Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-7, Issue-5 | September-October 2021
Page no- 420-426 | Section- Research Article (Anatomy)

Study of Lower End of Fibula and Its Clinical Significance

Vishal Bhadkariya[1], Rupa Chhaparwal[2]*, Sharda Joshi[3], Subhash Joshi[4]

[1]Assistant Professor, Department of Anatomy, Bundelkhand Medical College, Sagar, Madhya Pradesh, India,
Email: anavis23022012@gmail.com,
Orcid ID: 0000-0002-6867-1316
[2]Associate Professor, Department of Anatomy, Sri Aurobindo Medical College and Post Graduate Institute, Indore, Madhya Pradesh, India, Email: cdrupa29@gmail.com,
Orcid ID: 0000-0003-1166-7022
[3]Director Professor, Department of Anatomy, Sri Aurobindo Medical College and Post Graduate Institute, Indore, Madhya Pradesh, India. Email: sharda_joshi02@yahoo.co.in,
Orcid ID: 0000-0002-5446-9811.
[4]Director Professor, Department of Anatomy, Sri Aurobindo Medical College and Post Graduate Institute, Indore, Madhya Pradesh, India. Email: drsdjoshi1@gmail.com,
Orcid ID: 0000-0003-3289-2253

*Corresponding author

Received: 19 May 2021
Revised: 05 July 2021
Accepted: 16 July 2021
Published: 21 August 2021

Abstract

Background: Fibula is the most slender lateral bone of the leg. It provides the surface area for the attachment of the muscles. It forms bony mortice for the ankle joint. It is an ideal cortical bone graft. Fibula plays an important role in the tibiofibular syndesmosis for the stabilization of the talocrural joint. Ankle is one of the most commonly injured joint and very few studies are available on morphometry of the articular surfaces of bones forming the tibio-fibular mortise. Looking to the significant contribution of fibula in the body economy and movements; it has hardly received much attention from the anatomist. Hence this study was undertaken. **Methods**: Forty six (23 Right & 23 Left) dry fibulae were obtained from the department of Anatomy. **Results:** Height & breadth of the articulating surface of the fibula is 19.04 mm & 17.19mm. Taler articular facet is Plane 65.21% and concavo-convex 34.77%. Average surface area of articular facets is 211.73mm. Articular facet is triangular in 76.08%. **Conclusions:** An attempt has been made to elucidate the details of lower end of fibula and to correlate it with its functional significance. The standard osteometry of fibula investigated in this study is novel and unique which may lead to advances in the operative management and design of prosthetics regarding the talocrural joint.

Keywords:- Fibula, Distal end, Talar facet, Bone graft, Talocrural joint, Malleolus.

INTRODUCTION

Humans are the only primates who are bipedal and the body weight is transmitted to the ground through the lower limbs. So some great characteristics have been evolved in humans to keep the body upright. Medial malleolus of tibia and lateral malleolus of fibula form a deep recess to accommodate the body of talus. The body weight is transmitted from the tibia and fibula to the talus and one sixth of the static load of the leg is carried by the fibula at the tibiofibular joint. The lateral malleolus of the fibula form a deep socket to accommodate the body of talus. Fibula rotates laterally, due to the slope of the talar lateral malleolar surface during dorsiflexion at the ankle.[1] Fibula is the most slender lateral bone of the leg.[2] It is an ideal cortical bone graft (common donor site). Fibular flap is most commonly used in head and neck for bony reconstruction.[3] Fibular grafts has proved more successful in the management of extensive bone loss.[4] Looking to the significant contribution of fibula in the body economy and movements; it has hardly received much attention from the anatomist. Hence it was thought prudent to study the morphological features of its lower end which provides for the stability at the ankle as well as transmission of various forces along the shaft of fibula.

