

Brief Communication: The Popliteal Sesamoid Bone (Cyamella) in Primates

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ABSTRACT A study of 246 adult nonhuman primates belonging to 34 genera indicates that a popliteal sesamoid bone is always present in the tendon of the popliteus muscle in Prosimii and Callitrichidae. The bone occurs only variably in Atelidae and *Pongo*, and is usually absent in *Gorilla*. The bone is absent, or very rare, in *Cebus*, Cercopithecidae, Hylobatidae, *Pan*, and humans. When the bone is present, it articulates with the posterior part of the articular surface of the lateral condyle of the tibia, and lies very close to the head of the fibula, at the angulated part of the popliteal tendon, near the tendomuscular junction. The presence of the popliteal sesamoid bone in primates is a primitive character.

The popliteus muscle has a similar arrangement in all primates and most other mammals (Taylor and Bonney, 1905; Vallois, 1914; Weinberg, 1929; Gluhbegovic and Hadziselimovic, 1968; Hadziselimovic and Gluhbegovic, 1969; Jouffroy, 1971; Lovejoy and Harden, 1971; Mörke, 1973). Its tendon arises from the lateral femoral epicondyle and runs posteriorly and distally, close to the lateral meniscus. The muscle belly, which is short, flat, and of triangular shape, runs mediodistally to end on the proximal third of the posterior face of the tibial diaphysis.

A sesamoid bone may exist in the tendon of the popliteal muscle. This popliteal sesamoid bone has also been called *cyamella* (Pearson and Davin, 1921), or *popliteal fabella* (Taylor and Bonney, 1905), or *fabella distalis* (Slanina, 1956), or *os sesamoideum genu inferius laterale* (Pfitzner, 1892). The popliteal sesamoid bone has been described in numerous mammal orders—Edentata, Fissipeda, Rodentia, Chiroptera, Insectivora (Taylor and Bonney, 1905; Pearson and Davin, 1921)—but no study based on an extensive series has documented its distribution in primates. The present work was undertaken to ascertain the distribution and evolution of this skeletal element in our own order.

MATERIALS AND METHODS

The material used in this study consisted of 246 adult nonhuman primates belonging

to 34 genera. The material consisted of dried skeletons and bodies preserved in formalin.

The 240 dried skeletons representing 34 genera (Table 1) came from the collections of the Laboratoire d'Anatomie Comparée (Muséum National d'Histoire Naturelle, Paris), of the Laboratoire d'Anatomie (UER Biomédicale des Saints-Pères, Paris), and of the Institut d'Anatomie Normale (Faculté de Médecine, Strasbourg). These skeletons were dried after maceration with all ligaments and periarticular tissues, so that the sesamoid bones were not lost as in conventional preparation of bones. All subjects were adult, and the epiphyseal closure was complete. I examined macroscopically both the right and left knees of each subject and I searched for the presence or absence of the popliteal sesamoid bone.

Formalin-preserved bodies of the following 6 nonhuman primates were also studied: 3 *Lemur* (Institut d'Embryologie, Faculté de Médecine, Strasbourg), 1 *Cebus* (Laboratoire d'Anatomie Comparée, Muséum National d'Histoire Naturelle, Paris), and 2 *Macaca* (Unité de Primatologie, Université Louis Pasteur, Strasbourg). All subjects were adult and their osseous growth completed. I radiographed both knees of each subject in frontal, profile, and oblique projections. The knees of one *Lemur* and one *Macaca* were

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TABLE 1. List of the studied skeletons

