IX (Diogo and Wood 2011). These muscles originated from the 2nd to the 5th metacarpal bones and were inserted on the radial or ulnar surface of the proximal phalanx. According to the available data, the flexor brevis profundus I corresponds to the superficial head of the flexor pollicis brevis and opponens pollicis. Flexor brevis profundus II is similar to the deep head of the flexor pollicis brevis, and the flexor digiti minimi and opponens digiti minimi muscles arise from the flexor brevis profundus X.

Some studies (Swindler and Wood 1973) assumed that there are three palmar interossei and four dorsal interossei in baboons. However, this assumption was probably influenced by the arrangement of these muscles in humans (Diogo and Wood 2011).

Intermetacarpal muscles

Intermetacarpal muscles originated from the intermetacarpal spaces adjacent to the metacarpal bones and are attached to the proximal phalanx. A similar finding of independently developed intermetacarpal muscles is also described by Diogo (2009).

Flexores breves profundi and intermetacarpal muscles in humans represent the embryonic basis for the formation of palmar interossei and dorsal interossei (Čihák 1972).

Hypothenar group

The palmaris brevis has the same arrangement as in humans, but in baboons the muscle is more massive. The presence of the palmaris brevis in the baboon is also confirmed by Swindler and Wood (1973) and Diogo and Wood (2011). In the opponens digiti minimi, it was possible to observe its superficial and deep part, and this claim is supported by the works of Lewis (1989) and Diogo (2009). Some authors refer to these two parts of the muscle as two different muscles with different functions (Brooks 1886).

Brooks (1886) and Diogo and Wood (2011) describe that even the abductor digiti minimi has two parts. Our finding agrees with the description of the arrangement of the abductor digiti minimi by Swindler and Wood (1973), who do not mention the division of the muscle.

In the baboon, the flexor digiti minimi brevis started only from the flexor retinaculum. Diogo and Wood (2011) also confirm this finding in their work. Some authors also describe a variable origin from the hook of the hamate (Champneys 1871; Swindler and Wood 1973). In humans, the origin of the muscle from the flexor retinaculum and the hook of the hamate as part of the ulnar eminence of the wrist is the norm.

In the baboon, abductor digiti minimi and flexor digiti minimi brevis attach more proximally compared to humans; this is the area of the joint capsule of the 5th metacarpophalangeal joint. The attachment of the muscle at the level of this joint in the baboon is also described by Brooks (1886), Swindler and Wood (1973), and Diogo and Wood (2011).

Comparison of the regional anatomy of the forearm and hand in human and baboon

Pronator canal

The pronator canal is a slit between the heads of the pronator teres in humans. The median nerve passes through this site, between the humeral and ulnar heads (Stingl et al. 2012). In the baboon, the ulnar head is not developed and the median nerve thus passes only under the humeral head of the pronator teres. Therefore, this site is not the preferred localisation of median nerve compartment syndrome in baboon, as it is in humans.

Carpal canal

The boundaries and arrangement of the carpal canal differ in humans and baboons. The boundaries of the carpal canal in humans are represented radially by the radial eminence of the wrist (tubercle of the scaphoid and tubercle of the trapezium), ulnarly by the ulnar eminence of the wrist (pisiform and hook of the hamate), dorsally by the ligamentous apparatus of the wrist joints, and palmarly by the flexor retinaculum. The flexor retinaculum is stretched between the radial and ulnar eminence of the wrist (Stingl et al. 2012).

In the baboon, the bones of the wrist do not have such distinct structures developed as in humans (tubercle of the scaphoid, tubercle of the trapezium, hook of the hamate). Therefore, the flexor retinaculum, with its beginning on the radial side, extends more dorsolaterally, and its origin can already be traced from the distal parts of the radius. On the ulnar side, the flexor retinaculum begins at the level of the accessory carpal bone (pisiform in humans), which is significantly stronger than in humans. The flexor pollicis longus, the flexor carpi radialis, the flexor digitorum superficialis and profundus and the median nerve run in the carpal canal in humans and baboons. The only difference is that the flexor pollicis longus is a rudimentary muscle in the baboon and runs through here as part of the flexor digitorum profundus.

Ulnar (Guyon's) canal

In humans, the ulnar canal represents the space between the pisiform and the hook of the hamate, where we find the ulnar nerve and ulnar vessels (Stingl et al. 2012). In the baboon, the hook on the 4th carpal bone is not developed (hamate in humans) and the accessory carpal bone (pisiform in humans) is larger than in humans. Here, however, a short fibrous solid structure splits off from the flexor retinaculum, which replaces the hook of the hamate and creates, together with the accessory carpal bone, a small channel for the ulnar nerve and ulnar vessels.

