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Morphological and Topographical Assessment of Nutrient Foramina of the Clavicle: A Study with Clinical Implications

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ABS TRAC T

Background: The clavicle is a horizontally oriented bone that connects the upper limb with the axial skeleton and contributes substantially to the stability and mobility of the shoulder girdle. Its vascular supply is clinically important during fracture fixation, reconstructive procedures, and vascularized bone grafting. Nutrient foramina provide passage for nutrient arteries and demonstrate considerable variation in their number, position, and direction. The present study was undertaken to assess the morphological and topographical characteristics of nutrient foramina in human clavicles and to discuss their clinical importance.

Materials and Methods: A total of 100 dried human clavicles obtained from Maharashtrian cadaveric material were examined, consisting of right and left clavicles. Specimens showing damage, deformity, or significant pathological changes were excluded. Each clavicle was examined for the number, surface position, regional location, and direction of the nutrient foramen. The distance of the nutrient foramen from the sternal end and the total length of the clavicle were measured. The foramen index was calculated using the Hughes formula: FI = (DS/TL) × 100.

Results: At least one nutrient foramen was identified in every examined clavicle. A single nutrient foramen was reported in 70% of specimens, two foramina in 24%, and three foramina in 6%. The posterior surface was the most frequent site, accounting for 55.88% of observed foramina, followed by the inferior surface at 41.17% and the superior surface at 2.94%. The middle one-third was the most common regional location, accounting for 70.58%, followed by the lateral one-third at 19.11% and medial one-third at 10.29%. The mean distance of the nutrient foramen from the sternal end was 69.63 mm, while the mean clavicular length was 133.26 mm. The calculated foramen index was 52.25. The nutrient canals were directed toward the acromial end.

Conclusion: The nutrient foramina of the clavicle show considerable variation in number and location, although a predominance of a single foramen, posterior-surface location, and middle-third distribution was observed. Recognition of these anatomical patterns is important during clavicular surgery, internal fixation, and procedures involving vascularized bone grafts because preservation of the nutrient blood supply may contribute to satisfactory bone healing.

Keywords: *Clavicle; Nutrient foramen; Nutrient artery; Foramen index; Morphometry; Anatomical variation; Bone vascularity.*

INTRODUCTION

The clavicle is a distinctive long bone situated horizontally at the junction of the upper limb and thorax. It serves as an important structural component of the shoulder girdle and helps maintain the upper limb away from the trunk while transmitting forces between the upper limb and axial skeleton. Anatomically, the clavicle consists of a medial or sternal end, a lateral or acromial end, and an intervening shaft with characteristic changes in its morphology along its length.

Like other long bones, the clavicle possesses nutrient foramina through which nutrient vessels enter the bone. The nutrient artery has an important role in maintaining the vascularity of osseous tissue, particularly during

growth and repair. The direction of the nutrient canal generally follows the established principle that the canal is directed away from the growing end of the bone.

The number and location of nutrient foramina may differ among individuals and populations. Such anatomical variations have practical importance in orthopedic and reconstructive surgery. During internal fixation of clavicular fractures, extensive exposure or inappropriate placement of implants may potentially interfere with vascular structures. Similarly, knowledge of nutrient vascularity is relevant when planning vascularized bone grafts and other reconstructive procedures.

The present article provides a related assessment of the morphological and topographical characteristics of clavicular nutrient foramina, emphasizing their possible clinical relevance.

AIM

To evaluate the morphological and topographical characteristics of nutrient foramina of the clavicle and to assess their clinical significance in relation to clavicular surgical procedures.

OBJECTIVES

- To determine the number of nutrient foramina present in the clavicle.
- To identify the surface on which the nutrient foramen is most frequently located.
- To determine the distribution of nutrient foramina across the medial, middle, and lateral thirds of the clavicle.
- To assess the direction of the nutrient canals.
- To calculate the foramen index using the distance from the sternal end and the total clavicular length.
- To discuss the relevance of nutrient foramina to surgical procedures involving the clavicle.

MATERIALS AND METHODS

Study Design

The study was an observational anatomical study based on the examination of dried human clavicles.

