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Research Article

Study on variability in the location of nutrient foramen in fibular diaphysis of Indian population

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Abstract: The location of nutrient foramen is particular and variable to each bone. It is important in orthopedic surgery, forensic science, anthropology and anatomy. This study was aimed to evaluate the variation in the location of nutrient foramen in fibular diaphysis of right and left side and its relation with length of bone. Materials and methods: Simple random sample of 116 unpaired fibulas [R-58, L-58] of Indian population were used. The student's t-test and Pearson's correlation coefficient were used to evaluate the objectives. Results: Totally 116 nutrient foramen were found. Distance of nutrient foramen from the proximal end was 16.45±2.83cm [R] and 14.70±2.71cm [L]. Total length of bone was 35.16±3.32 [R] and 34.35±3.10 [L]. Foramina index was 46.31±3.89 [R] and 42.23±4.22 [L]. Conclusion: Significant variability in the location of nutrient foramen in fibular diaphysis was observed between right and left side groups. Strong and linear positive correlation was found between the location and total length of bone.
Keywords: Fibula, Nutrient Foramen, Index, Diaphysis, Location.

INTRODUCTION:

Fibula is a non weight bearing bone on lateral part of the leg. Its nutrient foramen is usually located proximal to the midpoint of the posterior surface of shaft and directed distally [1]. Its location is particular for each bone [2] and usually on the flexor aspect [3]. Location is variable and may alter during growth [4] in mammalians. Location of nutrient foramen where nutrient artery enters the bone is important in anatomy, orthopedic surgery (including bone graft and treatment of fracture), forensic science and anthropology. Aim of this study was the evaluation of variation in the location of nutrient foramen in fibular diaphysis of right and left side and its relation with length of bone.

MATERIALS AND METHODS:

This cross sectional primary research study was done on one hundred and sixteen fibula (n=116), not paired, of Indian origin. They were collected with following criteria and study was performed in the Department of Anatomy, Malabar Medical College and Research Centre, Modakkallur, Calicut, Kerala, India, during February 2014 to January 2015.

Table-1: Summary of methods and materials

1	Sample size (n)	116 (right-58, left-58), not paired.
2	Unit of Investigation	Dry Fibula bone
3	Study population	Indian
4	Pilot study	On thirty bones
5	Calculation of Sample size	With minimum 80% power
6	Inclusion criteria	Bone in regular form
7	Exclusion criteria	Deformed and fractured bone
8	Method	Simple random sampling
9	Instruments & materials	Vernier Caliper, Magnification hand lens, divider, camera, tables of random digits, fine metallic wire
10	Parameters	(1). Location: distance between proximal end of the bone to the nutrient foramen [D-NUF]. (2). Total length (TL) [5] (3). Foramina index [6] (FI)=(DNUF/TL)*100

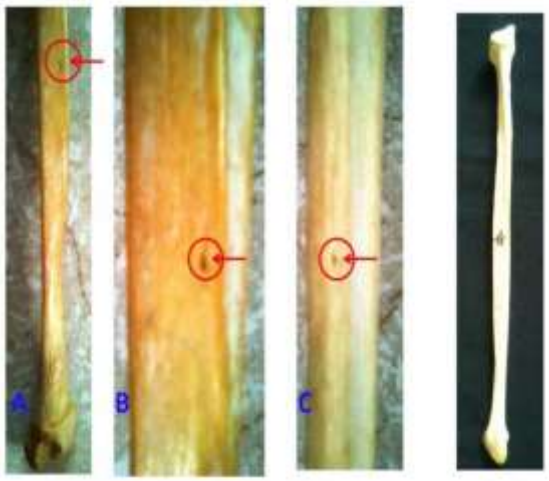

Fig-1: Nutrient foramen in fibular diaphysis directed to distal end.

Procedure

After careful inspection, nutrient foramen [fig-1] was identified in study [7] by Carroll SE. The measurements of parameters were taken carefully by single investigator. Average of three reading was taken and entered in the corresponding right and left side groups. Master chart was prepared and data analysis was done.

