STUDY OF VARIATIONS OF NUTRIENT FORAMINA IN LOWER LIMB LONG BONES

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ABSTRACT

BACKGROUND

The objective of the present study is to know the variations of the numbers, the directions, the locations and the shapes of the nutrient foramina that is observed in the long bones of lower limbs i.e., Femur, Tibia and Fibula. Place of Study: This study was done in the Department of Anatomy at Sree Mookambika Institute of Medical Science, Kulasekharam in Kanyakumari district of Tamil Nadu. Period of Study: This study was done during the month of July and August of 2015.

MATERIALS AND METHODS

The bones of lower limb from the Department of Anatomy of the above institute constituted the materials for the present study. A thorough study was done on Nutrient Foramina of the long bones of Lower limb i.e., femur, tibia, fibula. Each bone was carefully observed for the variations of nutrient foramina, about their numbers, shapes and directions. All the findings were observed and then noted in the tabular form and later they were well compared and correlated with available literatures.

RESULTS

Present study was done on 29 femora on the right side and 30 on the left side. The study showed, double foramina in only one bone on the right side but not on left side and no bone showed more than two foramina. The highest percentage of single foramen was seen on femur of left side [69.69 %] followed by 59% on the right side. Double foramina were more seen on the right side [28.12%] and the absence of foramina were 12.5% on the right side and 3.03% on the left side. Our study showed double foramina in only one bone on the right side, but not on left side and no bone showed more than two foramina.

CONCLUSION

This study provides an additional information regarding the morphology and topographical study. The knowledge of nutrient foramina is the paramount importance in some of the surgeries in order to preserve the circulation of the bone. Hence, it has been studied in detail and reported.

KEYWORDS

Femur, Tibia and Fibula, Nutrient Foramina, Accessory Nutrient Foramina, Nutrient Artery, Direction of Foramina.

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BACKGROUND

Nutrient foramen is the larger opening in the form of foramen that is present on the shaft/diaphysis of long bones through which passes nutrient artery and provides nutrients and help in the growth of bone [Gray.[1]]. The direction follows general rule that is "towards the knee and away from the elbow I flee." Nutrient artery makes a groove outside the nutrient foramen. The direction of nutrient canal shows the growing end of the bone which is very important. The role of nutrient foramina in the development of bone and nutrition is evident in the term nutrient itself [-Kate B R].[2] In certain operative procedures, the knowledge of these nutrient foramina is useful to preserve circulation (vascularity) of the bones [Mysorekar VR, Taylor GI, McKee et al[3-5]]. The knowledge of location of nutrient foramina is essential both in medicolegal as well as important procedures, surgeries (Mysorekar-1971).

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AIM AND OBJECTIVE

During childhood, blood supply to long bones is from 80% of the interosseous blood supply from the nutrient arteries but when nutrient artery is absent, the vasculation of the long bones is by periosteal arteries.[Trueta-1953].[6] Bones are the structures that adapt to their mechanical environment and in the foetal state adapt to the presence of naturally present holes which are nothing but nutrient foramina that allow blood vessels to pass through the cortex of the bone [Gotzen-2003].[7] The nutrient artery is mainly supplied to long bone which is the only source of blood supply and it is important during growing period of the embryo as well as in foetus during early phase of ossification [Lewis, O.J].[8] The knowledge of nutrient foramina in fibula is of great importance to establish the vascularity in the hip bone and to prevent the necrosis of the same bone by using the bony graft having the good blood supply and this bone can also be used in mandibular reconstruction [Arun Kumar

S Bilodi and Siva Reddy (2014)[9]]. The knowledge of location of nutrient foramina is essential both in medicolegal as well as important procedures, surgeries (Mysorekar-1971).

MATERIALS AND METHODS

The present study has been done on unknown dry bones of lower limbs, they are 32 femora on the right side and 33 femora on the left side, 30 tibiae on the right side and 30 tibiae on the left side, 34 fibulae on the right side and 31 fibulae on the left side. Each bone was examined for the presence of nutrient foramina and their variations in number, shapes, directions and locations. The diameter of the nutrient foramina were measured. Even smaller foramina were measured by means of needle and their directions, depth was noted. The presence of any accessary foramina were also observed. The direction of the foramina was also studied. Absence of foramina if any were also noted. The surfaces of location of nutrient foramina were also noted, then they were classified into the right, left, and tabulated in the tabular form.

	Upper One Third	Percentage%	Middle One Third	Percentage%	Jn Bet Upper and Middle	Percentages %
Right side	16	50%	8	25	9	28.12%
Left side	18	54.54%	7	21.21	8	24.24%

Table 1. Showing the Percentages, Locations and the Variations of Nutrient Foramina in the Shaft of the Femur [L-33, R-32]

In upper one third of femur, the percentages of nutrient foramina were 54.54% on left side and 50% on right side. In middle one third, the positions of nutrient foramina were 24.24% on the left side and 28.12% on right side. No femora showed nutrient foramina on the lower one third.

