

Anatomy and Functional Architecture of the Anconeus Muscle

Anatomía y Arquitectura Funcional del Músculo Ancóneo

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CORIOLANO, M. G. W. S.; LINS, O. G.; AMORIM, M. J. A. A. L. & AMORIM, A. A. JR. Anatomy and functional architecture of the anconeus muscle. *Int. J. Morphol.*, 27(4):1009-1012, 2009.

SUMMARY: The anconeus is a small muscle situated at the elbow. Although the anconeus is active during elbow extension its importance for the movement is probably small. It could work as an elbow stabilizer. The object of this study was to investigate some anatomic and architectural characteristics of the anconeus, in the hope of shedding light on its function. We studied twenty adult cadaveric specimens. The anconeus originates by the lateral epicondyle of the humerus and inserts along the proximal ulna. The superficial shape of the anconeus is triangular. Tridimensionally the anconeus resembles a hemisected rectangular-based pyramid, with the base at the ulna and apex at the lateral epicondyle. The muscle fibers arise obliquely from the tendinous expansion and inserts at the ulna. Thus, the architecture of the anconeus is penniform, an architecture able to produce more force than displacement. The design index of 0.3 also suggests a force muscle.

KEY WORDS: Anconeus muscle; Muscle architecture; Function of the anconeus.

INTRODUCTION

The anconeus muscle shows peculiar features and is scarcely mentioned in the scientific literature. Some authors regard it as a part of the triceps brachialis (Platzer, 1988; Moore & Dalley, 2007), whereas other authors consider it as being an independent muscle (Gray, 1988). Although the anconeus muscle is active during elbow extension (Bozec & Maton, 1982) the importance of the anconeus for the movement itself is probably very small. The triceps brachialis muscle is by far the major muscle responsible for elbow extension (Kapandji, 2000). The anconeus could work basically as a stabilizer of the elbow joint (Kendall *et al.*, 1980). The anconeus is a useful muscle in neurophysiological diagnostic tests for myasthenia gravis and others neuromuscular transmission disorders (Coriolano *et al.*, 2007).

In many standard anatomical atlases (Goodgold, 1974; Netter, 2004; Schumacher *et al.*, 2006) the anconeus is described and illustrated as a triangular shaped muscle with fibers diverging from its tendon of origin as in a fan. To our knowledge there are very few studies on the muscular architecture of the anconeus muscle (Hora, 1959).

The object of this study was to investigate some of the anatomic and architectural characteristics of the anconeus muscle, its origin and insertion, its macroscopic shape and the arrangement of its muscle fibers, in the hope of shedding some light on its function.

MATERIAL AND METHOD

The study received the approval of the Ethics Committee on Human Research of the Health Sciences Centre, Federal University of Pernambuco, Brazil. We studied twenty upper limbs of formalin-fixed adult cadavers, without distinction of sex, ethnical group, antimetry or daily activities. For the dissection procedures, we used conventional surgical material: forceps, scissors, scalpel and gloves. For the measurements we used a millimetered ruler. The photographs were taken with a digital camera.

After having exposed the muscle from each limb; we observed and registered its general shape, the arrangement

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and course of its tendon and muscle fibers. We then used the ruler to measure the length of the borders (superior, lateral inferior and base), the width at the proximal base, the tendon and the muscle fibers. We divided the fibers in 4 groups: proximal fibers: those arising from the proximal third of the tendon, adjacent to the superior border of the muscle; middle fibers: those arising from the middle third of the tendon; distal fibers: those arising from the distal third of the tendon; and terminal fibers: those originating from the tip of the tendon, following the same orientation as it. We also calculated the design index (the ratio between the average length of the muscle fiber and the body of the muscle).

RESULTS

Origin and insertion. In all our material the anconeus originated just posteriorly to the lateral epicondyle of the humerus and inserted along the proximal third of the posterior face of the ulna.

General shape and morphometry. The shape of the anconeus bidimensional surface was nearly one of a right angle triangle, with the corner of the right angle situated at the proximal extremity of the ulna, about 1 cm distal to the olecranon. In order to identify the sides of the anconeus, we used the nomenclature suggested by Hora: superior border (from the lateral epicondyle to the ulna adjacent to the olecranon), lateral inferior border (from the lateral epicondyle to the union of the proximal and middle thirds of the ulna) and base (insertion of the anconeus along the ulna). The measures of these borders are tabulated in Table I. The length of the ulna (from the olecranon to the styloid process) was about 26 cm therefore the base of the anconeus occupied the proximal one third of the ulna. The correlation between the length of the base of the anconeus and the length of the ulna was not significant ($R^2=0.2$, $p>0.05\%$). Tridimensionally, the anconeus resembled one side of a hemisected rectangular-based pyramid, with the base located at the ulna and apex next to the lateral epicondyle.

