Original research article

An observational study to analyse the morphometrical and topographical variations of nutrient foramina in human clavicles of Gaya, Bihar, India

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Abstract

Background: The nutrient artery, which enters the bone shaft through the nutrient foramen, is the principal source of the blood to a long bone, particularly during its growth period in the embryo and fetus, as well as during early phases of ossification during childhood. From recent hypothesis it has been confirmed that vascularized bone and joint allograft survival depends strongly on the blood supply of bone.

Aim: to determine the morphometrical and topographical variations of nutrient foramina in human clavicles of Gaya, Bihar, India.

Material and methods: The study material consisted of 100 dry human clavicles of unknown age and sex, without any deformity or fracture, which were collected from the Department of Anatomy. All the bones were macroscopically observed using magnifying handlens for the number, position and direction of the nutrient foramina. The nutrient foramina were identified by the presence of a well marked groove and often with slightly raised edge at the commencement of the canal. The distance of foramina from the sternal end & the total length of the clavicle were measured in millimeters, ignoring curves of clavicle. **Results:** The foramina were single in 41(41%) clavicles, double in 53 cases (53%), and more than two foramina in 6 clavicles (6%). Most of the right clavicles contained single foramina (28%) whereas left clavicles contained double foramina (33%). Three foramen were found in 2 clavicle of right side and 4 clavicles in left side. Total 110 number of nutrient foramen was found, out of which, 34.54% foramen were on inferior surface and 65.46% foramen were on posterior surface of the clavicles. Percentage of clavicle containing nutrient foramina on inferior surface was 47.5% and on posterior surface was 52.5%. Total number of clavicles considered was 80 as some clavicles contained nutrient foramen on both posterior and inferior surfaces. We found 18.18% foramens at the medial 1/3 region, 71.82% at the middle 1/3 region and 10% at the lateral 1/3 region of the shaft of the clavicles. In our study 63.75% of clavicles contained nutrient foramen in middle one third region, 23.75% contained on medial one third and 12.5 % on lateral one third. Average distance of the foramina from the sternal end was found to be 66.3 mm (6.63 cm) and the average total length of clavicles was 13.12 cm resulting in the mean foraminal index of 51.77.

Conclusion: Nutrient foramina vary in their position, number and distribution on the bone surface. Knowledge of nutrient foramen is helpful in surgical procedures like bone grafting and in microsurgical bone transplantation.

Keywords: Clavicle, nutrient foramen, foramen index, sternal end, growing end.

Introduction

The Clavicle is a modified long bone placed horizontally and subcutaneously at the root of neck. It also transmits the weight from upper limb to the axial skeleton. The inferior surface of shaft of clavicle presents a subclavian groove. A Nutrient foramen lies at the lateral end of the groove running in a lateral direction.[1] These nutrient foramina allow blood vessels and the peripheral nerves to pass through the cortex into the medullary cavity of a bone. From fetal age, the bones adapt to the presence of naturally occurring holes which are known as nutrient foramen The location and number of nutrient foramina remains a nonconstant feature in long bones.[2] A nutrient foramen of clavicle is found in the lateral end of the subclavian groove running in lateral direction. This foramen transmits the nutrient artery and at times, the supraclavicular nerve.[3]In contrast, in one study it was reported that clavicle is supplied only by periosteal arteries and the nutrient artery is not found.[4] However, the nutrient foramina of the clavicle are clinically important as these are involved in the repair of clavicular fracture, which produces obvious neurovascular complication like supraclavicular nerve entrapment syndrome and brachial plexus injury. The traditional view that the vast majority of clavicular fractures heal with good functional outcomes following nonoperative treatment is no longer valid. Recent studies have identified a higher rate of nonunion and specific deficits of shoulder function in subgroups of patients with this injuries.[5] Thus, orthopaedic procedures like nail plating, K wire fixation and more recently microsurgical vascularized bone transplantation are becoming popular. The knowledge of nutrient foramen is important in surgical procedures like bone grafting and more recently in microsurgical vascularized bone transplantation. As these techniques are becoming popular, information relating to the anatomical description of these foramina is of vital importance to preserve the circulation of affected bony structure. It is also of relevance to the orthopedician involved in surgical procedure where patency of arterial supply is crucial and it should be preserved to promote fracture repair.[6,7] In free vascular bone grafting, the nutrient blood supply is extremely important and must be preserved to promote fracture repair, a good blood supply being necessary for osteoblast and osteocyte cell survival, as well as facilitating graft healing in the recipient.[8,9] Accordingly the present study was conducted to determine the morphometrical and topographical variations of nutrient foramina in human clavicles of Gaya, Bihar, India.

Materials and methods

The study material consisted of 100 dry human clavicles of unknown age and sex, without any deformity or fracture, which were collected from the Department of Anatomy, Anugrah Narayan Magadh Medical College and Hospital,gaya, Bihar, India, for one year, after taking the approval of the protocol review committee and institutional ethics committee.

Methodology

All the bones were macroscopically observed using magnifying handlens for the number, position and direction of the nutrient foramina. The nutrient foramina were identified by the presence of a well marked groove and often with slightly raised edge at the commencement of the canal. The distance of foramina from the sternal end & the total length of the clavicle were measured in millimeters, ignoring curves of clavicle. The foramen index was calculated by applying the Hughes formula: FI = (DNF/TL) x 100. DNF = the distance from the proximal end (sternal end) of the clavicle to the nutrient foramen. TL = total length of clavicle.[10]

Results

The foramina were single in 41(41%) clavicles, double in 53 cases (53%), and more than two foramina in 6 clavicles (6%). Most of the right clavicles contained single foramina (28%)

whereas left clavicles contained double foramina (33%). Three foramen were found in 2 clavicle of right side and 4 clavicles in left side (Table 1).

