Morphometric Study of Nutrient Foramen of Human Adult Humerus and Its Clinical & Medico-legal Implications

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Humerus, Nutrient artery, Surgery, Orthopedics, Anatomy.

ABSTRACT
BACKGROUND: Nutrient arteries, along with other arteries supplying the humerus, are crucial not only for the healing of serious injuries such as humeral shaft fractures but also for microsurgical vascularized bone transplantation. Therefore, understanding the precise location and morphometry of nutrient foramen in bones like the humerus is essential to prevent common complications, such as non-union of fractures. This study aims to examine the location and topography of nutrient foramen in the humerus and to establish their clinical & medico-legal significance.
MATERIAL METHODS: The study was conducted on 400 dried adult humerus bones of both sexes from Western Uttar Pradesh, sourced from the Department of Anatomy & Department of Forensic Medicine & Toxicology at Mahatma Vidur Autonomous State Medical College, Bijnor. Measurements and observations were carried out using an osteometric board.
RESULT: Nutrient foramen was absent in 30 humerus (7.50%), single in 76.50%, and double in 16% of cases. Most humerus had medium-sized foramina (1-2 mm) on both the left and right sides, accounting for 78.80%. The majority of foramina were found on the anteromedial surface (85.02%), with fewer on the posterior surface. Additionally, most foramina were located in the middle third of the humeral diaphysis.
CONCLUSION: Surgeons and orthopedists must possess precise knowledge of the number, size, shape, direction, and location of the nutrient foramen to accurately assess the humerus's vascular supply and avoid injury during surgical procedures. Morphometric data is also essential in identifying unknown remains, evaluating the severity and timing of trauma, and determining potential surgical complications in cases of medical malpractice.

1. Introduction

In recent times, changes in lifestyle, growing human desires, and increased use of machines have led to a rise in bone injuries and fractures. Proper blood supply plays a major role in ensuring adequate oxygen delivery, which is crucial for the healing of wounds and

fractures [(1)]. Blood supply to long bones comes from nutrient, periosteal, metaphyseal, and epiphyseal arteries. The primary source among these is the diaphyseal nutrient artery. These nutrient arteries enter the shaft obliquely through nutrient foramina, which are typically located consistently and directed away from the growing end, the epiphysis. [(2)]. The position of nutrient foramen in mammalian bones can vary and may change during the growth process [(3)]. Understanding the location and structure of nutrient foramen in bones is essential for surgical procedures like microvascular bone transfer, as it helps in preserving proper blood circulation. [(4)]. Understanding the position, number, and variations of nutrient foramen can be a valuable tool in medico-legal practice. This study aimed to document the size, location, and quantity of nutrient foramina in the humerus of adults from the Western Uttar Pradesh population.

2. Material and Methods

A total of 400 dried, macerated adult human humerus from both sexes (200 right and 200 left) of Western Uttar Pradesh were selected for a morphometric study of nutrient foramen. The study was conducted by the Department of Anatomy & Department of Forensic Medicine & Toxicology at Mahatma Vidur Autonomous State Medical College in Bijnor, Uttar Pradesh, India. The instruments used included an osteometric board, metallic calibrated wires of 0.5 mm, 1 mm, 2 mm, and 2.5 mm in diameter, a magnifying hand lens, measuring

tape, scale, and divider. Digital cameras were used to photograph the specimens. All bones were thoroughly examined with a hand lens to ensure no foramen was overlooked. Identification of the nutrient foramen was confirmed using fine wire. The size of each foramen was measured using metallic wires of various diameters, categorizing them as small (diameter less than 1 mm), medium (diameter between 1-2 mm), and large (diameter greater than 2 mm). The number and location of foramina was measured and documented. Statistical analysis was conducted using SPSS version 25.0, and data were collected via Excel sheets (MS Excel software) from the medical records department. All graphs and tables were compiled using MS Excel.

