ORIGINAL ARTICLE

Significance of Morphometric Anatomy of Diaphyseal Nutrient Foramen in dried Pakistani Femurs and its Clinical Applications in Microvascular Bone Graft

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ABSTRACT

Success of microvascular bone graft is related to proper endo-periosteal blood flow depends upon exact understanding of surgical anatomy of diaphyseal nutrient foramen. Diaphyseal nutrient artery is main supply to the femur. Diaphyseal nutrient foramen provides entry channel for this vessel. Bone ossification, growth and healing is dependent on intactness of this vessel. Orthopaedic operative procedures of bone defect repair such as microvascular bone graft, depends mainly on the vascularity of the femur for survival of donor and recipient bones. This study was conducted on 100 dried adult Pakistani femurs (46 rights, 54 lefts) of unknown sexes. We investigated the topography and morphometry of diaphyseal nutrient foramen in these femurs. Direction of the nutrient foramen related to the growing end and the foramen Index (FI) were also calculated.83.98% of the bones forming majority had single diaphyseal nutrient foramen while only 16.02% had double nutrient foramen. The single diaphyseal nutrient foramen was located on the Linea aspera in 51.91%, on the medial lip of Linea aspera in 16.91%, on the lateral lip of Linea aspera in 15.85%, on the medial surface in 12.01% and on the lateral surface in 3.32%. Medial surface and Linea aspera was the most common site of occurrence of double diaphyseal nutrient foramen.

Keywords: Diaphyseal nutrient foramen, Femur, Microvascular bone graft, Foramen index.

INTRODUCTION

Surgically aided bone defect repair and femur growth and are related events that are dependent on bone vascularization. Diaphyseal artery principal vessel supplying femur and is supported by metaphaseal and epiphyseal arteries[1]. The diaphyseal nutrient foramen is a surface opening leading into the oblique nutrient canal. The diaphyseal nutrient artery emerges from second perforating artery, enters the diaphyseal nutrient foramen andpasses through the nutrient canal. As it reaches medullary canal, the artery entering nutrient foramen divides into "ascending and descending branches which anastomose with epiphyseal and metaphyseal arteries"[2,3]. As a rule, diaphyseal nutrient foramen is found coursing in opposite direction from the growing extremity of femur[3]. The reason is differential growth of the two ends of long bones. Normal anatomical location of diaphyseal nutrient foramen is usually in vicinity of middle of the linea aspera[4]. Nutrient foramen has been documented to have variable position and it undergoes changes with growth[5]. In one study two diaphyseal nutrient arteries of femur were found. First originated from the first and second emerged from third perforating arteries. Those vessels passed into the diaphysis via couple of diaphyseal nutrient foramen documented at the nearer and "distal" extremity of lineaaspera.[1] In clinical settings such as trauma or tumour resection, when orthopaedic surgeon decides a bone graft for a patient, the blood supply of the healthier bone in the patient who is contributing e.g., bone site is really important as it has a premier effect on variety of graft to be utillised.[6] It is recommended to eliminate possibilities of abnormalities related to blood vessels in patients who is contributing bone and who is receiving bones by performing pre-operative angiography in patients[7]. Vascularized bone graft is the preferred method used in bone reconstruction as it ensures the survival of both donor and recipient bones[8]. In Pakistani people the anatomy of diaphyseal nutrient foramen of the femur has not yet been fully documented.

The objective of the study was to determine the number and localization of diaphyseal nutrient foramen in Pakistani femurs.

METHODOLOGY

One hundred cadaveric Pakistani femurs were used for current research work, gender not the consideration, (46 RT sided, 54LT sided), obtained from Departments of Anatomy, King Edward Medical

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University, Fatima Jinnah Medical College, Postgraduate Medical Institute/Ameerudin Medical College, Sahiwal Medical College Sahiwal. Abnormal looking bones with were not included in the research work. We determined side of the bones first, the nutrient foramen was then investigated with reference to: 1. How many nutrient foramen were located on the shaft 2. Where exactly nutrient for a men is found 3. In which direction nutrient foramen going from the growing extremity of the bone 4. Exact anatomical placement of nutrient foramen with reference to the length of the femur. Gross survey of femur demonstrated nutrient foramen as a narrow entry point marginally prominent borders coursing into visibly demarcated passage way. We passed a wire/needle into the canal make sure whether nutrient foramen was patent and also to observe in which direction of the nutrient foramen was going a. distance We took a measurement between the a point on fovea on of the head of femur to the distal most part of the medial condyle of femur, and that was declared as femur length (L). The second measurement was taken as the distance (D) between the nutrient foramen and proximal end of the head of the femur. Sliding calipers and scale were used to take all measurements. Hughes (1952) formula was applied to calculate the nutrient foramen index (FI) as stared here FI = D/L x 100.In those femurs where we found two diaphyseal nutrient foramen, the grossly bigger of the two nutrient foramen was accepted as main foramen to calculate foramen index. Sony digital camera (14.1mega pixels) was used topictures of Femurs with the nutrient foramen.

