A Study of Variation of Nutrient Foramen of Dry Adult Humerus

Poudel A[1], Satyal B[2]

ABSTRACT

Introduction: Nutrient artery is the chief artery for the blood supply of the long bone and passes through the nutrient foremen which lie towards the medial border in the anteromedial surface below the midpoint in humerus. During the surgical procedures like bone grafting and microsurgical vascularized bone transplantation, the knowledge of nutrient foramen is important. The nutrient artery plays an important role in nonunion and delayed union of fracture bone. **Aims and Objectives**: The aim of this study is to determine the number, position and direction of the nutrient foramina of humerus. **Materials and Methods:** 50 humerus, 21 of right and 29 0f left side were studied without any pathological disorders. **Results:** Single nutrient foremen was observed in 80% humerus. Double foramen 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. **Conclusion:** The presence of single foramen in the zone II was dominant. The nutrient foramina were also dominant in the anteromedial surface of the humerus.

Keywords: *Foraminal Index, Humerus, Nutrient foramen*

INTRODUCTION

Due to an increase numbers of industrial and road traffic accidents, sports injuries and pathological factures in osteoporotic victims the fractures of the long bones are increasing in numbers. The medullary arterial system plays an important role in the revascularization of the necrosing cortex and the uniting callus of the fracture site[1].

The nutrient artery is a principal source of blood supply to long bones and is particularly important during their active growth period in the embryo and fetus, as well as during early phase of ossification[2]. Nutrient foramina through which the nutrient artery enters the bone, is directed obliquely, and edges of the oblique part are elevated for entrance of the nutrient artery[3,4] .

To promote the fracture healing of any long bone, the nutrient artery should be preserved[5]. Moreover, the presence of preserved nutrient blood supply is essential for the survival of the osteocytes in cases of tumor resection, trauma, and congenital pseudoarthrosis.[6] Nutrient foramen is usually single in number and located on the antero-medial surface of the humerus a little below the midpoint close to medial borer[7,8] .It has been suggested that the direction of the nutrient foramen is determine by the growing end of the bone, which is supposed to grow at least twice as fast as the non-growing end. As a result, the nutrient vessels move away from the growing end of the bone[9]. As stated popularly they "seek the elbow an flee from the knee", showing their variation in both the limbs.

The number and location of the foramina are not constant in long bones[10] .The variation of their location during the growth in the mammalian bone is also reported by Henderson[11]. Knowledge of the number and location of nutrient foramina is useful in some of the surgical proceure[12].

Studies on the vascularization of long bones of various populations have been conducted to analyze the nutrient foramina morphometry, the nutrient blood supply, the vascular anatomy in reconstructive surgeries, and the microsurgically vascularized bone transplant, [13-20] but the nutrient foramina in the humeri are rarely studied among Nepali population.

Therefore, our aim was to determine the number, direction, location of the nutrient foramen in adult dry humeri present in Nepalgunj Medical College and weather the nutrient foramina obey the general rule i.e., directed away from the growing end.

MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Nepalgunj Medical College, Chisapani during the period of one month in November 2017. The materials for the present study consisted of 50 adult humans cleaned and dried Humeri (29 left and 21 right). All the selected humeri were normal with no appearance of pathological changes and fracture. The total

1. Mr. Abhishek Poudel
2. Mr. Biswas Satyal

Address for correspondence:
Abhishek Poudel
Lecturer
Department of Anatomy
Nepalgunj Medical College, Chisapani, Banke, Nepal
Email: poudelabhishek@gmail.com

length of individual humerus was taken as the distance between superior point on the head and most distal point of medial projection of trochlea of humerus. Length was measured in mm through osteometric board. In the entire humerus after determining the sides, the nutrient foramina were studied based on:

i. The number of foramina
ii. Direction and obliquity of nutrient foramen -18G, 20G, 21G, 24G, 25G needle was used to confirm the direction and obliquity of the foramen.,
iii. Surface on which nutrient foramina were located- Humerus was examined to know the position of nutrient foramen according to the antero-medial, posterior and antero-lateral.
iv. Calculation of foraminal index Foraminal Index = (the distance from the proximal end of the bone to the nutrient foramen/ total length) X 100 [21,22] .
All measurements were taken to the nearest 0.1mm using Vernier caliper [23].
v. Location of nutrient foramina according to FI- location of foramina was divided into three types according to FI as follows:
Type 1: FI below 33.33, the foramen was in the proximal third.
Type 2: FI below 33.33 up to 66.66, the foramen was in the middle third.
Type-3: FI above 66.66, the foramen was in the distal.