3. Observation and Results

Table I: Incidence of no. of nutrient foramina in the humerus

Side and No. of bones	Absent (0)	One (1)	Two (2)	Three (3)
Right (200)	16 (8%)	150 (75%)	34 (17%)	0
Left (200)	14 (7%)	156 (78%)	30 (15%)	0
Total (400)	30 (7.5%)	306 (76.5%)	64 (16%)	0

The nutrient foramina were classified by their presence or absence and recorded. The frequency ranged from zero to two foramina. Nutrient foramina were absent in 30 humerus (7.50%). The most common observation was a single nutrient foramen, found in 306 bones (76.50%). Two nutrient foramina were present in 64 cases (16%). None of the humerus, either on the left or right side, had three nutrient foramina. (Table 1)

Table II: Incidence of the size of nutrient foramen in the humerus

Side of bone & total no. of Foramina (n)	Small (<1mm)	Medium (1- 2mm)	Large (>2mm)
Right (n=218)	43 (19.80%)	169 (77.52%)	6 (2.68%)
Left (n=216)	35 (16.20%)	173 (80.09%)	8 (3.70%)
Total (434)	78 (17.97%)	342 (78.80%)	14 (3.23%)

The nutrient foramina were classified into three groups based on their diameters: small (<1 mm), medium (1–2 mm), and large (>2 mm). Of the total 434 nutrient foramina observed, the majority were medium-sized, accounting for 78.80% (342), followed by small-sized foramen at 17.97% (78), and large-sized foramen at 3.23% (14). (Table 2)

Table III: Situation of nutrient foramen on different surfaces of the humerus

Side of Bone	Total no. of Bones	Total no. of Foramina	Antero-medial Surface	Posterior Surface	Anterolateral Surface
Right	200	218	184 (84.40%)	28 (12.84%)	6 (2.76%)
Left	200	216	185 (85.65%)	26 (11.96%)	5 (2.39%)
Total	400	434	369 (85.02%)	54 (12.44%)	11 (2.54%)

The position of nutrient foramen on various surfaces of the humerus (200 right and 200 left) was studied, revealing their presence on the anteromedial, anterolateral, and posterior surfaces. Among the 434 nutrient foramina recorded (218 on the right and 216 on the left), 85.02% were located on the anteromedial surface, 12.44% on the posterior surface, and 2.54% on the anterolateral surface. (Table 3)

Table IV: Site of nutrient foramen about different parts of the humerus

Side Of bone	Total no. of bones	Total no. of foramina	Situation of foramen		
			Proximal 1/3rd	Middle 1/3rd	Distal 1/3rd
Right	200	218	1 (0.46%)	211 (96.79%)	6 (2.75%)
Left	200	216	0 (0%)	213 (98.23%)	3 (1.38%)
Total	400	434	1 (0.23%)	424 (97.70%)	9 (2.70%)

The location of the nutrient foramen in relation to different sections of the humerus shaft was also recorded, distinguishing between the proximal, middle, and distal thirds. Of the 434 nutrient foramina (218 on the right and 216 on the left), the majority, 97.70% (424), were found in the middle third, followed by 2.7% (9) in the distal third, and only 0.23% (1) in the proximal third. (Table 4)

4. Discussion

The nutrient artery is the primary source of blood supply to the shaft of the humerus. Understanding the anatomy