As a cursory view point, we begin with recapitulating the functions of fibula including its biomechanics and blood supply which may help in furthering the knowledge about fibula. It provides the surface area for the attachment of most of the extensors, flexors and peroneal muscles. It forms bony mortice for the ankle joint.[5] Lateral malleolus acts as a pulley for the tendons of peroneal muscles, otherwise eversion of the foot will not be possible. It helps in weight transmission. Transmission of load to fibula is from its lower to upper end and is crucial to all sports activities involving movements at the ankle and the knee.[6] Compressive forces directed distally, where the interosseous membrane provides lower leg function by actively involving the fibula in load transference. Fibula plays an important role in the tibiofibular syndesmosis for the stabilization of the talocrural joint.[2] The human fibula responds to its mechanical environment accordingly with foot usage.[7]

Blood supply of fibula is significant for planning free tissue transfer. Peroneal artery gives nutrient vessel to the fibula. Sometimes it may be absent at the distal end. Three arteries of leg connected to form perimalleolar arterial ring. The vascular supply to the fibula bone, is a central factor in ensuring the success of orthopedic procedures, plastic surgeries, and cosmetic surgeries.[8]

Ankle is one of the most commonly injured joint and very few studies are available on morphometry of the articular surfaces of bones forming the tibio-fibular mortise which will help in the reconstruction surgeries and in the manufacture of implants in central Indians. The aim of this study was to evaluate osteometric parameters of lower end of human fibula in central Indian population group.

MATERIAL AND METHODS

Sixty eight (34 Right & 34 Left) dry fibulae of unknown sex were obtained from the department of Anatomy, SAMC & PGI, Indore for this study. Damaged bones were excluded. There are three important areas seen on the medial aspect of lower one-fourth of fibula: a) Rough triangular area which gives attachment to interosseous tibiofibular ligament, b) Triangular articular facet for talus, c) Malleolar fossa. [Figure 1A]. Measurements were taken with digital vernier caliper. All important observations and variations were photographed. Descriptive statistical methods like mean, and percentage was used for depicting data. Surface area of articular facets was measured. Articular facets were mapped out on the graph paper with the help of transparency & surface area was obtained. We counted the smallest square of graph paper (1 smallest square = 1mm). [Figure 3C, Table 1]

Following parameters were recorded:

a) Height and base of rough triangular area.
b) Maximum vertical and transverse length of articular facet.
c) Different shapes of articular facets.
d) Surface of articular facet

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-7, Issue-5 | September-October 2021
Page no- 420-426 | Section- Research Article (Anatomy)

e) Surface area of articular facets was measured.
f) Depth of Malleolar fossa.
g) Formation of apex at the lower end of fibula by articular or non- articular part.
h) Number of vascular foramina in the Malleolar fossa

RESULTS

The results obtained from the present study have been tabulated in [Table 1].

Some important observations:

a) Triangular articular area (Blue) is divided into two by a ridge (Red Dotted Line).Smaller lower triangular area slopes downwards and laterally. A prominent spinous process (yellow arrow) is seen in one fibula projecting superiorly from the posterior end of the bases of two triangles. [Figure 1B]
b) Lower part of triangular articular facet is concave. [Figure 1B,C]
c) Large vascular foramina in the Malleolar fossa. [Figure 1C, 3B, Table 1].
d) Disparity in the size of taller articular facet. [Figure 2A, Table 1]
e) Different shapes of articular facets were noted. [Figure 2B, Table 1]
f) Disparity in the size of the rough triangular area. [Figure 1A,B, Table 1]
g) Apex of the lower end of fibula is formed by articular or non- articular part in 28.25 % and only by non- articular part in 71.73 %. [Figure 3A, Table 1]
h) Taler articular facet is Plane 65.21% and concavo- convex 34.77 [Figure 2C, Table 1]
i) Average surface area of articular facets is 211.73mm. [Figure 3C, Table 1]
j) Malleolar fossa is deep in 73.91% & shallow in 26.08%. [Figure 2C, Table 1]

Table 1: Measurements of lower end of Fibula.

Observations	Right (mean)	Left (Mean)
Rough triangular area - Height (H) / Base (B)	H – 35.67 mm B – 19.30 mm	H – 30.77 mm B – 18.29 mm
Shape of taller articular facet	Triangular – 69.56% Pear – 26.08% Diamond – 4.34% Circular – 0%	Triangular – 82.60% Pear – 13.04% Diamond - 0% Circular - 4.34%
Surface of taller articular facet	Plane – 73.91% Concavo- convex – 26.08%	Plane – 56.52% Concavo- convex- 43.47%
Surface Area of articular facet	208.91mm2	214.56mm2
Dimensions of articular facet- Vertical (V) / Transverse (T)	V -19.02 mm T – 17.54 mm	V -19.06 mm T – 16.84 mm
Depth of Malleolar fossa	Deep – 73.91% Shallow – 26. 08%	Deep – 73.91% Shallow – 26. 08%
Number of vascular foramina	10	10
Apex is formed by	Articular and non- articular part - 34.78% Only by non- articular part – 65.21%	Articular and non- articular part – 21.73% Only by non- articular part- 78.26%

