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Functional anatomy of the radial sesamoid bone in the giant panda (*Ailuropoda melanoleuca*)

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ABSTRACT

The function of the radial sesamoid bone (RS) in the giant panda (*Ailuropoda melanoleuca*) was examined by macroscopic study of RS-related bones and muscles. The RS was observed to be connected to the scapholunar and the 1st metacarpal bones. A joint cavity was present between the proximal surface of the RS and the distal area of the scapholunar bone but the RS possessed a fibrous joint connecting it to the proximal radial surface of the 1st metacarpal bone. It is suggested that the RS possesses no substantial abductor–adductor function as the articulation between the RS and the 1st metacarpal bone (FM) seems not to permit flexible movement of the RS. The RS may be a supporting process opposite the digits in the palm when the animal flexes its 5 digits to grip objects, but it is not an active grasping apparatus. In the muscular system, abductor pollicis longus provided strong tendons to the RS as an RS-abductor, whereas the abductor pollicis brevis, opponens pollicis and aponeurosis palmaris were well developed as an RS-adductor muscle group. Observation of RS articulations, however, showed that the muscles do not provide appreciable abduction-adduction actions for the RS.

Key words: Giant panda; radial sesamoid bone.

INTRODUCTION

Since the beginning of the 20th century, the large radial sesamoid bone (RS) of the giant panda has been of interest to anatomists (Lankester & Lydekker, 1901; Pocock, 1939; Wood-Jones, 1939*a*, *b*; Davis, 1964*a*, *b*; Beijing Zoo et al. 1986). The animal uses the digits and the strongly-developed RS to grasp food as indicated in photographs of panda feeding on bamboo (Wood-Jones, 1939*a*). It has been suggested that the RS may take an active abduction–adduction movement, functioning as a pseudometacarpal and acting as a grasping apparatus when the animal flexes its 5 digits to manipulate bamboo stems or other plant food (Wood-Jones, 1939*a*; Davis, 1964*a*, *b*). However, the action pattern of the RS has been deduced only from descriptions of the development of RS-related muscles such as the abductor pollicis longus (APL), abductor pollicis brevis (APB), opponens pollicis (OP) and aponeurosis palmaris (AP) (Wood-Jones, 1939*a*; Davis, 1964*a*, *b*). In the present study, we carried out detailed macroscopic observations to examine RS movement and function from the standpoint of bone-articulation-muscle relationships. Bone shape for the RS, and the scapholunar and 1st metacarpal bones was examined, together with the RS-related articulations, muscles and nerves. The functional significance of APL, APB, OP and AP was evaluated from these findings to clarify the RS movement pattern.

MATERIALS AND METHODS

In this study we used a male giant panda (*Ailuropoda melanoleuca*) which died of senility at Ueno Zoological Park (Tokyo, Japan). The animal, weighing approximately 150 kg, was estimated to be more than 25 years old. Both the left and right forelimbs were separated from the carcass and the forearms dissected in a −4 °C cold room. Fixation of the carcass in formalin was not undertaken so that the skeleton and attached

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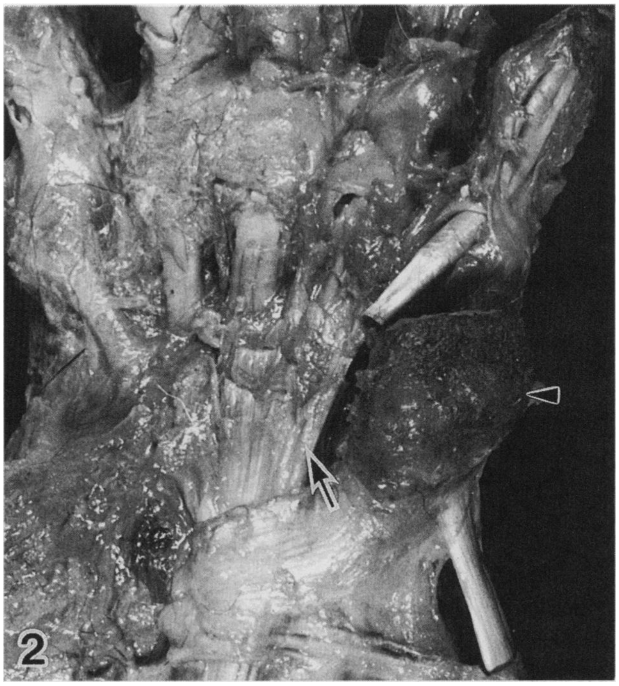


