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RESEARCH ARTICLE

A MORPHOMETRIC STUDY ON THE NUTRIENT FORAMEN OF METACARPAL BONES IN JHARKHAND POPULATION

***Kumari Sandhya and Camellia Chanda**

Department of Anatomy, RIMS, Ranchi

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ABSTRACT

A study was performed on nutrient foramen of metacarpal bones; it included a total of 161 bones of unknown sex and age. The objective was to examine the topography and morphology of nutrient foramen. Nutrient foramen were identified macroscopically and with the help of magnifying glass. It's location in relation to the surface of the bone was examined. The total length of the bone and distance of foramen from the base of metacarpal bone was measured for calculation of foramen index. All the first second and third metacarpal bones showed single foramen whereas 18.75% fourth metacarpals and 9.38% fifth metacarpal bones showed absent foramen also. In majority of first and second metacarpals foramen were located on medial side of palmer surface whereas in case of third fourth and fifth metacarpal bones it was located on lateral side of palmer surface. Mean value of foramen index of 1st, 2nd, 3rd, 4th and 5th metacarpal bones were found respectively as 54.85, 45.84, 41.00, 42.63 and 44.33. An idea of foramen index of metacarpal bones can help surgeons in planning reconstruction surgery on hand.

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INTRODUCTION

The metacarpal bones are the miniature long bones and peculiar in having, epiphysis at one end only. These bones have an opening known as nutrient foramen into the shaft which gives passage to the blood vessels of the medullary cavity . These blood vessels supplying the medullary cavity of the metacarpal bone are known as nutrient artery of the metatarsal bone. The nutrient artery is the artery to the shaft of the long bone and as the name suggests is the main source of blood to any long bone it is the largest among all the arteries supplying long bone i.e.; diaphyseal artery, metaphyseal artery, epiphyseal artery and periosteal plexus .It's role during the active growth period of the bone is very important as it is the principal source of blood to a long bone particularly during its active growth period. Nutrient artery entering the nutrient foramen traverses through a canal to reach the medullary cavity and this canal is known as nutrient canal. The fact that nutrient canal typically becomes slanted during growth and the direction of slant from surface to marrow cavity points away from the fast growing end was established first time by Havers (1691). He stated that the long bone is supplied by a nutrient artery, which enters the bone obliquely through the nutrient foramen, which is directed away, as a rule, from the growing end. Later Berard (1835) explained that this was due to greater longitudinal growth at the faster growing end and thus it was correlated with mode of ossification and growth of bone (Berard, 1835). Still later Clark (1965) stated that greater longitudinal growth at the growing end of a bone resulted in the deflexion of the nutrient artery so that its entrance, which is initially at right angles to the shaft, becomes oblique, the obliquity being directed towards the non-growing end of the bone (LE GROS CLARK, 1965). It is well known that they seek the elbow and flee from the knee. Henderson RG reported that their position in mammalian bones are variable and may alter during the growth (Henderson, 1978). Metacarpal bones has pivotal role in reconstruction and repair procedures done on hand. Bertelli (2004) stated that in long-standing cases of scaphoid non-union of thumb metacarpal, vascularised bone graft has been used successfully via dorsal or palmer approach (Bertelli *et al*., 2004). Bony pedicle grafts arising from the second metacarpal have also been described, mainly for the treatment of recurrent pseudarthrosis of the scaphoid. And the clinical use of this graft has been extended for the management of nonunion of the proximal phalanx of the thumb. Michael (1998) Dubert (1994) has published his article describing a technique in which he performed the so-called "stabilized arthroplasty," In this particular method, fifth-metacarpal base was excised followed by fourth and fifth metacarpal arthrodesis (Dubert, 1994). Most surgeons have preferred to use autologous cancellous bone graft to ensure a

Corresponding author:* **Kumari Sandhya,
Department of Anatomy, RIMS, Ranchi

successful fusion. Yang (2015) also recommended fifth Carpometacarpal arthrodesis in cases of Fifth-Carpometacarpal arthritis causing severe ulnar wrist pain and weakness (Yong Yang *et al*., 2015). He utilized the removed fifth metacarpal base as a bone graft to fuse the proximal parts of the fourth and fifth metacarpal bones to avoid damage to a donor site. Pedro (2010) suggested that the base of the M5 is a suitable donor site of osteochondral grafts for the condyles of P1 based on anatomical grounds (Pedro *et al*., 2010). The metacarpal bones has also been frequently used for construction of split metacarpal musculoosseous flap, in the reconstruction surgery of hand. Therefore vascular anatomy of metacarpal bones needs to be explored thoroughly, including diaphysial, metaphysial & epiphysial artery and periosteal plexus for metacarpal bones separately. Though there are few reports available on the morphology of nutrient foramina of the lower limbs (Kizilkanat *et al*., 2007; Collipal *et al*., 2007; Murlimanju *et al*., 2011), the upper limb foramina that's too of metacarpal bone have rarely been studied. And this fact necessitates for the need of work upon nutrient foramen of metacarpal bone. Present study on topographical aspect of foramen of nutrient artery that is diaphysial artery of metacarpal bone, is one step in this direction to understand this part of blood supply with its variations in a better way.