Instruments used:

1. Hand lens- used to locate nutrient foramen
2. Osteometric board – used to measure the length of Humerus.
3. Vernier calipers, both curved and straight- used to measure distance of NF from the superior end.

Nutrient foramina were identified by their elevated margins and by the presence of distal groove proximal to them. Only well-defined foramina on the diaphysis were accepted. Foramina at the end of the bones were ignored.
All the numerical data were analyzed through SPSS 23.0.

RESULTS

Number of foramina

While observing the foramina in different zones, no foramen was seen in left and right humerus in zone I. Maximum number of foramina i.e. 81% (17) in right and 82.8% (24) in left were present in zone II.

Fig: 1 Showing the nutrient foremen in humerus

Zones	Right		Left		Total	
	Number	%	Number	%	Number	%
(Null)	1	4.8	1	3.4	2	4
Zone I	0	0	0	0	0	0
Zone II	17	81	24	82.8	41	82
Zone III	2	9.5	3	10.3	5	10
Zone II and Zone III	1	4.8	0	0	1	2
Zone I and Zone II	0	0	1	3.4	1	2
Total	21	100	29	100	50	100

Table I: Showing distribution of nutrient foremen in respect to zone of humeri

In zone II total of 82% (42) humeri were observed. While observing in zone III 9.5% (2) were found in right humerus and 10.3% (5) were seen in left humerus. Total of 10% (5) were seen in zone III. In 3.4% (1) cases the foramina were present in left and none in right side. In zone I and II total number of foramina was observed in 2% (1) humerus. While the foramen in zone II and zone III in right humerus was 4.8% (1) and that in left humerus was nil. Foramen in total humerus in zone II and III, only 2% (1) humerus was observed. There was no foramen in 4.8% (1) cases in right side while 3.4% (1) in left side. There was no foramen in 4% (2) humerus in total.

No. of NF	Right		Left		Total	
	Number	%	Number	%	Number	%
0	1	4.8	1	3.4	2	4
1	16	76.2	24	82.8	40	80
2	4	19	4	13.8	8	16
Total	21	100	29	100	50	100

Table II: Showing distribution of number nutrient foremen of humeri

Total of 4% (2) humerus there were no foramen. No foramen was observed in 4.8% (1) in right humerus and 3.4% (1) in left humerus. One foramen was seen 76.2% (41) in right and 82.8% (24) in left humerus. When looked upon in total humerus the percentage was 80% (40) which had only one foramen. In 19%

(4) humerus in right side there were two foramina and in left side that was 13.8% (4). Adding both side humeri, 16% (8) bones had two foramina.

Location of Foramina

In 4% (2) humerus there were no foramen. It comprises of 4.8% (1) in right humerus and 3.4% (1) in left humerus. While observing foremen in AMS 90.5% (19) were observed in right humerus and that in left humerus was 86.2% (25). The foramen 4.8% (1) in right and 3.4% (1) in left humeri was seen in PS. Total of 4% (2) was observed in PS. While going in ALS none was seen in right humerus and 3.4% (1) was seen in left humerus. In both AM and PS none of the foramen was observe in right humerus but 3.4% (1) was in left humerus.

Surfaces	Right		Left		Total	
	Number	%	Number	%	Number	%
Null	1	4.8	1	3.4	2	04
AMS	19	90.5	25	86.2	44	88
PS	1	4.8	1	3.4	2	4
ALS	0	0	1	3.4	1	2
AM, PS	0	0	1	3.4	1	2
AM, AM	0	00	0	0	0	0
Total	21	100	29	100	100	100

Table III: Showing distribution of nutrient foremen in respect to surface of humeri

The mean total length for right side humerus was 301.48mm and to left side was 292.69. Distance from the proximal end to dominant NF was 142.52mm in right side and 143.38 mm in left side.

