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MORPHOMETRIC STUDY OF NUTRIENT FORAMINA ON DRIED HUMAN NAVICULAR BONE AND ITS CLINICAL SIGNIFICANCE IN TELANGANA REGION

Anatomy

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ABSTRACT

INTRODUCTION: The navicular bone is one of the tarsal bones present on the medial side of the foot which has an important role in the maintenance of the medial longitundinal arch of the foot. The navicular bone articulates with the head of talus proximally and with cuneiform bones distally.

AIM AND OBJECTIVE: To study the morphometric details of nutrient foramina on dried adult human navicular bones.

MATERIAL AND METHODS: The study was done on 100 dried adult human navicular bones (50 right and 50 left) of unknown sex available in the Department of Anatomy, Osmania Medical College, koti, Hyderabad and other medical colleges of Telangana. Damaged bones were omitted from the study. A magnifying hand lens was used to observe the location and the number of foramina on various surfaces of the bone .The parameters studied for the vasculature of navicular bone were the location, number, shape, and size of the nutrient foramina.The midpoint of the navicular tuberosity was taken as the reference point (RP). The distance of each foramen on the dorsal surface measured from the reference point .The distance from the RP to the most prominent point on the lateral surface of navicular bone was taken as the length of navicular bone. All measurements were made using the digital vernier caliper with accuracy of 0.01 mm.

RESULTS: All the navicular bones showed the nutrient foramina over the nonarticular surfaces. The foramina were observed over the medial, lateral, dorsal and plantar surfaces of the navicle. The dorsal surface presented maximum number of foramina followed by the plantar and lateral surfaces. The number of foramina ranged from 1 to 12 in each navicular bone. On the medial surface the foramina ranged between 0 to 6, lateral surface ranged between 1 to 8 and plantar surface between 1 to 10. The number of the foramina at the dorsal surface varied between 3 to 10 with a mean of 6 foramina . The shape of the nutrient foramen was oval or circular in appearance (Fig. 2). Majority of the foramina 1,420 (96%) were circular in appearance and 59 foramina (4%) were oval in appearance. A total of 1,479 nutrient foramina size was measured in 100 navicular bones. Majority of the foramina 1,449 (98%) were <1 mm in size and 30 foramina (2%) were ≥1 mm in size. A P-value less than 0.05 was taken statistically significant.

CONCLUSION: The navicular bone is supplied by more than one artery hence the knowledge of the nutrient foramina is important to understand the pathogenesis and management of navicular bone fractures. Navicular stress fracture is common among athletes and may have devastating consequences including avascular necrosis .Thus, the knowledge about the nutrient (vascular) foramina of the navicular bone becomes important for anatomist, orthopaedic and vascular surgeons.

KEYWORDS

Nutrient Foramina,navicular Bone,navicular Tuberosity,navicular Fractures.

INTRODUCTION:
The navicular bone is one of the tarsal bones present on the medial side of the foot which has an important role in the maintenance of the medial longitundinal arch of the foot. The word navicular in Latin means a little ship [1]. Proximally, the navicular bone consists of an ovoid shape concave surface that articulates with the head of the talus. At its distal end the bone has smooth areas known as articular facets, which articulate with the three cuneiform bones. Both the convex dorsal and concave plantar surfaces of the bone are roughened and give attachment to different ligaments. The medial surface is also rough and contains a prominent tuberosity, the navicular tuberosity. This tuberosity is separated medially from the plantar surface by a groove. The lateral surface is irregular and contains a facet for articulation with the cuboid. The medial plantar artery supplies the plantar surface of the navicular bone. The dorsal aspect of the bone is supplied directly or from a branch of the dorsalis pedis artery and the anastomosis between the medial plantar and dorsalis pedis arteries supplies the navicular tuberosity.

AIM AND OBJECTIVE: To study the morphometric details of nutrient foramina on dried adult human navicular bones.

MATERIAL AND METHODS:
The study was done on 100 dried adult human navicular bones (50 right and 50 left) of unknown sex available in the Department of Anatomy, Osmania Medical College, koti, Hyderabad and other medical colleges of Telangana. Damaged bones were omitted from the study. The side determination of the bones was done using various anatomical features [2]. The nutrient (vascular) foramina were identified by the presence of a well-marked groove leading to foramen indicating the site of vessel entry (Fig. 1A). The navicular bones were macroscopically examined for the foramina on both articulating and non-articulating surfaces. The parameters studied for the vasculature of navicular bone were the location, number, shape, and size of the nutrient foramina. A magnifying hand lens was used to observe the location and the number of foramina on various surfaces of the bone. The shape of the foramina was determined by observing the marginal outline of the foramina on the surface of the bone. Based on this the shape of the foramina were classified as circular or oval in appearance. The size of vascular foramen was measured using a Krischner-wire (K-wire) with diameter of 1 mm. Those foramina which did not allow the K-wire to pass through were classified as <1 mm in size and those which allowed the Kwire to pass through were classified as ≥1 mm in size. The foramina on the dorsal surface were numbered as first, second and so on till ten based on its proximity to the midpoint of the navicular tuberosity. The midpoint of the navicular tuberosity was taken as the reference point (RP). The distance of each foramen on the dorsal surface measured from the RP was taken as D1, D2, D3, D4, D5, D6, D7, D8, D9, and D10. The distance from the RP to the most prominent point on the lateral surface of navicular bone was taken as the length of navicular bone (Fig. 1B). All measurements were made using the digital vernier caliper with accuracy of 0.01 mm. The counting and measurements were done by the same person twice to avoid the inter-observer error.