MATERIALS AND METHODS

The study included 161 unpaired, human metacarpal bones of unknown age and sex which were available in the department of Anatomy, RIMS. Damaged or bones with any pathology were excluded from the study. Foramina for the nutrient artery were identified at first macroscopically and then with the help of magnifying lens on the shaft of all the metacarpal bones, in relation to their number and location. An elastic rubber band was applied around these foramina as landmark so that foramen could not get out of the sight, while working on it for morphometric measurements. Measurements were taken with the help of slide callipers in millimetres. The bones were photographed with the digital camera. The foramina index was calculated by applying the Hughes formula (Hughes, 1952):

FI= (d/l) x 100

Where FI stands for foramen index, d stands for distance of foramen from base and l stands for length of bone

Statistical analysis of indices was done and data were pooled in a tabular fashion

OBSERVATION AND RESULTS

Out of 29 first metacarpal bones studied, all 29 bones showed single foramen. Out of these foramina, 55.17% were present on palmero-medial surface whereas 34.78% foramina were located on palmero-lateral surface. 17.24 % foramina were located on dorsal surface of metacarpal bone but palmer ridge of no metacarpal bone showed any foramen (Table I). In relation to length of the bone these foramina were found to be located in majority (65.51%) of cases on the middle third of the bone. Foramina situated in distal third were 20.68 % and those in proximal third were found to be13.79 % (Table II). Mean value of foramen index for nutrient foramen of first metacarpal was found to be 54.85 with a range of (25-73.8) ±2.34 and SD 12.83 (Table II). Out of 33 second metacarpal bones studied all 33 bones showed single foramen. Out of these 66.67% of foramina were present on palmero-medial surface whereas 33.33% foramina were located on palmero-lateral surface. No foramen was found either on palmer ridge or dorsal surface (Table I). In relation to length of the bone these foramina were found to be located in majority (90.9 %) of cases on the middle third. No Foramina was situated in distal third whereas those in proximal third were found to be 09.09 % (Table II). Mean value of foramen index for nutrient foramen of second metacarpal was found to be 45.84 with a range of (16.9-60) ±1.98 and SD 11.4. (Table II).

Out of 35 third metacarpal bones studied all 35 bones showed single foramen. Out of these 17.14 % of foramina were present on palmero-medial surface whereas 80 % foramina were located on palmero-lateral surface. 2.86% foramen were found on palmer ridge and none was located on dorsal surface (Table I) . In relation to length of the bone these foramina were found to be located in majority (88.57 %) of cases on the middle third. 2.85% foramina were situated in distal third whereas those in proximal third foramina were found to be 8.57 % (Table II). Mean value of foramen index for nutrient foramen of third metacarpal was found to be 41 with a range of (17.6-47.7) ±1.05 and SD 6.22 (Table II). Out of 32 fourth metacarpal bones studied 26 bones showed single foramen. Remaining 6 metacarpal bones did not show any foramina. Out of fifth metacarpal bones studied 27 bones showed single foramen. Remaining 5 metacarpal bones did not show any foramina.

Table I. Table showing location of foramina in relation to different surface of bone

Name of metacarpal bone	No of foramina on PM surface	% of foramina on PM surface	No of foramina on PL surface	% of foramina on PL surface	No of foramina on Ridge	% of foramina on Ridge	No of foramina on Dorsal surfaces	% of foramina on Dorsal surface	Foramen absent	% of absent foramen	Total No. of Foramen	No of metacarpal bones
I	16	55.17	08	34,78	00	-	05	17.24	00	-	29	29
II	22	66.67	11	33.33	00	-	00	-	00	-	33	33
III	06	17.14	28	80	01	2.86	00	-	00	-	35	35
IV	07	26.92	18	69.23	01	3.85	00	-	06	18.75	26	32
V	3	10.34	25	86.20	0	-	1	3.45	03	9.38	29	32

Table II. Table showing distance of nutrient foramen from base of the metacarpal bone and statistical analysis of foramen indices

Name of bone	No of foramina in Proximal third	No of foramina in Middle third	No of foramina in Distal third	Total no of bones studied	Range of F.I.	Mean	SD	SE
I	04	19	06	29	25 -73.8	54.85	12.83	2.34
II	03	30	0	3	16.9-60	45.84	11.4	1.98
III	03	31	01	35	17.6-47.7	41.00	6.22	01.05
IV	02	24	00	32	21.6-59.6	42.63	7.37	01.45
V	02	27	00	32	25.5-56.9	44.33	8.55	1.62

