

Hypothesis: Morphology & Development of Patella

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Abstract- A Sesamoid bones are embedded in tendons, and are essentially hardened calcifications of the tendon itself. The largest sesamoid bone in the human body is the patella, which lies suspended in between the quadriceps tendon above and the patellar tendon below. They are found in locations where a tendon passes over a joint, such as the hand, knee, and foot. Functionally, they act to protect the tendon and to increase its mechanical effect, The presence of a bone serves to hold the tendon slightly further away from the centre of the joint this increases its movement, and stops the tendon from flattening into the joint. This differs from menisci, which are made of cartilage and rather act to disperse the weight of the body on joints and reduce friction during movement. There are two sesamoid bones in the thumb, within the adductor pollicis and abductor pollicis brevis tendons, and one in each forefinger and one in each wrist. Each foot also has two sesamoid bones in the ball of the foot, at the base of the big toe, both located within the flexor hallucis brevis tendon. About 2% of the population have a congenital condition in which each sesamoid bone is separated into two parts this condition, known as bi-partite sesamoid bones, can also be caused by trauma, such cases are rare.² The tendency to form sesamoids may be linked to intrinsic genetic factors. Evolutionary character analyses suggest that the formation of these sesamoids in humans may be a consequence of phylogeny, observations indicate that variations of intrinsic factors may interact with extrinsic mechanobiological factors to influence sesamoid development and evolution.³ The sesamoid bones are primarily made of trabecular bone, also called cancellous bone or spongy bone.

Index Terms- Sesam, Patella, Fabella, Sesamoid bones, Morphology

I. INTRODUCTION

The sesamoid bones (ossa Sesamoidea)⁴ They are more frequent in hands and feet fingers near the phalanges⁵ and the most common is the patella. In humans we can find about 46 sesamoid bones.³ In knee joint we can find the fabella, placed inside the tendon of the lateral head gastrocnemius muscle, in posterior part of the lateral condyle femur.⁶ In fabella one of the structural changes is the presence of the fabellofibular ligament is the form of short collateral ligament.⁷ The arcuate and fabellofibular ligaments are structures that contribute with the stabilization of knee joint together with the tendon of the popliteus muscle⁸ the posterior-lateral compartment of the knee stabilized by popliteo fibular ligament^{8,9} Those ligaments an important function in the stabilization during the rotatory movements of the knee¹⁰ histologically fabellar structure are

fibrocartilaginous according to Minowa & Gardner (1970)¹¹ Llorca (1963)¹² states that it is formed by bone tissue and that its prevalence is larger in men. Sesamoid bones and their functions probably are to modify pressure, to diminish friction, and occasionally to alter the direction of a muscle pull. That they are developed to meet certain physical requirements, evidenced by the fact that they are present as cartilaginous nodules in the fetus, and in greater numbers than in the adult. According to Thilenius, as integral parts of the skeleton phylogenetically inherited. Physical necessities probably come into play in selecting and in regulating the degree of development of the original cartilaginous nodules. Nevertheless, irregular nodules of bone may appear as the result of intermittent pressure in certain regions, e.g., the "rider's bone," which is occasionally developed in the Adductor muscles of the thigh. They are, however, present in several of the tendons of the lower limb, e.g., one in the tendon of the Peroneus longus, where it glides on the cuboid; one, appearing late in life, in the tendon of the tibialis anterior, opposite the smooth facet of the first cuneiform bone; one in the tendon of the tibialis posterior, opposite the medial side of the head of the talus; one in the lateral head of the gastrocnemius, behind the lateral condyle of the femur; and one in the tendon of the psoas major, where it glides over the pubis. Sesamoid bones are found occasionally in the tendon of the gluteus maximus and in the tendons which wind around the medial and lateral malleoli.¹³

In other animals

The patella is also found in the horse. The radial sesamoid is larger than the same bone in counterparts such as bears. It is primarily a bony support for the pad above it, allowing the panda's other digits to grasp bamboo while eating it. The panda's thumb a classical example of exaptation, where a trait evolved for one purpose is commandeered for another.¹⁴

