THE ANTEBRACHIAL BONE MORPHOLOGY AND PRONATION AND SUPINATION MOVEMENT POSSIBILITIES IN DOMESTIC MAMMALS AND HUMANS

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Abstract

In according to species, forearm bones have a different topography and development in conjunction with the use of the hand. When mobile they can rotate one around the other to perform pronation and supination movements. Otherwise, they are welded, radius being more developed than ulna. Study was to describe motfologiei articular surfaces in mammals, including humans, linking data obtained with pronation and supination possibilities of autopodium.

Keywords: forearm, radius, ulna, pronation, supination.

INTRODUCTION

Limb morphology in mammals is the result of a long evolution of vertebrates. In a phylogenetic way we can highlight three stages in the progress of terrestrial locomotion: a) transforming the fins in rudimentary, horizontal limbs, perpendicular to the body axis, b) the emergence of zeugo and stilozeugopodial-autopodial angles c) lifting the trunk at ground level, with a tendency to verticality of the limbs (5). because of the lack of works related to limb skeletal development (1,2,3,4,6,7,9) and to aspects of the morphology adaptation of this skeleton, correlated with a certain specialization of limbs (8,10,11), in literature there are few data on the detailed morphology of the anatomical basis of forearm,the begining of the pronation and supination movements of autopodium, which is why I addressed this topic.

MATERIALS AND METHODS

Research has been conducted on parts from Anatomy Laboratory of Domestic Animals Faculty of Veterinary Medicine Bucharest. Actual study was done on 20 horse zeugopodiums, 20 from large ruminants, 30 ovines and swines

zeugopodiums, 30 carnivore zeugopodiums (15 cats and 15 dogs) and 20 from rabbits. The studied bones were from animals of different ages. Also, in the discipline collection were studied also 4 zeugopodiums from human skeletons. Components of articular surface on the proximal and distal end(length, width, depth, etc.) were studied as well as relations between the bodies of the two bones. The most suggestive aspects were photographed.
Identification, description and formations approval was made in accordance with Nomina Anatomica Veterinaria — 2005

RESULTS AND DISSUTION

At horse, the forearm bones are welded, radius encompassing the distal third of ulna,, which is represented at this level, only by a epiphyseal core of ossification. From the antebrachial interosseous space only radioulnar proximal arch remains, and it's elongated in a proximo-distal direction (Fig. 1-9).
Radius presents an articular surface for the ulna, represented by the two diartrodiale relatively planiforme sides, located on the proximo-caudal extremity (Fig. 2-5). Between them and the distal there is a rough surface used for ligament insertion.
In ulna's case, diartrodiale surfaces belonging to radius are supported by lateral and medial coronoid processes. Cranial front of ulna's body is welded to radius, the surface of synostosis resembling a triangle, whose peak, distal oriented, reaches the boundary between the middle and distal third of the diaphysis.
At large ruminants, the forearm bones are shorter and thicker than a horse's. Ulna, welded to the radius, is reduced, but individualized to its distal end (Fig. 3). Antebrachial interosseous space is represented by two radio-ulnar arcades, one proximal, wider, and one distal, which reduced (Fig. 3 to 8.9). Caudal front of radius body presents on its full length a synostosis surface with the ulna, interrupted only at the two radio-ulnar arcade.
Radius has a articular surface for the ulna, represented by two planiforme surface, a lateral one and another medial with dimensions of 1.8 / 1,4 cm, respectively 1,6 / 1,2 cm (wider than at the horse) (Fig. 4 - 3).
Diartrodiale articular surfaces of the ulna are congruent with those of the radius, being slighly widened.

Fig. 1 Horse radius and ulna (lateral surface of the right member)
R-radius; U-ulna; 1 - lateral tuberosity; 2 - bicipitală tuberosity;3- ulnar styloid apophysis;4-olecranon; 5-olecranon beak; 6-semilunar notch; 7 - tendon slide; 8 – ulna body; 9 radio-ulnar proximal arch.