Prosimii (53 skeletons—13 genera)	Cheirogaleidae: 4 <i>Cheirogaleus</i> , 3 <i>Microcebus</i> Daubentonidae: 2 <i>Daubentonia</i> Galagidae: 2 <i>Galago</i> Indridae: 1 <i>Avahi</i> , 3 <i>Indri</i> , 5 <i>Propithecus</i> Lemuridae: 2 <i>Hapalemur</i> , 15 <i>Lemur</i> Lorisidae: 1 <i>Loris</i> , 2 <i>Nycticebus</i> , 2 <i>Perodicticus</i> Tarsiidae: 1 <i>Tarsius</i>
Platyrrhini (23 skeletons—7 genera)	Atelidae: 1 <i>Alouatta</i> , 3 <i>Ateles</i> , 4 <i>Lagothrix</i> , 1 <i>Pithecia</i> Callitrichidae: 6 <i>Callithrix</i> , 2 <i>Saguinus</i> Cebidae: 6 <i>Cebus</i>
Catarrhini (155 skeletons—11 genera)	Cercopithecidae: 13 <i>Cercocebus</i> , 45 <i>Cercopithecus</i> , 8 <i>Colobus</i> , 7 <i>Erythrocebus</i> , 40 <i>Macaca</i> , 2 <i>Nasalis</i> , 30 <i>Papio</i> , 4 <i>Presbytis</i> , 1 <i>Pygathrix</i> , 4 <i>Theropithecus</i> , 1 <i>Trachypithecus</i>
Hominoidea (9 skeletons—3 genera)	Hylobatidae: 6 <i>Hylobates</i> Pongidae: 2 <i>Pan troglodytes</i> , 1 <i>Pongo pygmaeus</i>

also studied with CT scan (CGR, CE 10000) in contiguous axial sections of 1 mm thickness (Service de Radiologie I, Centre Hospitalier Universitaire, Strasbourg).

RESULTS

The popliteal sesamoid bone was present in each of the 53 Prosimii (Fig. 1), and in the 17 members of the genera *Alouatta*, *Ateles*, *Callithrix*, *Lagothrix*, *Pithecia*, *Saguinus* in Platyrrhini. The popliteal sesamoid bone was not observed in the platyrrhine genus *Cebus*, in the 155 Catarrhini studied, or in the 9 apes (6 *Hylobates*, 2 *Pan troglodytes*, 1 *Pongo pygmaeus*).

When the bone was present, it took the form of a half-sphere or half-ellipsoid, of which the flat articular surface articulated with the posterior part of the articular surface of the lateral condyle of the tibia (Fig. 2), and the rounded nonarticular surface was contained in the tendinous tissue. The bone was located proximal to the head of the fibula near the tendomuscular junction, where the posterodistal direction of the muscle's fibers changes to medio-distal.

DISCUSSION

The invariable presence of the popliteal sesamoid bone in Prosimii is borne out by the data in the literature (Forster, 1903; Fürst, 1903; Taylor and Bonney, 1905; Vallois, 1914; Pearson and Davin, 1921; Woollard, 1925; Jouffroy, 1962). There is less uniformity among Platyrrhini. The popliteal sesamoid is invariably reported in all Callitrichidae studied (Forster 1903; Fürst, 1903; Vallois, 1914; Pearson and Davin, 1921), but

is variable among Atelidae. In *Ateles*, the bone was present in the three subjects of this study and in the two subjects studied by Vallois (1914), but its absence has also been reported (van Westrienen, 1907; Pearson and Davin, 1921). The bone was present in the single *Alouatta* that I examined; Vallois (1914) found it present in one specimen but absent in another. The bone is almost always absent in *Cebus* (Forster, 1903; Fürst, 1903; Taylor and Bonney, 1905; van Westrienen, 1907; Vallois, 1914; Pearson and Davin, 1921; this study); only Vallois (1914) reported a case in which the bone was present. No data exist for many genera of platyrrhines (e.g., *Aotus*, *Cacajao*, *Callicebus*, *Cebuella*, *Chiropotes*, *Leontopithecus*, *Saimiri*).

The present study and published observations indicate that the popliteal sesamoid bone is absent in Cercopithecoidea (Forster, 1903; Fürst, 1903; Taylor and Bonney, 1905; Vallois, 1914; contra Pearson and Davin, 1921), and in Hylobatidae (Kohlbrugge, 1891; Keith, 1894; Fürst, 1903; van Westrienen, 1907; Vallois, 1914; Pearson and Davin, 1921). In the Pongidae, precise data are rare. In *Pongo pygmaeus*, the popliteal sesamoid bone was present in 16 of 19 reported cases (Forster, 1903; Fürst, 1903; van Westrienen, 1907; Vallois, 1914; Pearson and Davin, 1921; this study). Among 8 *Gorilla gorilla* described in the literature, the bone was present in 2 cases (Macalister, 1873; Keith, 1894) and absent in 6 (van Westrienen, 1907; Vallois, 1914). It was also absent in 12 reported individuals of *Pan troglodytes* and *Pan paniscus* (Keith, 1894; Vallois, 1914; Pearson and Davin, 1921).