In conclusion, during the anatomical dissection of the forearm and hand in a baboon, some important facts were discovered that could contribute in the future to determining the anatomical norm and anatomical variability of the muscles of the forearm and hand in baboons. Our findings differed from the literature sources, mainly in the extensor digiti minimi, where two separate muscle bellies were dissected. We believe that, in this individual, it was the extensor digiti quarti proprius and extensor digiti quinti proprius. For the deep layer of forearm muscles, there are still differences in the origins and insertions of individual muscles as described by different authors. Small differences can also be found in the thenar and hypothenar muscles; the anatomical norm is still not established in the baboon, even in the contrahentes muscles and their number. This study, even though of a single individual, might contribute to the future determination of the anatomical standard of the forearm and hand muscles in baboons.

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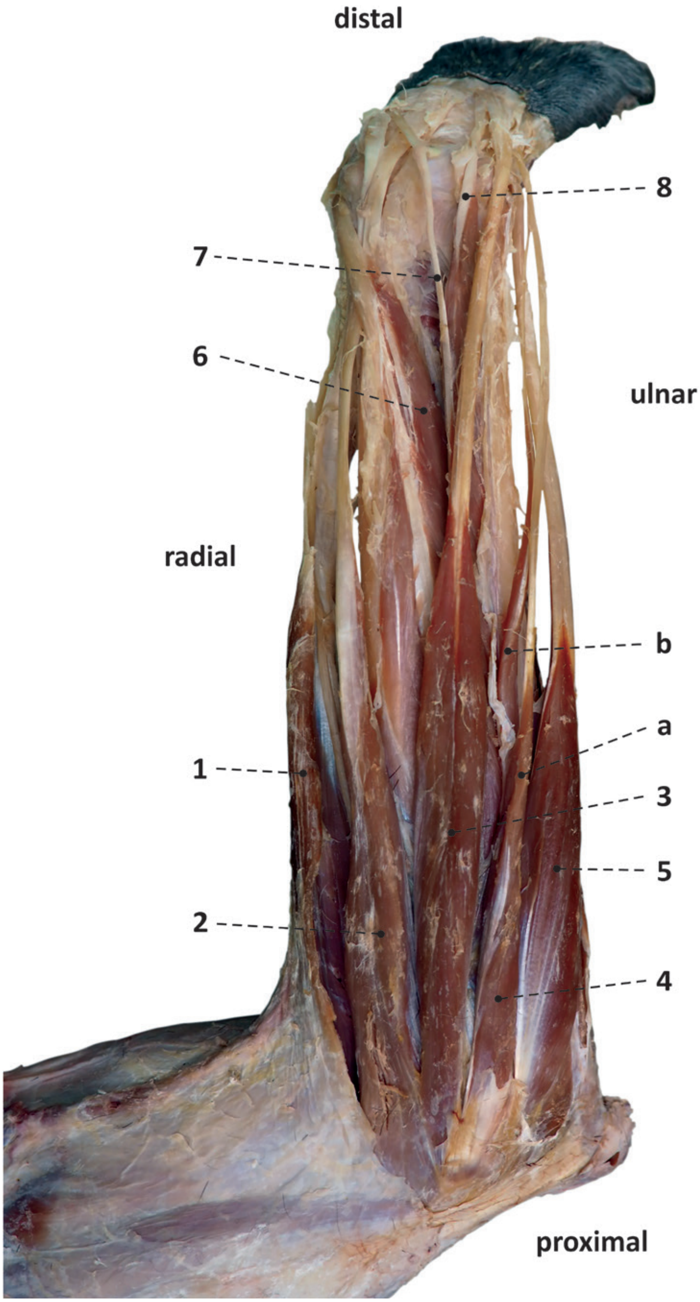

Fig. 1. Right antebrachium, lateral and dorsal group of antebrachial muscles of the Anubis baboon.

1 – Brachioradialis; 2 - extensor carpi radialis; 3 - extensor digitorum; 4 - extensor digiti minimi (extensor digiti V), a - extensor digiti V, b - extensor digiti IV (in this specimen); 5 - extensor carpi ulnaris; 6 - abductor pollicis longus (abductor digiti I longus); 7 - extensor pollicis longus (extensor digiti I longus); 8 - extensor indicis (extensor digiti II) (photo by Jana Vachová).

