Section: Anatomy

Original Research Article

A STUDY OF MORPHOLOGY AND MORPHOMETRY OF VASCULAR FORAMINA OF THE UPPER END OF DRIED ADULT FEMUR

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Abstract

Background: Upper end of the Femur is supplied by numerous arteries which enter the femur through vascular foramina. The knowledge of femoral head vasculature is very important, as it has to be protected during any femoral fracture repairing procedures. Preservation of blood supply of femur head is critical during an open or arthroscopic intra capsular surgical procedure of the hip and for the treatment of pre-arthritic conditions to prevent avascular necrosis of the femoral head. Reaming for resurfacing arthroplasty may endanger the blood supply at the head and neck junction, possibly predisposing to osteonecrosis and femoral neck fracture. **Materials and Methods:** This study is a cross-sectional study done over a period of 2 years from August 2010 to August 2012. 200 Adult Human Femurs were studied for the location, number, size and direction of the foramina of the upper end measured by using 26, 22, 21-gauge hypodermic needles. **Result:** Total number of vascular foramina observed was 7018 on the upper end. The maximum number of vascular foramina (1952) average of 9.76 was observed on posterior aspect of the neck. Majority of the foramina were medium sized (2876). Direction of the foramina was lower oblique (2834). **Conclusion:** Knowledge of the localization and number of the vascular foramina is very useful in certain surgical procedures such as bone grafting, and microsurgical vascularized bone transplantation, to preserve the circulation intact and for open reduction surgeries thus avoiding postoperative osteonecrosis and avascular necrosis.

INTRODUCTION

Precise knowledge of the vascular supply to the femoral head is critical when contemplating surgery in the region surrounding the femoral head and neck junction.[1] Femur is the longest bone of the body, which is one of the weight bearing bones of the body. It is about a quarter of the entire height of the individual.[2] A typical long bone is supplied by four groups of arteries, which are a nutrient artery, epiphyseal arteries, juxta epiphyseal or metaphyseal arteries and periosteal arteries.[3] The important blood supply is by the nutrient artery which enters the femur through nutrient foramen. Vascular arteries enter the long bone, via numerous vascular foramina present all over the bone, but more numerously present at the ends of the long bones. These vascular foramina are often at fairly specific sites, some are occupied by the arteries, but most of them contain thin walled veins.[4] All these foramina are located only on the non-articular surfaces.

Femur is supplied mainly by the femoral artery branches. The proximal end of the femur is supplied mainly by the anastomoses between ascending branch of nutrient artery of the shaft with the Retinacular or Capsular arteries and the Artery of ligamentum teres or Foveolar arteries derived from Medial and lateral circumflex femoral arteries. These arteries as a rule are arranged in three groups-postero-superior, postero-inferior which are derived from medial circumflex femoral artery and anterior group are derived from lateral circumflex femoral artery.

The postero-superior group of retinacular vessels also known as called as lateral epiphyseal or superior capital vessels doesn't pierce the epiphyseal cartilage. They cross the epiphyseal plate at its periphery and then run towards the centre of the femoral head supplying the superior, medial, central and also lateral parts of the head thus forming the most important arterial supply to the head.

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Postero-inferior vessels supply the infero-lateral part of the head mainly posteriorly. Postero- inferior and anterior vessels often cut the corner of the epiphyseal plate. Within the substance of the head, these vessels anastomose with each other, and with the nutrient and foveolar arteries. The foveolar artery arises from the obturator and medial circumflex femoral arteries, or from both.[5]

Lateral circumflex femoral artery supplies the anterior part of the neck along the intertrochanteric line extracapsularly, the capsule, and base of the neck,[6] which constitute the metaphyseal arteries. [3]

Medial circumflex femoral artery supplies base of the neck, through many foramina at the trochanteric fossa.[6]

These epiphyseal arteries are found on the non-articular bony surfaces, are of two types. In one type, articular and epiphyseal cartilages are continuous and the artery pierces the epiphyseal cartilage and supplies the epiphysis. This is vulnerable to injury in epiphyseal separation, producing avascular necrosis. In another type, articular cartilage is not continuous with the epiphyseal cartilage where the blood vessels enter the epiphysis without piercing epiphyseal cartilage; consequently avascular necrosis is not possible.[3]

Trochanteric anastomoses are formed in the trochanteric fossa by the vessels of descending branch of superior gluteal artery, ascending branches of circumflex femoral arteries and a branch from the inferior gluteal artery. These branches pass along with the retinacular fibres.[7]