Arrangement and course of the tendon. The tendon of the anconeus, named by us tendinous expansion, arises just posteriorly to the lateral epicondyle of the humerus and extends along the lateral inferior border of the muscle, towards the junction of the proximal and middle thirds of the ulna. The tendinous expansion was about 5 cm in length and constituted roughly two-thirds of the total length of the lateral inferior border of the muscle. The other third was formed by the terminal muscle fibers of the anconeus (see below). The tendinous expansion was cylindric in 15 limbs (75%) and flat in 5 limbs (25%).

Table I. Anconeus measurements (in centimeters): borders and width.

	Mean (SD)
Superior margin	2.2 (0.3)
Lateral inferior margin	8.2 (1.0)
Base	7.8 (1.1)
Width	1.2 (0.2)

Arrangement and course of the muscle fibers. The muscle fibers of the anconeus arise obliquely from the tendinous expansion and travels toward the posterior face of the ulna, where they insert. The angle the fibres make with tendinous expansion decreases along the length of the muscle. Similarly, as they insert, the muscle fibers make with the ulna decreasing angles. Like Hora, we have categorized the anconeus muscle fibers as proximal, middle and distal. Additionally, we named “terminal muscle fibers” the fibers that arise in the end of the tendinous expansion, running in the same direction as it, to insert in the junction of the proximal and middle thirds of the ulna. The terminal muscle fibers constitute with the tendinous expansion the lateral inferior border of the anconeus. The gross measures of the muscle fibers are tabulated in Table II.

Table II. Anconeus measurements (in centimeters): muscle fibers.

Fibers	Mean (SD)
Proximal	2,2 (0,3)
Medial	3,0 (0,4)
Distal	2,2 (0,4)
Terminal	2,7 (0,8)

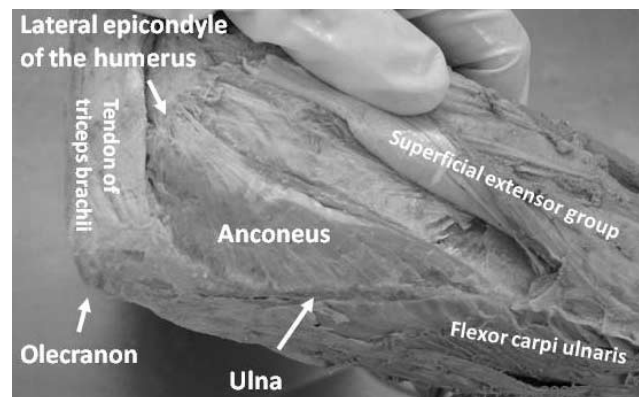


Fig. 1. Dissected right anconeus muscle. Shown are its origin posteriorly to the lateral epicondyle of the humerus, insertion along the proximal ulna contiguous to the olecranon, and pennate (featherlike) architecture.

The design index (mean length of the muscle fibers divided by the mean length of the muscle measured on the lateral inferior border) was 0.3.