Parameters	Right	Left	Total
Mean total length	301.48mm	292.69mm	297.09mm
Distance from proximal end to NF	142.52mm	143.38mm	142.95mm
Foraminal Index	47.27%	48.99%	48.12%

Table IV: Showing mean values of statistical measurements of humeri

The foraminal index for right side was 42.27% and for left humerus was 48.99%. The mean length for all the humeri was 297.09mm, distance of dominant NF was 142.95mm and foraminal index was 48.12%.

The direction of foramina was directed downwards towards the distal end, without deviation from anatomical feature.

DISCUSSION

Location of foramina

Situation of nutrient foremen is on the antero-medial surface close to medial border a little below the midpoint of humeri[8] .However the position and location of foramen may vary. The present study showed that 88% of the foramen were on anteromedial surface. This findings in accordance to the finding of Mansur et.al (88.86%), Halagatti et al (87%) and Yaseen et al (88.5%)[24,25,26]. While comparing the foramen in cadavers by Khan et al in Pakistan, they also noted the higher incidence (96%) of nutrient foramen situated in anteromedial surface[27]. But Gopalakrishna et al observed 70.97% and Vinay et al reported only 30.23% of nutrient foramen in anteromedial surface[28,29].

This study also concluded that the presence of nutrient foremen in posterior surface to be 4%. Similar study conducted in Kathmandu by Mansur et al reported the incidence of 6.52%, Ukoha et al in Nigeria reported 7.5% and Gopalakrishna et al in their study observed 8.06% nutrient foremen on posterior surface which were similar to the study[24,26,30]. The study conducted by Anusha et al, Forriol et al, and Kizilikant et al observed the incidence of presence oh nutrient foremen in the posterior surface as 19%, 15.55% and 18.1% respectively[31,32,33].

The present study showed the majority of the nutrient foramina (82%) were found in zone II which was correlated with the study of Mansur et la who reported 94.84% in human dry bones, Khan et al who reported 96.20% of nutrient foramen in Pakistani cadevers[24,27]. Studies reported from India by Kumar et al and Ukoha et al from Nigeria showed the 100% foramina present in zone II[30,34]. These reports are higher than present study.

Direction of the Nutrient Foramen

All of the nutrient foramen in the present study were directed towards the lower end which is supported by many studies, which were constant and supports the law of ossification[8, 24,25,27,28,34].Kumar et al reported that the direction of nutrient foramen was towards the lower end but in one humerus the direction was towards the upper end[34].

The foraminal index in present study was found to be 48.12%. Foraminal index reported by Mansur et al was 55.20%, Pereira et al was 55.2%, Parmar et al was 55.2% Ukoheal et al was 56.28% and Muralimanju et al was 57.6%[24,30,35,36,37]. All of the study showed the greater foraminal index than the present study.

Number of Foramina

This study showed that the single foramen was present in 80% humeri. Study conducted by Peirera et al reported the incidence of 88.5% in southern Brazil and in India study by Bhatnagar et al showed the incidence to be 90% which were higher than the present study[35,38]. Findings done by Mansur et al in Kathmandu was 60.87%, Shaheen in Saudi Arabia was 60%, Mysorekar et al in Indian population was 58%, Joshi et al in

Gujarati population was 63%, which were lower than the present study [12,24,39,40].

The present study showed double nutrient foramina in 16% humeri. Similar studies done by Solanke et al (4%), Bhatnagar et al (7.14%) showed the frequency of double foramina in less humeri than the present study[38,42] . Whereas the greater frequency of the nutrient foramen were reported by Halagatti et al(17.5%), Carroll et al (28.16%) in London, Mansur et al (28.85%) in Kathmandu, Joshi et al (33%)and Shaheen et al (33.3%)[24,25,39,40,41].

There are different reports on the presence of the triple nutrient foramen[24,25,26,38]. But the present study did not show the triple foramen.

Study done by Mansur et al (1.98%) and Kizilikant et al (0.99%) reported the presence of quadruple nutrient foramen[24, 33]. There were no four foramina in present study.

There was no nutrient foramen in 4% humeri. Study reported by Mansur et la and Kizilikant et al had the same frequency of absence of nutrient foramen in 1.98% humeri[24,33]. A higher incidence of absence of foramen was seen in the study done by Ukoha et al. which was 26%.[30] If there is the absence of nutrient foramen, the bone is supplied by the periosteal arteries[8].