Study Material

A total of 100 dried human clavicles from Maharashtrian cadaveric material were examined in the Department of Anatomy. The source study describes the sample as comprising right and left clavicles. The age and sex of the specimens were not available.

Inclusion Criteria

Apparently intact clavicles without gross deformity were included for examination.

Exclusion Criteria

Clavicles showing damage, deformity, or significant pathological abnormalities were excluded from the investigation.

Examination of Nutrient Foramina

Each clavicle was examined for the number of nutrient foramina, surface position, regional location along the shaft, direction of the nutrient canal, distance from the sternal end, and total length of the clavicle. A magnifying lens, hypodermic needle, and digital vernier caliper were used during the examination.

Measurement of Foramen Index

$FI = (DS / TL) \times 100$

FI = Foramen Index; DS = Distance of nutrient foramen from the sternal end; TL = Total length of the clavicle.

RESULTS

A nutrient foramen was identified in every examined clavicle. The reported distribution showed that 70% of clavicles possessed a single nutrient foramen, 24% had two foramina, and 6% had three foramina. The total number of nutrient foramina reported across the specimens was 136.

Table 1. Distribution of nutrient foramina according to number

Number of nutrient foramina	Right	Left	Total
1	16 (64.0%)	19 (76.0%)	35 (70.0%)
2	7 (28.0%)	5 (20.0%)	12 (24.0%)
3	2 (8.0%)	1 (4.0%)	3 (6.0%)

The posterior surface represented the most frequent site of nutrient foramina, followed by the inferior and superior surfaces. Overall, 55.88% were located on the posterior surface, 41.17% on the inferior surface, and 2.94% on the superior surface.

Table 2. Surface distribution of nutrient foramina

Surface	Right	Left	Total
Posterior	22 (61.11%)	16 (50.0%)	38 (55.88%)
Inferior	14 (38.88%)	14 (43.75%)	28 (41.17%)
Superior	0	2 (6.25%)	2 (2.94%)

With respect to longitudinal location, the middle one-third of the clavicle showed the highest concentration of nutrient foramina. Overall, 70.58% were located in the middle third, followed by 19.11% in the lateral third and 10.29% in the medial third.

Table 3. Regional distribution of nutrient foramina

Region of clavicle	Right	Left	Total
Medial 1/3rd	3 (8.33%)	4 (12.50%)	7 (10.29%)
Middle 1/3rd	26 (72.22%)	22 (68.75%)	48 (70.58%)
Lateral 1/3rd	7 (19.44%)	6 (18.75%)	13 (19.11%)

The mean distance of the nutrient foramen from the sternal end was 69.63 mm, and the mean total clavicular length was 133.26 mm. The corresponding foramen index was 52.25. All nutrient foramina were reported to be directed away from the sternal end, toward the acromial end.

Table 4. Morphometric measurements and foramen index

Parameter	Mean value
Distance from sternal end (DS)	69.63 mm
Total clavicle length (TL)	133.26 mm
Foramen Index (FI)	52.25

DISCUSSION

The nutrient foramen is an important anatomical feature because it provides a pathway for vessels entering the bone. Variation in its number, position, and direction may influence the approach used during surgical procedures involving the clavicle.

In the present analysis, a single nutrient foramen was the most frequently reported pattern, occurring in 70% of clavicles. Two foramina were observed in 24%, while three were identified in 6%. These findings were broadly comparable with the values reported by Malukar et al. and Ruchi Ratnesh et al., whereas Rahul Rai et al. reported a relatively higher proportion of clavicles with two nutrient foramina.

The surface distribution demonstrated a clear predominance of the posterior surface, accounting for 55.88% of the observations. This finding corresponds closely with the observations of Malukar et al. and Rahul Rai et al. In contrast, Ruchi Ratnesh et al. reported the inferior surface as the predominant location. Such differences may reflect population-related variation or differences in sampling and anatomical assessment.

The middle one-third of the clavicle was the most common location for the nutrient foramen, accounting for 70.58% of the observations. This finding is consistent with the 73.8% reported by Rahul Rai et al. The concentration of nutrient foramina within the middle third is of particular relevance because this region is commonly involved in clavicular fractures and is frequently approached during operative fixation.

