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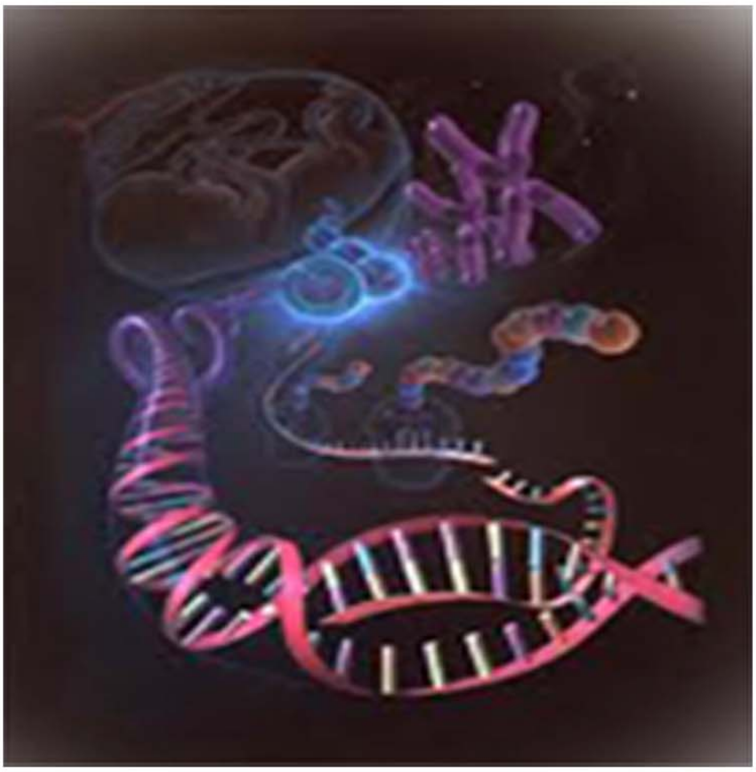

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Research Paper

MORPHOLOGY OF KNEE JOINT OF TETRAPOD – CLASS MAMMALIA – GENUS – HIPPOSIDERUS – SPECIES – ARMIGER (BAT) TO MAMMALS (HUMAN BEING)

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Advancement in knowledge of the comparative anatomy of joints has generally lagged behind than that of other structural systems. The knee joint has been chosen for present study as it represents the largest and functionally important articular unit, provided with an extensive synovial cavity and a variety of both intra and extra articular structures.The knee joint is of peculiar interest as manifesting a change of mechanism of locomotion in passing from tetrapods (Bat) to mammals and affording a means of studying, the corresponding modifications of anatomical structure. 10 bats armiger were selected and 10 human knee joints were selected from dissection hall in Anatomy department of Hi-Tech Medical College, Rourkela (Odisha). McMinn HMR has mentioned (5) that the bat is the only mammal which does not possess the menisci and popliteus muscle because it does not rotate the knee joint. The femorotibial articulation has both internal and external ligamentous connections. There is a single broad intra articular ligament which. may represent the initial form of the crucial ligaments and fibula merged with tibia. In the bat leg, the tibia and fibula are fused together.

Keywords: Bony articular part, Intra capsular and extra capsular structures and Muscular changes

INTRODUCTION

In this study of chordate skeletal anatomy it was found that in the hind limbs of bats, all the elements are elongated. In the leg, the tibia and fibula are fused together Weichert (1953).

Vaughan (1970a) stated that the hind limb in bats are highly built and the largest muscle is situated near the center of gravity in contact to forelimb. During flight the hind limb of bats extend laterally, the femur is directed laterally and the tibia points caudally.

The bats are practically incapable of terrestrial locomotion. Most of the differences between the pelvic girdle and hind limb of bat and those of

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terrestrial mammals are clearly associated with striking differences between hind limb posture and between modes of locomotion. He also noted that the femur is roughly of the same length as the tibia. The distal end of femur presents two condyles, the articular surfaces of which extend around the posterior aspect of the condyles to meet the shaft, the inter condyloid fossa of the distal epiphysis is deep.

