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A cadaveric study on prevalence, morphology, morphometry, and histology of os peroneum in the South Indian population

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ABSTRACT

Background: The complex framework of the human foot enables movement and weight support. The os peroneum (OP) is a sesamoid bone located in the tendon of peroneus longus. Though tiny, it plays crucial roles in foot movement and arch stability injuries to the tendon are significant, and the OP itself can fracture, dislocate, or impinge. Its presence, size, and even histological type influence the proper functioning of the foot. Studying this sesamoid bone, with its variable prevalence and morphology, can fill gaps in foot and ankle pathology research. **Aims and Objectives:** To analyze the prevalence, morphology, morphometry, and histology of OP in human adult cadavers in the South Indian population. **Materials and Methods:** Forty-two formalin-fixed human adult cadaveric free lower limbs were selected and studied from the Department of Anatomy, Pushpagiri Institute of Medical Sciences and Research Centre, Tiruvalla, Kerala. The prevalence of OP in peroneus longus tendons (PLT) and its various configurations were carefully observed, along with their histological types, and then statistical analysis of the data was done using SPSS version 20. **Results:** Thirty-nine out of the forty-two free lower limbs showed the presence of an OP bearing a smooth oval facet, except for one OP with a round facet. All OP were invariably present in the tunnel for PLT on the plantar surface of the cuboid bone. Three different histological types of this tissue were observed, i.e., osseous, cartilaginous, and fibrous. **Conclusion:** The present study has attempted to fill the gap in the research data regarding OP in the adult South Indian population. In addition, the knowledge of OP and its configuration in PLT could provide a better radiological and clinical approach to mid- and fore-foot pathologies.

Key words: Os peroneum; Osteology; South Indian population; Histology; Peroneus longus

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INTRODUCTION

The human foot is a complex structure in which many bones, joints, ligaments, and tendons are positioned, which work together to support our weight and facilitate locomotion. Os peroneum (OP) is a small sesamoid bone in the tendon of the peroneus longus muscle of the lateral compartment of the leg, the functions of which include eversion of the foot and maintaining the lateral longitudinal arch of the foot. The distal peroneus longus tendon (PLT) makes a sharp turn at the lateral border of the foot and passes through the peroneal groove on the plantar surface of the cuboid bone before getting inserted into the medial aspect of the plantar surface of the foot. The knowledge of OP is an interesting area of research for anatomists, radiologists, orthopedic surgeons, and podiatrists because of its potential clinical significance.[1] Any injury to the PLT would be significant, and it is essential to work up the basic pathology, diagnosis, and further treatment modalities. PLT tears are associated with

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pathologies related to OP, even though these account for a trivial entity.[2] In addition, the OP has been associated with various pathological conditions, including fractures, dislocations, and impingements.[3]

This sesamoid bone may be multipartite, and this has to be differentiated from its acute fracture. In radiological imaging, knowledge of the OP is fundamental for accurate interpretation of X-rays, CT scans, and MRI studies of the foot and ankle.[4] Its presence, size, and location can be crucial in diagnosing and treating various foot pathologies. The histological type of OP can vary, with osseous, cartilaginous, and fibrous tissues being described. The histological type of OP may have implications for its susceptibility to injury and disease.[5]

The reported prevalence of OP varies greatly across studies, with estimates ranging from 02% to 30% of the population. In addition, in some of the studies, its presence was found to be unilateral.[6] These inconsistencies may be due to differences in sample size, demographics, and imaging techniques. Even though some studies have measured the dimensions of the OP, there is a lack of standardized morphometric data. The paucity of comprehensive research on the OP highlights a significant research gap in the fields of anatomy of the foot and orthopedics. Therefore, a systematic research study on the prevalence of the OP in a diverse and representative population is necessary.

Aims and objectives

In this study, we aim to assess the prevalence and morphological variations, describe the morphometry, define the histological types of OP, thereby filling the gap in the literature among the adult South Indian population. This information can serve as a foundation for future research in the field of foot and ankle pathology. To study the prevalence, morphology, morphometry and histological types of Os Peroneum in human adult cadavers in the South Indian population.