II. RESEARCH ELABORATIONS

The Sesamoid bones are so named because they resemble a sesame's seed, is considered to be the oldest oilseed crop known to man, domesticated well over 5000 years ago. Sesame is very drought-tolerant. It has been called a survivor crop, with an ability to grow where most crops fail.¹⁵



Sesame's seed

There are two theoretical propositions for the development of sesamoid bones, a functional and phylogenetical.⁵The functional theory has a support in the biomechanical aspect, where sesamoid bones are described as pulleys, reducing the friction of the tendons and potentiating the muscular handspike.¹⁶ The phylogenetic suggests genetic intrinsic factors developed during the evolutionary process that can be the key for the development of sesamoid bones.³ They appear in the womb period. Initially cartilaginous they can calcify or not after the birth depending on the kind of activity done by the individual, that is, a "biomechanics-embryological" origin. Testut¹⁷ stated that the fabella was fibrocartilaginous. However, Minowa¹¹ divided the fabella according to the texture and the histology. According to the texture, the exam was done by touching. This way, Minowa characterized the sesamoid as "hard" and "elastic". According to the histological point of view, the fabella was classified about the predominant tissue. Of the 39 fabellas studied, 29 were made of bone tissue; 9 of fibrous tissue and 1 fibrocartilaginous. Following the criterion proposed by Minowa all the fabellas found were "hard", constituted of bone tissue without osteoclasts.. The absence of osteoclasts told this fact allows to state that the fabella is not susceptible to bone remodeling after its ossification.

Patella

The patella (knee cap or kneecap) is the largest sesamoid bone in the human body it is a thick, circular-triangular bone which articulates with the femur and covers and protects the anterior articular surface of the knee joint. It being developed in a tendon, its center of ossification presenting a knotty or tuberculated outline; being composed mainly of dense cancellous tissue. It serves to protect the front of the joint, and increases the leverage of the quadriceps femoris by making the greater angulation of the line of pulling. It has an anterior and a posterior surface three borders, and an apex.

Ossification.—The patella is ossified from a single center, which usually makes its appearance in the second or third year, but may be delayed until the sixth year. More rarely, the bone is developed by two centers, placed side by side. Ossification is completed about the age of puberty.

Function

Being a part of knee joint the primary functional role of the patella is knee extension. It is in the way of quadriceps femoris muscle, which contracts to extend/straighten the knee. The vastus

intermedialis muscle is attached to the base of patella. The vastus lateralis and vastus medialis are attached to lateral and medial borders of patella respectively, insertion of vastus medialis stabilizes patella & prevent lateral dislocation during flexion. The retinacular fibres of the patella also stabilize knee during exercise.

Ligamentum patellæ also called patellar tendon, it is a strong, flat, ligament, about 5 cm. in length originates from the apex, rough depression on its posterior surface and the adjoining margins of the patella. Inserts on the tuberosity of the tibia. superficial fibers of the quadriceps femoris continuous over the front of the patella. The medial and lateral portions of the tendon of the quadriceps passes down on either side of the patella, to be inserted into the upper end of the tibia on either side of the tuberosity; these portions merge into the capsule forming the medial and lateral patellar retinacula. The patellar ligament is the central portion of the ligamentum patellæ which is continued from the patella to the tuberosity of the tibia, it is single in carnivores, pigs and sheep and triple in horses and cattle. The posterior surface of the ligamentum patellæ is separated from the synovial membrane of the joint by a large infrapatellar pad of fat, and from the tibia by a bursa.

The pisohamate ligament is in the hand. It is the volar ligament that connects the pisiform to the hamate. It is a prolongation of the tendon of the flexor carpi ulnaris. It serves as part of the origin for the abductor digiti minimi, pisometacarpal ligament is a palmar ligament and is a strong, fibrous band. joins the pisiform to the base of the fifth metacarpal bone, which joins the little finger.