Smith Bonne (1945) observed that a faintly visible oval structure presumed to be patella is observed within the tendon at insertion of the quadriceps femoris, inserted on the tibial tuberosity.

Carleton Alice (1976) stated that bats differ from all other vertebrates in having the hind limb so rotated outward by the wing membrane, that the knee is directed backwards like the elbow. When the bats rest on the ground, the foot would therefore point in the posterior direction and this is corrected by a forward and medial rotation.

Parsons (1900) found that the typical origin of the extensor digitorum longus muscle in mammals is by a tendon from the front of the lateral condyle of femur and its insertion is in man into the middle and distal phalanges of the four lateral toes and when they are present, their description applies to the bats.

MATERIALS AND METHODS

10 bats collected from the animal house department of pharmacology and 10 knee joint of human beings from dissection hall, department of Anatomy, Hi-Tech medical College and Hospital, Odisha. All the animals were sacrificed after giving Euthanasia dose of phenobarbitone and preserved in 10% buffer formalin.

The morphological study of knee joint of bat was carried out under the following headings.

1. Articular surfaces
2. Muscles
3. Ligaments

OBSERVATION

1. Articular Surfaces

Distal end of femur—in bats the lower end is expanded and consists of two condyles, viz. lateral and medial condyle. The two condyles of femur are separated by inter condylar notch. The medial condyle is more prominent. The medial condyle has bulging, convex medial aspects and on it medial aspect there is low rounded elevation known as the medial epicondyle; lateral condyle of femur is flat and less prominent and presents a low rounded elevation on its lateral aspect known as the lateral epicondyle (Figure 1A and 1B).

Upper end of tibia: It is observed that the leg consists of only one bone, the tibia is longer than the femur. The upper end of tibia is triangular in outline and bears two condyles. The anterior border of tibia at its proximal end bears the prominent tibia crest (Figure 1A,).

Patella: Patella is small, thin and tubular bone

Figure 1A: Photograph of Bony Characteristics of Distal End of Femur, Upper End of Tibia (Bat)

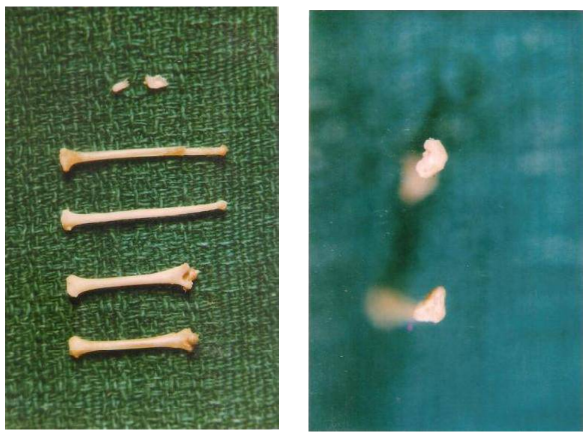


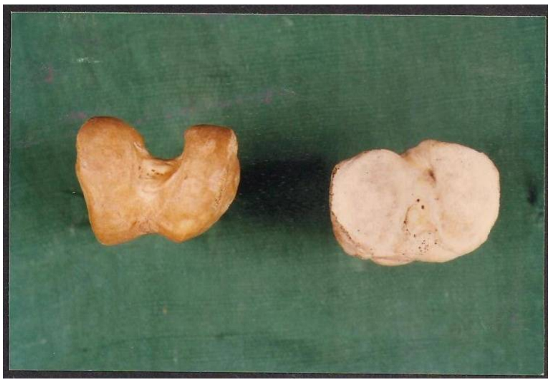
Figure 1B: Photograph of Intracapsular Structure of Knee Bat

articulates by its inner surface with the patellar surface of femur. Its upper end is broader and lower end is narrow (Figure 1A).