of the nutrient foramen is crucial to avoid damaging the artery during surgery, which could lead to bone ischemia. The arcuate artery, a branch of the anterior circumflex artery, supplies blood to the proximal humerus. Additionally, the humerus receives blood from metaphyseal and periosteal arteries, which are branches of the axillary and brachial arteries. In our study, the incidence of a single nutrient foramen was 76.50%, which is consistent with findings by Manjunath and Pramod, who reported it in 80.5% of cases [7] and Arvind Kumar and Rakesh Kumar, who observed it in 80.86% of cases. [10]. In the present study, the occurrence of double foramen was 16%, which aligns with the findings of Manjunath and Pramod, who reported 17.5%, [7] and Arvind Kumar and Rajesh Kumar, who found 13.42%. [10] This is in contrast to Sanjay Kumar's study, which reported an incidence of 3.75%. [8]. In our study, no cases with three foramina were observed, whereas Sanjay Kumar reported an incidence of 1.25% [8] and D. I. Mansur reported 6.32%. [9]. Additionally, our study found an absence of nutrient foramen in 7.5% of humerus, which is consistent with the 5.43% reported by Arvind Kumar and Rajesh Kumar [10]. The nutrient foramen of the humerus were categorized by size into small (<1 mm), medium (1-2 mm), and large (>2 mm). In our study, 17.97% of the humerus had small foramen, 78.80% had medium-sized foramen, and 3.23% had large foramen. A study by S. Chandrasekaran and K.C. Shanthi [6] reported an average foramen size of 0.828 mm. The position of the nutrient foramen on various surfaces of the humerus was assessed in our study. The highest incidence was found on the anteromedial surface (85.02%), followed by the posterior surface (12.44%) and the anterolateral surface (2.54%). These findings align with those of Arvind Kumar and Rajesh Kumar, who reported anteromedial, posterior, and anterolateral incidences of 84.74%, 12.11%, and 3.16%, [10] respectively, and with Chandrasekaran and Shanthi, who reported 89.92%, 8.53%, and 1.53%, [6] respectively. Nutrient foramen were also classified according to their location on different segments of the humerus. In the present study, the majority were found on the middle third of the humerus (97.70%), followed by the distal third (2.07%), and the least number were observed on the proximal third (0.23%). These results are consistent with the findings of Arvind Kumar and Rajesh Kumar, who reported occurrences in the middle third, distal third, and proximal third at 97.63%, 1.84%, and 0.53% [10], respectively. Most of the nutrient foramen were single, although some humerus had more than one. The majority of nutrient foramen were located in the middle third of the humeral shaft, followed by the distal third. The highest incidence of foramen was observed on the anteromedial surface, with fewer on the anterolateral surface, and the least on the posterior surface.

5. Medico-Legal Implication

Age, Sex, and Stature Estimation: The morphometry of the humerus, particularly the location, size, and number of nutrient foramina, can be useful in estimating age, sex, and stature of unknown remains. Population-specific variations in these parameters are particularly valuable for forensic anthropologists.

Surgical Errors and Vascular Compromise: During surgeries such as open reduction or intramedullary nailing of humeral fractures, the inadvertent damage to nutrient foramina can result in vascular compromise, leading to complications like non-union or necrosis. In medico-legal cases, morphometric data on the nutrient foramen helps assess whether surgical techniques adhered to anatomical landmarks.

Nutritional and Pathological Conditions: The size and morphology of nutrient foramina may vary with certain conditions such as osteoporosis or malnutrition. Forensic experts can use changes in these anatomical features to infer underlying health conditions, which might be relevant in determining the cause of death or explaining certain pathological fractures.

Ante-mortem vs. Post-mortem Injury Identification: Nutrient foramina can help in differentiating trauma patterns. The degree of vascularity can indicate whether a fracture was healing at the time of death (ante-mortem) or occurred post-mortem, helping to clarify the manner of death.

Archaeological and Mass Disaster Cases: The morphometry of nutrient foramina has been used to study ancient populations, providing insights into their health, trauma, and living conditions. This can be relevant in forensic cases involving historical investigations or mass burials.

6. Conclusion:

Surgeons and orthopedists must possess precise knowledge of the number, size, shape, direction, and location of the nutrient foramen to accurately assess the humerus's vascular supply and avoid injury during surgical procedures. Morphometric data is also essential in identifying unknown remains, evaluating the severity and timing of trauma, and determining potential surgical complications in cases of medical malpractice.

DECLARATION

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