The greater trochanter has a separate blood supply even after bony fusion with the shaft. There are few anastomoses with the adjacent diaphyseal vessels and a relatively avascular plane separates two circulations. It receives branches from both circumflex femoral arteries, which encircle the trochanter and penetrating vessels enter its medial, lateral and posterior surfaces. Gluteal vessels enter it at the insertion of gluteus medius,[8] which constitute the periosteal arteries.[4] The medial circumflex femoral artery gives branches, which enter the trochanter medially in trochanteric fossa.[8]

All these arteries ramify beneath the periosteum and enter the Volkmann's canals to supply the Haversian system in the outer 1/3rd of the bone.[3]

The most common and serious complication of femoral head is necrosis.[9] The main cause of traumatic femoral head necrosis is the destruction of the femoral head blood supply. The greater the displacement degree of the fracture, the more severe will be the degree of vascular injury. In vascularized bone flap transplantation or other techniques that can reconstruct the blood supply hip joint the knowledge of Vascular supply of upper end of Femur is very essential,[10] and the success of any transplant lies in surgeon's ability to preserve the vascular supply of the bone.[11] Combined periosteal and medullary blood supply to the cortex helps to explain the success of nailing of long bone fractures, particularly in the weight bearing bone like femur.[12] There is no satisfactory description of the detailed vascular channels of the femur. The knowledge regarding the vascular foramina helps to protect them carefully during conservative operative procedures of the bone.[1]

MATERIALS AND METHODS

This study is a cross-sectional study done on 200 Adult Human Femurs of unknown sex over a period of 2 years from August 2010 to August 2012. The study was done at Gandhi Medical College, Secunderabad, Osmania Medical College, Hyderabad, Deccan Medical College, Hyderabad & SVS Medical College, Mahabubnagar, in Telangana.

The location, number, size and direction of the vascular foramina in each part of the upper end of the dried human adult femurs were noted.

The upper end was studied under the following areas of distribution.

1. Head along with fovea
2. Neck anterior
3. Neck posterior
4. Greater trochanter
5. Lesser trochanter
6. Intertrochanteric line
7. Intertrochanteric crest

The size of the vascular foramina was observed by using 21, 22 and 26 size gauge needles and categorized into 3 groups.

1. Small 0.45 to 0.70mm which admitted 26-gauge needle
2. Medium 0.71 to 0.80 mm which admitted 22-gauge needle
3. Large > 0.81mm which admitted 21-gauge needle.

Statistical analysis was done.

RESULTS

The present study was conducted to know the quantitative analysis of the morphology of vascular foramina of upper end of femur.

Location & Number of Vascular Foramina

[Table 1] shows the Location and Number of Vascular Foramina in various segments of Upper end of Femur. Number of Vascular foramina in the upper end of the Femur, studied in 200 femora was 7018. Maximum number of vascular foramina were observed in the Posterior aspect of the Neck of Femur (n=1952, 9.76) and minimum were on Lesser Trochanter (n=115, 0.575).

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Table 1: Showing the location and number of vascular foramina in various segments of Upper end of Femur.

Segments of Upper end	Average number of Vascular foramina	Total No.of VF	Min	Max	SD
HEAD	8.68	1736	1	16	2.62
NECK ANT	4.025	805	0	15	1.96
NECK POST	9.76	1952	4	19	2.5779
GT	5.02	1004	0	11	1.6923
LT	0.575	115	0	3	0.6832
IL	2.685	537	0	6	1.1716
IC	4.345	869	0	10	1.4822

Size of the Vascular Foramina

[Table 2] shows the Size of the Vascular Foramina in various segments of upper end Femur. The average number of vascular foramina of different sizes, at the upper end was noticed, and the maximum number of large and medium sized foramina was on the posterior aspect of the neck and small sized foramina were on the head. The minimum number of large and medium sized were on the lesser trochanter.

Table 2: Showing the Mean & Standard Deviation of vascular foramina of various sizes in different segments of the Femur (upper end)

Segment of the upper end	SMALL			MEDIUM			LARGE		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
HEAD	428	2.14	1.33	598	2.99	1.84	710	3.6	2.2
NECK ANT	302	1.51	1.79	372	1.86	1.42	131	0.655	0.9
NECK POST	342	1.71	1.81	778	3.89	1.53	832	4.16	2.15
GT	257	1.285	1.48	440	2.2	1.36	307	1.535	1.49
LT	90	0.45	0.58	20	0.1	0.31	5	0.025	0.15
IL	270	1.35	1.21	231	1.155	1.09	36	0.18	0.58
IC	161	0.805	1.11	437	2.185	1.22	271	1.355	1.35

Table 3: Showing the correlation between size and number of vascular foramina of Femur (upper end)

Segment of the Femur	Small Size 0.45-0.70mm	Medium Size 0.71-0.80mm	Large Size >0.81mm	Total Noof VF
HEAD	428	598	710	1736
NECK ANT	302	372	131	805
NECK POST	342	778	832	1952
GT	257	440	307	1004
LT	90	20	5	115
IL	270	231	36	537
IC	161	437	271	869
Total no.of VF	1850	2876	2292	7018

Correlation between Number & Size of Vascular Foramina

[Table 3] shows the correlation between the number and size of the Vascular Foramina in various segments of upper end Femur. The maximum noof small sized foramina was located on the Head and minimum on the Lesser Trochanter. The maximum number of Medium sized vascular foramina was on the located on the Neck Posterior and least on the Lesser trochanter. The maximum number of Large sized vascular foramina was located on the Neck Posterior and least on the Lesser Trochanter.