Evolutionary variation

The patella has convergently evolved in placental mammals and birds, most marsupials have only rudimentary, non-ossified patellae although a few species possess a bony patella. A patella is also present in the living monotremes, the platypus and the echidna. In more primitive tetrapods, including living amphibians and most reptiles (except some Lepidosaurians), the muscle tendons from the upper leg are attached directly to the tibia, and a patella is not present.¹⁸

Fabella

The fabella (Latin-little bean) is a small sesamoid bone found in some mammals embedded in the tendon of the lateral head of the gastrocnemius muscle behind the lateral condyle of the femur in about 25% of people. It is a variant of normal anatomy and present in humans in 10% to 30% of individuals, fabella is a standard finding on radiographs of the dog and cat, and both. It can thus serve as a surrogate radio-opaque marker of the posterior border of the knee's synovium. On a lateral radiograph of the knee, an increase in the distance from the fabella to the femur or to the tibia can be suggestive of fluid or of a mass within the synovial fossa. This is of particular use in radiographic detection of knee effusions.¹⁹

Development of patella

During the third week of embryonic life the limb buds become filled with a vascular mesenchyme. In may come from the primitive body-segments. Toward the end of the fourth week a slight condensation of the mesenchyme can be seen at the

centre of the arm bud, and early in the fifth week a similar condensation may be noted in the leg bud. This condensation represents the first rudiment of the skeleton of the limb. The tissue composing it may therefore be called scleroblastema. which develops a membranous skeleton. In this a cartilaginous skeleton is differentiated, and this in turn is replaced by the permanent osseous skeleton, 3 overlapping periods, a blastemal, a chondrogenous, and an osseogenous.

Blastemal Period

At the time when the condensation takes place in the leg bud. The bud projects considerably from the body, but do not shows definite resemblance to the limb The condensed tissue, scleroblastema, is not sharply outlined. It represents the region of the acetabulum and the proximal end of the femur. In an embryo 11 mm. long, the condensation of tissue has extended both distally and proximally, but much more freely in the distal direction. The leg of this embryo, therefore, represents a stage of transition from the blastemal to the chondrogenous stage of development.

Chondrogenous Period

The further development of the skeleton of the limb during the second and third months of intra-uterine life development of the several parts of the skeleton will be taken up as follows: The blastemal anlagen of the tibia and fibula are here very incompletely separated. Within the blastema of the femur, tibia, and fibula chondrification begins as soon as the outlines of the blastemal skeleton are fairly complete (Fig. 1) The cartilages of the lower leg lie nearly in a common plane appears slightly kneewards from the centre of the shaft of each bone and then toward the ends.. That of the tibia is larger than that of the fibula and toward the knee it broadens out considerably. At this stage the joints consist of a solid mass of mesenchyme (Figs.5 &9). The tissue uniting the femur and tibia has temporarily somewhat the appearance of precartilage From this period onwards the development of the individual bones and joints is rapid.²⁰

Fig. 1-4 Lateral view of models to illustrate the development of the distal part of the spinal column and of the inferior extremity of embryos 9-50 mm. long, In Figs.. 1, and 2 shows the scleroblastema&the centres of chondrification. In Figs. shows 3 and 4 the cartilaginous skeleton. **Fig. 5-7** shows joints consists of a solid mass of mesenchyme