MATERIALS AND METHODS

An observational cross-sectional study was conducted in the Department of Anatomy, Pushpagiri Institute of Medical Sciences and Research Centre, Tiruvalla. The study was conducted for a period of 6 months after obtaining the Institutional Ethics Committee [IEC] clearance (No. PIMSRC/E1/388A/02/2022). The sample size was 42 free lower limbs of formalin-fixed adult human cadavers used for routine undergraduate teaching in the department during the study period. A simple random sampling method was used for sample selection. Deformed cadaveric lower limbs and those with torn PLT were excluded. The age, stature, and gender of the studied limbs were not considered. After doing a clear, layer-by-layer dissection of the sole of the foot (as per the standard dissection protocol mentioned in Cunningham's Manual of Practical Anatomy), PLT with OP was exposed in the peroneal sulcus on the plantar surface of the cuboid bone. Then the tendon along with the OP was removed, and various dimensions of the OP (maximum length, maximum breadth, and maximum thickness) were measured along its various axes with the help of a thread, ruler, and Vernier caliper. The specimens of OP were then fixed in 10% formalin and decalcified in nitric acid. Then, sections of 05 micrometers in thickness were taken after the histological processing and stained with hematoxylin and eosin. The tissues were examined under a microscope to identify the histological type, and photos were taken using a photomicrometer. The data obtained were tabulated, and its statistical analysis was done by SPSS version 20.

RESULTS

The following observations were subjected to systematic interpretation. Among the 42 specimens studied, 39 PLT (93%) showed the presence of OP. All of them were found in the groove meant for the tendon of Peroneus longus, which runs medially and forwards in the plantar surface of the cuboid bone (Figure 1a). Morphologically, all OP appeared to be single-faceted, which was concave, smooth, and shiny. A corresponding convex facet was seen on the groove on the plantar aspect of the cuboid bone. The shape of the OP was found to be oval in 97% and round in 03% of the specimens (Figure 1b and c). The morphometric analysis of the observations is depicted in Table 1.

Histology

We found that 27 (69%) of the specimens showed osseous tissue, 07 (18%) showed cartilaginous tissue, and 05 (13%)

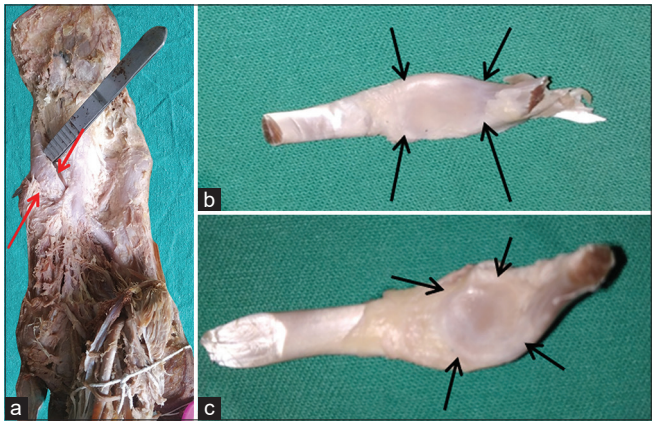

Figure 1: Morphology of os peroneum showing (a) Os peroneum in the tendon of peroneus longus, (b) oval faceted os peroneum (c) round faceted os peroneum

showed fibrous tissue. The osseous type was characterized by the presence of well-defined haversian systems showing concentric lamellae with osteocytes and haversian canals. The cartilaginous type showed cartilaginous tissue with plenty of well-defined chondrocytes of varying size within lacunar spaces, interspersed with irregular fiber bundles. Mitotic figures could also be seen among the cartilage cells. The fibrous type of OP was composed of interlacing bundles of dense collagen fibers with scattered fibroblasts (Figure 2).