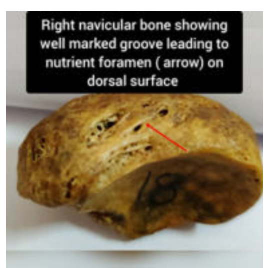

Fig:1-Right navicular bone showing nutrient foramen

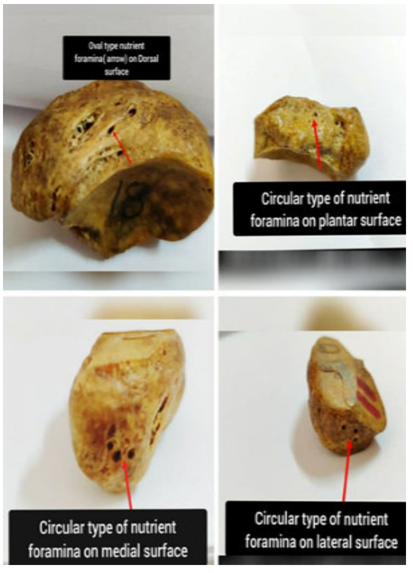

Fig:2-Showing shapes of nutrient foramina on different surfaces

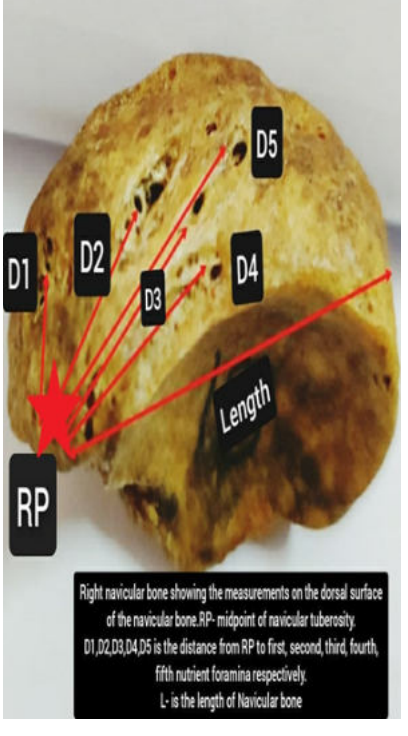

Fig:3-Right navicular bone showing the measurements on dorsal surface of the navicular bone

RP- Refrence point: mid point of navicular tuberosity.
D1,D2,D3,D4,D5 is the distance from RP to first, second, third, fourth, fifth nutrient foramina respectively.

L- length of navicular bone.

RESULTS:

All the navicular bones showed the nutrient foramina over the nonarticular surfaces. The foramina were observed over the medial, lateral, dorsal and plantar surfaces of the navicle (Fig. 2). The proximal and distal surfaces did not show any nutrient foramina. The dorsal surface presented maximum number of foramina followed by the plantar and lateral surfaces. The medial surface presented the least number of foramina. 25% specimens showed complete absence of vascular foramina on the medial surface. The number of foramina ranged from 1 to 12 in each navicular bone. On the medial surface the foramina ranged between 0 to 6, lateral surface ranged between 1 to 8 and plantar surface between 1 to 10. The number of the foramina at the dorsal surface varied between 3 to 10 with a mean of 6 foramina . Total number of foramina in 100 navicular bones are- on Dorsal surface - 612(41.4%), on Plantar surface - 452(30.6%), on Lateral surface – 260(17.6%), on Medial surface-155(10.4%) . On the dorsal surface 60% of the bones exhibited ≥6 foramina and 40% of the bones exhibited <6 foramina. In total 612 foramina observed on dorsal surface , 398(65%) foramina were located within 50% of length of navicular bone. Table 1 summarizes distribution of foramina on various surfaces between the right and left navicular bones. The shape of the vascular foramen was oval or circular in appearance (Fig. 2). Majority of the foramina 1,420 (96%) were circular in appearance and 59 foramina (4%) were oval in appearance. The oval foramina were present only in 30% specimens and their distribution was confined mostly to the dorsal or plantar surface of the navicular bone. A total of 1,479 vascular foramina size was measured in 100 navicular bones. Majority of the foramina 1,449 (98%) were <1 mm in size and 30 foramina (2%) were ≥1 mm in size. The foramina ≥1 mm in size were present only in 25% specimen and their distribution was confined mostly to the dorsal and plantar surfaces of the navicular bone. The mean length of navicular bone was 36.97±2.42 mm. A P-value less than 0.05 was taken statistically significant.