In human being the tibial plateau presents medial and lateral articular surfaces for articulation with the corresponding femoral condyles. The medial articular surface is oval and longer than the lateral articular surface. The lateral articular surface is more circular and coapted to its meniscus, the surface has a raised medial margin that spreads to the lateral intercondylar tubercle. Its articular margin is sharp, except posterolaterally, where the edge is rounded and smooth: here the tendon of popliteus is in contact with bone (Figures 2A and 2B)

Figure 2A: Anterior and Posterior Aspect of Femur, Tibia and Patella (Human)

Figure 2B: Lower End of Femur and Superior Aspect of Upper End of Tibia (Human)



The patellofemoral joint is a synovial joint and a part of knee joint, the articular surface of the patella is adapted to that of the femur. The patella extends on to the anterior surface of both femoral condyles. The articular surface of the patella articulates with the anterolateral aspect of the medial femoral condyle in full flexion, while the highest lateral patellar facet contacts the anterior part of lateral femoral condyle.

In semi flexion of knee the middle patellar facet comes in contact with lower half of the femoral surface, in full extension only the lowest patellar facet are in contact with the femur. The tibio-femoral joint is a complex synovial joint and a part of the knee joint.

1. Muscles

Table 1, Figures 3A and 3B.

Quadriceps Femoris: According to Smith (1945) who described two parts of this muscle in bat, one fused with vastus lateralis, vastus intermedius, vastus medialis and other with rectus femoris. The observation in bat in the present study is same as above.

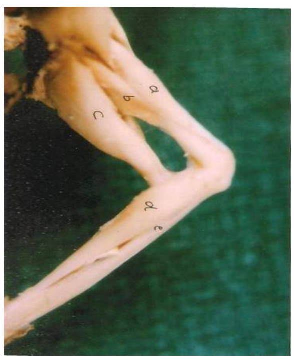
Sartorius: Both in the bat and human being, it is observed that the sartorius is the superficial muscle situated in the front of thigh, running from

Table 1: Showing Origin and Insertion of Various Muscles Acting of Knee Joint of Species (Bat) to Human Being

Animal	Quadriceps Femoris		Sartorius		Semitendinosus		Semimembranosus	
	Origin	Insertion	Origin	Insertion	Origin	Insertion	Origin	Insertion
Bat	2 Head vm+vi+vl from femur, R.f.Ilium	Patella	Ant. Superior iliac spine	Post medial surface of tibia	Ischial tuberosity	Post, medial surface of tibia	Ischial tuberosity	Back of medial condyle of tibia 1. Back of medial epicondyle of femur.
Human	4 head, 3 vasti-femur, R. femories -ilium	Patella	Ant. Superior iliac spine	medial surface of tibia	Ischial tuberosity	Post, medial surface of tibia	Ischial tuberosity	2. medial condyle of tibia
Animal	Biceps Femoris		Popliteus		Gastrocnemius		Ext. Digi longus	
Bat	Post. Aspect of ischial tuberosity	Back of lateral tibial condyle	Absent	Absent Back of tibia above the soleal line	2 heads medial and lateral femoral condyle	Calcaneas tuberosity	Ant. Surfaces of lateral femoral condyle	Dorsal aspects of distal phalanges of digits.
Human	1.ischial tuberosity and sacro tuberous ligament 2.upper part of lat. Supra condylar line and lateral inter muscular septum	Upper and lateral part of head of fibula	Lat. Aspect of lat. Femoral condyle		2 heads medial andlateral femoral condyle	Calcaneas tuberosity	Med. Surfaces of fibula	Dorsal aspects of prox. mid and distal phalanges of 2-5 digits.

