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"The Morphological and Morphometric Study on Diaphyseal Nutrient Foramina of Dry Human Fibula Bones"

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***Abstract*:** *The fibula is a lower limb long bone which is mainly used for bone grafting and the main aim of Study is to know about the variations in positions, number and directions of nutrient foramina in the fibulae. Material and methods: The study was done on 109 fibulae in which 53 were of right sided and 56 were of left sided. Every bone was carefully observed for the variations of nutrient foramina, about their numbers, position and directions. All the findings were observed and noted in the tabular form and are compared with available literatures. RESULTS: Out of 109 bones, 53 were right sided and 56 were left sided in which 84 bones showed single nutrient foramina (77.06%) and 10 bones showed double nutrient foramina (9.17 %) and 15 bones showed no nutrient foramina (13.76 %).*

Key Words: *Foramen, Bone graft, Direction, Location, foramen index.*

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I. Introduction

Foramina are the openings that carry blood vessels to the bones and provide nutrition through which the growth of the bone is determined and nutrient artery grows in the periosteal bud and enters the middle of the shaft of the bone. Before piercing the bone, artery presents a tortuosity which minimizes the blood pressure and allows the movement of the bone without affecting the nutrient vessel. Within the bone the artery divides into two branches known as the nutritiae, one for each end. Each branch subdivides into a number of smaller parallel vessels which enter the metaphysis and form hair pin like loops. The loops anastamose with periosteal, juxta epiphyseal and epiphyseal arteries. Therefore the metaphysis is the most vascular area of the long bone.1. Nutrient foramina reflect the degree of bone vascularity[2].Thier directions are indicated by a jingle, "to the elbow I go, from the knee I flee" [3]**.** This blood supply is essential during the growth period, during early phase of ossification congenital pseudoarthrosis, in procedures like bone grafts, tumour resection, traumas, and in transplant techniques. Fibula is an important site for muscle attachment and significant source of bone graft. The fibula reverses the ossification pattern in respect to other long bones [4]. Neurovascular injury, weakness of extensor hallucis longus and instability of ankle might occur as a complication of fibular graft [5]**.**

II. Meterials And Methods

The study was done on 109 fibulae in which 53 were of right sided and 56 were of left sided. Every bone was carefully observed for the variations of nutrient foramina, about their numbers, position and directions. All the bones were measured for their total length on the osteometric board and distance of the nutrient foramina are also measured from the upper end. All the findings were observed and noted in the tabular form and are compared with available literatures

Foramina index (FI) is calculated by: Distance of nutrient foramina from the upper end / total length of the bone × 100 (Hughes 29 formula)

III. Obserrvations And Results

Out of 109 bones, 53 were right sided and 56 were left sided in which 84 bones showed single nutient foramina (77.06%) and 10 bones showed double nutrient foramina (9.17 %) and 15 bones showed no nutrient foramina (13.76 %).Maximum length of bone is 42.8 cms and minimum length of the bone is 30 cms and Mean ± Standard deviation of length on right sided bones is 35.8±2.6cms , for left side is 34.2±2.2 cms and Mean ± standard deviation for the distance of foramina from the upper end on right side is 14.67±2.7 cms and on left side is 15.4 ±3.17 cms. Maximum number of bones (83) showed nutrient foramina in the miidle third and 10 bones showed on upper third and only 1 bone is having in lower third and also maximum number (35 bones)

showed nutrient foramina on posterior surface followed by 16 bones on the crest, 16 bones on the interosseous border, 13 bones on lateral surface, 11 bones on medial surface, 3 bones on anteromedial surface.

TABLE SHOWING LENGTH, DISTANCE OF NUTRIENT FORAMINA FROM UPPER END, NUMBER (NO), SURFACE/ BORDER, FORAMINA INDEX (F.I), POSITION OF NUTRIENT FORAMINA ON RIGHT SIDE:

SL.NO	LENGTH	DISTANCE	NUMBER	SURFACE /BORDER	F.I	POSITION
1	39	12.7	1	LATERAL	32.5	Upper1/3
2	38.1	15.8	1	CREST	41.4	Middle1/3
3	38.4	NO N.F				
4	34.3	NO N.F				
5	37.2	16.4	1	LATERAL	44.08	Middle1/3
6	30.9	12.3	1	CREST	39.8	Middle1/3
7	36.4	13.6	1	CREST	37.36	Middle1/3
8	35.8	16.9	1	LATERAL	47.2	Middle1/3
9	35.2	NO N.F				
10	34.8	21.3	1	CREST	61.2	Middle1/3
11	31.8	12.8	1	CREST	40.25	Middle1/3
12	36.6	18.2	2	LATERAL	49.76	Middle1/3
13	36.2	NO N.F				
14	36.8	21.1	1	LATERAL	57.33	Middle1/3
15	33.7	15.2	1	CREST	45.1	Middle1/3
16	35.3	14.4	1	CREST	40.7	Middle1/3
17	37.6	12.3	1	CREST	32.7	Upper1/3
18	34.2	15.2	1	A/M	44.4	Middle1/3
19	35	12.2	1	IB	34.8	Middle1/3
20	39.3	17.4	1	IB	44.2	Middle1/3
21	36.7	13.9	2	IB	37.87	Middle1/3
22	34.6	10.8	1	IB	31.2	Upper1/3
23	33.3	12.4	1	IB	37.23	Middle1/3
24	34.9	11.2	1	LATERAL	32.09	Upper1/3
25	36.4	15.1	2	CREST	41.4	Middle1/3
26	39.2	23.4	1	A/M	59.69	Middle1/3
27	38	15.3	1	IB	40.26	Middle1/3
28	37	17.2	1	LATERAL	46.4	Middle1/3
29	35.4	NO N.F				
30	35.8	11.3	1	CREST	31.5	Upper1/3
31	36.2	15.4	1	IB	42.54	Middle1/3
32	34	13.8	1	A/M	40.5	Middle1/3
33	42.8	14	1	IB	32.7	Upper1/3
34	33.8	14.2	1	LATERAL	42.01	Middle1/3
35	43	19.5	1	POSTERIOR	45.3	Middle1/3
36	30.5	15.9	1	POSTERIOR	52.1	Middle1/3
37	35.8	12.2	1	POSTERIOR	34.07	Middle1/3
38	36.2	13.8	1	LATERAL	38.12	Middle1/3
39	37.3	11.7	1	LATERAL	31.3	Upper1/3
40	32.5	12.3	1	CREST	37.8	Middle1/3
41	31.4	16.2	1	IB	51.5	Middle1/3
42	35	14.8	1	LATERAL	42.2	Middle1/3
43	37.3	14.2	1	CREST	38.06	Middle1/3
44	38	15.3	1	CREST	40.26	Middle1/3
45	35.2	12.4	2	IB	35.2	Middle1/3
46	41.3	12.5	1	LATERAL	30.2	Upper1/3
47	33.3	13	1	CREST	39.03	Middle1/3
48	36.2	14.5	1	IB	40.05	Middle1/3
49	37.5	15.3	1	POSTERIOR	40.8	Middle1/3
50	37.3	14.1	1	POSTERIOR	37.8	Middle1/3
51	34	14.7	1	POSTERIOR	43.2	Middle1/3
52	33.2	11.2	2	POSTERIOR	33.73	Middle1/3
53	32.4	14.8	1	POSTERIOR	45.6	Middle1/3

TABLE SHOWING LENGTH, DISTANCE OF NUTRIENT FORAMINA FROM UPPER END, NUMBER (NO), SURFACE/ BORDER, FORAMINA INDEX(F.I), POSITION OF NUTRIENT FORAMINA ON LEFT SIDE:

SL.NO	LENGTH	DISTANCE	NUMBER	SURFACE /BORDER	F.I	POSITIOIN
1	33.8	NO N.F				
2	31.4	14.8	2	MEDIAL	47.13	Middle 1/3
3	33.6	13.4	1	MEDIAL	39.8	Middle1/3
4	34.7	18.1	1	CREST	52.1	Middle1/3
5	33.4	NO N.F				
6	36.6	15.3	1	CREST	41.8	Middle1/3
7	35.4	13.6	1	POSTERIOR	38.4	Middle1/3
8	34.7	13.1	1	POSTERIOR	37.7	Middle1/3
9	34.2	NO N.F				
10	31	14.6	1	POSTERIOR	47.09	Middle1/3
11	36.5	NO N.F				
12	32.4	16.7	1	IB	51.5	Middle1/3
13	35.8	14.2	1	MEDIAL	39.6	Middle1/3
14	33.7	14.5	1	POSTERIOR	43.02	Middle1/3
15	34.2	12.2	1	MEDIAL	35.6	Middle1/3
16	29.3	14.2	1	MEDIAL	48.4	Middle1/3
17	36.5	16.8	1	POSTERIOR	46.02	Middle1/3
18	33.2	20.2	2	POSTERIOR	60.8	Middle1/3
19	31.4	12.3	1	POSTERIOR	39.1	Middle1/3
20	32.8	10.8	1	IB	32.9	Upper1/3
21	35.7	11.2	1	IB	31.3	Upper1/3
22	33.5	12	1	LATERAL	35.8	Middle1/3
23	32.3	13.2	1	POSTERIOR	40.86	Middle1/3
24	35.4	NO N.F				
25	32.8	12.8	1	POSTERIOR	39.02	Middle1/3
26	33.8	15.4	1	POSTERIOR	45.5	Middle1/3
27	33.2	12.6	1	IB	37.9	Middle1/3
28	34.4	16.3	1	IB	47.3	Middle1/3
29	37.5	21	1	POSTERIOR	56	Middle1/3
30	37	16.4	2	MEDIAL	44.3	Middle1/3
31	30	15.3	1	POSTERIOR	51	Middle1/3
32	38.5	NO N.F				
33	34.2	NO N.F				
34	31	12	1	MEDIAL	38.7	Middle1/3
35	34.2	15.6	1	POSTERIOR	45.6	Middle1/3
36	35	16.7	1	MEDIAL	47.7	Middle1/3
37	31	NO N.F				
38	33.7	NO N.F				
39	36.8	14.8	1	MEDIAL	40.21	Middle1/3
40	30.5	15.9	1	POSTERIOR	52.1	Middle1/3
41	34.4	13.9	2	MEDIAL	40.4	Middle1/3
42	36.5	21	1	POSTERIOR	57.5	Middle1/3
43	33.5	NO N.F				
44	36.6	16.3	1	POSTERIOR	44.5	Middle1/3
45	36.4	15.5	1	POSTERIOR	42.5	Middle1/3
46	35.6	16.6	1	MEDIAL	46.6	Middle1/3
47	30.2	11.7	1	POSTERIOR	38.7	Middle1/3
48	34.8	12.2	1	POSTERIOR	35.05	Middle1/3
49	36	18.7	1	POSTERIOR	51.9	Middle1/3
50	34.5	15.7	1	POSTERIOR	45.5	Middle1/3
51	37.5	26	1	POSTERIOR	69.33	Lower1/3
52	34.2	19.5	2	POSTERIOR	57.01	Middle1/3
53	38.8	15.4	1	POSTERIOR	39.6	Middle1/3
54	37.5	22.6	1	POSTERIOR	60.2	Middle1/3
55	32.8	18	1	POSTERIOR	54.8	Middle1/3
56	32.2	12.9	1	POSTERIOR	40.6	Middle1/3

PICTURE SHOWING MEASUREMENT OF BONE IN OSTEOMETRIC BOARD

PICTURE SHOWING DOUBLE NUTIENT FORAMINA ONE TOWARDS AND OTHER AWAY FROM UPPER END

PICTURE SHOWING 2 NUTRIENT FORAMINA, BOTHN IN SAME DIRECTION.

IV. Discussion

Berard[6] was the first to correlate the direction of the canal with the ossification and growth of the bone. Humphrey[7] was working on the direction and obliquity of nutrient canals postulated periosteal slipping theory, the canal finally directed away from the growing end.

In embryonic period all the nutrient arteries course caudally. This is true in hemodynamic point of view to force the blood from cephalic to caudal side. This agrees with adult rules "towards the knee and away from elbow". This is said to be due to unequal growth of the ends of the long bones. The arrangement of diaphyseal nutrient foramen in long bones usually follows a definite pattern. Position is constant and seen on flexor surfaces.[8]

Jayaprakash T [9] et.al observed 90% fibulae showed single nutrient foramen, in 8% of fibulae nutrient foramen was absent and 2% fibulae presented with double nutrient foramina. 95.74% nutrient foramina were directed away from growing end, while 4.54% nutrient foramina were directed towards the growing end. 82.7% nutrient foramina were observed in the middle zone. All the foramina were present on the posterior surface. 48.93% of the foramina were present on the medial crest, 38.29% were present between the medial crest and posterior border. The mean foramen index of all the fibulae studied was 43.73.

