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TOPOGRAPHY OF THE NUTRIENT FORAMEN OF HUMAN ADULT FIBULA AND ITS CLINICAL IMPLICATIONS.

Anatomy

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ABSTRACT

Vascularized fibular grafts are commonly used in reconstructive surgeries by general, orthopedic and dental surgeons. So in order to procure a vascular graft, surgeon should have detailed knowledge about the nutrient artery and nutrient foramen of fibula. Graft with adequate vascularity increases the success rate of surgical procedure and results in better prognosis. This study was done to analyze the nutrient foramina in dry adult human fibulae. The study was aimed to note the number, location and direction of nutrient foramen on fibular shaft. Total 180 dry human fibulae were studied and 80.6% had a single nutrient foramina while 13.9% had two and 1.7% had three nutrient foramina present. Most commonly nutrient foramen was present on posterior surface (47%) followed by medial crest (44.6%). 94.8% foramina were observed in the middle of the fibular shaft.

KEYWORDS

Nutrient foramina, Nutrient artery, Vascularised fibular graft, Reconstructive surgery.

INTRODUCTION:

Long bones are supplied by four set of arteries- nutrient artery, epipyseal artery, metaphyseal artery and periosteal artery. Nutrient artery is the major source of blood supply to the long bones. Nutrient artery enters the shaft obliquely through nutrient foramen, which leads into nutrient canal. The site of entry is angulated and directed away from the dominant growing epiphysis[1]. The position of the nutrient foramina in mammalian bones are variable and may alter during growth. Though the foramina are directed away from the growing end, their topography might vary. So the location of these nutrient foramina may differ. The topographical knowledge of these foramina is useful in certain operative procedures to preserve the circulation[2,3].

Fibula is very commonly used for grafting as it is long and straight, has good bone mass and a graft of significant length can be obtained[4]. Nutrient artery to the fibula arises from the main trunk of fibular artery approximately 7 centimeters from its origin. Proximal to the mid-point of the posterior surface of the fibular shaft, a distally directed nutrient foramen receives a branch of the fibular artery. Detailed anatomy of the fibular artery in relation to the fibular shaft should be known before procuring the osteo-fascio-cutaneous free flaps[1]. These free vascularised bone grafts from fibula are used for mandibular reconstruction, stabilization of spine in spinal arthrodesis, reconstruction of musculoskeletal defects due to trauma or after tumor resection and have shown promising results in patients with congenital pseudoarthrosis[5] .Potential complications of fibular graft harvesting include neurovascular injury and compartment syndromes. The neurovascular structures which are likely to be injured during fibular bone graft harvesting are peroneal nerve and muscular branch in the proximal 1/3rd of fibular shaft and fibular vessels in the middle third[6]. So the awareness of the location of nutrient foramen of fibula is important when performing free vascularised fibular transfers[7]. Hence a surgeon is required to acquire full knowledge about the location of nutrient foramen of fibula before proceeding for graft harvesting. It is important not only to improve the results but also to prevent complications. This study was undertaken to determine the number of nutrient foramen, its position with respect to fibular shaft and the direction of nutrient canal. The foraminal index was also determined.

AIMS AND OBJECTIVES:

The aim of the study was to determine the topography of the nutrient foramen of adult fibula.

MATERIAL AND METHOD:

The present study was conducted on 180 dried adult human fibulae, collected from the department of Anatomy, Maulana Azad Medical College, Delhi. The bones were collected irrespective of race and gender. Bones which had gross pathological deformities and which were broken were excluded from the study. After determining the side of the bone, they were numbered with pencil. With the help of an osteometric board, total length of the bone was measured from the apex of head to the tip of lateral malleolus. The nutrient foramen was studied with respect to the number of the foramina present, the surface or border on which it was present. The distance of nutrient foramen from the proximal end was also measured with osteometric board. Direction of nutrient foramen was observed by a magnifying hand lens and then passing a thin stiff wire through it. The nutrient foramen was identified by a raised margin around it and presence of well marked groove proximal to it which led into the foramen. The position of all the nutrient foramina was determined by calculating the foraminal index (FI) according to Hughe's formula[8]. If more than one nutrient foramen was present then the distance of larger one from the proximal end was considered for calculating FI.

FI=DNF/TL X 100
DNF= Distance of nutrient foramen from the proximal end of the bone.
TL= Total length of the bone.

With the help of FI, position of foramen with respect to the total length of fibula was determined. If FI was up to 33.33, then foramen was in upper 1/3rd of the bone, if FI was between 33.33-66.66, it was in the middle 1/3rd of the bone and if it was above 66.66 then nutrient foramen was in the lower 1/3rd of the bone.