Fig. 1. Posterior view of the right knee in *Lemur*, showing the popliteal sesamoid bone (white arrow) close to the head of the fibula.

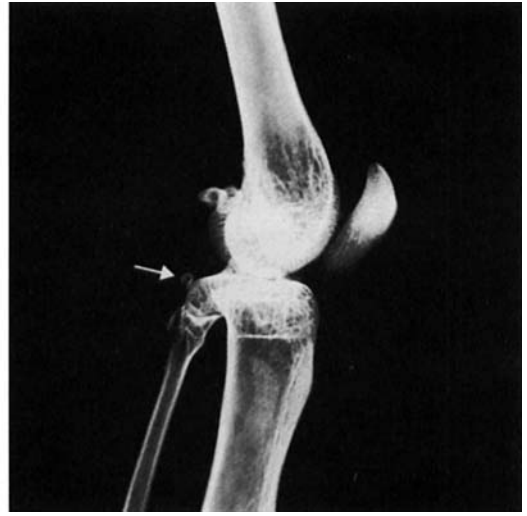


Fig. 2. Radiograph in oblique projection of the knee in *Lemur*, showing the popliteal sesamoid bone (white arrow) articulated with the posterior part of the lateral condyle of the tibia.

In humans, the popliteal sesamoid bone can be considered absent, although exceptional cases have been reported in the literature (Le Double, 1897; Pearson and Davin, 1921; Slanina, 1956; Keats, 1988). This rare anomaly usually has no pathological implications; however, one case revealed by a painful symptomatology has been described (Hillion, 1982).

From a phylogenetic point of view, the popliteal sesamoid bone might be reasonably regarded as a shared homologous feature in primates. The presence of this sesamoid bone in numerous mammals allows us to interpret the presence of the bone as primitive for primates, that is to say as a plesiomorphic character retained among prosimians (Strepsirhini and Tarsiidae). The absence of the ossicle in primates is indisputably a derived or an apomorphic character which is restricted to anthropoids. Among anthropoids, this character may be interpreted either as a convergence (the primitive character being lost independently in the Cebidae and in the ancestral Old World monkey) or as a parallelism. By the latter interpretation, a predisposition to the disappearance of this bone would be an anthropoid synapomorphy, inherited from the last common ancestor of all anthropoids and variably expressed in different anthropoid groups by a complete disappearance of the sesamoid in

Cebidae, Cercopithecidae, Hylobatidae, *Pan*, and humans, and by the variable maintenance of the bone in Callitrichidae, Atelidae, *Pongo*, and *Gorilla*. The common presence of the popliteal sesamoid bone in orangutans, in conjunction with its usual absence in African apes and humans, supports the notion of an African ape-human clade.

The popliteal sesamoid bone is located in the angulated part of the tendon around the tibia. In this area, unusual mechanical stress occurs, and a part of the tensile stress in the muscle is transformed into pressure on the tendon. The sesamoid bone presumably functions to resist this pressure. However, specializations of the tendon itself serve this function in the human species (Sick, 1964; Meyer et al., 1964) and other primates that lack the popliteal sesamoid bone. The presence or absence of the bone may be connected to particular postural or locomotor behavior, but no such connection is evident from its distribution among primates. The functional significance of sesamoids in general is not well understood (van den Broek and Barents, 1947; Mottershead, 1988). The widespread loss of many other sesamoid bones in primates (Wikander et al., 1986; Le Minor, 1987, 1988) and of accessory bones such as intrameniscal ossicles (Le Minor, 1990) suggests that variably expressed

tendencies toward the disappearance of these primitive structures may reflect genetic affinities more accurately than functional similarities.

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