Figure 3A: View of Bat Knee Joint Showing 3vasti (a), Semimem-branosus (b), Semitendinosous(c), Sartorius(d)

Figure 3B: Lateral View of Bat Knee Joint Showing 3 Vastii (a), Sartorius(b), Semimembranosus(c), Gastrocnemius(d), Extensor Digitorum(e)



the suprolateral angle to infromedial angle of thigh. Similar finding were observed by Holmes (1934).

The semimembranosus, semitendinosus and biceps femoris: These muscle are the member of the hamstring group. They are the muscle of the flexer compartment of the thigh. In bat as well as human beings the semitendinosus muscle is originated from lower medial part of ischial tuberosity and gets inserted into the upper part of the medial surface of the tibia.

Semimembranosus: Muscle arises from the upper and lateral part of ischial tuberosity and run downwards and medially to be inserted into back of the medial condyle of tibia in man as well as bat. It flexes and medial rotates the leg and extends the hip joint.

Biceps Femoris: In bat, it has only one head of origin. The muscle arises from the posterior surface of the ischial tuberosity and is inserted on the back of the lateral condyle of the tibia. Similar findings were observed by Vaughan (1970a and 1970b).

Popliteus: The popliteus is not present in bat McMinn (1994). We also could not find it.

Gastrocnemius: It is a large muscle forming the calf of the leg. It has two heads of origin in both the species that were studied; the medial head arises from the posteromedial surface of femur just proximal to the medial condyle while the lateral head arise from the posterolateral aspect of the lateral condyle of femur. The lower part of it fuses to form a very strong tendon known as tendo-calcaneus which gets inserted into middle of the posterior surface of calcaneus in bat and human being. Similar finding are observed by Vaughan (1970a and 1970b) in bat; Grey (1989) in human beings.

Extensor Digitorum Longus: Its origin varies in both the species. Parsons (1900) and Kaplan (1958) found in bat , the muscle takes origin from the small fossa on the lateral femoral condyle. The muscle run downwards on the lateral side of leg and get inserted into the middle and distal phalanges of the lateral four toes, and apparently acts mostly on the tarsus as an extensor of the foot.

2. Ligaments

The Menisci: In Bat menisci are absent. In human being it is semilunar in shape, Intra-capsular and made up of fibrocartilage. They serve to widen, protect and deepen the tibial articular surfaces that receive the femoral condyles. Their peripheral attached borders are thick and convex and their free, inner borders thin and concave. The proximal surfaces are smooth and concave and in contact with the articular cartilage on the femoral condyles. The distal surfaces are smooth and flat, resting on the tibial articular cartilage (Table 2 and Figure 4A).

The structural arrangement suggests specific biomechanical functions for the two regions: the inner thin portion of the meniscus is suited to resist compressive forces while the thick periphery is capable of resisting tensional forces.

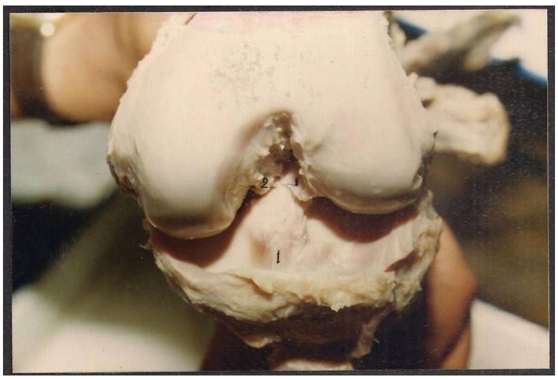
Outward displacement of the menisci from the femoral condyle is resisted by firm anchorage of the peripheral circumferential fibers to the inter-condylar bone at the meniscal horns. Menisci spread load by increasing the congruity of the articulation and give stability by their physical presence and also provides the proprioceptive feedback, probably assist lubrication and may cushion the underlying bone from the considerable forces generated during extremes of flexion and extension.

