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A Study on Nutrient Foramina of Dry Humerus in Adult Human Cadavers in Rayalaseema Region

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Abstract: *Introduction: Nutrient foramina are the openings in the bone which leads into the canal of medullary cavity through which blood vessesls pass through and provide nutrition for the bone. Nutrient artery which is the major source of blood supply for the bone during the growth and development. Materials & Methods: The present study was conducted on 91 adult humerii, damaged and pathologically deformed bones were excluded from the study. The number, direction and location of nutrient foramen were observed with thehelp of a hand lens. Total length of the humerus and the distance of the nutrient foramen from its upper end, number and size of the nutrient foramina. Location of the nutrient foramen with respect to the surfaces,zones and the foramen index. Results: Out of 91 humerii, 50 were right sided and 41 were left sided in which 81 bones showed single nutient foramina (89.01%) and 10 bones showed double nutrient foramina (10.98%) and no bones showed absent nutrient foramina. All the bones showed nutrient foramina in the miidle third on Antero medial surface and the bones with double nutrient foramina showed secondary foramen on posterior surface. All the nutrient foramen are observed in the middle third of the bone which is calculated by foramen index.Conclusion: It is important clinically as number of fracture cases due to various causes and also importance in bone reduction and grafting techniques.*

Key words: *nutrient foramen, blood supply, fractures, nutrient artery.*

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I. Introduction

Nutrient foramina are the openings in the bone which leads into the canal of medullary cavity through which blood vessesls pass through and provide nutrition for the bone. The artery entering into the foramen is called as the Nutrient artery which is the major source of blood supply for the bone during the growth and development. The osseous circulation supplies bone tissue, marrow, perichondrium, epiphysial cartilages in young bones, and, in part, articular cartilages. The vascular supply of a long bone depends on several points of inflow that feed complex and regionally variable sinusoidal networks within the bone. The sinusoids drain to venous channels that leave through all surfaces that are not covered by articular cartilage. The flow of blood through cortical bone in the shafts of long bones is mainly centrifugal One or two main diaphysial nutrient arteries enter the shaft obliquely through nutrient foramina, which lead into nutrient canals. Their sites of entry and angulation are almost constant and characteristically directed away from the dominant growing epiphysis. Nutrient arteries do not branch in their canals but divide into ascending and descending branches in the medullary cavity; these approach the Volkmann's canals, which run obliquely or at right angles to the long axes of the osteons. The majority of these channels appear to branch and anastomose, but some join large vascular connections with vessels in the periosteum and the medullary cavity[1]. The *nutrient foramen* is directed away from the growing end of the bone; their directions are indicated by a jingle, 'To the elbow I go, from the knee I flee'[2]. It is important clinically as number of fracture cases due to various causes, the knowledge of nutrient foramina is much of importance in bone reduction and grafting techniques.

II. Materials And Methods

The present study was conducted on 91 adult humerii, damaged and pathologically deformed bones were excluded from the study. The number, direction and location of nutrient foramen were observed with thehelp of a hand lens. Total length of the humerus and the distance of the nutrient foramen from its upper end, number and size of the nutrient foramina. Location of the nutrient foramen with respect to the surfaces,zones and the foramen index. The total length of the bone was measured from the superior end of the greater tubercle

to the inferior most aspect of the medial epicondyle of the humerus by using an osteometric board. The location of the nutrient foramen was noted

with respect to the surfaces. Foramen Index was calculated using the following formula: FI = (DNF/TL) x 100.

III. Observations & Results

Out of 91 humerii, 50 were right sided and 41 were left sided in which 81 bones showed single nutient foramina (89.01%) and 10 bones showed double nutrient foramina (10.98%) and no bones showed absent nutrient foramina. All the bones showed nutrient foramina in the miidle third on Antero medial surface and the bones with double nutrient foramina showed secondary foramen on posterior surface. All the nutrient foramen are observed in the middle third of the bone which is calculated by foramen index. Maximum length of bone is 35.6 cms and minimum length of the bone is 23.4 cms and maximum distance of nutrient foramen from proximal end of bone is 21.4 cms and minimum distance is 13.6 cms. Mean ± Standard deviation of total length for right sided bones is 30.13 cms ± 2.40 cms , for left side is 30.4 ± 2.01 cms and Mean ± standard deviation for the distance of foramina from the proximal end on right side is 17.46 ± 1.77 cms and on left side is 17.8 ± 1.88 cms.

Table No.1: SHOWING TOTAL LENGTH (T.L), DISTANCE OF NUTRIENT FORAMEN (D.N.F) FROM PROXIMAL END, NUMBER (No.), SURFACE, FORAMEN INDEX(F.I) & POSITION OF NUTRIENT FORAMEN (N.F) ON RIGHT SIDE.