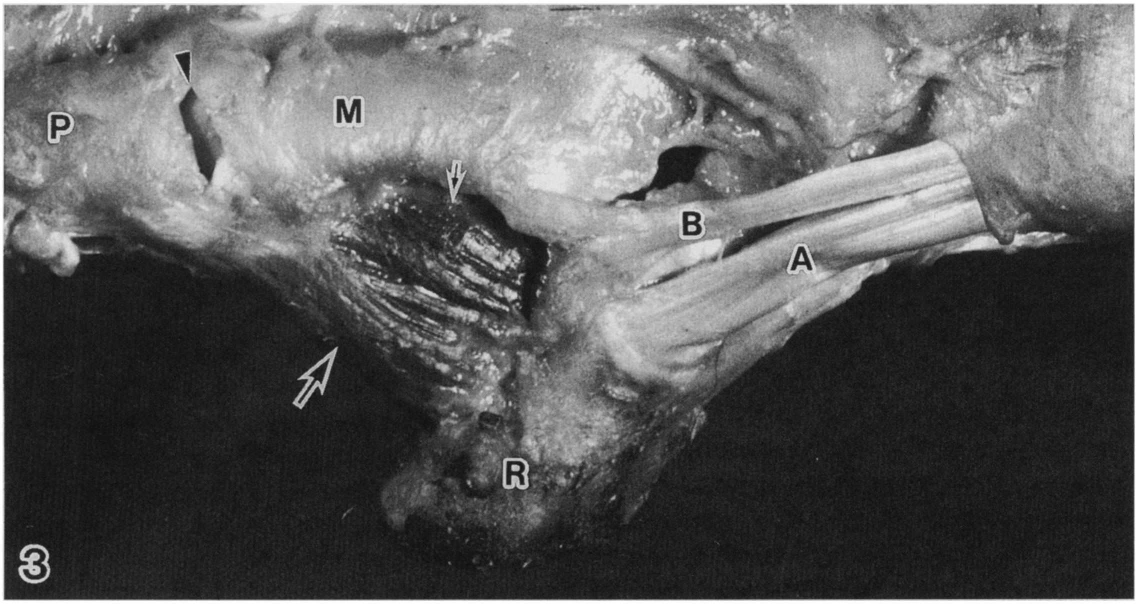


Fig. 1. Superficial muscles of the left palm in the giant panda. Aponeurosis palmaris (large arrows), partly torn off (small arrow), extends to the medial side of radial sesamoid (arrowhead).

Fig. 2. Superficial muscles of the right palm. Aponeurosis palmaris has been excised. Palmaris longus (arrow) does not attach to radial sesamoid (arrowhead).

Fig. 3. Dorsolateral aspect of right palm and carpus. Abductor pollicis brevis (large arrow) lies in the interspace between the medial surface of the radial sesamoid and the proximal portion of the 1st phalanx, while opponens pollicis (small arrow) is located between the radial sesamoid and the radial surface of the 1st metacarpal. The arrowhead indicates the dissected joint between the 1st metacarpal and the 1st phalanx. R, radial sesamoid; P, 1st phalanx; M, 1st metacarpal. Abductor pollicis longus has 2 tendon groups (A, B) inserted onto the radial sesamoid and 1st metacarpal. All the lateral tendons (A) attach to the radial sesamoid, whereas the medial group (B) separates into 2 branches. One branch attaches to the radial sesamoid and the other to the 1st metacarpal.

muscles could be suitably prepared. The RS-related muscles and their innervation were examined after excising the skin and subcutaneous tissues. Radiographs were taken to visualise the articulation between the RS and the scapholunar and 1st metatarsal bones. After dissection of the skeletal muscular system, the soft tissues were excised. The size and shape of the carpal, metacarpal and digit bones were then examined and the articulating surfaces of these bones with the RS were observed.