The mean distance of the nutrient foramen from the sternal end was 69.63 mm, with a calculated foramen index of 52.25. The reported values were comparable with previous observations, including the findings of Rahul Rai et al., who reported a mean distance of 67.6 mm and a foramen index of 48.01, and Santosh K. Sahu et al., who reported a mean distance of 65.8 mm and a foramen index of 52.06.

The direction of the nutrient canals toward the acromial end is consistent with the general anatomical principle that nutrient canals are directed away from the growing end. Awareness of this directional pattern may assist anatomists and surgeons in understanding the vascular architecture of the clavicle.

From a clinical perspective, preservation of the nutrient vessels is important during operative management of clavicular fractures and reconstructive procedures. Excessive stripping of the periosteum or disruption of vascular channels may potentially compromise local vascularity. Similarly, knowledge of nutrient foramina may be useful when designing vascularized bone grafts.

Comparative Analysis with Previous Studies

Table 5. Comparison of nutrient foramen characteristics

Parameter	Malukar et al.	Rahul Rai et al.	Ruchi Ratnesh et al.	Present study
Single foramen	68%	42.50%	65%	70%
Two foramina	21%	52.50%	26.66%	24%
More than two	10%	5%	8.33%	6%
Superior surface	1.40%	—	1.66%	2.94%
Inferior surface	42.50%	35.40%	72.90%	41.17%
Posterior surface	56.30%	64.60%	26.74%	55.88%
Medial 1/3rd	8.40%	15.40%	11.66%	10.29%
Middle 1/3rd	59.10%	73.80%	66.66%	70.58%
Lateral 1/3rd	32.30%	10.80%	21.66%	19.11%
Direction	Toward acromial end	Toward acromial end	Toward acromial end	Toward acromial end

The comparative data demonstrate that although the exact percentages differ between studies, the middle one-third and an acromial-directed nutrient canal are recurrent observations. The present study also showed a posterior surface predominance.

Clinical Significance

• Clavicular fracture fixation: The middle third is a frequent location of nutrient foramina and is also clinically important in clavicular fractures. Surgeons should therefore consider the vascular anatomy during fixation.

• Preservation of blood supply: Avoiding unnecessary disruption of nutrient vessels and surrounding soft

tissues may help preserve local bone vascularity.
• Vascularized bone grafting: Knowledge of nutrient artery entry points may assist in planning procedures requiring preservation of osseous blood supply.
• Anatomical education: Knowledge of the variable number and location of nutrient foramina is important for undergraduate and postgraduate anatomical training.
• Radiological and surgical correlation: Awareness of normal anatomical variation can assist in interpreting imaging findings and planning operative approaches.

Limitations

The study has several limitations. The original investigation was restricted to 100 clavicles from a Maharashtrian population, and demographic information such as age and sex was unavailable. Consequently, the findings cannot necessarily be generalized to all populations. The study also did not evaluate possible ethnic, geographical, age-related, or sex-related differences in nutrient foramen morphology. In addition, the original report does not provide sufficient information regarding specimen preservation procedures. Such information could be relevant when interpreting morphometric characteristics. Larger multicentric studies involving specimens with known demographic characteristics would provide stronger evidence regarding population-based anatomical variation.

Data consistency note: The source manuscript states that 100 clavicles were examined, but some of the displayed tables use right and left groups of 25 specimens, while the Methods section describes 50 right and 50 left clavicles. The numerical tables should therefore be checked against the original laboratory records before publication.

CONCLUSION

The clavicle demonstrates considerable variation in the number and topographical distribution of nutrient foramina. In the present analysis, a single nutrient foramen was the most frequent pattern, while the posterior surface represented the predominant surface location. The middle one-third of the clavicle showed the greatest concentration of nutrient foramina. The mean distance from the sternal end was 69.63 mm, and the calculated foramen index was 52.25. Nutrient canals were directed toward the acromial end.

These anatomical observations emphasize the importance of understanding clavicular vascular anatomy during internal fixation, fracture management, and vascularized bone grafting. Preservation of the nutrient blood supply should be considered whenever surgical intervention involves the clavicular shaft.

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Conflict of Interest

The source article reported no conflict of interest.

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