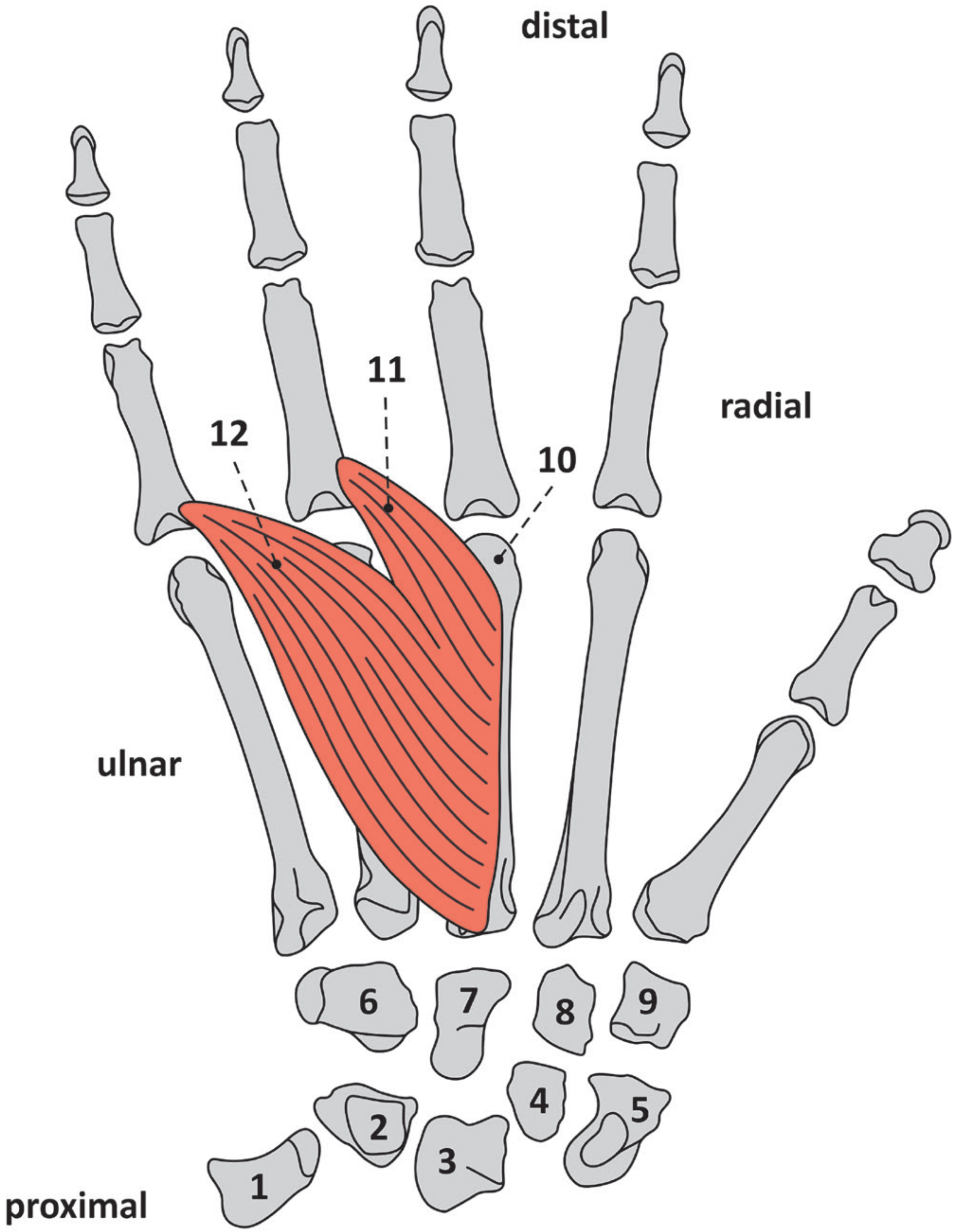

Fig. 2. Right hand, palmar side, contrahentes muscles of the Anubis baboon (scheme).

1 - Pisiform (accessory carpal bone); 2 - triquetrum (ulnar carpal bone); 3 - lunate (intermediate carpal bone); 4 - central carpal bone; 5 - scaphoid (radial carpal bone); 6 - hamate (carpal bone IV); 7 - capitate (carpal bone III); 8 - trapezoid (carpal bone II); 9 - trapezium (carpal bone I); 10 - metacarpal bone III; 11 - contrahens muscle IV; 12 - contrahens muscle V (graphics by Jana Vachová).