	Single Foramen	Percentage %	Double Foramina	Percentage%	Absence of Foramina	Percentage%	Accessory Foramina
Right side	19	59%	9	28.12%	4	12.5%	Absent
Left side	23	69.69%	9	27.27%	1	3.03%	Absent

Table 2. Showing the Percentages of Nutrient Foramina in the Femur of Both Sides [L-33, R-32]

The above table-2, showed percentage of nutrient foramina single or double, absent or accessory foramina. The highest percentage of single foramen was seen on femora of left side [69.69 %] followed by 59% on the right side. Double foramina were more seen on the right side [28.12%], and the absence of foramina was 12.5% on the right side and 3.03% on the left side.

Authors	Race		Single Foramen	Double Foramina	Three Foramina
Chattrapati (1967)	Indian(Gujarat)	Right side	31	-	-
		Left side	38	-	-
Mysorekar (1967)	Indian(Poona)	Right side	89	01	-
		Left side	89	01	-
Kate (1967)	Indian (Nagpur)		30	160	10
Longia (1980)	Indian (Jhansi)	Right side	92	06	-
		Left side	98	04	-
Collipol (2007)	Chile	Right side	24	01	-
		Left side	23	02	-
Kizilkanat (2007)	Turkish		98	02	-
Swati Gandhi (2013)	Indians	Right side	50	-	-
		Left side	50	-	-
Present study		Right side	29	01	-
		Left side	30	-	-

Table 3. Showing the Number of Nutrient Foramina in the Tibial Shaft by Different Authors

Above table showed results on nutrient foramina by various authors. Studies of Mysorekar showed two foramina both on right and left sides, While Kate. B. R studies showed double foramina in 160 femora and triple foramina in ten femora. Longia study showed more nutrient foramina on the right side (six) than on left side (four). Collipol studies have shown double foramina in the one bone on the right side and double foramina in two bones on left side. While Kizilkant showed double foramina in two bones. Our study showed double foramina in only one bone on the right side, but not on left side and no bone showed more than two foramina which is similar to the studies of Chathrapathi (1965), Mysorekar [1967], Longia {1980}, Collipal [2007] and Kizilkant [[2007]., but unlike in Kate .B.R [1971] study.

Authors (Year)	Race	Side	Upper One Third	Middle One Third	Junction between Upper and Middle Third
Mysorekar (1967)	Indian (Poona)		141	39	02
Kate (1971)	Indian (Nagpur)		-	-	200
Longia (1971)	Indian (Jhansi)	Right	96	08	-
		Left	97	09	-
Collipal (2007)	China		50	-	-
Swati Gandhi (2013)	North Indians	Right	50	-	-
		Left	50	-	-
Present study (2015)	India	Right	28	02	-
		Left	30	-	-

Table 4. Situation of Nutrient Foramina in Relation to the Length of the Tibia in the Works of Various Authors

The above table showed location of nutrient foramina on the shaft of the tibiae as studied by various authors. Their study showed more number of nutrient foramina in upper one third of tibiae, followed by presence of nutrient foramina in middle one third. Only Kate B R (1971) study showed the presence of nutrient foramina at the junction of upper one third and middle one third in 200 tibiae. But our study showed more number of nutrient foramina in the upper one third, only two tibiae showed the presence of nutrient foramina in their middle one third.

	Posterior Surface	Lateral Surface	Medial Surface	Medial Crest	Interosseous Border	Posterior Border	Anterior Surface
Right side	17	07	02	01	02	05	-
Left side	15	05	01	02	01	07	-

Table 5. Location of Nutrient Foramina in Various Borders and Surfaces of Fibula

The above table showed the presence of nutrient foramina on the borders and surfaces of fibulae. The highest number of nutrient foramina were seen on the posterior surface in the seventeen fibulae on the right side, while on left side nutrient foramina were seen only in fifteen fibulae. The least number of nutrient foramina were seen in medial surface, medial crest and interosseous border. No nutrient foramina were seen on the anterior surface on both sides.

	Upper 1/3	Percentage	Middle 1/3	Percentage	Lower 1/3	Percentage
Right side	10	29.41%	24	70.58%	05	14.70%
Left side	07	22.58%	21	67.74%	03	9.67%

Table 6. Nutrient Foramina at Different Levels of Shaft of Fibulae

RESULTS

The above table shows the presence of nutrient foramina at different level in the shaft of fibulae. The maximum number of nutrient foramina were seen on middle one third of the shaft [70.58%] on the right side and 67.74% on the left side, followed by 29.41% on the right side of the upper one third of fibulae and 22.58% on the left side.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