Mean value of foramen index for nutrient foramen of fifth metacarpal was found to be 44.33 with a range of (25.5-56.9) ±1.62 and SD 8.55 (Table II).
All

of these, 26.92 % of foramina were present on palmero-medial surface whereas 69.23 % foramina were located on palmero-lateral surface. 3.85% foramen were found on palmer ridge and none was located on dorsal surface (Table I). Iin relation to length of the bone these foramina were found to be located in majority (75 %) of cases on the middle third. No Foramina were situated in distal third whereas those in proximal third this proportion was found to be 6.25 % (Table II). Mean value of foramen index for nutrient foramen of fourth metacarpal was found to be 42.63 with a range of (21.6-59.6) ±1.45 and SD 7.37 (Table II). Out of 32 fifth metacarpal bones studied, 29 bones showed single foramen. Remaining 3 metacarpals had no nutrient foramina. Out of the foramina on 29 metacarpals, 10.34 % were present on palmero-medial surface whereas 86.2 % were located on palmero-lateral surface. No foramen was found on palmer ridge and 3.45% were located on dorsal surface (Table I) In relation to length of the bone these foramina were found to be located in majority (84.37 %) were located on the middle third . No Foramina was situated in distal third whereas those in proximal third this proportion was found to be 6.25 % (Table II). Direction of foramen showed obeying the law of being away from the growing end.

DISCUSSION

It is evident that most metacarpals have one nutrient foramen only. Patake (1977) in their series found 84.52% metacarpal bones with single foramen, 9.52% with absent foramen while 7.73%bones showed double foramen (Patake and Mysorekar, 1977). Premchandran (2013) in their study found 93.1% metacarpals with single foramen, 2% had double foramina, 0.3% of the bones had triple foramina and in 4.6% of cases the foramen was absent (Premchandran *et al*., 2013). Present study found 94.4 % metacarpal bones with single foramen and 5.6 % bones with absent foramen. Absence of nutrient foramina in the long bones is well known (Liitken, 1950; Mysorekar, 1967). McGregor & DuPlessis (1969), in discussing the blood supply of short long bones, state that after cessation of growth the periosteal vessels take a much larger part in the blood supply of the bone and the nutrient artery becomes relatively unimportant. In cases of absent nutrient foramen, it is therefore likely that the periosteal vessels are entirely responsible for the blood supply of the bone.

Table III. Table showing Mean value of Foramen Index found in different study series

Name of metacarpal bone	Patake	Premchandran	Present study
I	59.43±0.58	60.1	54.85 ± 2.34
II	46.06±0.53	53	45.84 ± 1.98
III	40.83±0.52	43.1	41.00 ± 01.05
IV	43.04±0.59	43.7	42.63 ± 01.45
V	45.91±0.48	45.9	44.33 ±1.62

Out of 29 first metacarpal bones studied all 29 bones showed single foramen, and so morphometry of 29 nutrient foramina was performed in case of first metacarpal bones. Patake in their series found 88.34 % foramina on medial surface, 5.52 % on lateral surface and 9.2% on palmer ridge. Premchandran in their series found 92 % foramina on medial surface, 4 % on lateral surface and 4% on palmer ridge In our study out of 29 foramina 55.17% were present on palmero-medial whereas 34.78% foramina were located on postero-lateral surface 17.24 % foramina were located on dorsal surface of metacarpal bone but palmer ridge of no metacarpal bone showed any foramen (Table I). In relation to length of the bone these foramina were found to be located in majority (65.51%) of cases were located on the middle third. Foramina situated in distal third were 20.68 % and those in proximal third were found to be13.79 % (Table II). Patake in their series found Mean value of foramen index for nutrient foramen of first metacarpal as 59.43 with a range of (40.42-40.00) ±0.58 and SD 7.55. Wheras D Premchandran in their study found the mean value of foramen index of first metacarpal as 60.1 (Table III). In present study mean value of foramen index for nutrient foramen of first metacarpal was found to be 54.85 with a range of (25-73.8) ±2.34 and SD 12.83 (Table II). Out of 33 second metacarpal bones studied all 33 bones showed single foramen, and so morphometry of 33 nutrient foramina was performed in case of second metacarpal bones. Patake in their series found 56.75 % foramina on medial surface of the second metacarpal bones, 29.72 % on lateral surface and 13.51% on palmer ridge, Premchandran in their series found 29.67 % foramina on medial surface of the second metacarpal bones, 63.73 % on lateral surface and 6.59% on palmer ridge. In our series of study 66.67% of foramina were present on palmero-medial whereas 33.33% foramina were located on palmero-lateral surface. No foramen was found either on palmer ridge or dorsal surface (Table I). In relation to length of the bone these foramina were found to be located in majority (90.9 %) of cases were located on the middle third. No Foramina was situated in distal third whereas those in proximal third were found to be 09.09 % (Table II). Patake found Mean value of foramen index for nutrient foramen of second metacarpal was found to be 46.06 with a range of (28.30-69.36) ±0.53 and SD 7.45. D Premchandran in their study found the mean value of foramen index of second metacarpal as 53 (Table III). In the present study mean value of foramen index for nutrient foramen of second metacarpal was found to be 45.84 with a range of (16.9-60) ±1.98 and SD 11.4 (Table II).