After collecting the data, it was compiled, tabulated and analyzed by calculating percentage and mean.

RESULT:

Among 180 fibulae studied, 90 were right sided and 90 were left sided. The length of fibulae ranged from 29.1 to 40.3 cm's and mean length was 35.4 cm's.

Number of nutrient foramina:

Majority of fibula had single nutrient foramen. 145 fibulae had 1 foramen while 25 had 2 and 3 had 3 foramina. 7 fibulae had no nutrient foramen (table 1)

Table 1: Shows the number of nutrient foramen on right and left sided fibula along with combined percentage.

No. of foramen	Right side		Left side		Combined	
	Number (90)	Percentage %	Number (90)	Percentage	Number (180)	Percentage
0	4	4.4%	3	3.3%	7	3.9%
1	72	80%	73	81.1%	145	80.6%

2	14	15.6%	11	12.2%	25	13.9%
3	0	0%	3	3.3%	3	1.7%

Location and position of nutrient foramen in relation to the surface or border of the fibula and foraminal index:

Out of 180 bones, 7 had no nutrient foramen, while 25 bones had 2 nutrient foramen and 3 bones had 3 foramina making total of 204 foramina, out of which 96 were present on posterior surface followed by 91 on medial crest, 9 on interosseous border, 5 on lateral surface, 3 on medial surface and none was found on anterior and posterior border (table 2).

Bones which had more than 1 foramen, larger one was considered to calculate the FI. So total number of foramina taken for determination of FI was 173, out of which 164 were in middle 1/3rd, 7 in lower 1/3rd and 2 in upper 1/3rd of fibular shaft (table 3).

Table 2: Shows the surface and border on which the nutrient foramen is present on right and left sided fibula along with combined percentage

	Right side		Left side		Combined	
	Number(100)	Percentage	Number(104)	Percentage	Number(204)	Percentage
Posterior surface	41	41%	55	52.9%	96	47%
Lateral surface	3	3%	2	1.9%	5	2.5%
Medial surface	1	1%	2	1.9%	3	1.5%
Medial crest	48	48%	43	41.4%	91	44.6%
Interosseous border	7	7%	2	1.9%	9	4.4%
Posterior border	0	0%	0	0%	0	0%
Anterior border	0	0%	0	0%	0	0%

Table 3: Shows the position of nutrient foramen on shaft of fibula according to FI.

	Right side		Left side		Combined	
	Number(86)	Percentage	Number(87)	Percentage	Number(173)	Percentage
Upper 1/3rd	1	1.1%	1	1.1%	2	1.2%
Middle 1/3rd	81	94.2%	83	95.4%	164	94.8%
Lower 1/3rd	4	4.7%	3	3.5%	7	4%

Direction of nutrient foramen:

Out of 204 nutrient foramina found, 172 were directed distally that is away from the growing end and 32 were directed proximally, towards the growing end (table 4).

Table 4: Shows the direction of nutrient foramen

	Right side		Left side		Combined	
	Number(100)	Percentage	Number(104)	Percentage	Number(204)	Percentage
Towards growing end	14	14%	18	17.3%	32	15.7%
Away from growing end	86	86%	86	82.7%	172	84.3%

Fig 1: Fibulae of right side. Bone no 31 showing Nutrient foramina (NF) on lateral surface, directed upwards. Bone no 46 showing NF on medial surface, directed downwards. Bone no 56 showing two NF, one on medial crest, directed downwards and other on posterior surface, directed upwards. Bone no 71 showing two NF, one on medial crest, directed downwards while second on interosseous border, directed upwards.

Fig 2: Fibulae of Left side. Bone no 22 showing two NF, one on medial crest, directed downwards and other on posterior surface, directed upwards. Bone no 29 showing two NF, one on posterior surface, directed downwards while second on interosseous border, directed upwards. Bone no 65 showing NF on lateral surface, directed upwards. Bone no 87 showing three NF, one on medial crest, directed downwards while other two on posterior surface and medial surface, directed upwards.

