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Morphological Patterns of Linea Aspera on Human Femurs

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Abstract:

Background - The linea aspera of femur is a prominent ridge on the posterior surface of shaft of femur. It helps for support and stabilization of the femur during walking and running. It serves for attachment site of several muscles. The linea aspera acts as a fixed anatomical landmark during the surgical procedure. It also acts as an important intraoperative landmark for orthopedic surgeons identifying the true posterior aspect of the femur.

Purpose of study- 1) To determine the morphological variations of the linea aspera in human femurs. 2) To determine the number and location of nutrient foramina on shaft of femur in relation to linea aspera.

Results- Four different types of linea aspera to be determined: parallel (type I - 32%), concave (type II -42%), convex (type III-5%), and variform (type IV-21%).Amongst all, more mean length of linea aspera was found on convex type (9.92 cms). while, least mean length found on variform type (8.27cms.).Maximum number of femurs (60%) showed single nutrient foramina, while few number of femurs (2%) possesses triple nutrient foramina on its shaft. On 38% of femurs double nutrient foramina was found. More number of femurs (47%) showed nutrient foramina at the proximal end; while 5% of femurs showed foramina on the medial lip, rest 5% femurs showed on the lateral lip of linea aspera.

Conclusion- The linea aspera possesses clinical significance for orthopaedicians, vascular surgeons, anatomist, anthropologists. It acts as an important anatomical guideline for proximal and distal femur endoprosthetic replacements. Knowledge about morphological variations of linea aspera may be helpful for appropriate clinical diagnosis. Such type of study may be useful during various orthopaedic surgeries.

Key-words - Linea aspera, femur, morphological pattern.

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Introduction:

The linea aspera is a rough, longitudinal crest on the posterior surface of the femoral shaft.[1] The linea aspera, also known as the linea asperapilaster complex is a characteristic ridge that runs along the posterior aspect of the human femur.[2] It is much less pronounced in the non-human primate than in the adult human femur.[3] It consists of medial and lateral lips, that may be separated by up to 1cm.[4] It is frequently elevated by an underlying bony ridge or pilaster resulting in a prismatic configuration.[5]

It acts as an important insertion point for the adductors, lateral and medial intermuscular septa that divides the thigh into three compartments. The topography of the linea aspera is an important factor in some surgical techniques like posterior approach of the femur, modified transfemoral approach.[6] Femur possesses the rich vascular supply from various arteries of lower limb.[7]

Nutrient artery for femur enters through nutrient foramen, directed proximally appear in the linea aspera, varying in number and site.[8] The nutrient foramina are important morphologically as well as from clinical aspect.[9] This foramen possesses variable position and it undergoes changes with growth.[10] Hence this study aimed at determining different morphological patterns of linea aspera on adult human femurs and to determine the number, location of nutrient foramen in relation with linea aspera.

Material and method:

The study was conducted on 100 adult human femurs (of right side and of left side) of Maharashtrian population available in the Anatomy department of Rural Medical College, Pravara Institute of Medical Sciences Deemed to Be University, Loni; Maharashtra, India. Only adult human, cleaned and dried femurs were included in study. Damaged, defective bones, bones with callous formation, neonatal bones were excluded from study. Present study had been approved by institutional ethical committee of our institute.

The materials used to calculate the parameters in this study are as follows: 1) Sliding calliper, 2) Magnifying lens, 3) 18, 20, 22-gauge hypodermic needles. Parameters related to linea aspera and nutrient foramina of human femurs were;

1. Maximum length of linea aspera – Maximum length of linea aspera was measured with the help of sliding calliper (Fig. 5). Determination of total length of linea aspera of individual bones was done by taking the measurement between the proximal and distal ends.

2. Maximum mid-width of linea aspera – It was measured in the horizontal plane of linea aspera in the middle between medial and lateral lips with the help of sliding calliper (Fig. 6).

3. Shapes of linea aspera –The different shapes of linea aspera observed during study were parallel (type-I), concave (type-II), convex (type-III) and variform (type-IV).

4. Number of nutrient foramina -The number of nutrient foramina on femurs were noted with the help of magnifying lens. Single double and triple foramina were found on different femurs.

5. Location of nutrient foramina in relation with linea aspera-Location of nutrient foramina in relation with linea aspera was determined with the help of magnifying lens.