S.NO.	RIGHT					
	T.L (cm)	D.N.F.(cm)	NO.	SURFACE	F. I	POSITION
1	28.4	14.2	1	A.M	50	MIDDLE
2	32	19.2	1	A.M	60	MIDDLE
3	28.4	19.3	2	A.M,P	67.9	MIDDLE
4	31	17	1	A.M	54.8	MIDDLE
5	30.6	18	1	A.M	58.82	MIDDLE
6	26.4	15.2	1	A.M	57.57	MIDDLE
7	28	15.4	1	A.M	55	MIDDLE
8	31	18	1	A.M	58.06	MIDDLE
9	28.6	16.4	1	A.M	57.34	MIDDLE
10	27	15	1	A.M	55.55	MIDDLE
11	35.6	20	2	A.M,P	56.17	MIDDLE
12	33.6	18.6	1	A.M	55.35	MIDDLE
13	31	16	1	A.M	51.61	MIDDLE
14	31.6	16	1	A.M	50.63	MIDDLE
15	27.4	18	1	A.M	65.69	MIDDLE
16	31.8	20.2	1	A.M	63.52	MIDDLE
17	32.6	19	1	A.M	58.28	MIDDLE
18	23.4	13.6	1	A.M	58.11	MIDDLE
19	29	19	2	A.M,P	65.51	MIDDLE
20	30.8	19	1	A.M	61.68	MIDDLE
21	28.2	16.4	1	A.M	58.15	MIDDLE
22	32.6	18.2	1	A.M	55.82	MIDDLE
23	32.4	18.2	2	A.M,P	56.17	MIDDLE
24	28.2	17.2	1	A.M	60.99	MIDDLE
25	33.8	18.2	1	A.M	53.84	MIDDLE
26	27.2	15.2	1	A.M	55.88	MIDDLE
27	29.2	17.2	1	A.M	58.9	MIDDLE
28	28.4	16.2	2	A.M,P	57.04	MIDDLE
29	27.2	15.4	1	A.M	56.61	MIDDLE
30	27.2	16.4	1	A.M	60.29	MIDDLE
31	28	16.2	1	A.M	57.85	MIDDLE
32	29.2	17.2	1	A.M	58.9	MIDDLE
33	34.6	21	1	A.M	60.69	MIDDLE
34	31	19	1	A.M	61.29032	MIDDLE
35	32.2	20	2	A.M,P	62.1118	MIDDLE
36	32	19.4	1	A.M	60.625	MIDDLE
37	32	18	1	A.M	56.25	MIDDLE
38	26.4	15.4	1	A.M	58.33333	MIDDLE
39	31.2	16.6	1	A.M	53.20513	MIDDLE
40	28.2	16	1	A.M	56.73759	MIDDLE
41	31	17.8	1	A.M	57.41935	MIDDLE
42	33.2	21.4	1	A.M	64.45783	MIDDLE
43	29	15.2	1	A.M	52.41379	MIDDLE
44	29.8	17.2	1	A.M	57.71812	MIDDLE
45	31	20	1	A.M	64.51613	MIDDLE

46	32.2	18.4	1	A.M	57.14286	MIDDLE
47	31.4	16.2	1	A.M	51.59236	MIDDLE
48	31.4	17.2	1	A.M	54.77707	MIDDLE
49	29.2	18.8	2	A.M,P	64.38356	MIDDLE
50	31.2	16.6	1	A.M	53.20513	MIDDLE

Table No.2: SHOWING TOTAL LENGTH (T.L), DISTANCE OF NUTRIENT FORAMEN (D.N.F) FROM PROXIMAL END, NUMBER (NO.), SURFACE, FORAMEN INDEX(F.I) & POSITION OF NUTRIENT FORAMEN (N.F) ON LEFT SIDE.