Statistical assessment [8, 9]:

The descriptive measures [table-1] and inferential calculations were done manually. Frequency distribution [figure-2] was observed and data exploration was carried out. The student t-test and Pearson's correlation coefficient were used [figure-2, 3] to evaluate the objectives in right and left side groups. Statistical assessment with p-values < 0.05 was considered significant.

RESULT:

Totally 116 nutrient foramina were found in this study. The results of present study were shown in the following tables and figures.

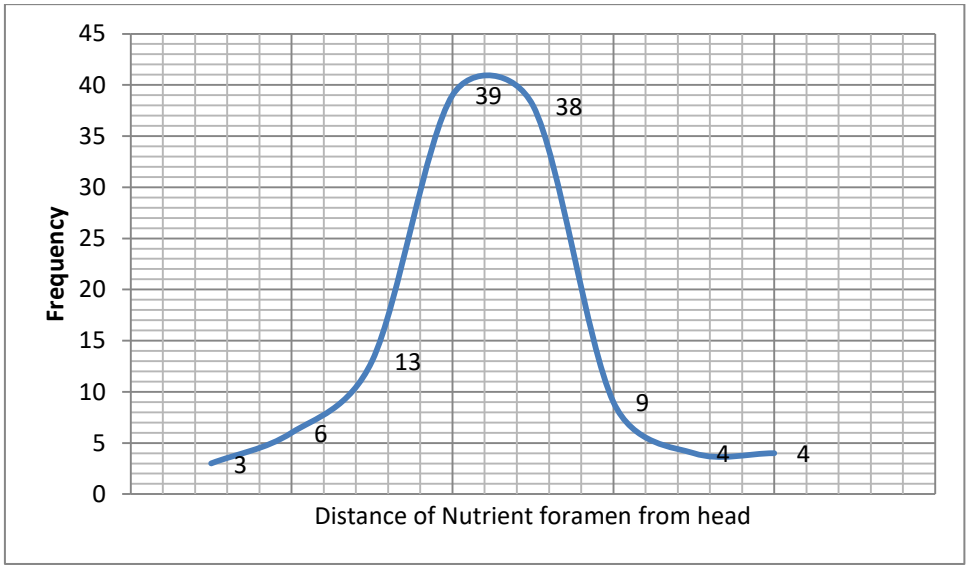

Fig-2: Frequency distribution of distance of nutrient foramen.

Frequency distribution [8, 9]: The frequency distribution curve of location of nutrient foramen (Figure-2) is symmetrical and uni modal with negligible skewness to right side. Outliners were not observed in the data set. Values for location of nutrient foramen were distributed around the mean (15.58) with depth of 15.62 and spread from 8.02cm to 29.98 cm with 2.75 cm standard deviation. Values of mean and median are approximate with each other.

Table-1: Summary statistics of present study (n=116)

No	Title	Mean	SD	SE	Median	Min	Max
1	D-NUF:[R]	16.45	2.83	0.38	16.11	9.01	23.98
2	D-NUF:[L]	14.70	2.71	0.34	15.12	8.02	21.76
3	TLB:[R]	35.16	3.32	0.43	35.54	27.03	43.16
4	TLB:[L]	34.35	3.10	0.40	34.53	26.86	42.08
5	FI:[R]	46.31	3.89	0.51	45.68	33.33	55.91
6	FI:[L]	42.23	4.22	0.55	43.21	29.85	52.73
R= Right, L=Left, D-NUF= Distance of nutrient foramen from proximal end, TLB=Total length of bone, FI=Foramen index, SD=Standard Deviation, SE=Standard Error, Min= Minimum, Max= Maximum. [Measurements in cm]							

The half the (mean) length of the fibula is 17.85cm [R] and 17.17cm [L]. So the nutrient foramen is proximal to the middle of fibular diaphysis.

Comparison right and left side groups: Significant variability in the location was found [table-2] between the bilateral groups at 5% type-1 error.