Bichitrananda Roul [10] et.al observed two nutrient foramina were observed in Fibula 18.91% cases, In Fibula the nutrient foramina in some cases found in upper1/3rd & in most of the cases found in middle 1/3rd.

Sharma M et al [11] et.al with respect to fibulae, observed that 92% fibulae (46 out of 50) (Fig 6) had single nutrient foramen. In the remaining 8% (4 out of 50) of the cases, nutrient foramen was absent. In his study none of the fibulae showed the multiple foramina. In 43.5% fibulae (20 out of 46) showing single nutrient foramen, it was located on medial crest (Fig 6). In 26.1% (12 out of 46) it was found between medial crest and

interosseous border. In 17.4% (8 out of 46) it was observed between medial crest and posterior border and in 13% (6 out of 46) it was located on interosseous border.

Venkatesh Kamath [12] et.al in a study all the foramina were on the posterior surface. The mean foraminal index was 44.60 in fibula. 95.45% of the foramina were in the middle third.

Uzma Rasool [13] et.al observed most common distribution of nutrient foramina was on middle one third of the bone (Type-2), seen in 86.59% of fibulae, followed by 7.2% in lower one third (Type-3), and then 6.18% on upper one third of bone (Type-1) with mean Forminal Index(FI) 43.04±9.35, mean length of fibulae is 35.87 (SD_2.35), distance of nutrient foramina (DNF) is 15.41 (SD_3.63).

K.W. Ongeti [14] et.al in a study observed 5.5% of fibula did not have any nutrient foramen. Most (53.4%) of the nutrient foramina were located posteriorly. The average length of the fibula was 365±30 mm long while the nutrient foramen was located 153±24mm from the tip of the styloid process of the head of the fibula; it was 3 cm proximal to the mid length of the fibula.

Prashanth KU [15] et.al also observed 90.2% had single foramen and foramen was absent in 9.8% mean foraminal index was 49.2. The majority of the foramina were located at 60% of fibulae at the 3/5th part

Sinha P [16] et.al in their study, out of 100 bones, 78% bones showed single foramen and 22% bones had double foramen. On right side, 98.3% foramen were present on posterior surface and 1.6% was present on medial crest. On left side, 96.7% of foramen were present on posterior surface and 3.2% of foramen were present on medial crest. All the foramina were located in the middle third of the shaft and directed distally, away from knee joint and cocluded that the nutrient foramen in fibula is most commonly located on posterior surface (97.5%), in the middle third of shaft and directed distally.

Manish Dev Sharma[17] et.al observed out of 150 fibulae, in 9 (6%) fibulae nutrient foramen was absent, 130 (86.66 %) fibulae showed single NF, 10 (6.50%) fibulae had double NF and 1 % fibulae had triple NF; 85.36% foramen were directed away from growing end and abnormal direction of NF were seen in 22 (14.63%) foramen, i.e., towards the growing end, violating the law of ossification. Nutrient foramina on medial crest were frequent with 43 (53.77%) on right and 35 (47.47%) on left fibulae, least frequent was on anterior border on one each right (0.94%) and left fibula (1.01%).

Kalyanasundaram Mohan[18] et.al in fibula, single nutrient foramen was found in 98.66% of the bones and double nutrient foramina were found in 1.33% of the bones. The most common location of the nutrient foramen in fibula was on the posterior surface on the medial crest, which was noted in 41.44% of the bones and in 90% of the bones the nutrient foramen was on the middle third of the shaft of fibula.

In the present study, 84 bones showed single nutient foramina (77.06%) and 10 bones showed double nutrient foramina (9.17 %) and 15 bones showed no nutrient foramina (13.76 %). Maximum number of bones (83) showed nutrient foramina in the middle third and 10 bones showed on upper third and only 1 bone is having in lower third. This study correlates with the studies done by Bichitrananda Roul [10] , Venkatesh Kamath [12] **,** Uzma Rasool [13] , Prashanth KU [15] , Sinha P [16] , Manish Dev Sharma[17]**,** Kalyanasundaram Mohan[18]**.**

V. Conclusion

The present study is very useful during the surgical procedures to preserve bone vasculature, tumour resection, traumas, and in transplant techniques. Adequate dissection around the location of nutrient foramen allows harvesting the fibular graft with minimum incision. The anatomical description of nutrient foramina which is important as microvascular bone transfer is becoming more popular.

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