S.NO	LEFT					
	T.L (cm)	D.N.F.(cm)	NO.	SURFACE	F. I	POSITION
1	33.4	19.6	1	A.M	58.68	MIDDLE
2	31.2	20.4	1	A.M	65.38	MIDDLE
3	28.2	16.4	1	A.M	58.1	MIDDLE
4	32.2	19.8	1	A.M	61.49	MIDDLE
5	30	17.4	1	A.M	58	MIDDLE
6	29.6	15.8	2	A.M,P	53.37	MIDDLE
7	32.2	19.8	1	A.M	61.49	MIDDLE
8	32	19	1	A.M	59.37	MIDDLE
9	32	17.2	1	A.M	53.75	MIDDLE
10	27.4	17.4	1	A.M	63.50	MIDDLE
11	31.5	19.8	1	A.M	62.85	MIDDLE
12	27.8	16.6	1	A.M	59.71	MIDDLE
13	28.4	16.2	1	A.M	57.04	MIDDLE
14	32.4	19.4	1	A.M	59.87	MIDDLE
15	31.2	18	1	A.M	57.69	MIDDLE
16	31.2	19.6	1	A.M	62.82	MIDDLE
17	27.4	16	1	A.M	58.39	MIDDLE
18	31.2	17.4	2	A.M,P	55.76	MIDDLE
19	30.4	16.2	1	A.M	53.28	MIDDLE
20	27.4	15.6	1	A.M	56.93	MIDDLE
21	30.6	16.4	1	A.M	53.59	MIDDLE
22	28	15.6	1	A.M	55.71	MIDDLE
23	36	25	1	A.M	69.44	MIDDLE
24	30.2	15.2	1	A.M	50.33	MIDDLE
25	29	18.4	1	A.M	63.44	MIDDLE
26	27.4	17	1	A.M	62.04	MIDDLE
27	32.4	18.4	1	A.M	56.79	MIDDLE
28	27.4	15.4	1	A.M	56.20	MIDDLE
29	31.4	20	1	A.M	63.69	MIDDLE
30	29.2	16.2	1	A.M	55.47	MIDDLE
31	30	18.2	1	A.M	60.66	MIDDLE
32	31	19	1	A.M	61.29	MIDDLE
33	31	20	1	A.M	64.51	MIDDLE
34	30	17	1	A.M	56.66	MIDDLE
35	32.4	16.4	1	A.M	50.61	MIDDLE
36	31.6	17.6	1	A.M	55.69	MIDDLE
37	27.2	17	1	A.M	62.5	MIDDLE
38	33.6	17.8	1	A.M	52.97	MIDDLE
39	30.4	17.2	1	A.M	56.57	MIDDLE
40	31	17.4	1	A.M	56.12	MIDDLE
41	30.6	19	2	A.M,P	62.09	MIDDLE

FIGURE 1: SHOWING MEASUREMENT OF BONE ON OSTEOMETRIC BOARD.

FIGURE 2. SHOWING SINGLE NUTRIENT FORAMINA

FIGURE 3. SHOWING DOUBLE NUTRIENT FORAMINA.

IV. Discussion

Shanta Chandrasekaran[4] et.al, in their study of 258 adult dry humerii the mean length of the humerii was 27.96 cm, with a SD of 2.18. The mean distance of th dominant nutrient foramen from the mid point of the humerus was 2.31 cm, with a SD of 1.25 cm. In majority of the humerii (86.43%), the nutrient foramen was located in the middle 1/3rd of the bone and in 13.57% of the bones, it was located in the lower 1/3rd of the bone. The location of the nutrient foramen in the anteromedial surface was 89.92%, that in the posterior surface was 8.53% and that in the anterolateral surface was 1.55%. Dil Islam Mansur[5] observed that 60.87% of the humeri had a single nutrient foramen, 28.85% double foramen, 6.32% triple foramen and 1.98% of humeri had four nutrient foramina where as 1.98% humeri did not have any nutrient foramina. It was concluded that the majority (88.86%) of the nutrient foramina were present on the antero-medial surface, 6.52% on the anterolateral surface and 4.62% on the posterior surface of the shaft of humeri.

Chintala Durga Sukumar[6] observed number, direction and location of nutrient foramen in relation with surfaces and zones of humeri were determined. Majority 79.51% of the humeri had single nutrient foramen, 13.93% double, 3.28% triple, whereas 3.28% humeri no nutrient foramina. Majority 85.24% of the nutrient foramina were located on antero-medial surface, followed by 10.65% on posterior surface and 6.56% on anterolateral surface of shaft of the humerus. In majority 85.24% of bones foramina were present in zone II, followed by zone I (9.02%), then zone III (5.74%). All foramina were found to be directed towards the lower end of humeri. Poudel A[7] in a study, single nutrient foremen was observed in 80% humerus. Doubleforamen in 16%. There was no foramen in 4% humerus. It was also concluded that 88% humerus had the nutrient foremen in anteromedial surface. Nutrient foremen were dominant in Zone II with 82%. All foramen were directed towards the lower end of humeri and concluded the presence of single foramen in the zone II was dominant. The nutrient foramina were also dominant in the anteromedial surface of the humerus.

Ankana Saha[8] observed 60% bones had single foramen while 30% bones had double foramen, and 5% bones had triple foramen 5% bones showed no foramen. Major nutrient foramina were directed distally i.e. towards elbow and 76.85% NF were located on antero-medial surface of shaft and there were no change in the obliquity of the foramina. Vijayalakshmi S[9] observed the mean length of humerus in their study was 30.7 cm. The NF was situated at 17.8 cm from the proximal end, 12.4 cm from the distal end and ~2.9 cm below the mid length of humerus. The mean foramina index and circumference of NF was 57.7 and 6.2 cm respectively. Majority of the humeri (77%) had single NF while in 3% of humeri NF was absent. Middle one-third and on the anteromedial surface of the humerus was the most common location of the foramen. Majority of the dominant foramen was large in size and all were directing toward the distal end.