DISCUSSION

The morphometric study was done on the unknown dry long adult bones of the lower limb which showed following observations on nutrient foramina. Swathi Gandhi et al [2013][10] did the study on 100 human adult tibiae of known sex in the Department of Anatomy, Government Medical College, Amritsar, Punjab, India. Their study comprised 50 male and 50 female tibiae with same number of right and left side bones. The intercondylar eminence and the medial malleolus is the important landmark. Their study showed the position of nutrient foramina was related to vertical line in the poster surface of tibia. There were 89% tibiae showing nutrient foramina lateral to the vertical line, whereas 11% showing the presence of nutrient foramina medial to the vertical line. The distance of the nutrient foramina from the upper end were more in males on both sides and statistically significant. But when compared between two sexes, measurements were found to be greater in males, but they are statistically significant only on the right side. But when it is compared between both the sides, it was greater on right side in both the sexes, where it is statistically insignificant. The mean distance of nutrient foramina was more in males on both sides from the lower end of the tibia. But when

compared between two sides, distances were more on the right side in both the sexes but the difference was statistically insignificant [8-Swati Gandhi]. According to Rhinelander et al, the tibial nutrient artery supplies inner two third of the cortex which is the main blood supply of the cortical bone [Rhinelander].[11] The knowledge of position and number of nutrient foramina in the case of long bone is essential in orthopaedic surgical procedures like joint replacement therapy, fracture of bones, bone graft and vascular bone microsurgeries [Kizilkanat-2007].[12] The Periosteal arteries are only the source of blood supply when the bones do not have nutrient foramina and nutrient arteries [Shulman S.S-1959].**[13]** In Gupta et al studies, they found direction of nutrient foramina was towards the growing end in 20-30%. There were no nutrient foramina in 4.6% of the fibular bone and there were two foramina in 12.5%, three foramina in 2.67% and four foramina in 1.79%. This study was done at Rohilkhand Medical College [Gupta et al-2013].[14] Pereira et al conducted studies on 885 long bones of southern Brazil. Out of them, 174 were humeri, 157 radii, 146 ulnae, 152 femora, 142 tibiae and 114 fibulae. Majority of nutrient foramina were located on the anterior aspect of the upper limb long bones and on the posterior aspect of lower limb long bones. Majority of the bones that were studied had only one nutrient foramina and that was the single source of blood supply. The mean foramina index for the upper limb bone was 55.2% for the humerus, 35.7% for the radius and 37.9% for the ulna. In the lower limb, 43.7% for the femur, 32.75 for the tibia 46.1% for the fibula. This study provides the ethnic data which was commonly used for comparison and interpretation for surgical images [Pereira et al-2011].[15] Rajkumar et al studied on 101 adult femur bones for the location and number in the Department of Anatomy in Teerthanker Mahaveer Medical College, Moradabad in the region of Rohilkhand, this study shows the majority of nutrient foramina were double in number, dominating in size, having double source of blood supply and their locations were predominately on the middle one third of the diaphysis. Their study showed the presence of nutrient foramina mainly on the linea aspera in 57.32%. The mean foramina index was 56.72%. This was the study done in the population of Rohilkhand in the region of Uttar Pradesh [Rajkumar et al-2013].[16.]Chirag et al studied on 188 dried tibiae from the Tertiary Care Hospital of Gujarat. The nutrient foramina was studied for the location, number, direction and its relation to the bony landmarks. The study showed single nutrient foramen runs downwards and closely resembles to previous studies in other part of the world [Chirag et al].[17]

Present Study

Regarding femur, the percentage of nutrient foramina were 54.54% on left side and 50% on right side in upper one third of femur whereas in middle one third, the positions of nutrient foramina were 25% on the left side and 28.12% more on right side. But there were no femora showing nutrient foramina in the lower one third. The highest percentage of single foramen was [69.69%] on left side followed by 59% on the right side whereas, double foramina was 28.12% on right side only. There was no double foramina on the left side and the absence of foramina was 12.5% on the right side and 3.03% on the left side. Study showed double foramina in only one bone on the right side, but not on left side and no bone showed more than two foramina which is similar to the studies of Chathrapathi (1965), Mysorekar [1967], Longia {1980}, Collipal [2007] and Kizilkant [[2007]., but unlike in Kate .B.R[1971] study.

TIBIA

This study showed more number of nutrient foramina in the upper one third of tibia, whereas only two tibiae showed the nutrient foramina in middle one third of the shaft.

FIBULA

Had middle one third of the shaft [70.58%] on the right side and 67.74% on the left side. Followed by 29.41% on the right side of the upper one third of fibula and 22.58% on the left side.

CONCLUSION

The present study on nutrient foramina gives profound knowledge of the position of nutrient arteries to the orthopaedic surgeon. This knowledge is very useful in cases of fracture of long bones and restoration of vasculature during surgeries. This knowledge of nutrient arteries, periosteal arteries will be useful in reconstructive surgeries and plastic surgeries as well as medicolegal practices.

TAKE HOME MESSAGE

The study on vasculature of bone is very important for healing of fracture and also in restoration of the bone architecture. Hence, this has been studied and reported.

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