Proportions of the lateral tibial condyle and posterior meniscal notch size in *Homo sapiens*

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Tibial condylar proportions have been linked to lateral meniscus insertion number in hominoids.

A number of distinguishing features that relate to bipedalism have been observed in the human knee joint when compared to other extant apes. Apes have an enlarged medial femoral condyle relative to the lateral condyle, but humans have femoral condyles that are roughly equal in size.[3,4,6,8] The morphology of the distal femur and the proximal tibia are functionally integrated, and the increased area of contact between the femur and tibia in the knee joint in humans results in a tibial plateau that is rectangular in shape and shows anteroposterior lengthening of the articular surfaces.[3]

Another major difference between the human and ape knee is the morphology and number of attachments of the lateral meniscus. While apes have a ring-shaped lateral meniscus with a single attachment, humans have a crescent-shaped lateral meniscus with two insertions into the tibial plateau.[7] Condylar elongation and the posterior insertion of the lateral meniscus in humans are thought to maximize knee stability in extension at the expense of rotational capacity.[5]

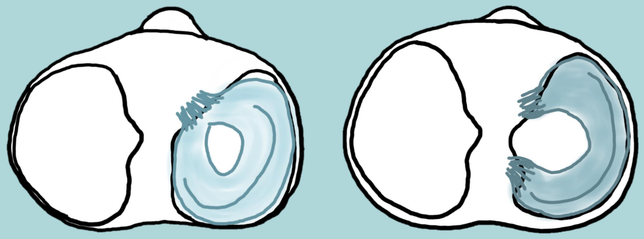

Fig. 1. Proximal view of the right tibia showing the ring-shaped morphology of the lateral meniscus in hominoids (left) and crescent-shaped morphology in humans (right).

It has been argued that among hominoids, lateral meniscus shape is determined by the length of the lateral femoral and tibial condyles. Under such a scenario, the human crescent-shaped lateral meniscus, with two meniscotibial insertions, is the developmental byproduct of the elongation of the bony components of the lateral knee compartment.[7]

Humans vary in the size and presence of the posterior meniscal notch.

Some humans lack the posterior lateral meniscal insertion and/or its bony indicator, the meniscal notch.[1,2] In a previous analysis, I found that the size and presence of the meniscal notch differs significantly by sex and body size.

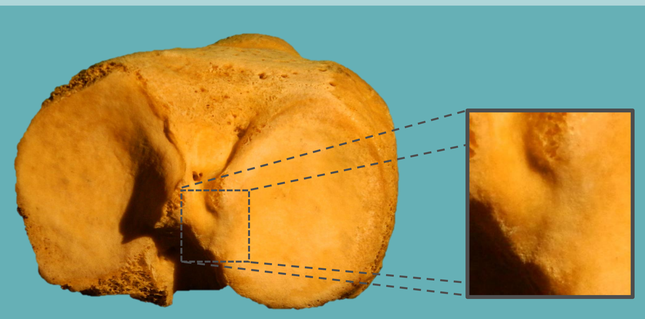

Fig. 2. Digital photograph of a right human tibia, oriented with proximal end perpendicular to the camera for measurement in ImageJ. Inset: enlarged picture of the lateral meniscal notch.

Is human meniscal notch size related to the proportions of the tibial plateau?

If elongated articular proportions and the posterior insertion of the lateral meniscus are functionally integrated, then we should expect to see a correlation between condylar proportions and the size of the meniscal notch in modern humans.

Materials and methods

Photographs were taken of 350 modern human (137 female, 209 male) proximal tibiae curated by the American Museum of Natural History. Individuals were selected to span a wide range of body sizes. Linear dimensions and areas of features of the proximal tibia were collected in ImageJ. Meniscal notch area was compared to three lateral tibial condyle length proportions: ratio of medial and lateral condyle lengths, lateral condyle length and mediolateral tibial breadth, and length and width of the lateral condyle.

A-P lengths of the medial and lateral condyles

The ratio of the A-P length of the medial tibial condyle to the A-P length of the lateral tibial condyle was compared to meniscal notch area.

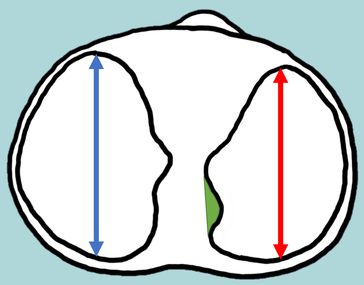

Fig. 3. Proximal view depicting measurements of the right tibia: A-P length of the lateral condyle (red), A-P length of the medial condyle (blue), meniscal notch area (green).

No scaling relationship was found between this ratio and notch area. Those who lack a meniscal notch do not have a larger difference between the lengths of their medial and lateral condyles. (p=0.41).

A-P length of the lateral condyle relative to M-L tibial breadth

The A-P length of the lateral condyle was divided by M-L tibial breadth and compared to meniscal notch area.

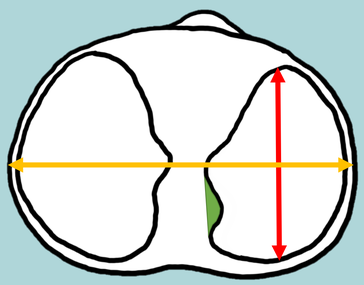

Fig. 4. Proximal view depicting measurements of the right tibia: A-P length of the lateral condyle (red), M-L breadth of the proximal tibia (yellow), meniscal notch area (green).

No scaling relationship was found between the relative A-P length of the lateral condyle and meniscal notch area. Those who lack a meniscal notch do not have significantly shorter lateral condyles for their body size than those with a larger notch (p=0.15).

A-P length and M-L breadth of the lateral condyle

The ratio of A-P length to M-L breadth of the lateral condyle ("roundness") was compared to notch area.

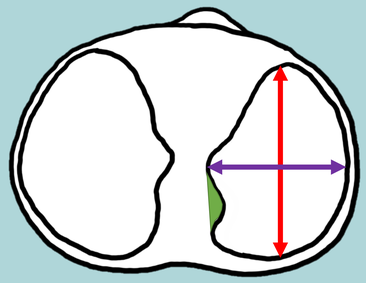

Fig. 5. Proximal view depicting measurements of the right tibia: A-P length of the lateral condyle (red), M-L breadth of the lateral condyle(purple), meniscal notch area (green).

No scaling effect was found between the roundness of the lateral tibial condyle and absolute notch area. Those who lack a meniscal notch do not have significantly rounder lateral condyles than those with a larger notch (p=0.10).

No significant relationship was found between any of the lateral tibial condyle proportions and meniscal notch area.

These results suggest that variation in the insertion anatomy of the lateral meniscus cannot be clearly related to tibial articular proportions in modern humans, and may challenge its developmental origin in an intraspecific context.

Condylar proportions differ significantly in females and males.

Interestingly, females were found to have significantly longer lateral condyles compared to mediolateral tibial breadth than males (mean A-P lateral condyle/M-L tibial breadth: F=0.53, M=0.52, p=0.004). Biological sex may significantly impact condylar proportions, which has implications for the reconstruction of fossil hominin locomotor behavior.

Acknowledgements

I would like to thank Adam D. Sylvester (JHUSOM), Gisselle Garcia (AMNH), Terry Harrison (NYU), and Susan Antón (NYU).

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