DISCUSSION

OP is a sesamoid bone found in the tendon of the peroneus longus muscle.[7,8] According to the study by Mittal et al., a flattened oval enlargement, *i.e.*, OP, was found in all the PLT examined; all of them showed a smooth, concave, and deeper surface.[5] In the present study, 93% of the PLT examined had OP, with a concave surface facing cuboid. Mittal et al., observed OP with both single and double articular facets in their study.[5] But in our study, all the OP studied had a well-defined single concave facet. In the present study, the average length of OP was 13.9 mm, the average breadth was 8.3 mm, and the average thickness was 4 mm, which were comparable to previous studies.[5] The exact site of OP is a matter of dispute among some authors, as most of them observed it in relation to cuboid bone, but some report it as inferior to the calcaneum, close to the calcaneocuboid joint.[7,9,10] In our study, we observed that the location of OP is invariably in the peroneal groove on the plantar aspect of the cuboid bone.

Table 1: Morphometry of os peroneum

Os peroneum	Maximum length (mm)	Maximum breadth (mm)	Maximum thickness (mm)
Mean	13.9	8.3	4
Median	14.0	8	4
Standard deviation	2.23	2.17	1.01
Minimum	10	5	3
Maximum	18	14	6

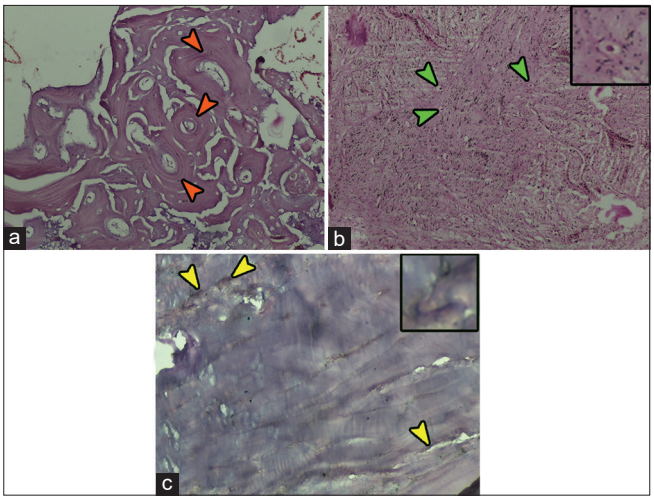

Figure 2: Photomicrographs of os peroneum [H and E (×10)] showing (a) Osseous tissue: Haversian systems showing concentric lamellae with osteocytes around Haversian canals (red arrows), (b) Cartilaginous tissue: Chondrocytes in lacunae (green arrows); Inset: a single chondrocyte within lacunar space, (c) Fibrous type: With dense collagen bundles with scattered fibroblasts (yellow arrows); Inset: a few fibroblasts

Le Minor suggested that OP in human is infrequent and irregular as it is a regressive form of a typical bone seen in primates, and it is due to the fact that peroneus longus muscle in humans has lost its function in hallux opposability during evolution.[11] The prevalence and appearance of accessory bones and sesamoids in the foot have shown variations.[8] Hence, these may warrant further studies in various populations.

Injuries or trauma to peroneal tendons are quite often encountered by clinicians. However, PLT tears associated with OP fractures seem very rare. The pathologies of OP include acute fracture, stress fracture due to chronic trauma, sesamoiditis, osteoarthritis, osteomyelitis, fracture dislocation, avascular necrosis, and foot pain syndromes.[12] One such entity, Painful OP syndrome, is a group of conditions presenting with lateral mid-foot pain in the cuboid area due to the pathologies involving OP.[13] Multipartite OP can also become symptomatic and be a cause of lateral foot pain.[14] A fracture of the OP is a consequence of direct trauma, muscle contraction, inversion injuries, or chronic overuse injuries and presents as pain on the lateral aspect of the foot.[15]

The OP fracture or its dislocation can lead to PLT tears, and if not treated properly at an early stage, it may cause instability of the ankle and peroneal compartment syndrome.[16] Furthermore, these fractures can mimic a styloid or Jones fracture.[9] Hence, awareness about its presence and morphological variations is essential to avoid errors like misinterpreting them as fractures.[12] The physicians must be cognizant to include it in the differential diagnosis of acute ankle trauma.[17] Adequate knowledge regarding the clinical and imaging findings can foil undiagnosed or misdiagnosed lateral mid-foot pain.[18]