CONCLUSION

The presence of single foramen in the zone II was dominant. The nutrient foramina were also dominant in the anteromedial surface of the humerus. This study therefore confirms the previous reports regarding the number, position, direction of the nutrient foramina in the humerus. As nutrient artery may be damaged during the surgical procedures if location, number, and position are not known. The damage of nutrient artery may lead to non-union or delayed union of the fractured humeral shaft. Knowledge regarding variation of position, location and number of the nutrient foramina of humeri, placement of internal fixation devices can be done appropriately which leads to faster union of fracture of shaft of humerus. Anteromedial surface of intermediate zone if avoided by surgeons during any surgical procedures such as bone graft, microvascular bone surgery, bone repair leads to minimize the damage of nutrient artery of humeri.

REFERENCES

1. Rhinelander FW. The normal microcirculation of diaphyseal cortex and its response to fracture. J Bone and Joint Surg. 1927;50A:643–62.
2. Lewis OJ . The blood supply of developing long bones with special reference to the metaphysis. J Bone Joint Surg Br 1956 Nov;38–B(4):928-33.
3. Collipal E, Vargas R, Parra X, Silva H, de Sol M. Diaphyseal nutrient foramina in the femur, tibia and fibula bones. Int J Morphol 2007 Apr;25(2):305-8.
4. Krishna Garg. BD Chaurasia's Hand Book of General Anatomy. Blood supply of bones. 4th ed. 2011. CBS Publishers and Distributors Pvt. Ltd:43-44.
5. Longia GS, Ajmani ML, Saxena SK, Thomas RJ. Study of diaphyseal nutrient foramina in human long bones. Acta Anat. 1980;107:399-406.
6. Sendemir E, Cimen A. Nutrient foramina in the shafts of lower limb long bones: situation and number. Surg Radiol Anat. 1991;13:105-8.
7. Datta AK. Essentials of Human Osteology: General Consideration. 2nd ed. Kolkata. Current Books International 1997:5.
8. Standring S. Gray's Anatomy, 40th ed. CHURCHILL LIVINGSTONE ELSEVER, 2008:798.
9. Bokariya P, Gudadhe D, Kothari R, Murkey PN, Shende MR. Comparison of humerus and femur with respect to location and number of nutrient foramina. Ind J of For Med Pathol 2012;5(2):79-81.
10. Mysorekar VR. Diaphysial nutrient foramina in human long bones. J Anat. 1967;101(4):813–22.
11. Henderson RG. The position of the nutrient foramen in the growing tibia and femur of the rat. J Anat. 1978; 125(3):593-9.
12. Sharma M, Prashar R, Sharma T, Wadhwa A. Morphological variations of nutrient foramina in upper limb long bones. Int J Med and Dent Sci 2013;2(2):177-81.
13. Chen, B.; Pei, G.X.; Jin, D.; Wei, K.H.; Qin, Y. & Liu, Q.S. Distribution and property of nerve fibers in human long bones tissue. Chin. J. Traumatol., 2007, 10: 3-9.
14. Kocabiyik, N.; Yalçin, B. & Ozan, H. Variations of the nutrient artery of the fibula. Clin. Anat., 2007, 20: 440-3.
15. Thammaroj, T.; Jianmongkol, S. & Kamanarong, K. Vascular anatomy of the proximal fibula from embalmed cadaveric dissection. J. Med. Assoc. Thai., 2007, 90: 942-6.
16. Dyankova, S. Vascular anatomy of the radius and ulna diaphysis in their reconstructive surgery. Acta Chir. Plast., 2004, 46: 105-9.
17. Schiessel, A. & Zweymüller, K. The nutrient artery canal of the femur: a radiological study in patients with primary total hip replacement. Skeletal Radiol., 2004, 33: 142- 9.
18. Guo, F. Observations of the blood supply to the fibula. Arch. Orthop. Traumat. Surg., 1981, 98: 147-51.
19. Bonnel, F.; Desire, M.; Gomis, R.; Allieu, Y. & Rabischong, P. Arterial vascularization of the fibula microsurgical transplant techniques. Anat. Clin., 1981, 3: 13-22.