Figure 1: Vascular foramina in the fovea of the head.

Direction of Vascular Foramina

Out of 7018 foramina in the upper end, 1445 number of vascular foramina were directed horizontally, 2597 number of vascular foramina were in upper oblique direction and 2975 number of vascular foramina were in lower oblique direction.

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Figure 2: Vascular foramina located on the superior aspect of the neck and foramina entering into the head cutting at the articular rim.

Figure 3: Vascular foramina on the intertrochanteric crest.

Figure 4: Vascular foramina on the anterior part of the neck, intertrochanteric line, and greater trochanter.

DISCUSSION

In the present study maximum number of vascular foramina in the upper end of the Femur, studied in 200 femora were 7018. Maximum number of vascular foramina was observed in the Posterior aspect of the Neck of Femur (n=1952, 9.76) and minimum were on Lesser Trochanter (n=115, 0.575). Maximum average number of vascular foramina was observed in the neck posterior region (9.76) and minimum average number of vascular foramina was observed in the lesser trochanter (0.575). The maximum number of small sized foramina was located on the Head and minimum on the Lesser Trochanter. The maximum noof Medium sized vascular foramina were on the located on the Neck Posterior and least on the Lesser trochanter. The maximum number of Large sized vascular foramina were located on the Neck Posterior and least on the Lesser Trochanter. Most of the foramina were in lower oblique were 14.87 followed by upper oblique direction were 12.98.

Vascular foramina on the head in the present study included those vascular foramina that have entered the head at the superior aspect of neck. Fovea showed considerable number of vascular foramina. No vascular foramina were found on articular surface of the head of femur.

M. A. Churchill et al,[7] in 1992 stated that the greater trochanter got its supply from its medial, lateral, superior surfaces.

M. Lavigne et al in 2005,[12] analysed 150 cadaveric femora, the average number of vascular foramina recorded was 15 (range, 8-21) per femur. Most of the foramina were located on the posterior aspect of the head and neck, i.e.., about 68%, and anteriorly about 32%, and most of the foramina were located between 9 o'clock and 2 o'clock which is the postero-superior part and part of antero-superior part. This study shows that only a few significant retinacular vessels may reach the adult femoral head on its anterior aspect and that most vascular foramina are located close to the antero- and posterosuperior regions of the femoral head and neck junction.

Christopher J. Dy et al 2012,[13] detected the distribution of vascular foramina at the femoral head neck junction. They identified the vascular foramina on 6 cadaveric femora and registered on computed tomographic models. Almost half (41.8%) of the vascular foramina were located in the antero-superior quadrant.

Poornima B et al,[14] in 2016 studied 100 dry femora and stated that maximum average number of vascular foramina was observed in the neck posterior region (18.2) and minimum average number was observed in head (0). Size of vascular foramina varies from > 1.27mm to < 0.71 mm. Maximum average number of vascular foramina was directed horizontally (5.79).

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Dr. Vivekanand et al,[15] in 2022 studied 100 dried femurs and stated that Maximum average number of vascular foramina directed in lower direction was observed in upper end.
Venkatesh Kamath et al,[16] in 2022 studied 200 adult dry femora and stated that the number of foramina, size and their distribution in relations to the retinacula of Weitbrecht in which 40.01% of foramina were observed in the subcapital region, 31.74% in basicervical and 28.24% were noted in transcervical region. The nutrient foraminal density was significantly higher in the upper retinacula (57.03%), followed by anterior retinacula (27.3%) and least in the region of inferior retinacula (15.66%). It was observed that most foramina were less than 1 mm diameter followed by 1–2 mm diameter foramina.

CONCLUSION

This study deals with the quantitative analysis of vascular foramina of upper end of femora and provides the information about the areas of maximum and minimum blood supply of upper end of femora to the surgeons. This knowledge helps direct in preservation of blood supply of femoral head thus making femoral head less vulnerable to avasular necrosis, which is most common complication after femoral head fractures. This knowledge is also useful in certain surgical procedures such as bone grafting, and microsurgical vascularized bone transplantation, to preserve the circulation intact and for open reduction surgeries thus avoiding postoperative osteonecrosis and avascular necrosis.

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