RESULTS

We found one diaphyseal nutrient foramen in 83 femurs (83%) and in 17 bones (17%) double out of the 100 femurs studied, while only (Table 1). Diaphyseal nutrient foramen was commonly found on Linea aspera while the least common was on LS lateral surface (Table 2). In femurs with two diaphyseal nutrient foramen, common sites of the dual diaphyseal nutrient foramen were on medial surface MS and Linea aspera LA, occurring in 36.95% of femurs with double diaphyseal nutrient foramen (Table 3).

Table 1: Presence of unilateral and bilateral diaphyseal nutrient foramen in the right and left femurs

Side	Single DNF	Double DNF	Total
Right	31(31%)	41(41%)	41(41%)
Left	48(45.26%)	11(11%)	59(59%)

The diaphyseal nutrient foramen was destined upwards in the direction of upper end of in 99 femurs (99%) and only in one femur (1%), diaphyseal nutrient foramen was directed further in front. The diaphyseal nutrient foramen as documented on linea aspera of bone: The single diaphyseal nutrient foramen was observed on the in 51.91%, on the "medial lip of Linea aspera" in 16.91%, on the "lateral lip" of Linea aspera in 15.85%, on the "medial surface in 12.01% and on the lateral surface in 3.32% (Figs1&2).

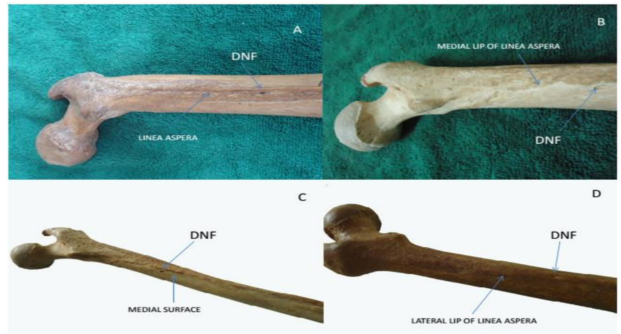
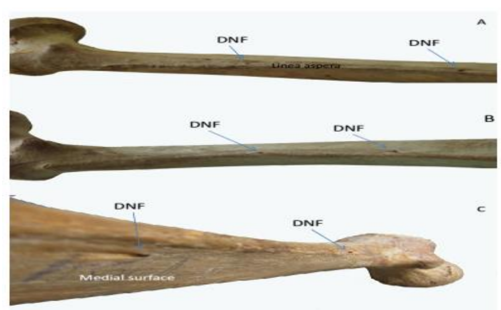


Table 2: Occurrence if DNA in the vertical zones of femur

Side	Left	Right
LA	23(23%)	23(23%)
ML	9(9%)	9(9%)
LL	7(7%)	8(8%)
MS	11(11%)	7(7%)
LS	2(2%)	1(1%)

Table 3: Presence and anatomy of two sided DNF in femurs with double DNF

Site	Frequency	Percentage
MS,LA	4	19.06
LA,LA	4	!9.06
ML,MS	2	9.52
MS,MS	2	9.52
LA,ML	2	9.52
LA,LL	2	9.52
ML,ML	1	4.76
LL,MS	1	4.76



The more proximal of the two diaphyseal nutrient foramen was found on medial surface while the distal was documented on the lateral aspect of linea aspera

The mean foramen Index of all the studied diaphyseal nutrient foramen (DNFs) was 43.85±7.12. The mean foramen Index of diaphyseal nutrient foramen on the left femurs (45.13±8.79) was significantly higher than that onthe right femurs (41.18±7.15) (p= 0.02).