Table-2: Comparison right and left side groups: by student t-test

Description	Group-[Right]	Group-[Left]
Mean	16.45	14.70
P value [two tail]	0.049	
Significance	Significant at α=0.05	
95% confidence interval	0.714 to 2.786	

Table-3: Relationship between total length and location of nutrient foramen

Side	Right side	Left side
Correlation coefficient [r]	0.926	0.903
Regression model	y=17.29+1.085x	y=18.91+1.050x
Coefficient of determination	0.857	0.841
P value	P<0.05	P<0.05
Significance	Significant at α=0.05	Significant at α=0.05

Correlation [8, 9]: The length and position of foramen in each bone were shown significant relationship on right (r=0.926) and left side (r=0.903) [table-3].The correlation between bivariate values for the length and location of nutrient foramen in each bone is explored with Scatter plot. Positive and linear correlation is observed on both sides [fig-3, 4].

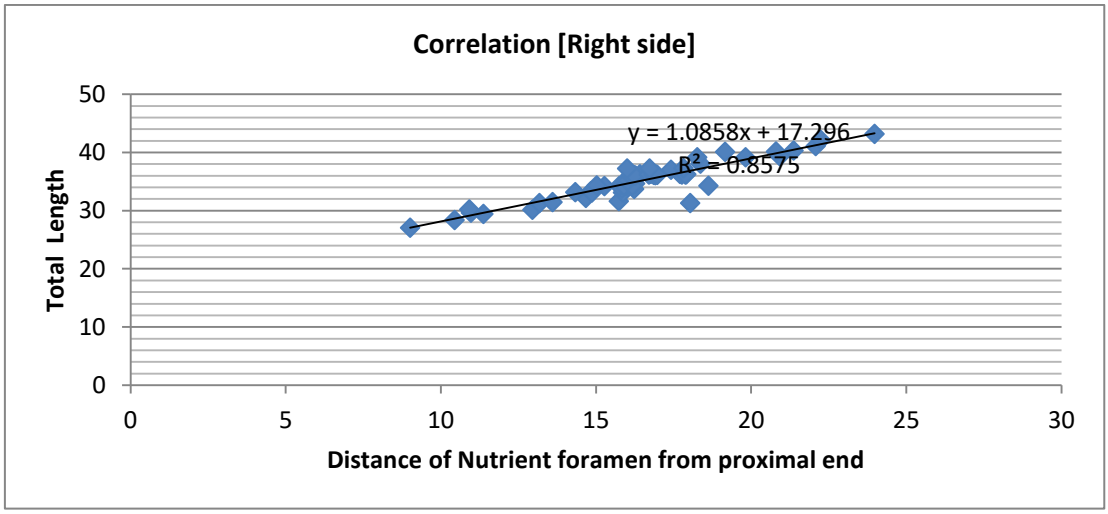

Fig 3: Scatter diagram with least square line and regression model [Right side Fibula].

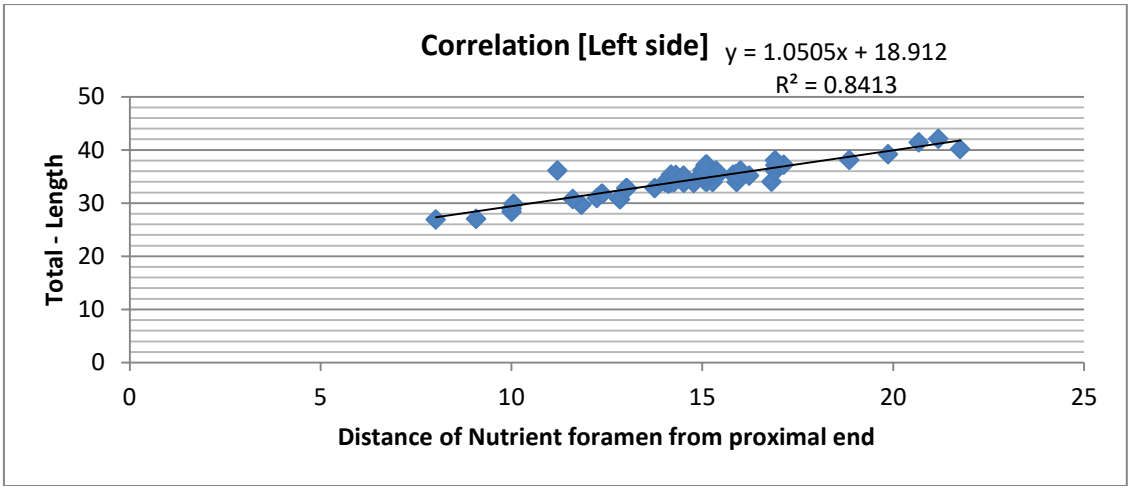

Fig 4: Scatter diagram with least square line and regression model [Left side Fibula].