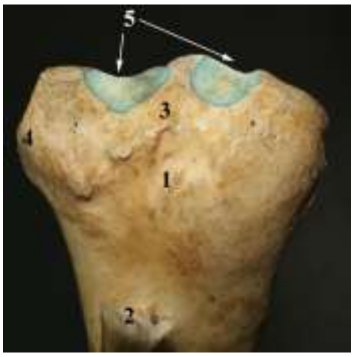

Fig. 2 Caudal face aspect of proximal extremity of horse radius (left member)
1-head of the radius; 2-detachment place of the olecranon;3 -area of ligament insertion; 4-lateral tuberosity; 5 – diartrodial surfaces for ulna.

Fig. 3 Cow radius and ulna (left member side)
R-radius, U-ulna; 1-lateral tuberosity; 2-distal extremity; 3-olecranon; 4-olecranon beak;5-semilunar notch; 6-ulna body; 7-ulnar styloid apophysis; 8-proximal radioulnar arch; 9- distal radioulnar arch.

Fig. 4 Caudal face of the proximal extremity of cow radius (the left forelimb)
1-lateral tuberosity; 2-detachment place of the olecranon; 3- diartrodial surfaces for ulna

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Fig. 5 Radius and ulna in pig
(right member, lateral side)
R-radius; U-ulna; 1-radius head 2-distal extremity; 3-olecranon; 4-olecranon beak; 5-semilunar notch; 6-ulnar styloid apophysis; 7-proximal radioulnar arch

Fig. 6 Radius and ulna in rabbit (left member, lateral side) R-radius; U-ulna; 1-semilunar notch; 2-olecranon; 3-ulnar styloid apophysis

Fig. 7 Proximal extremity in dog radius
(the left member,
caudal view) 1 - proximal articular surface; 2 - joint circumference; 3 –the neck of radius

Fig. 8 Proximal end of dog's ulna
(the left member, cranial view)
1 - olecranon beak; 2 - semilunar notch; 3 - radial notch, 4 - interosseous line; 5 - medial coronoid process.

At ovines, bones are thinner and longer and proportionally higher than the large ruminants.

At pig the two bones are rude, short, joined together but seamless(Fig. 5). The link between them is achieved by short fibers, corresponding interosseous membrane from carnivores (fibrous joints). However, there aren't possible any movements between them. Proximal radio-ulnar arch is very narrow, the distal rarely being present in the form of small cracks.

At rabbits, forearm bones, strongly recurved, are fixed between them, throughout their length's contact, which contributes to strengthening the region (Fig. 6). As in pigs, the bond between the two bones's body is realised through a short fibrous interosseous ligament. Planiforme diartrodial articular surfaces, are placed on the perimeter of caudal circumference.

The dog's forearm bones are independent, mobile and crossed with each other. Because of the articulation only between the extremities,at dogs, they delimit an interosseous space (Spatium interosseum antebrachii). The interosseous space is completed by an interosseous membrane, whose proximal portion is very thick and strong. The supination movement is done with an amplitude of about 20 °.

The proximal radius articular surface is represented by a joint circumference (Circumferentia articularis) located on the perimeter of the caudal extremity (Fig. 7). Distal, to the side, concave and elongated proximo-distal direction, for the ulna.

Proximal ulna articular surface for the proximal extremity of the radius is represented by a radial notch (Incisura radialis), supported mostly on medial coronoid process (Fig. 8). Distal articular surface (Circumferentia articularis)for the radius is elongated and slightly convex.

At cat, the forearm interosseous space is wider than the dog's. The ulna joint circumference is larger, located caudomedial. Supination movement is done with an amplitude of about 80 °. At carnivores, the supination movements are favored by the articulation mode of the proximal radius extremity with the humerus. Thus, at these species, the proximal articular surface of the radius only gets to joint humeral condyle, tending to become a spheroidal joint.

At humans, pronation and supination movements are very ample. Unlike other mammals, they do not occur only in the two radio-ulnar joints (Fig. 9). but are accompanied by limb movements in the scapular-humeral articulation.