Patake in their series found 19.49 % foramina on medial surface of the third metacarpal bones, 64.77 % on lateral surface and 15.72% on palmer ridge, Premchandran in their series found 29.67 % foramina on medial surface of the second metacarpal bones, 63.73 % on lateral surface and 6.59% on palmer ridge. Out of 35 third metacarpal bones studied in present study all 35 bones showed single foramen, and so morphometry of 35 nutrient foramina was performed in case of third metacarpal bones. Out of these 17.14 % of foramina were present on palmero-medial surface whereas 80 % foramina were located on palmero-lateral surface. 2.86% foramen were found on palmer ridge and none was located on dorsal surface (Table I) in relation to length of the bone these foramina were found to be located in majority (88.57 %) of cases were located on the middle third . 2.85% Foramina were situated in distal third whereas those in proximal third foramina were found to be 8.57 % (Table II). Patake found Mean value of foramen index for nutrient foramen of third metacarpal as 40.83 with a range of (29.41-76.60) ±0.52 and SD 6.53. D Premchandran in their study found the mean value of foramen index of third metacarpal as 43.1 (Table III). Mean value of foramen index for nutrient foramen of third metacarpal in our study was found to be 41 with a range of (17.6-47.7) ±1.05 and SD 6.22 (Table II). Patake in their series found 15.52 % foramina on medial surface of the fourth metacarpal bones, 74.02 % on lateral surface and 7.79% on palmer ridge, Premchandran in their series found 18.18 % foramina on medial surface of the third metacarpal bones, 63.73 % on lateral surface and 6.59% on palmer ridge.

Out of 32 fourth metacarpal bones studied in present series, 26 bones showed single foramen, and so morphometry of 26 nutrient foramina was performed in case of fourth metacarpal bones. Out of these foramina found, 26.92 % were present on palmero-medial surface whereas 69.23 % foramina were located on palmero-lateral surface. 3.85% foramen were found on palmer ridge and none was located on dorsal surface (Table I) in relation to length of the bone these foramina were found to be located in majority (75 %) of cases were located on the middle third. No Foramina were situated in distal third whereas those in proximal third this proportion was found to be 6.25 % (Table II). Patake described the Mean value of foramen index for nutrient foramen of fourth metacarpal to be 43.04 with a range of (30.20-78.40) ±0.59 and SD 7.49. D Premchandran in their study found the mean value of foramen index of fourth metacarpal as 43.7 (Table III). Mean value of foramen index for nutrient foramen of fourth metacarpal in present study was found to be 42.63 with a range of (21.6-59.6) ±1.45 and SD 7.37 (Table II). Patake in their series found 2.51 % foramina on medial surface of the fifth metacarpal bones, 92.45 % on lateral surface and 5.03% on palmer ridge, Premchandran in their series found 3.84 % foramina on medial surface of the fifth metacarpal bones, 89.74 % on lateral surface and 6.41% on palmer ridge. Out of 32 fifth metacarpal bones studied 29 bones showed single foramen, and so morphometry of 26 nutrient foramina was performed in case of fifth metacarpal bones in our study. Out of these 26 foramina, 10.34 % were present on palmero-medial surface whereas 86.2 % foramina were located on palmero-lateral surface. No foramen were found on palmer ridge and 3.45% were located on dorsal surface (Table I) In relation to length of the bone these foramina were found to be located in majority (84.37 %) of cases were located on the middle third. No Foramina were situated in distal third whereas those in proximal third this proportion was found to be 6.25 % (Table II). Paatake found in their study the mean value of foramen index for nutrient foramen of fifth metacarpal as 45.91 with a range of (31.70-63.04) ±0.48 and SD 6.03. D Premchandran in their study found the mean value of foramen index of fifth metacarpal as 45.9 (Table III). In our study mean value of foramen index for nutrient foramen of fifth metacarpal was found to be 44.33 with a range of (25.5-56.9) ±1.62 and SD 8.55 (Table II).

Conclusion

On the basis of results found in above study it can be concluded that Foramen index of the nutrient foramen of metacarpal bones could be of help while planning for reconstruction surgeries of hand particularly if it involves the third metacarpal bone.

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