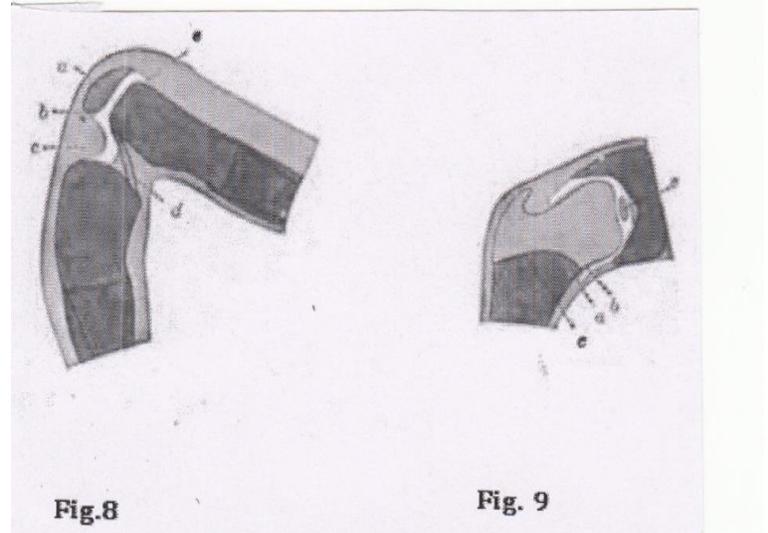
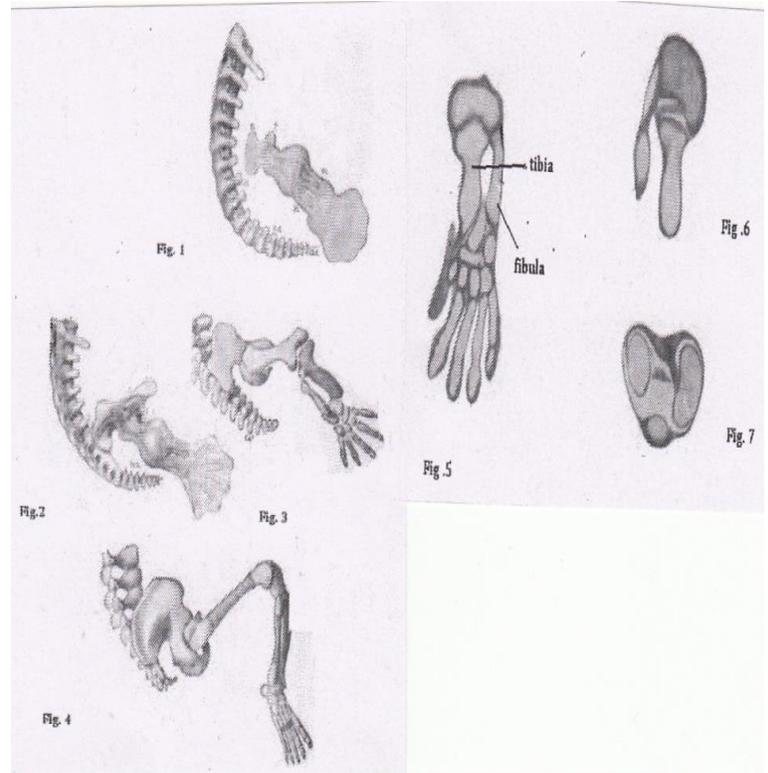


Fig. 8 & 9 shows Median section through the knee-joint of a fetus 13 cm long. a patella, b connective tissue over patella, c ligamentum patellae