RESULTS

RS-related muscles

AP inserted onto the medial side of the RS (Fig. 1). This membranous muscle had a thin and long branch that extended to the RS in a longitudinal direction. Excising it exposed the palmaris longus descending to the distal phalanges; it did not insert onto the RS (Fig. 2). APB originated from the proximal portion of the radial surface of the 1st phalanx and inserted onto the medial side of the RS, whereas OP extended from the distal portion of the radiopalmar surface to the medial side of the RS (Figs 3, 4). OP accompanied the whole length of APB, and a line of separation was readily recognised. These muscles both possessed fleshy bellies. Branches of the median nerve innervated APB and OP (Fig. 5). The strongly developed APL lay on the dorsoradial side of the forearm (Fig. 6). In this

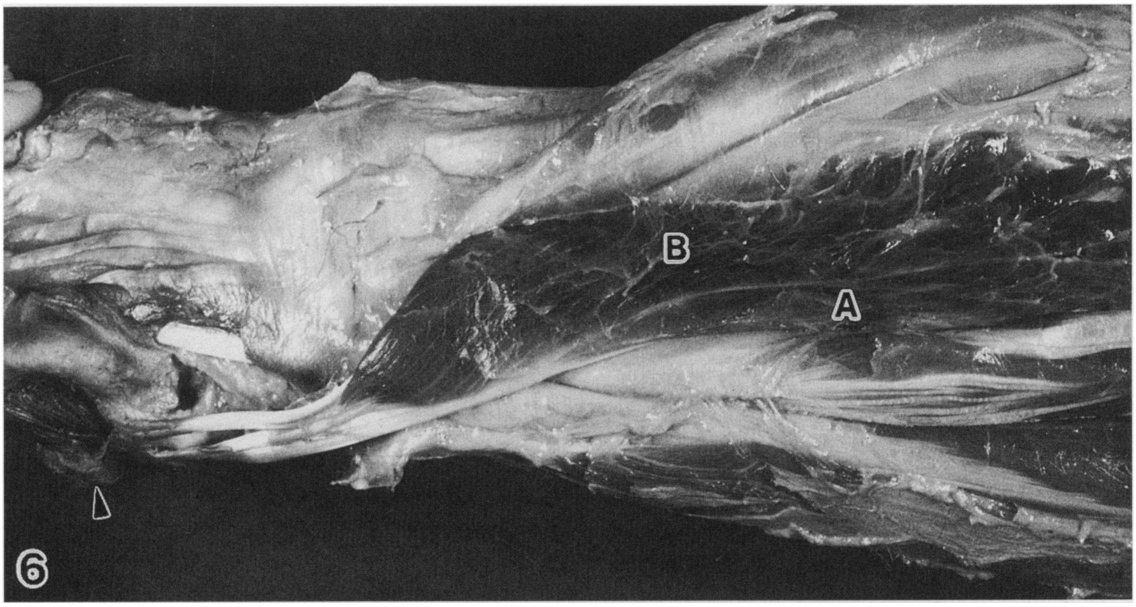
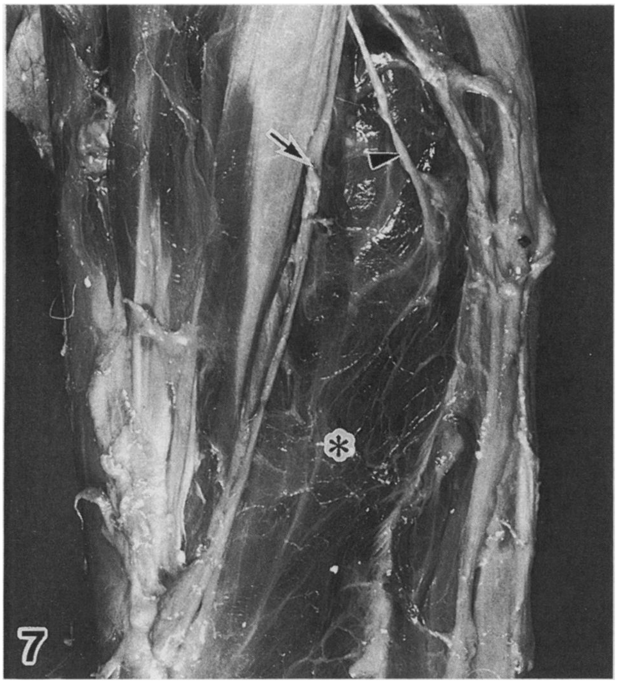


Fig. 4. Right palm. Abductor pollicis brevis (arrow) lies between the radial sesamoid and the proximal portion of the 1st phalanx. The dissected tendon of palmaris longus to 1st digit can be seen. R, radial sesamoid.