Our histological findings of OP demonstrate significant variability among the specimens. According to our study, osseous tissue was the most common histological type, followed by cartilaginous tissue; fibrous tissue was the most infrequent. This is consistent with previous studies, which have reported a similar distribution of histological types.[5] The haversian systems and lamellar architecture in the osseous tissue suggest that OP could have a load-bearing function. The cartilaginous tissue might probably help in

reducing friction and thereby facilitate gliding movements of the tendon. Further research needs to be conducted to understand the development of these different histological types of tissues within OP and their functional importance.

Radiological studies like roentgenograms, including an oblique radiograph of the foot for better visualization of OP,[13] ultrasound,[3,19] bone scintigraphy,[20] computed tomography,[21] and magnetic resonance imaging,[22] in collaboration with clinical findings, provide an accurate diagnosis and thereby guide patient management.[12,17,23] If conservative and rehabilitation methods fail, a surgical approach would pave the way for a better outcome in the management course of OP pathologies.[14,19,22,24,25]

Limitations of the study

Current study did not consider the age and sex differences in the variations in the morphology and morphometry of Os Peroneum.

CONCLUSION

The variability in the prevalence, gross, and microscopic anatomy of OP is reported by various authors. We anticipate that the results and observations derived from the present study will create a better understanding of OP in the South Indian population. A clear knowledge of the normal anatomical variants of these sesamoids is necessary to enhance diagnostic and treatment skills in clinical settings. The study on the histology of OP clearly depicts that there are variants of OP other than bone tissue, and this knowledge, would provide a new insight in future research studies.