6. Patency of nutrient foramina – It was detected with the help of 18, 20, 22-gauge hypodermic needles.

Detailed measurements of the linea aspera were taken by using classical anthropometric method using a sliding calliper with an accuracy of 0.05 mm. [11] Finally, data obtained was statistically analysed.

Results:

1. Patterns of linea aspera – **(Fig 1, 2, 3, 4)**

Morphologically, four different basic types of linea aspera were determined during study. In type I (42%), medial and lateral lips of linea aspera were parallel to each other and all width of the linea aspera found to be equal. Type II (32%) had a concave shape. The width at the proximal and distal ends of the linea aspera were the largest and at mi width was lowest.

In type III (5%) this shape was inverted - the width at the middle of the linea aspera was largest and the widths at the proximal end and distal end were the lowest. Type IV (21%) had a variform shape. All widths of the linea aspera were different. Most common type linea aspera found during study was concave (42%). While, second and third common types of linea aspera found was parallel (32%) and variform (21%). Least common type of linea aspera found during study was convex type (5%).

The mean length of the concave-shaped linea aspera (9.92cms.) was higher than that of those with parallel (8.844cms), concave (8.790cms.) and variform (8.277cms.) shapes. However, this difference was statistically insignificant according the Mann-Whitney test ($p < 0.05$).

Table 1: Osteometric measurements of linea aspera

Measurements of linea aspera	Right femur (60)			Left femur (40)		
	Mean	Standard Deviation	Median	Mean	Standard Deviation	Median
Maximum length of linea aspera (in cms.)	9.103	3.017	9.521	8.932	2.988	8.532
Maximum mid width of linea aspera (in cms.)	0.605	0.777	0.3112	0.535	0.731	0.6111

Fig 1: Type I (Parallel) Linea Aspera

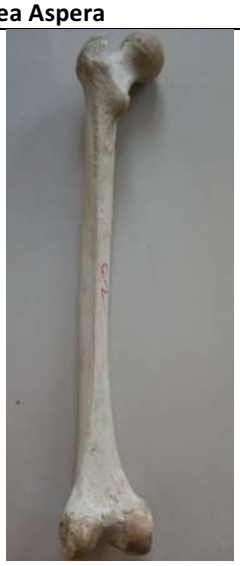


Fig. 2: Type II (Concave) Linea Aspera

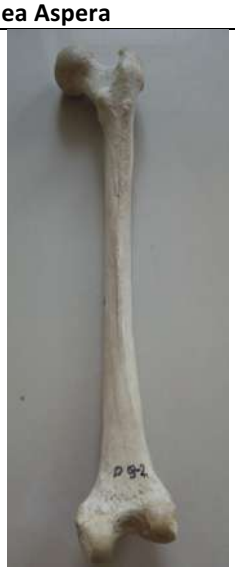


Fig 3: Type III (Convex) Linea Aspera

Fig. 4: Type IV (Variform) Linea Aspera

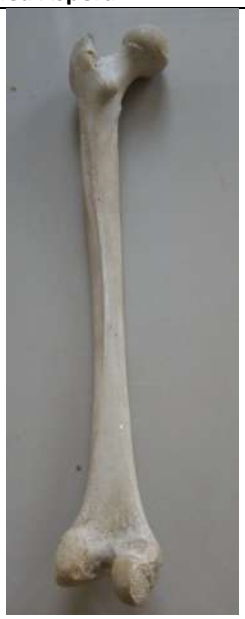


Table 2: Comparison of lengths of linea aspera in its different morphologies (cms)

Statistical Parameters	Types of Linea aspera			
	Type-I (Parallel)	Type-II (Concave)	Type-III (Convex)	Type-IV (Variform)
Mean	8.844	8.790	9.92	8.277
Standard deviation	2.973	0.0705	0.629	2.877
Median	8.901	8.231	10.9	8.211
Min - Max.	5.4 -13.1	5.5 - 14.5	8 - 10.9	6.4 - 12.2

Table 3: Number of nutrient foramina found on femurs

Number of nutrient foramina	Total number of femurs	Percentage
1	60	60%
2	38	38%
3	2	2%

Table 4: Location of nutrient foramina on femur in relation with linea aspera (LA)

Location of nutrient foramina	Number	Percentage
Proximal end of linea aspera	47	47%
Distal end of linea aspera	43	43%
Medial lip of linea aspera	5	5%
Lateral lip of linea aspera	5	5%