Table 2: Showing Attachment of Menisci

	Medial Menisci		Lateral Menisci	
Animal	Attachment of anterior horn	Attachment of posterior horn	Attachment of anterior horn	Attachment of posterior horn
Bat	Absent	Absent	Absent	Absent
Human	Anterior intercondylar area of tibia	Posterior intercondylar area of tibia	Anterior inter condylar area of tibia	Posterior inter condylar area of tibia

Figure 4A: Medial and Lateral Meniscus and Anterior Cruciate Ligament

Figure 4B: Anterior and Posterior Cruciate Ligament of Human



Cruciate ligaments: In bat there is a single broad intraarticular ligament. In human being the anterior and posterior cruciate ligament cross each other and are very strong Intracapsular structures. The point of crossing is located a little posterior to the a centre of gravity. The anterior cruciate ligament is attached to the anterior intercondylar area of tibia, partly blending with the anterior horn of the lateral meniscus. The posterior cruciate ligament is thicker and stronger than the anterior cruciate ligament. It is attached to the lateral surface of the medial femoral condyle and extends up to the anterior part of the roof of the intercondylar notch, where its attachment is extensive in the antero-posterior direction. They pass distally and posteriorly to a fairly compact attachment posteriorly in the intercondylar region (Table 3, Figures 1B and 4B)

Collateral Ligament: In bat the proximal attachment of medial and lateral collateral ligament is to the medial and lateral conyles of femur while the distal attachment is to the medial and lateral aspect of the proximal part of tibia respectively. In human beings the two ligaments are superiorly attached to the medial and lateral epicondyles of the femur and inferiorly the medial ligament is attached to the medial condyle of tibia, proximal part of medial surface and medial border of tibia. The distal attachment of lateral collateral ligament is to the styloid process and adjoining part of head of fibula (Table 3).

DISCUSSION

In the present study, comparison of the muscle acting on the knee joint of bat with corresponding one in the lower limb of man is done. The stability of the knee joint depends on the tone of the strong muscle acting on the joint and strength of the ligaments. In human knee maintaining stability of patellofemoral joint and tibiofemoral joint plays a major role in stability of menisci, collateral ligament and cruciate ligament. That the knee joint of the bat is excep-tional among the mammals due to absence of semilunar menisci and single intraarticular liga-ment is as the there is no axial rotation at the knee.

Loading at the Knee During Walking: The forces across the tibiofemoral joint for most of the cycle is between two and four times of body weight and can be more. In contrast the forces across the patello femoral joint is no more than 50% of the body weight. Peak force transmission across the joint increases sequentially as the movement increases. Walking up or down the stairs has little influence on tibiofemoral loading, but significantly increases patello femoral forces to two or three times of the body weight. In human knee—the popliteus is a flat muscle that forms the floor of the lower part of the popliteal fossa. It arises within the capsule of the knee joint by a strong tendon which is attached to a depression at the anterior end of the groove on the lateral aspect of the lateral condyle of femur. The pop-liteus tendon is normally about 2 cm. This liga-ment is a single most important stabilizer of the posterolateral region of the knee and resists external rotation of tibia on the femur during locking.

Fleshly fibers expand from the inferior limit of the tendon to form a triangular muscle that descends medially to be inserted in to the medial two thirds of the triangular area above the soleal line on the posterior surface of tibia and sends an expansion that covers its surface, popliteus rotates the tibia medially on the femur or when the tibia in fixed, rotates the femur, laterally on the tibia. It is usually regarded as the muscle that unlocks the joint at the beginning of flexion of the fully extended knee.