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-7, Issue-5 | September-October 2021
Page no- 420-426 | Section- Research Article (Anatomy)

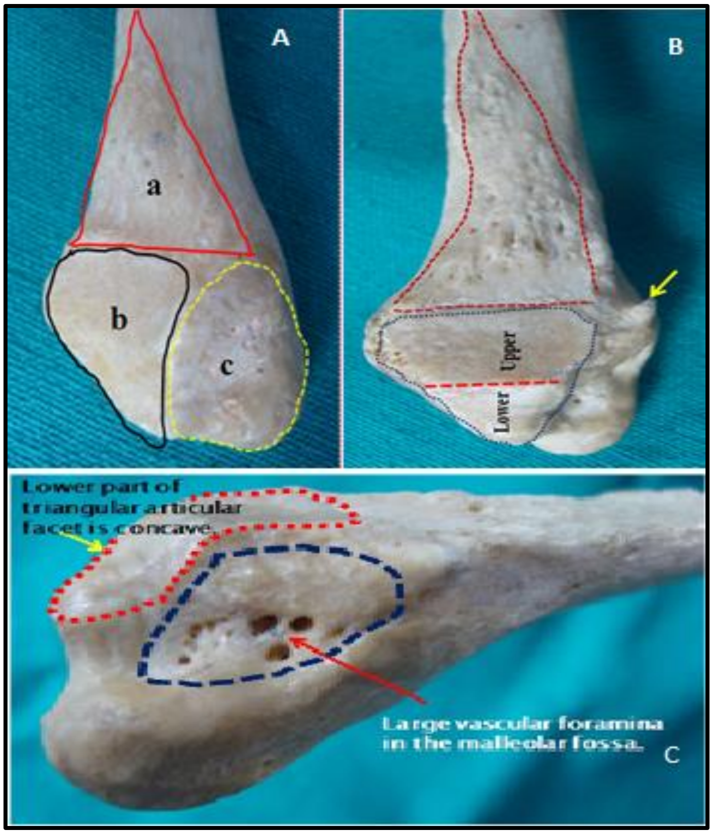

Figure 1: Three important areas seen on the medial aspect of lower one-fourth of fibula

Figure 2: A- Disparity in the size of taller articular facet. B-Different shapes of articular facets. C-Depth of Malleolar fossa.

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-7, Issue-5 | September-October 2021
Page no- 420-426 | Section- Research Article (Anatomy)