Asharani S K[10] in a study observed 87% bones have one and 11% have two nutrient foramina respectively. In Majority of the bones studied, the nutrient foramen is located either on the medial border (57%) or on the anteromedial surface (43%). In the rest nutrient foramen is located on lateral border(3%), posterior surface(3%) or anterior border(2%). 87% have the nutrient foramen located in Zone II , 22% at the junction between Zone II and Zone III and 2% in Zone III. The direction of foramen is towards the elbow joint i.e. away from the growing end.

Dr. Rita Kumari[11] in a study, the nutrient was single in 90.62%, double in 7.8% and absent in 1.56 % of bones. The maximum number of foramen present on anteromedial surface in 65.62% humerii followed by medial border in 21.87%humerii. Majority of foramen (81.25%) was present on middle third of the diaphysis of humerus. Direction of nutrient foramen in all humerii was distal. Aashish J Rathwa[12] observed that 94.12% of

the humerus had a single nutrient foramen, 6.39% double foramen, all humerus have nutrient foramina. It was concluded that the majority (73.61%) of the nutrient foramina were present on the antero-medial surface, 8.33% on the anterolateral surface and 8.33% on the posterior surface of the shaft of humerus and 8.33% of nutrient foramina present on anterior border. It was also concluded that most (86.11%) of the foramina present in the zone II followed by zone I (8.33%) then by zone III (5.56%). All foramina were directed toward the lower end of humerus.

Dr. Kalpana. T**[13]** observed that 81.19% of the humeri had a single nutrient foramen, 18.35% double foramen, 0.45% triple foramen, where as 3.67% humeri did not have any nutrient foramina. The majority (82.11%) of the nutrient foramina were present on the antero-medial surface, 14.22% on the medial border and 9.63% on the anterolateral surface,7.8%on the posterior border and 0.46% on anterior border of the shaft of humeri. The foramen index was observed to be 56.35 ±7.36 on right side and 55.57±8.5 on left side, indicating the zonal distribution of foramina in the middle third of the bone. Savithri K**[14]** majority of humerus bones have single nutrient foramen(64.7%) and mainly located on the anteromedial surface(51.7%) followed by medial border (36.5%) especially in the middle one third (87.1%) of the humerus.

Dr.Meenakshi Parthasarathy**[15]** observed 93.8% of the humeri had single nutrient foramen. The double foramen was observed in3.1% of the cases and the foramen was found absent in 3.1% of the humeri. In case of radius, 94.4% had single foramen, 1.4% haddouble foramen, and in 4.2% of the cases, it was absent. With respect to ulna, all the 75 bones had single foramen. The mean foraminalindex was 57.6 for the humerus, 34.4 for both the ulna and radius. The majority (70%) of the foramina in humerus were located at the 3/5thpart, 83.6% of the ulnae foramina at the 2/5th part and 87.7% of the radii foramina at the 2/5th part.

In the present study 81 bones showed single nutient foramina (89.01%) and 10 bones showed double nutrient foramina (10.98%) and no bones showed absent nutrient foramina. All the bones showed nutrient foramina in the miidle third on Antero medial surface and the bones with double nutrient foramina showed secondary foramen on posterior surface. All the nutrient foramen are observed in the middle third of the bone which is calculated by foramen index. All the nutrient foramina were directed to lower end of bone. Maximum length of bone is 35.6 cms and minimum length of the bone is 23.4 cms and maximum distance of nutrient foramen from proximal end of bone is 21.4 cms and minimum distance is 13.6 cms. Mean ± Standard deviation of total length for right sided bones is 30.13 cms ± 2.40 cms , for left side is 30.4 ± 2.01 cms and Mean ± standard deviation for the distance of foramina from the proximal end on right side is 17.46 ± 1.77 cms and on left side is 17.8 ± 1.88 cms.

The study is in close relation with the studies done by Shanta Chandrasekaran[4] et.al, Vijayalakshmi S[9], Asharani S K[10], Aashish J Rathwa[12], Dr. Kalpana. T[13] , Dr.Meenakshi Parthasarathy[15].

V. Conclusion

The present study was conducted on 91 adult humerii and observed for number, position, direction and location of nutrient foramen and was tabulated and compared with various authors. The study is useful for orthopaedicians in a day to day surgeries like bone grafting, microsurgical vascularized bone transplantation and in fractures.

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