Fig 5: Maximum length of Linea Aspera

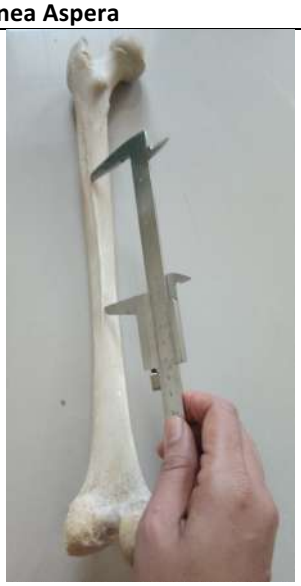
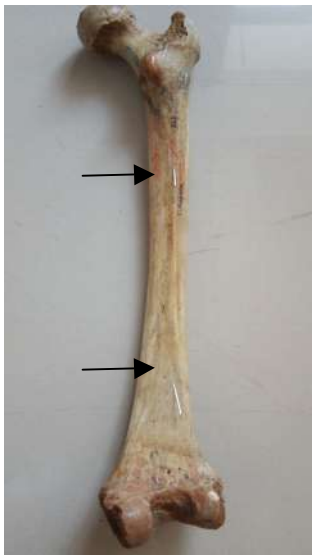


Fig. 6: Maximum width of Linea Aspera

Figure 7: Patency of nutrient foramina



2. Number of nutrient foramina -

Out of the 100 femur bones, 60 (60%) had single nutrient foramina, 38 (38%) had double nutrient foramina and 2 (2%) of femur bones had triple nutrient foramina. In the right femurs, the present study showed 76.27% of single nutrient foramina.

3. Location of nutrient foramina – (Fig. 7)

Maximum number of femur had nutrient foramina at the proximal end of linea aspera i.e. 47% at the distal end of linea aspera in 43%,5% of bones on medial lip of linea aspera and in rest 5% of bones on lateral lips of linea aspera.

4. Patency of nutrient foramina -

Three different 18, 20, 22 hypodermic gauge needles were passed into the nutrient foramina to make sure whether it was patent and also to observe in which direction of the foramen it was going a distance.

Discussion:

Main function of linea aspera is support and stabilization of the femur during walking and running as it provides attachment to several muscles.[12] The nutrient artery to the femur passes through the linea aspera; which may be in the medial or lateral lip, or even in between [13]. In 1995 Yamamoto et al. noted that either one or two additional large-sized nutrient vessels from the perforating branches of the profunda femoris artery also enter at different points along the linea aspera of the femur.[14] The topography of linea aspera is essential during the performance of surgical procedures on the femur. It is helpful in a modified transfemoral approach or in the posterior approach of the femur.[15]

According to Pitt M. J, frontal radiograph of femur shows the prominent development of the linea aspera on femur mainly in adults and in some cases of adolescents. Lateral radiographs may demonstrate filling in of the posterior shaft concavity.[16]

On the anteroposterior radiographs of the adolescent femur, linea aspera-pilaster complex may sometimes appear as so-called track sign and it can be readily mistaken for the pathological flame sign in Paget's disease.[17] The track sign is a normal but relatively rare finding. It is well known to radiologists and less known to orthopedic surgeons.[18]

According to M. Polguj (2013) more percentage frequency of linea aspera found on 100 human femurs were variform (type-I 41.4%), while least were of convex (type- III 5.7%) [19] According to Oladayo (2014) diaphyseal nutrient foramina were common on posteromedial surface while less frequent on lateral surface and rare on anterior surface.[20] Gustao Reple et al (2015) investigated that, linea aspera could be used as a rotational landmark for positioning distal femoral knee megaprostheses. [21] According to Bohra K.C (2016) nutrient foramina of human femurs were located on posterior surface.[22] According to Vedpriya A (2017) exact location and distribution of the nutrient foramina is important to avoid damage to the nutrient vessels and to preserve them during various surgical procedures.[23]

Conclusion:

The linea aspera possess surgical significance for both orthopaedic and vascular surgeons. Knowledge about variations of the line aspera will be beneficial in detecting possible tumor growth such as a calcinosis-like growth. Information about the variations in morphology of linea aspera may assist in ensuring an appropriate clinical diagnosis. Precise knowledge about morphological variations about linea aspera is helpful during orthopedic open procedures of posterior femoral region, proximal and distal femur endoprosthetic replacements, orthopedic tumor surgery. Along with this knowing exact location of the principal nutrient foramina is very important for orthopedic surgery. Information about diaphyseal nutrient foramen is valuable for postoperative success microvascular bone graft.

Conflict of interest – None.

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