DISCUSSION:

Fibula normally has one nutrient foramen present on the posterior surface in the middle 1/3rd of the shaft. The present study also found maximum number of fibula to have same topography of nutrient foramen but some variations were also found. These variations are important as fibula vascular graft is used in number of cases by orthopaedicians and surgeons. Bone grafts are broadly divided into nonvascularised and vascularizsed grafts. The success of nonvascularised grafting is possible if there is adequate blood supply of the recipient bone and surrounding tissue, otherwise these grafts are incapable of remodeling and results in failure of transplantation. This problem is not encountered in vascularised grafts as they almost always unite with the recipient bone and show healing charecteristics similar to simple fracture[9,10]. So the survival of the vascular fibular graft depends on the blood supply it receives from the fibular artery via nutrient artery. For the survival of osteocytes and osteoblasts it is important that the arterial supply of the free vascularised bone graft is preserved[11]. After reconstructive surgeries and tumor resection it is very important to have adequate blood supply to the bone for regeneration and proper healing. It is therefore essential for surgeons to keep in mind that the fibular artery must not be divided from the fibula during harvesting the graft for which detailed knowledge about the topography of the nutrient foramen of the fibula before acquiring the graft is necessary.

A study done Forriol et al[12] reported that 100% fibulae have 1 nutrient foramen which corresponded to the observation of study done by V.Kamath et al[13]. However other studies show different results. Mysorekar studied 180 fibulae and reported 92.8% to have 1 nutrient foramen, 3.3% having 2 nutrient foramina and 3.9% having no nutrient foramen[2]. Abhijeet J et al studied 189 fibulae and found 88.88% had single 1 nutrient foramen, 8.9% had 2 nutrient foramina while in 2.22% bones nutrient foramina was absent[14]. Prashanth K.U et al reported that 90.2% fibulae had single nutrient foramen and 9.8% cases nutrient foramen was absent[15]. The blood supply of bones with absent nutrient foramen is derived from the periosteal vessels[16]. In present study out of 180 fibulae, 80.6% had 1 nutrient foramen, 13.9% had 2 nutrient

foramina. Absent nutrient foramen was found in 3.9% fibulae. In present study 1.7% left sided fibulae were found to have 3 nutrient foramina which is a rear finding.

Most commonly nutrient foramen of fibula is found on posterior surface in middle 1/3rd of the shaft. Study done by Arun K et al on 186 fibulae, 29.62% had nutrient foramen on the posterior surface, followed by 22.23 % on lateral surface, 21.16% on medial surface, 8.99% on medial crest, 7.93% on interosseous border, 2.11% on posterior border while 0.53% on anterior surface.29.62% of nutrient foramina were located in upper 1/3rd of the shaft, 38.62% in the middle and 29.1% in lower 1/3rd of the shaft[17]. Study done by Ojaswini M at al reported that in 90.8% fibulae nutrient foramen was located posterior surface, in 6.8% on medial surface and in 2.2% on lateral surface of the shaft. 74% nutrient foramina were located in the middle 1/3rd, 9% in lower 1/3rd and 4% in upper 1/3rd of the shaft[18]. Uzma et al studied 100 fibulae and reported in 62.89% bones nutrient foramen was located on posterior surface, in 30.9% cases nutrient foramen was on medial crest. In 5% and 1% the nutrient foramen was located on posterior and interosseous borders respectively[19]. The present study varies from the previous studies in location of nutrient foramen on the surface/border of the shaft. Some of the previous studies have reported higher prevalence of nutrient foramen on medial and lateral surface which was 1.5% and 2.5% respectively in the present study. Also we observed higher incidence (44.6%) of nutrient foramen on medial crest as compared to previous studies.

Direction of nutrient foramen reported by Mysorekar was away from the growing end in 95% fibulae and 3.33% it was directed towards the growing end where as 1.6% fibulae had 2 nutrient foramina, out of which 1 was directed towards the growing end and other away from it[2]. Uzma et al reported direction of nutrient foramen in 92% cases away from the growing end and in 5% cases towards the growing end, whereas in 3% cases nutrient foramen was absent[19]. Study done by Roopam K et al on 251 fibulae, reported in 91.6% bones nutrient foramina was directed away from the growing end and in 8.3% cases it was directed towards the growing end[20]. Observation made in the present study about the direction of nutrient foramen correlates with the previous studies, where nutrient foramen in maximum number of fibula is directed towards the distal end of fibula that is away from the growing end.

CONCLUSION:

This study provides information on topography of nutrient foramen in fibula which is of great use in procurement of vascularised bone grafts used by orthopedic surgeons as well as dental surgeons. From this study it was quite well evident that the distribution of nutrient foramen in fibula is mainly on posterior surface, in middle 1/3rd of the bone. However other locations cannot be ignored. A detailed knowledge of the location of nutrient foramen becomes necessary while harvesting a vascular graft to avoid injury to the nutrient artery which is necessary for graft survival.

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