DISCUSSION:

In the present study the mean distance of nutrient foramen from the proximal end was 16.45cm [range 9.01 to 23.98cm] on right side and 14.70cm [range 8.02 to 21.76cm] left side. Significant difference (p=0.049) was observed between right and left side groups. The location of nutrient foramen and total length of bone showed strong and linear positive correlation (r=0.926) right and (r=0.903) left side groups. The foramina index was 46.31±3.89 on right side and 42.23±4.22 on left side.

Table 4: Comparison of researches on different populations

Researcher	(n=)	Population	D-NUF	TL	FI
Present study	116	Indian	16.45±2.83[R], 14.7±2.71[L]	35.16±3.32[R], 34.35±3.32[L]	46.31±3.89[R], 42.23±4.22[L]
E. Gumusburun et al.; [10]	305	Turkey	-	34.56 ± 0.14	48.13±0.46 [23-70]
Collipal E et al.; [11]	40	Chile	17.23±3.21[R], 17.38±3.02[L]	35.14±2.34[R], 34.10±2.74[L]	-
K.W. Ongeti et al.; [12]	200	Kenya, Nairobi.	15.3 ± 2.4	36.5 ± 3.0	-
(n)=sample size, (D-NUF)=Distance of nutrient foramen from proximal end, (TLB)=total length of bone, (FI)=Foramina index					

COMPARISON

1. Ocation of nutrient foramen: both intra-population and interpopulation variability can be observed [Table-4] regarding location and foramina index. But the total lengths of bones were not showing much difference in different populations. The tendency of nutrient foramen proximal to the midpoint is evident [12] and in present study. Incidence of nutrient foramina on the middle one third of the fibula was recorded by different scholars [13, 14, 10, 15]
2. Sufficient information was not available about the relationships between lengths to location in the previous literatures. Hence this feature was not compared.
3. Developmental evidence on blood vessel and bone formation [1, 16, 17]:
4. Development of blood vessel will occur in two phases: (1) vasculogenesis (2) angiogenesis.
5. When a tissue grows, blood vessels will proliferate. Initial capillary network will be formed. Ossification of fibula begins at eighth intrauterine week. Vasculogenesis (embryonic), angiogenesis (post embryonic) and ossification are regulated by multiple growth factors like- Vascular Endothelial Growth Factor (VEGF), Fibroblast Growth Factor (FGF), Fibroblast Growth Factor Receptors (FGFRs), Bone Morphogenic Proteins (BMPs), Platelet-Derived Growth Factor (PDGF), Transforming Growth Factor-β (TGF-β) and tissue hypoxia. These growth factors will bind to specific receptors and deliver signals to the target cells by signaling mechanisms in the formation of adult bone and blood vessels. Later the reconstruction or modeling and stabilization of vessels will take place to meet the local demand by the tissues.

SIGNIFICANCE

Location of nutrient foramen is variable [2]. It is needed in following fields-

1. In calculation of the length of bone and height of person in forensic science and anthropology [3].
2. In orthopedic surgical procedures, fracture repair, healing process [3, 7] of fracture and bone graft.

Fibula is the most suitable for bone auto graft because of length , shape of bone [18, 19] and with lower donor site morbidity [20].

3. In the reconstruction of other bones like mandible, spine and tibia [21].
4. Prognosis: Any damage to the precise area of nutrient vessel or foramina will affect the healing process [7]. The rate of healing of a fracture is related to the vascular supply of the bone. The segment of bone with good blood supply is more rapidly healed than those with poor blood supply. Hence this information is helpful regarding assessment of prognosis of healing of bone fracture or graft [10, 13, 15].
5. In vascularised fibula bone graft [1, 12, 22].

CONCLUSION

Significant variability in the location of nutrient foramen in fibular diaphysis was observed between right and left side groups. Strong and linear positive correlation was found between the location and total length of bone.

The limitations of study:

The angiography, radiographs were not used. Age and gender wise classification were not done.

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