Table 1: No. of Nutrient Foramen in Clavicles

Number of Nutrient Foramen	Right Clavicle (n=50)	Left Clavicle (n=50)	Total (n=100)
One	28(28%)	13 (13%)	41(41%)
Two	20 (20%)	33 (33%)	53 (53%)
Three	2 (2%)	4(4%)	6 (6%)

Total 110 number of nutrient foramen was found, out of which, 34.54% foramen were on inferior surface and 65.46% foramen were on posterior surface of the clavicles. Percentage of clavicle containing nutrient foramina on inferior surface was 47.5% and on posterior surface was 52.5%. Total number of clavicles considered was 80 as some clavicles contained nutrient foramen on both posterior and inferior surfaces (Table 2).

Table 2: Showing surface-wise distribution of Nutrient Foramen in Clavicles

Surface	Number of Nutrient Foramen	Number of Clavicle
Inferior	38 (34.54%)	38 (47.5%)
Posterior	72 (65.46%)	42 (52.5%)
Total	110	80

We found 18.18% foramens at the medial 1/3 region, 71.82% at the middle 1/3 region and 10% at the lateral 1/3 region of the shaft of the clavicles. Percentage-wise calculation of clavicles containing these foramens at different regions was also done. Total number of clavicles were 80 as some clavicles contained more than one foramina at different regions (medial, middle or lateral). In our study 63.75% of clavicles contained nutrient foramen in middle one third regions, 23.75% contained on medial one third and 12.5 % on lateral one third (Table 3).

Table 3: Showing length-wise distribution of Nutrient foramen in clavicle

Region of Clavicle	Number of Nutrient Foramen	Number of Clavicle
Medial 1/3 rd	20(18.18%)	19 (23.75%)
Middle 1/3 rd	79 (71.82%)	51(63.75%)
Lateral 1/3 rd	11 (10%)	10 (12.5%)
Total	110	80

Average distance of the foramina from the sternal end was found to be 66.3 mm (6.63 cm) and the average total length of clavicles was 13.12 cm resulting in the mean foraminal index of 51.77 (Table 4).

Table 4: Foramen Index

DNF in mm.	TL in mm.	FI
66.3	131.23	51.77

Direction of all nutrient foramina was found to be away from the growing end i.e. away from the sternal end.

Discussion

The nutrient foramen is defined as the largest foramen present on the shaft of long bone allowing nutrient artery to enter the bone, the role of which is important in providing nutrition and growth of long bones. Healing of fractures, as of all wounds, is dependent upon blood supply.[11-12] Injury to the nutrient artery at the time of fracture, or at subsequent surgeries, may be a significant factor predisposing to faulty union.[13-16] If surgeons could avoid a limited area of the cortex of the long bone containing the nutrient foramen, particularly during an open reduction, an improvement in the management of this problem might be attained. Recent results

confirmed the hypothesis that vascularized bone and joint allograft survival depends strongly on the blood supply of bone. Anatomical factors were suspected to be responsible for this phenomenon. Thus the knowledge of anatomy of nutrient foramina is significantly important for orthopaedic surgeons doing open reduction of fracture, in order to avoid injuring nutrient artery and there by lessens the chances of delayed or non-union of fracture.[17]

Total 110 number of foramina were found in all 100 clavicles and most of the clavicles (53%) presented double foramina. Most of the foramina were present in middle third region (71.82%) and also on posterior surface (65.46%) of the study clavicles. Similarly most of the study clavicles presented the nutrient foramina in middle third region (66.10%) and also in posterior surface (50.82%).

Rai *et al*. studied total 65 foramina in 40(100%) clavicles where 15.4% foramina were present at medial 1/3rd region, 73.8% at middle 1/3 rd region and 10.8% at lateral 1/3 rd region; 35.4% foramina were on inferior surface and 64.6% on posterior of clavicles.[18] Single foramina were present in 17 (42.5%) clavicles, double foramen in 21(52.5%) specimens and more than two foramina in clavicles (5%). Foramina were present on inferior surface in 42.6% clavicles and on posterior surface in 57.4% of clavicles. Murlimanju *et al*. found single nutrient foramina in 20 (38.5%) clavicles, two foramina in 23 (44.2%) specimens, and more than two foramina in 7 (13.4%) clavicles.[19] Foramina were present at middle 1/3rd region in 92.3% clavicles, at medial 1/3rd region in 9.6%, and at lateral 1/3rd region in 1.9% clavicles; on inferior surface in 55.8% clavicles, on posterior surface in 69.2%, and on superior surface only in 1.9%. The average distance of the foramen from sternal end was 64.4 mm, and the mean foraminal index was 44.72. Thus foramina were more common on posterior surface and were often multiple, directed toward the acromial end.

In our study, Average distance of the foramina from the sternal end was found to be 66.3 mm (6.63 cm) and the average total length of clavicles was 13.12 cm resulting in the mean foraminal index of 51.77. The findings of the present study are similar to those of Rai *et al*. who found the average distance of the nutrient foramen from the sternal end to be 67.6 mm and the mean foraminal index to be 48.01.

Conclusion

Nutrient foramina vary in their position, number and distribution on the bone surface. Knowledge of nutrient foramen is helpful in surgical procedures like bone grafting and in microsurgical bone transplantation.

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