20. Hughes H. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. Acta Anat. 1952;15:261-80.
21. Shulman SS. Observations of the nutrient foramina of the human radius and ulna. Anat. Rec. 1959;134:685-97.
22. Malukar O, Joshi H. Diaphysial Nutrient Foramina In Long Bones And Miniature Long Bones. NJIRM 2011;2(2):23-26.
23. Mansur DI, Manandhar P, Haque MK, Mehta DK, Duwal S, Timalsina B. A study on variations of nutrient foramen of humerus with its clinical implications. Kathmandu Univ Med J 2016;53(1):78-83.
24. Halagatti MS, Rangasubhe P. A study of nutrient foramina in dry adult humerii of south Indian subjects. NJCA. 2011;1(2):76-80.
25. Yaseen S, Nitya W, Ravinder M. Morphological and topographical study of nutrient foramina in adult humerii. Int J Innov Res Sci Eng Technol. 2014;3(4):7-10.
26. Khan AS, Shah Z, Inayat Q. Anatomical variations in diaphyseal nutrient foramina of humerus in cadavers from khyber pakhtunkhwa,pakistan. Khyber Med Univ J. 2014;6(1):18-21.
27. Gopalakrishna K, Sreekala MA, Rathna BS. A study on the incidence and direction of nutrient foramina in south Indian humeral diaphysis and their clinical importance. J Med Heal Sci. 2013;3(1):71-6.
28. Vinay G, Kumar AS. A study of nutrient foramina in long bones of upper limb. Anat Karnataka. 2011;5(3):53-6.
29. Ukoha UU, Umeasalugo KE, Nzeako HC, Ezejindu DN, Ejimofor OC, Obazie IF. A study of nutrient foramina in long bones of Nigerians.Natl J Med 2013;3(4):304-8.
30. Anusha P, Naidu MP. A study on the nutrient foramina of long bones. Jour of Med Sci and Tech. 2013;2(3):150-7.
31. Forriol FC, Gomez LP, Gianonatti MA, Fernandez RV. A study of the nutrient foramina in human long bones. Surg Radiol Anat. 1987;9:251-5.
32. Kizilkanat E, Boyan N, Ozsahin ET, Soames R, Oguz O. Location, number and clinical significance of nutrient foramina in human long bones. Ann Anat. 2007;189:87-95.
33. Kumar S, Kathiresan K, Gowda MST, Nagalaxmi. Study of diaphyseal nutrient foramina in human long bones. Anat Karnataka.2012;6(2): 66-70
34. Pereira GAM, Lopes PTC, Santos AMPV, Silveira FHS. Nutrient foramina in the upper and lower limb long bones: Morphometric study in bones of southern Brazilian adults. Int J Morph. 2011;29(2):514-20.
35. Parmar AMB, Vaghela B, Shah K, Patel B, Tridevi B. Morphometric analysis of nutrient foramina in human typical long bones of upper limb. Natl J Integr Res Med. 2014;5(5):26-9.
36. Murlimanju BV, Prashanth KU, Prabhu LV, Saralaya VV, Pai MM, RaiR. Morphological and topographical anatomy of nutrient foramina in human upper limb long bones and their surgical importance. Rom J Morphol Embryol 2011;52(3):859–62.
37. Bhatnagar S, Deshwal AK, Tripathi A. Nutrient foramina in the upper and lower limb long bones: A morphometric study in bones of western Uttar Pardesh. Int J Sci Res. 2014;3(1):301-3.
38. Shaheen SY. Diaphyseal nutrient foramina in human upper and lower limb long bones. A thesis submitted for the partial fulfillment of the requirement for the master degree in anatomy. 2009:20-21.
39. Joshi H, Doshi B, Malukar O. A study of the nutrient foramina of the humeral diaphysis. NJIRM 2011;2:14-17.
40. Carroll SE. A study of the nutrient foramina of the humeral diaphysis J Bone Joint Surg. 1963; 45: 176–181.
41. Solanke KS, Bhatnagar R, Pokhrel R. The number and position of nutrient foramina in humerus, radius, ulna of human dry bones of Indian origin with clinical correlation. OA. 2014;2(1):1-8.