Judging on the appearance of the articular surfaces, we find features of radio-ulnar joint morphology of the carnivores, animals that can perform supination movement, compared to ungulates and leporidss, at which the forearm bones are attached in the pronation position.

Supination movement a of the thorax autopodium has the center in the forearm region, due to radius rotation around a longitudinal axis and at the same time, oblique to this mobile element, while the ulna remains fixed. The rotation axis passes through the center of the proximal radius extremity and its neck after leaving the bone, so that the distal part of the forearm can pass through the center of the ulna's distal extremity. As in humans, proximal radio-ulnar articulation of this group of animals has the structure of a trochoide joint or swivel joint. Radius joint circumference is maintained in contact with the radial ulna notch, due to annular ligament.

Fig. 9 Radius and ulna (human left member)
R- radius; U-ulna; 1 - joint circumference; 2 - radial tuberosity; 3 – anterior edge;
4 - styloid process; 5 - interosseous edge; 6 - olecranon; 7- ulna trochlear notch; 8 - ulna tuberosity; 9 - ulna interosseous edge; 10 - styloid process.

It surrounds the radius proximal end and inserts ulna with its head in lateral and medial sides of radial notch. Radius proximal extremity, caught in this osteo-ligamentous ring, is able to rotate within the limits permitted by joint surfaces and other configurations of interosseous ligament.

At ungulates and leporids, proximal radio-ulnar joint is an articulation, which judging after joint surface shape can be classified as plane. The articular surfaces, more or less flat are located two by two on the caudal extremity of the radius's circumference, respectively, on the ulna coronoid process. In these animals, the mobility within the synovial joints is very low, with only tiny sliding movements.

Radius's and ulna's bodies are joined together by the forearm interosseous membrane, which fills the forearm antebrachial interosseous space, forming a syndesmosis. The membrane has a maximum development in carnivores. At horse the fibrous tissue counterpart membrane ossifies earlier and it forms a synostosis, forearm bones being fixed in a pronated position. Also at ruminants occurs interposed fibrous tissue ossification between two bones, but this process is extended for a longer period of time.

Pronation and supination movements are dependent not only of the fusion degree of the two bones, but also of the shape and height of the olecranon's articular head. Compared to species in which the articular head is flattened (horse, ruminant, pig and rabbit) at carnivores (especially cats) it's possible the supination movement. Its magnitude is even greater as the olecranon is shorter. The ratio between the olecranon's and radius's average length for the studied parts is presented in Table 1.

Table 1. The ratio between the radius and olecranon length at some domestic mammals and humans

Species	Olecranon lenght (cm)	Radius lenght (cm)	Ratio Lo/Lr	Observations
Horse	10	37	1 : 3,7	Ongulate average 1 : 3,38
Cow	12	33	1 : 2,75	
Sheep	4,5	17	1 : 3,7	
Pig	7	14	1 : 2	
Dog	4	20	1 : 5	Carnivores 1 : 5,5
Cat	1,5	9	1 : 6	
Human	3	22	1 : 7,3	Human 1 : 7,3

CONCLUSIONS

The forearm represents the center of pronated and supination movements, responsible for autopodium's mobility;

The amplitude of pronation and supination movements is directly proportional to the degree of specialization of the thoracic limb during evolution;

The highest degree of these possibilities is reached by human hands, which is able to transit from pronation to supination by a rotation of 180 °;

From the domestic mammals,the cat can supinate thorax autopodium but the rotation cannot exceed 80 ° . The possibility of executing this movement is closely linked with existing climbing ability in this species;
At dogs, autopodium's mobility is significantly reduced, while forearm bones remain independent;
At other mammals, due to autopodium's unilateral specialization, the thoracic member function is only to support in standing and locomotion, forearm bones being fixed in pronation position . Therefore, on these, the radio-ulnar proximal joint is characterized by lack of annular ligament and consolidation of collateral ligaments. In addition, it is found that pronation and supination movements are dependent not only on the degree of fusion of the two bones but also on the olecranon's articular head shape and olecranon's heigh.

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