Table:1:- Showing the distribution of vascular foramina on different surface between Right navicle (n=50)and Left navicle (n=50)

Surface	side	Minimum number	Maximum number	p-value
Dorsal	Rt	3	10	0.74
	Lt	3	10	
Plantar	Rt	2	10	0.21
	Lt	1	10	
Lateral	Rt	1	8	0.13
	Lt	1	6	
Medial	Rt	0	5	0.62
	Lt	0	6	

Difference between right and left sides was statistically not significant.

Table:2:-Showing the distance measured on dorsal surface of clavicle(n=100)

Measurement	Mean ±SD		p-value
	Right	Left	
D1	8.27±2.33	8.25±2.33	0.90
D2	10.14±1.50	13.02±3.30	0.76
D3	12.92±2.55	15.39±2.34	0.67
D4	15.29±1.55	17.36±1.98	0.53
D5	17.06±1.89	19.93±1.37	0.71
D6	21.22±2.76	23.59±0.97	0.61
D7	24.36±2.72	25.50±1.36	0.74
D8	26.82±3.15	27.63±3.05	0.74
D9	26.07±1.41	29.05±2.80	0.64
D10	26.46±1.65	30.03±2.52	0.55
Length of navicle	32.52±2.23	36.97±2.42	0.66

Difference between right and left sides was statistically not significant.

DISCUSSION:

The vascularity of the bone along with the biomechanical factors plays an important role in development of navicular stress fracture. A microangiopathic study by Torg et al. [3] on cadaveric feet stated that the navicular bone is supplied by both the anterior and posterior tibial arteries. Another study showed that arterial branches enter at the small "waist" of cortical bone and gets distributed to supply the medial and lateral thirds leaving the central one third as area of relative avascularity [4]. Golano et al. [5] also showed osteonecrosis or stress fractures can affect the navicular bone because of its poor vascularization, especially in its central portion. But, a study done by McKeon et al. [6] on vascularity of navicular bone using modified Spälteholz technique showed that the navicle had a dense intraosseous vascular supply throughout and only 11% bones had an avascular central zone. The branches of the arteries enter the bone through the vascular foramina on its surface. A study by Manners-Smith [7] showed that in human navicular bones, the plantar surface presented many foramina for nutrient vessels. However, the present study findings are different from the earlier report. Our findings showed the presence of nutrient (vascular) foramina on the dorsal, plantar, lateral, and medial surfaces. The occurrence of vascular foramina was a constant feature on the dorsal, plantar, and lateral surfaces. The vascular foramina on medial surface was found to be absent in 25% of the bones. The reason for variation in location of foramina on medial surface could possibly be that the navicular tuberosity receives its blood supply from the anastomosis between the branches of dorsalis pedis and posterior tibial artery as cited by previous studies [5].

The present study showed more number of nutrient (vascular) foramina on the dorsal surface in comparison to the other surfaces of the navicular bone .In the present study, 96% foramina appeared circular and 98% foramina were <1 mm in size. Our study also showed that the vascular foramina which appeared oval and ≥1 mm in size were present mostly on the dorsal and plantar surfaces of the bone. The mean length of navicular bone was 36.97±2.42 mm. Internal fixation has been used to treat acute navicular fractures that cannot be managed conservatively [8]. Knowing the mean length in a population helps in designing of the screw, plates and screw constructs used for internal fixation. The maximum number of vascular foramina was observed on the dorsal surface with 65% foramina present within 50% of the length of navicular bone. Modern operation procedures need a clear understanding of the surrounding anatomy [9].

CONCLUSION:

Understanding the morphological aspects about the structures will set a trend to open more contents into clinical considerations [10]. The present study may be an anatomical guide to surgical interventions involving the navicular bone. The navicular bone is supplied by more than one artery hence the knowledge of the nutrient foramina is important to understand the pathogenesis and management of navicular bone fractures. Navicular is the most frequently injured lesser tarsal bone and an important constituent in the transverse tarsal locking mechanism [1]. Köhler Disease is an osteochondrosis of the navicular bone usually found in children between 4 and 7 years of age. Boys are more commonly affected than girls and it is often unilateral. Loss of blood supply to the bone results in the death of the bony tissue and it collapses. Avascular necrosis of the navicular bone can also occur in adults and is referred to as Müller-Weiss Disease. Acute navicular fractures are broadly classified into three types: avulsion fractures, tuberosity fractures, and body fractures [11]. Tuberosity and displaced body fractures are treated surgically while others are treated conservatively [12]. Navicular stress fracture is common among athletes and may have devastating consequences including avascular necrosis [3,13]. Thus, the knowledge about the vascular foramina of the navicular bone becomes important for anatomist, orthopaedic and vascular surgeons.

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