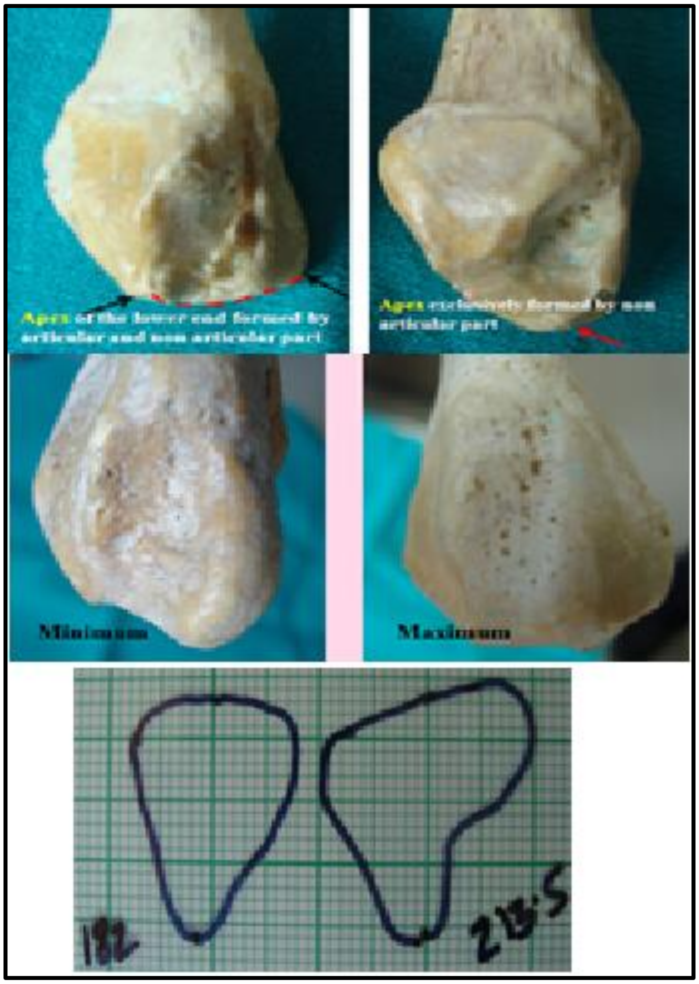

Figure 3: A- Formation of apex at the lower end of fibula. B- Vascular foramina in the Malleolar fossa. C- Surface area of articular facets.

DISCUSSION

The mean value of the height of the articulating surface of the fibula in the present series is 19.04 mm which is similar to the findings of Shishir Kumar et al.1 = 19.1 mm in South Indian bones. The mean value of the breadth of the articulating surface of the fibula as given by them is 20mm which is higher than our value =17.19mm. This may be accounted for by the regional variation. P.E. Lingamdenne described the breadth of the articulating surface 17.90 mm which is similar to our findings.[2] In the present study width of width of talar facet on fibula is 17.54mm on the right side and 16.84mm on the left side respectively. Juned Labbai et al,[5] described mean width of talar facet on fibula was 18.07mm on the left side and 18.03mm on the right side which was slightly higher than present study. Although the reason for these variations have not been validated, because of difference in measuring methods, sex, age and body mass index could be contributing factors. In present study Surface of taller articular facet is Plane 65.21% and 34.77% it is concavo-convex which may signify the amount of variation of coaptation between talus and fibula in the ankle bony mortice. Surface area of articular facets is 208.91mm^2 and 214.56 mm^2 on right and left side respectively. Articular facet is triangular in 76.08%, pear shape in 19.56%, diamond shape in 2.17%, and circular in 2.17%. In the reviewed literature there is paucity of data about the shape and surface area of taller articular facet; hence no comparable data was available.

Stability of the ankle depends on the contour of its articular surfaces and the integrity of the collateral and distal tibiofibular ligaments. Dynamic stability is conferred by the forces of gravity, muscle action and reaction between the foot and the ground. In humans range of motion (ROM) at ankle has been shown to have significant variations due to geographical and cultural differences in the activities of daily life.[9,10] All movements of the ankle during normal gait, occurs at multiple levels and involves several hindfoot and midfoot joints.[11]

In the present series the mean value of the height and base of rough triangular area which gives attachment to interosseous tibiofibular ligament is 33.22mm and 18.79mm. In present study the malleolar fossa is deep in 73.91% & shallow in 26.08%. The size and depth of malleolar fossa varies considerably indicating that the bond between two leg bones in its postero-inferior part is not of similar nature and it's dependent on ROM of ankle. We also noted few vascular foramina in the malleolar fossa which may signify the richness of vascularity of lower end of fibula. The vascular supply to long bones, especially the fibula bone, is a key factor in ensuring the success of orthopedic procedures, plastic surgeries, and cosmetic surgeries.[3] Apex of the lower end of fibula is formed by articular or non- articular part in 28.25 % and only by non- articular part in 71.73 %. Other workers in this field have not given this particular measurements hence it could not be compared. Tibiofibular syndesmosis is significant in the normal functioning of ankle joint, which helps to retain the normal articulation of the ankle joint by determining the specific relationship between the distal tibia and the fibula.[12]

During most activities of daily living, only a partial ROM is required: walking on an even surface (10-15 degree plantar flexion and 10 degree dorsiflexion), walking upstairs (37 degree total ROM), and walking downstairs (56 degree total ROM).[13] Mechanical loading in long bones is unidirectional along their long axes. Talar rotation is accompanied by axial rotation and anteroposterior movement of the fibula. Due to the varying slope of the talar lateral malleolar surface, the fibula rotates laterally a little bit during dorsiflexion at the ankle.[14]