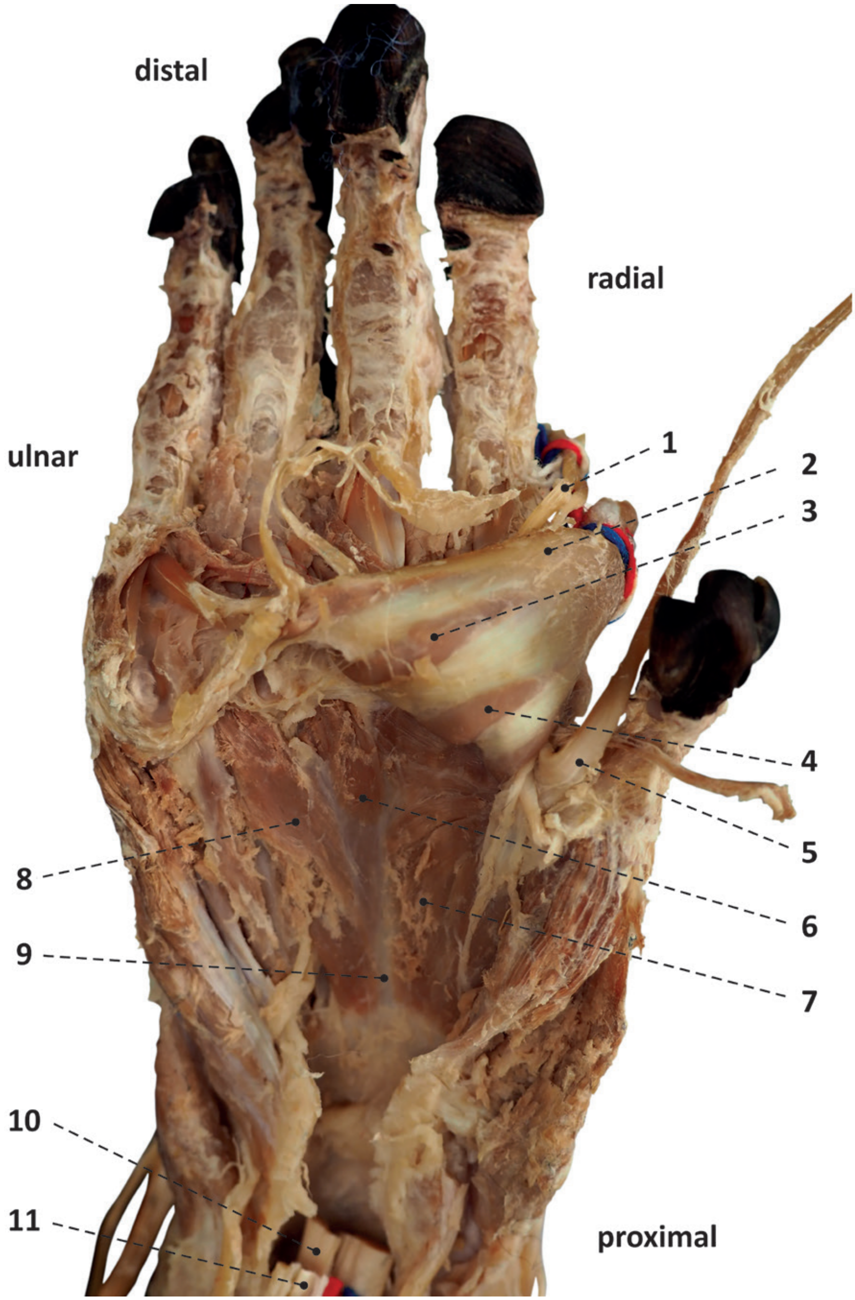

Fig. 3. Right hand, palmar side, contrahentes muscles of the Anubis baboon.

1 - Flexor digitorum superficialis (cut); 2 - flexor digitorum profundus (cut); 3 - lumbrical muscle III; 4 - lumbrical muscle II; 5 - flexor carpi radialis (cut); 6 - contrahens muscle IV; 7 - adductor pollicis (adductor of the first finger); 8 - contrahens muscle V; 9 - metacarpal bone III; 10 - flexor digitorum profundus (cut); 11 - flexor digitorum superficialis (cut) (photo by Jana Vachová).