Fig. 5. Left palm. Branches of the median nerve (arrows) reach the belly of the abductor pollicis brevis.

Fig. 6. Dorsolateral aspect of right forearm. Abductor pollicis longus can be seen. Two long muscle bellies (A, B) are distinguished throughout the whole length of this muscle. A and B converge to each tendon group that run to the radial sesamoid and/or 1st metacarpal. Arrowhead, radial sesamoid.



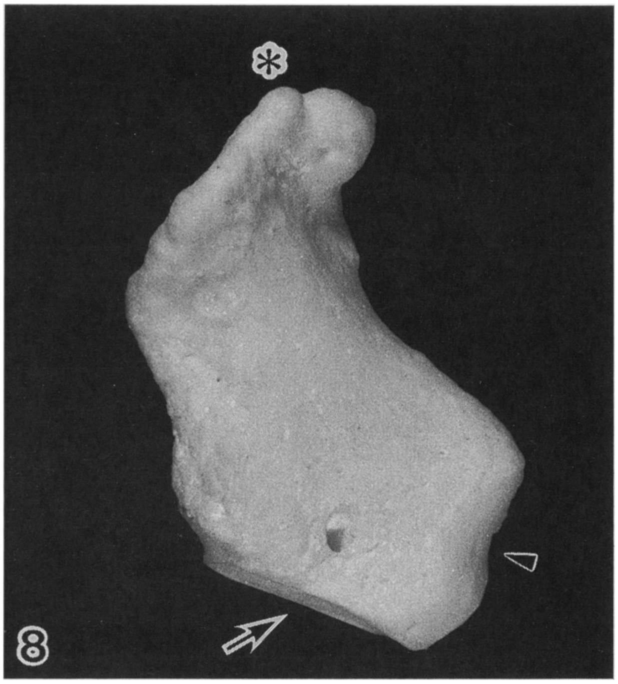


Fig. 7. Dorsal view of left forearm. The radial nerve (arrow) gives a branch (arrowhead) to the abductor pollicis longus (asterisk).
Fig. 8. Mediopalmar aspect of the left radial sesamoid. The areas connected to the scapholunar (arrow) and to the 1st metacarpal (arrowhead) are indicated. Asterisk, distal end of radial sesamoid.

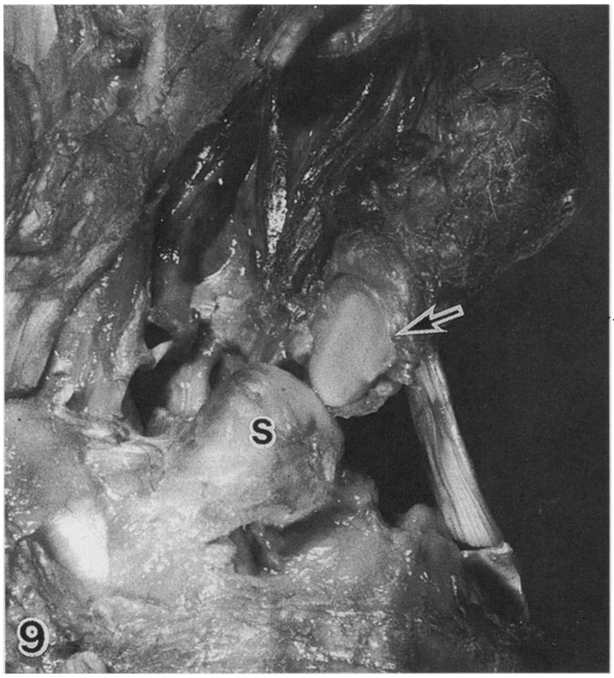
muscle, 2 bellies arranged in parallel were discernible and their 2 major tendon groups inserted onto the dorsolateral surface of the RS (Figs 3, 6). The lateral part of APL was composed of thin muscle fibres with some tendons attached to the RS (Fig. 3). The dorsomedial part was larger in width and gave rise to 2 tendons. One tendon ran to the dorsomedial area of the RS, whereas the other extended to the proximolateral part of the 1st metacarpal (Fig. 3). The radial nerve supplied some branches to APL (Fig. 7).