CONCLUSIONS

In spite of contributing immensely to biomechanics of foot, leg and knee not much attention has been paid to fibula as it deserves. In the present work an attempt has been made to elucidate the details of lower end of fibula and to correlate it with its functional significance. Great disparity has been found in the rough triangular non articular area signifying that there is a great variation in the amount of lateral displacement of the lower end during the movements of the ankle. The size and depth of malleolar fossa varies considerably indicating that the bond between two leg bones in its postero-inferior part is not of similar nature and it's dependent on ROM of ankle. The size and inclination of triangular articular facet also shows good amount of variation from plane to concave/ convex which may signify the amount of variation of coaptation between the talus and fibula in the ankle bony mortice. The number and the size of vascular foramina in the malleolar fossa may signify the richness of vascularity of lower end of fibula. The typical osteometry of fibula investigated in this study is novel and distinctive which may lead to advances in the operative management and design of prosthetics regarding the talocrural joint. The work done raises more questions than providing answers to the morphological significance of lower end of fibula in the biomechanics of ankle and its role in functions subserved by fibula.

REFERENCES

1. Kumar S, Nambiar S, Kumar A, Patil GV. Morphometric Study of the Articular Surfaces of Bones Forming the Tibio-Fibular Mortise in South Indian population. J Evid.-Based Med Hlthcare. 2014;1(4);190-196.
2. Lingamdenne PE. Evaluation of osteometric parameters of fibula and talar facet morphometry in Telangana region. Indian J Clin Anat Physiol. 2019;6(4):497–502. http://dx.doi.org/10.18231/j.ijcap.2019.109.
3. Santhanam P, Mohanraj KG. Morphological and morphometrical analysis of fibula in relation to fibular facet. Drug Invent Toda, 2019;12(9):2009-2012.
4. Carr AJ, Macdonald DA, Waterhouse N. The blood supply of the osteocutaneous free fibular graft. J Bone Joint Surg Br. 1988;70(2):319-21. doi: 10.1302/0301-620X.70B2.3346315.
5. Labbai J, Tapiyawala K. Morphometric Analysis of Distal End of Dry Adult Human Fibulae. IJCRR. 2019;11(12):7-10. http://dx.doi.org/10.31782/IJCRR.2019.11122.
6. Brockett CL, Chapman GJ. Biomechanics of the ankle. Orthop Trauma. 2016;30(3):232-238. doi: 10.1016/j.mporth.2016.04.015.
7. Rittweger J, Ireland A, Lüscher S, Nocciolino LM, Pilot N, Pisani L, et al. Fibula: The Forgotten Bone-May It Provide Some Insight On a Wider Scope for Bone Mechanostat Control? Curr Osteoporos Rep. 2018;16(6):775-778. doi: 10.1007/s11914-018-0497-x.
8. Naidoo N, Ishwarkumar S, Lazarus L, Pillay P, Satyapal KS. Osteometry and morphology of the human fibula: A South African study. Int J Morphol. 2015;33(3):1071-1077. http://dx.doi.org/10.4067/S0717-95022015000300042.
9. Roaas A, Andersson GB. Normal range of motion of the hip, knee and ankle joints in male subjects, 30-40 years of age. Acta Orthop Scand. 1982;53(2):205-8. doi: 10.3109/17453678208992202.
10. Ahlberg A, Moussa M, Al-Nahdi M. On geographical variations in the normal range of joint motion. Clin Orthop Relat Res. 1988;(234):229-31.
11. Kitaoka HB, Luo ZP, An KN. Three-dimensional analysis of normal ankle and foot mobility. Am J Sports Med. 1997;25(2):238-42. doi: 10.1177/036354659702500218.
12. Gupta C, Nayak N, Palimar V. A Morphometric Study of Incisura Fibularis in South Indian Population with its Clinical Implications. Int J Anat Appl Physiol. 2018;4(1):84-86. http://dx.doi.org/10.19070/2572-7451-1800014.
13. Stauffer RN, Chao EY, Brewster RC. Force and motion analysis of the normal, diseased, and prosthetic ankle joint. Clin Orthop Relat Res. 1977;(127):189-96.
14. Barnett CH, Napier JR. The axis of rotation at the ankle joint in man; its influence upon the form of the talus and the mobility of the fibula. J Anat. 1952;86(1):1-9.

Source of Support: Nil, Conflict of Interest: None declared