Table 4: Comparison of results of studies of Diaphyseal nutrient foramen of femur in the indexed literature

Investigator	Population	Sample size	Single DNF	Double DNF
Mysoreks (1962)	Indian (Hindus)	180	49%	51%
Forriol Compos(1987)	Spanish	31	40%	60%
Sendemir (1991)	Turkey	102	54%	46%
Prashanth (2011)	Indian	86	47.7%	42.2%
Anush (2013)	Indian	50	46%	52%
Present study	Nigerian	95	77.9%	22.1%

DISCUSSION

Current research work depicts single diaphyseal nutrient foramen in 83 (83%) of the studied femurs. This is higher than 40-54% stated by previous authers.[9-11] Another finding of present study wad double diaphyseal nutrient foramen noted in 17%. Literature reveals double diaphyseal nutrient by “Prashart et al. (2011); 4.6% by Sendermir and Cimen[11], 51% by Mysorek (1967); 52% by Anusha et al., (2013) and 60% by Forriol et al.[9] Genetic constitution and food habits account for the variability of incidence of diaphyseal nutrient foramen in the wide variety of inhabitants in various regions. Genotypic and phenotypic factors may influence number and site of diaphyseal nutrient foramen (Srivastava et al 2012). Literature survey tells absent diaphyseal nutrient foramen in 1.9% and 4.6% by Gumusburun et al[7] and Prashant et al (2011) though no bone showed absence of diaphyseal nutrient foramen in this research work. Periosteal vessels provide alternative blood supply when femur does not have diaphyseal nutrient foramen (Trueta 1953). It was observed in one femur that direction of the nutrient canal was towards hip joint and it was not straight but slanting. This is stated that similar l growth rate of either of two extremities of bone account for this direction of nutrient foramen. Schwalbe in 1876 and Prashant et al in 2011, have stated that, to start with, the diaphyseal nutrient passage was not curved, but directed straight anteriorly horizontally prior to stage the epiphysis becomes evident. The reason is similar rate of growth at proximal and distal ends of femur. The moment epiphysis becomes evident, the end of femur closer to the knee joint undergoes rapid growth in comparison to proximal end of femur and this eventuates in “the upwards lanting of diaphyseal nutrient foramen. Present study and past research are on same page as far as the occurrence of diaphyseal nutrient foramen along whole length of linear aspera or on either side of it is a discussion point.[10-12] Agreeing with Anushaet al[13] dual diaphyseal nutrient foramena was commonly found in the combined medial surface and linea aspera sites. Diaphyseal nutrient foramen are very uncommon on the “lateral surface of femur” in the current work also on “anterior surface” diaphyseal nutrient foramen are not present so orthopedic surgeons prefer these couple of locations as ideally safe for operative work. Iatrogenic surgical insult to the diaphyseal nutrient foramen at these locations in not possible. The mean foramen index was 2.89 and all, but one, femurs had their nutrient canal directed away from the growing end”. The value of mean foramen index (2.89) in current work is similar to results stated by Pereiraetal[14] (43.7), Forriet al[9] (38.42) and Gumuburun et al[15] (44.82). The decision about a long or short bone graft with profuse blood supply depends upon the size, level and extent of lesion to be managed. Different parts of femur have different blood supply, decision that which artery should be used in bone grafts, depends upon how much segment of the femur is to be grafted. Deep femoral artery is preferred in orthpaedic operative work on diaphysis of femur. Femoral artery, being main arterial channel to lower limb, is taken into use for larger bone grafts. For shorter grafts, number and location of the nutrient foramen is important.[16] In all surgical methods on femur, the ultimate aims and objective is not to inflict injury to diaphyseal nutrient foramen and to preserve the diaphyseal vasculature. The bone graft must be implanted without injuring the diaphyseal nutrient foramen.[17] The existence diaphyseal nutrient foramen is crucial the that part of the donor patient bone to be grafted. This will ensure adequate blood supply of endosteam. Current research was performed beyond gender differentiation the sex difference in FI was not accomplished. Parent vessel from which artery emerged and entered diaphyseal nutrient foramen was not documented.

CONCLUSION

Diaphyseal nutrient foramen is nonexistent in anterior surface of the shaft, less likely to be located on the lateral surface and commonly present on the postero-medial surface in local Pakistani population. Double diaphyseal nutrient foramen was found on lesser femurs compared to other regions. Information about diaphyseal nutrient foramen is crucial postoperative success microvascular bone graft which ensures profuse vasculature of endo-periosteal areas of femur.

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