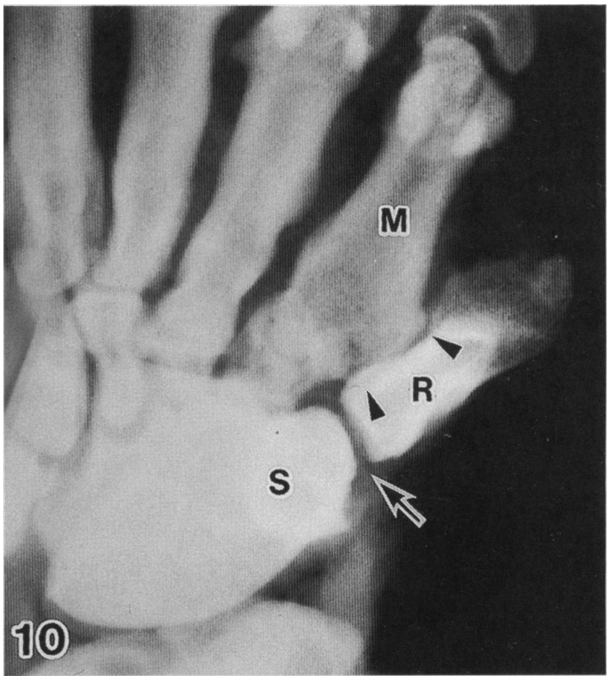
The RS and its articulations with the scapholunar and 1st metacarpal bones

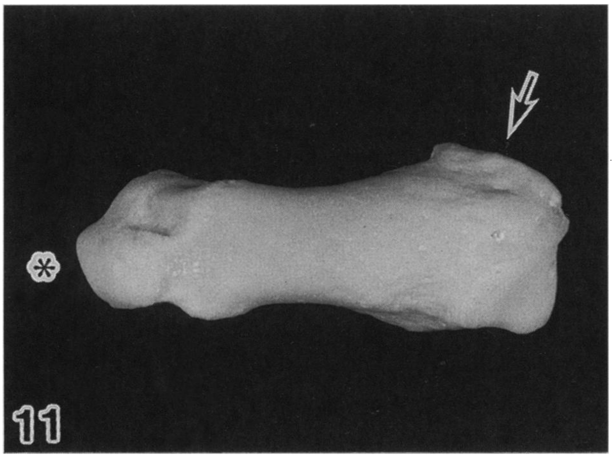
The RS was about 30 mm in length. Its proximal portion possessed 2 joint areas (Fig. 8). The surface for the scapholunar bone was compressed in a mediolateral direction and displayed a long elliptical area (Fig. 9), 16 mm in length and 7 mm in width. The joint cavity for the scapholunar was well developed (Fig. 9), where the elliptical articular surface was slightly concave in a distal direction. The convex scapholunar conformed to the surface contour of the RS. The articulation with the 1st metacarpal possessed a narrow concavity (Fig. 8). The RS became thinner and curved medially at its distal end. The joints between the RS and the scapholunar and 1st metacarpal bones are shown in a radiograph in Figure 10. The attachment between the RS and the 1st metacarpal was tight, a fibrous joint connecting these 2 bones over a large area. Strongly developed joint fibres 2–4 mm in length coupled the RS to the 1st metacarpal and did not permit RS mobility independent of the 1st metacarpal. The latter was 41 mm in length. In the proximal portion of its radial aspect there was a well-developed process (Figs 11, 12). The concavity of the RS seen in Figure 8 received the lateral protrusion from the 1st metacarpal bone.

DISCUSSION

The abduction–adduction movement of the large RS that the giant panda has developed is one of the most exceptional grasping mechanisms known among mammals. Lankester & Lydekker (1901) stated that the RS may be equivalent to a 6th metacarpal bone. Following this, some morphologists concluded that this pseudometacarpal acts as an active grasping apparatus when the animal flexes its 5 digits to seize bamboo stem (Wood-Jones, 1939*a*; Davis, 1964*a*, *b*; Beijing Zoo et al. 1986). Wood-Jones (1939*a*) suggested that the development of RS-related muscles provides an abduction–adduction capacity for the mobile RS. A more detailed examination was consistent with the conclusion that a substantial abduction–adduction function is possessed by the mobile RS for grasping objects (Davis, 1964*b*).