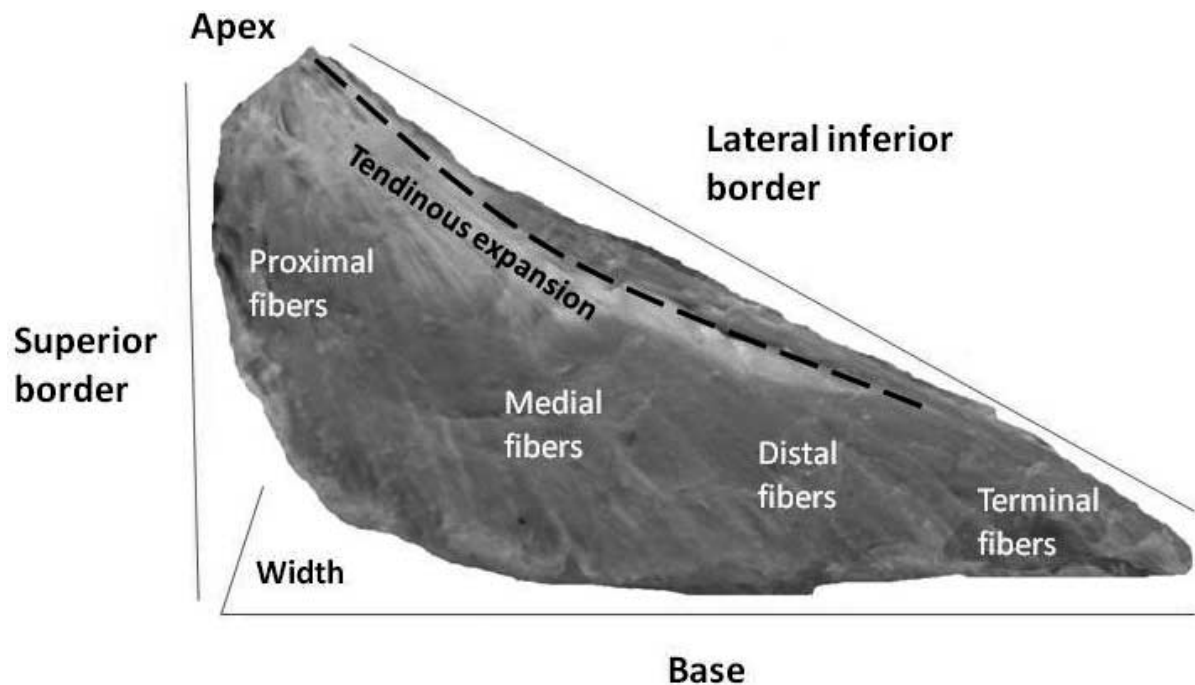


Fig. 2. Desinserted right anconeus muscle. Shown are the borders (superior, lateral inferior and base), width, tendinous expansion and muscle fibers. Note the tri-dimensional shape of a hemisected rectangular based pyramid and the pennate architecture.

DISCUSSION

In our data the flat shape of the anconeus was triangular, as shown in most anatomical atlases. However, in the illustrations of many known atlases (Palastanga *et al.*, 2000; Khale *et al.*, 2000; Netter; Schumacher *et al.*) the anconeus is shown as a fusiform muscle—a fan of fibers originating from a single point of a tendon (as in a fuse) and inserting at the ulna. In fact, the muscle fibers of the anconeus arise obliquely along a fairly long tendinous expansion (as in a feather). This penniform (penna: feather in latin) architecture may already be observed in atlases illustrated with photographs, instead of drawings (Putz & Pabst, 2000; Rohen & Lütjen-Drecoll, 2002).

The architecture of a muscle is closely related to the function executed by the muscle. There are two basic types of muscle architecture: fusiform and penniform. The muscles of the first type have a shape of a fuse. Its muscle fibers have the length similar to the length of the muscle itself and are oriented in the same direction as the axis of force production. These muscles are more adequate to produce displacement than force (Smith & Lehmkühl, 1987; Lieber & Friden, 2001). On the other hand, in a penniform muscle the muscle fibers contract diagonally in relation to axis of force production and are shorter than the muscle length. This architectonic arrangement allows a greater number of muscle fibers to be arranged on a same volume of muscle. For that reason,

penniform muscles are able to produce more force than fusiform muscles of similar volume, on the other hand they produce less displacement (Hamill, 1999; Watkins, 2001). The majority of the muscles of the human body need to exert more force than a simple fusiform architecture is able to provide. Thus, there are more penniform muscles than fusiform muscles in the human body (Smith & Lehmkühl).

The ratio between the length of the muscle fibers and length of the muscle is known as the design index. The design index is a simple and useful parameter for the study of muscle function. A design index close to one suggests an excursion muscle whereas a design index much smaller than one suggests a force muscle (Abrams *et al.*, 2005; Morse, 2005). Our calculated design index for the anconeus was 0.3, suggesting a muscle designed for force production.

The anconeus inserts along the proximal ulna, from one fourth to one third of its length. In fact, the anconeus insert in the whole posterior face of the ulna, not only in its border. The tridimensional shape of the anconeus is similar to a hemisected rectangular based pyramid. In its insertion in the ulna, the anconeus covers an area of the ulnar bone of around 10 cm² (7.8 times 1.2 cm). Therefore, the anconeus is a relatively thick muscle.

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RESUMEN: El ancóneo es un pequeño músculo situado en la región del codo. Aunque el músculo ancóneo es activo durante la extensión del codo su importancia para este movimiento es probablemente pequeña. Podría actuar como estabilizador del codo. El objetivo de este trabajo fue investigar algunas características anatómicas y arquitectónicas del músculo ancóneo, con la esperanza de lanzar una cierta luz en su función. Estudiamos 20 cadáveres de adultos. El músculo ancóneo se origina al lado del epicóndilo lateral y se inserta en la ulna. La forma superficial del músculo ancóneo es triangular. Tridimensionalmente, el músculo ancóneo se asemeja a la mitad de una pirámide de base rectangular, con la base en la ulna y el ápice lateral al epicóndilo lateral. Sus fibras musculares describen un trayecto oblicuo con una extensión tendinosa que se insertan en la ulna. Por lo tanto, la arquitectura del músculo ancóneo es peniforme, una arquitectura conveniente para producir mayor fuerza con el desplazamiento. El índice de diseño de 0,3 también lo sugiere como un músculo de fuerza.

PALABRAS CLAVE: Músculo ancóneo; Arquitectura muscular; Función del músculo ancóneo.

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Received: 07-03-2009

Accepted: 22-08-2009