In the human knee, the flexion-extension occurs on the mobile transverse axis, which shifts forward during extension and backward during

Table 3: Showing Collateral and Cruciate Ligament

Animal	Medial Collateral Ligament		Lateral Collateral Ligament		Anterior Cruciate Ligament		Posterior Cruciate Ligament	
	Proximal Attachment	Distal Attachment	Proximal Attachment	Distal Attachment	Proximal Attachment	Distal Attachment	Proximal Attachment	Distal Attachment
Bat	Medial condyle of femur	Medial aspect of proximal part of tibia	Lateral condyle of femur	Lateral aspect of proximal part of tibia	Ant. Inter -condyle area of tibia	Post. part of lateral wall of inter codylar fossa of femur	Absent	Absent
Human	Medial epicondyle of femur	Medial condyle Proximal part of medial surface and medial border of tibia	Lateral epicondyle of femur	Styloid process and adjoining part of head of fibula	Intermediate rough area on the proximal surface of tibia	Post part of lateral wall of inter condylar fossa of femur	Post part of intercondylar area of the tibia	Anterior part of medial wall of intercondylar notch of femur

flexion. In this movement the femoral condyles move on the tibia and the menisci in the meniscofemoral compartment.

The rotation occurs around a vertical axis in the meniscotibial compartment. There are two type of rotation in the knee joint. The conjunct rotation is part of locking-unlocking mechanism. The adjunct rotation occurs in the semiflexed knee.

From a fully extended knee the flexion begins by unlocking movement, which consists of lateral rotation of femur or medial rotation of tibia. The rotation is integral at the beginning of flexion hence it is conjunct rotation due to contraction of popliteus muscle key of knee joint.

The peculiar mode of action of the muscles of the leg of the bat are due to the act of perching, has long been a subject of interest to biologists. It is well known that even during stormy weather, or when asleep, bats easily maintain their position on the branches of trees.

The true explanation of the act of perching is, I believe, to be found in the peculiar arrangement of certain muscles of the limb in bats, the Biceps femoris muscle over at least two joints, and this is so arranged that when the limb is fully flexed as it is in the act of perching, this will, be passively stretched.

Bearing these facts in mind, let us observe what takes place when a bat settles upon a branch. In the first place, the muscles which act directly as flexors of the hip-joint, more especially the Gluteus medius and minimus come into play or it may be that the abstaining from all muscular exertion, the weight of the body is sufficient to accomplish the flexion of this joint. This flexion of the hip-joint, however, necessitates a corresponding flexion of the knee, as the ham-strings, and more especially the Bicepsfemoris from the peculiar arrangement of its tendon of insertion, are not sufficiently long to admit of flexion of the one joint without that of the other.

And here I would point out that, were it not for the fibrous pulley through which the tendon of insertion of the Biceps femoris passes, the different functions of that muscle could not be efficiently performed.

The knee-joint being flexed, it will be observed that the point of insertion of the Sartorius into the front of the tibia will be removed farther from its point of origin at the pelvis than during extension of the joint, and as its tendon of insertion is at the same time compelled to pass in front of the convexity of the knee, it is evident that the entire muscle must be passively extended.

It will thus be seen that by means of the mechanism just described, the bat is enabled to perch securely, and that the arrangement of the muscles is such, that by simple flexion of the limb, those passing in front of as well as those passing behind the various joints are necessarily drawn tens, and thus as it were brace the bat to its perch without any exertion of muscular action on its part.

That the Rectus femoris may assist those bat in which it is present to perch. It will be observed that when the hip and knee joints are flexed to the utmost, as they always are in such cases, that the Biceps and Sartorius will co-operate in balancing the bat precisely as in the act of perching.

Watson Morison has mentioned in his study that Prof. Owen in the Cyclopedia of Anatomy, writes as follows: "The disposition of the rectus femoris muscle is such (passing, viz., first over the convexity of the knee joint, and afterwards over the projection of the heel) that forms its connection with the flexor of the toes, these must necessarily be bent simultaneously with every inflection of the knee and ankle.

CONCLUSION

Bat is the only mammal which does not possess the menisci and popliteus muscle as the knee does not rotate. The femorotibial articulation has both internal and external ligamentous connection. The tibia and fibula are fused with each other. The hind limbs are weak and have clawed digits, the knee is directed backward and not forward as in other mammals so that the bat cannot walk actively.

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