III. SUMMARY & CONCLUSION

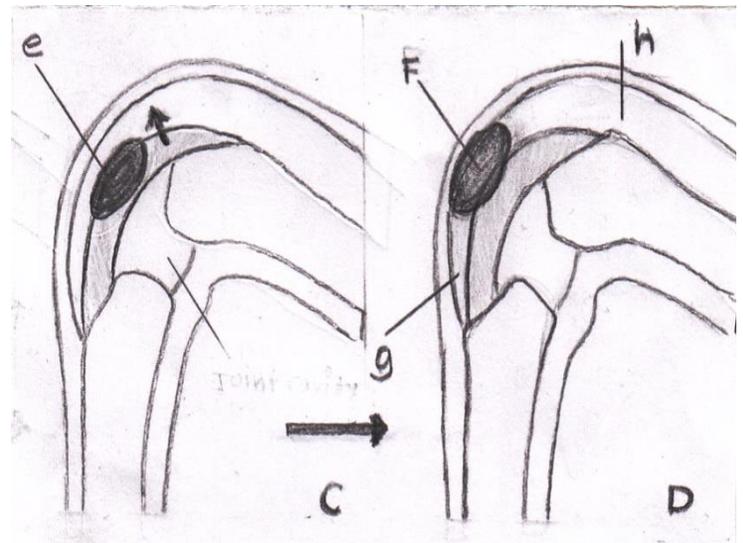
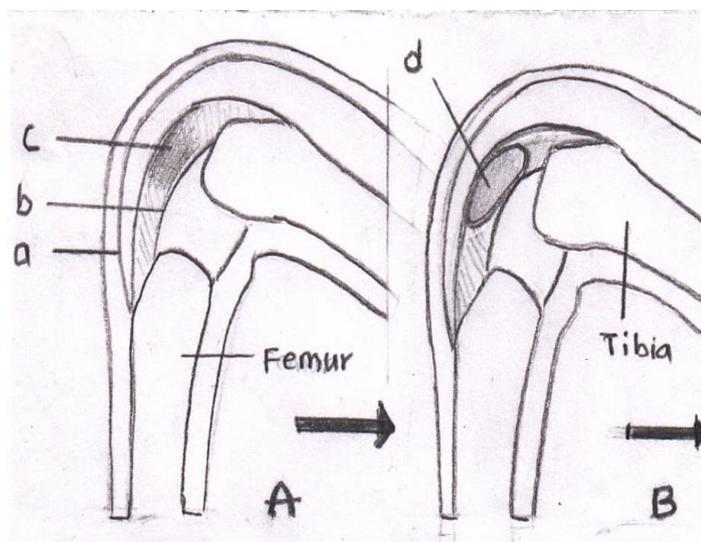
Tendons are closely fused to the joint capsule in many articulations of the extremities. In certain regions where this occurs sesamoid bones are developed. Well-marked sesamoid bones are found regularly on the flexor side of the metacarpo and metatarsophalangeal joints, usually of the first and frequently of the other digits of the hand and foot. Dorsally placed sesamoid bones have also been seen in connection with the thumb. On the flexor surface of the thumb a sesamoid bone is frequently found at the interphalangeal joint. Fibrous interphalangeal sesamoids

have been found in connection with the fingers. The sesamoid bones are better developed in some of the lower mammals than in man, and, they are more frequent in the human embryo than in the adult. They are developed at the periphery of the intermediate blastema zone. The blastema becomes condensed, and then in the better marked sesamoid bones becomes gradually transformed into cartilage. Ossification takes place relatively late in childhood²¹. In some tendons not intimately connected with a joint capsule a sesamoid bone may be developed in a region where the tendon is subjected to stress against a bone. An example, sesamoid bone often found in the tendon of the peroneus longus where it plays over the tuberosity of the cuboid. according to Lunghetti (1906), the sesamoid bone in the tendon of the peroneus longus develops in fibrous connective tissue, not in cartilage. It is commonly stated that it passes through a fibrocartilaginous stage before becoming ossified.²² Thus the development of patella is akin to a pulley which is interplaced for smoothening of conveyor belt system at bend.

How patella bone develops (Hypothesis) might be it could happened, shown in Fig.10

- A) where stress developed against bone, tendon fuses with joint capsule of knee joint
- B) blastema or fibrous tissue become condensed
- C) slowly transformation of tissue into cartilage (fibrocartilage) occurs & gradual forward movement of developing patella
- D) finally it splits the tendon and divides into quadriceps femoris proper (upper part) & ligamentum patellae (lower part)

Fig.10 shows- **a**-tendon, **b**-capsule, **c**-fusion of tendon & capsule, **d**-condensation of fibrous tissue or blastema, **e** -slowly transformation of tissue to cartilage **f**- gradual forward movement of developing patella, **g**-ligamentum patellae, **h**-quadriceps femoris



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