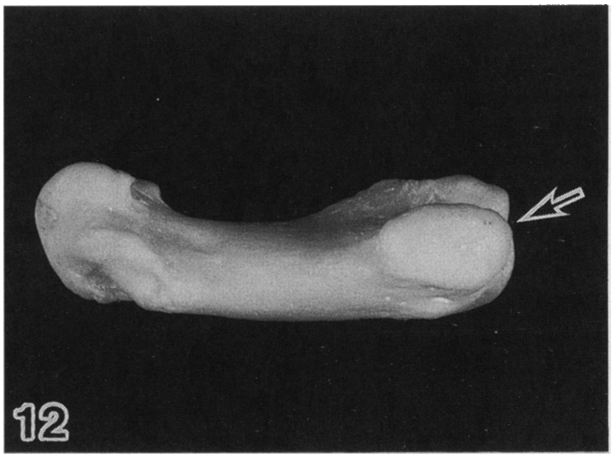


Fig. 9. The radial sesamoid articular surface and joint cavity can be observed (arrow). The connection with the scapholunar has been dissected and opened. The transverse section of radial sesamoid has a long elliptical shape. S, palmodistal area of the scapholunar.

Fig. 10. Radiograph of left palm and carpus in a dorsopalmar direction. The arrow indicates the articulation between the radial sesamoid (R) and the scapholunar (S). The 1st metacarpal (M) has a well developed process connected to the medial surface of the radial sesamoid (arrowheads), so that the 2 bones are tightly attached to each other.

Fig. 11. Dorsal aspect of the left 1st metacarpal. The strongly developed process connecting with the radial sesamoid is shown on its radial aspect (arrow). Asterisk, distal end of the 1st metacarpal.

Fig. 12. Radial aspect of the left 1st metacarpal. The surface of the process is oval in shape to connect with the radial sesamoid (arrow).

Because of the large area of the connection between the RS and 1st metacarpal bone, it was thought that the RS does not possess independent lateral mobility as had been proposed by Wood-Jones (1939*a*). The reports of Wood-Jones (1939*a*) and Davis (1964*a*, *b*), did not, however, take into account the fact that the well developed lateral process of the 1st metacarpal is linked tightly to the medial concavity of the RS by fibrous tissue. The 1st metatarsal process-RS connection may not permit an active abduction–adduction movement for the RS, i.e. the RS may scarcely be mobile against the metacarpal bones in a gripping action. The 1st metacarpal process that limits RS flexibility plays a most important role in the grasping pattern of the giant panda, although some reports have only paid attention to the size of the RS and to the development of RS-related muscles (Lankester & Lydekker, 1901; Wood-Jones, 1939*a*; Davis, 1964*a*, *b*). We propose that the well developed process on the radial aspect of the 1st metacarpal is named the *radial sesamoid connecting process* because of its importance. The nature of the joint fibres between the RS and the 1st metacarpal should be examined histologically in the future.

We conclude that the RS is only an elevated ridge or post opposite the 5 flexing digits and that it does not constitute an active mobile apparatus for grasping to any substantial extent. Although the RS-related muscles are well developed at the macroscopic level, we suggest that they may function to position and fix the RS in grasping, and that they do not contribute to RS abduction/adduction.

The size and shape of the RS seems to be different in each individual (Lankester & Lydekker, 1901; Wood-Jones, 1939*a*; Davis, 1964*a*). The proximal portion of the RS in this study was robust in comparison with other figures (Lankester & Lydekker, 1901; Davis, 1964*a*). The shape may vary greatly between individuals. This is in agreement with the suggestion that the RS is only a supporting post and has no specialized function in manipulation.

The twin-bellied APL was the most noteworthy muscle. The medial part of APL provided the most mediodorsal tendon to the dorsolateral area of the 1st metacarpal. Its insertion onto the 1st metacarpal was not consistent with the previous observations (Wood-Jones, 1939*a*; Davis, 1964*b*), however, the APL may possess functions not only to fix the RS, but also to extend the 1st metacarpal by the most dorsal tendon. The OP, identified only in the American black bear among all urside species (Shepherd, 1884; Wood-Jones, 1939*a*), was bulky and attached to the lateral side of the 1st metacarpal, unlike a former description (Davis, 1964*b*). This finding indicated that the OP and FM act to support the RS when the animal flexes its digits to grasp plant stems.

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