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REFERENCES

1. Hindi HF and Byerly DW. Os peroneum. In: StatPearls. Treasure Island, FL: StatPearls Publishing; 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK538329 [Last accessed on 2023 Feb 05].
2. Thompson FM and Patterson AH. Rupture of the peroneus longus tendon. Report of three cases. J Bone Joint Surg Am. 1989;71(2):293-295.
3. Brigido MK, Fessell DP, Jacobson JA, Widman DS, Craig JG, Jamadar DA, et al. Radiography and US of os peroneum fractures and associated peroneal tendon injuries: Initial experience. Radiology. 2005;237(1):235-241. https://doi.org/10.1148/radiol.2371041067
4. Bianchi S, Bortolotto C and Draghi F. Os peroneum imaging: Normal appearance and pathological findings. Insights Imaging. 2017;8(1):59-68. https://doi.org/10.1007/s13244-016-0540-3
5. Mittal PS, Joshi SS, Chhaparwal R and Joshi SD. Prevalence and mophometry of os peroneum amongst central Indians. J Clin Diagn Res. 2014;8(11):AC08-AC10. https://doi.org/10.7860/JCDR/2014/10452.5079
6. Coughlin MJ, Saltzman CL and Anderson RB. Mann's Surgery of the Foot and Ankle. 9th ed. Philadelphia, PA: Saunders/Elsevier; 2013. p. 544-551. Available from: https://books.google.co.in/books?hl=en&lr=&id=DYErAQAAQBAJ&oi=fnd&pg=PP1&dq=Coughlin+MJ,+Saltzman+CL+and+Anderson+RB.+Mann%E2%80%99s+Surgery+of+the+Foot+and+Ankle.+9th+ed.+Philadelphia,+PA:+Saunders/Elsevier%3B+2013.+p.+544-551.&ots=-QfcnnCNod&sig=ZA0DKiIVvQV-ITW0uSrmSuW9fdg&redir_esc=y#v=onepage&q&f=false
7. da Rocha Gomes M, Pinto AP, Fabián AA, Gomes TJ, Navarro A and Oliva XM. The os peroneum incidence - a cadaveric study. Foot Ankle Surg. 2020;26(3):325-327. https://doi.org/10.1016/j.fas.2019.04.009
8. Oyedele O, Maseko C, Mkasi N and Mashanyana M. High incidence of the os peroneum in a cadaver sample in Johannesburg, South Africa: Possible clinical implications? Clin Anat. 2006;19(7):605-610. https://doi.org/10.1002/ca.20224
9. Verma P and Arora A. Comparative anatomical study and incidence of os peroneum in peroneus longus tendon and its clinical significance. [Estudio anatómico comparativo e incidencia del os peroneum en el tendón de peroneo largo y su significación clínica]. Rev Argent Anat Clín. 2014;6(1):15-19. https://doi.org/10.31051/1852.8023.v6.n1.14093
10. Bloom RA. The infracalcaneal os peroneum. Acta Anat. 2008;140(1):34-36. https://doi.org/10.1159/000147034
11. Le Minor JM. Comparative anatomy and significance of the sesamoid bone of the peroneus longus muscle (os peroneum). J Anat. 1987;151:85-99.
12. Nwawka OK, Hayashi D, Diaz LE, Goud AR, Arndt WF, Roemer FW, et al. Sesamoids and accessory ossicles of the foot: Anatomical variability and related pathology. Insights Imaging. 2013;4(5):581-593. https://doi.org/10.1007/s13244-013-0277-1
13. Sobel M, Pavlov H, Geppert MJ, Thompson FM, DiCarlo EF and Davis WH. Painful os peroneum syndrome: A spectrum of conditions responsible for plantar lateral foot pain. Foot Ankle Int. 1994;15(3):112-124. https://doi.org/10.1177/107110079401500306
14. Wilson RC and Moyles BG. Surgical treatment of the symptomatic os peroneum. J Foot Surg. 1987;26(2):156-158.
15. Fabbro ME, Bigness AR and Taylor JA. Fracture of an os peroneum. J Can Chiropr Assoc. 2020;64(2):155-157.
16. Bianchi S, Abdelwahab IF and Tegaldo G. Fracture and posterior dislocation of the os peroneum associated with rupture of the peroneus longus tendon. Can Assoc Radiol J. 1991;42(5):340-344.
17. Bessette BJ and Hodge JC. Diagnosis of the acute os peroneum

fracture. Singapore Med J. 1998;39(7):326-327.

18. Jeppesen JB, Jensen FK, Falborg B and Madsen JL. Bone scintigraphy in painful os peroneum syndrome. Clin Nucl Med. 2011;36(3):209-211.
https://doi.org/10.1097/RLU.0b013e318208f349
19. Sofka CM, Adler RS, Saboeiro GR and Pavlov H. Sonographic evaluation and sonographic-guided therapeutic options of lateral ankle pain: Peroneal tendon pathology associated with the presence of an os peroneum. HSS J. 2010;6(2):177-181.
https://doi.org/10.1007/s11420-010-9154-3
20. Okazaki K, Nakashima S and Nomura S. Stress fracture of an os peroneum. J Orthop Trauma. 2003;17(9):654-656.
https://doi.org/10.1097/00005131-200310000-00010
21. Delamarter T and Benninger B. The os peroneum and accessory navicular: An integrated radiographic and cadaveric study. FASEB J. 2012;26(S1):lb25.
https://doi.org/10.1096/fasebj.26.1_supplement.lb25
22. Chadwick C, Highland AM, Hughes DE and Davies MB. The importance of magnetic resonance imaging in a symptomatic "bipartite" os peroneum: A case report. J Foot Ankle Surg. 2011;50(1):82-86.
https://doi.org/10.1053/j.jfas.2010.08.008
23. Bashir WA, Lewis S, Cullen N and Connell DA. Os peroneum friction syndrome complicated by sesamoid fatigue fracture: A new radiological diagnosis? Skeletal Radiol. 2009;38(2):181-186.
https://doi.org/10.1007/s00256-008-0588-3
24. Cachia VV, Grumbine NA, Santoro JP and Sullivan JD. Spontaneous rupture of the peroneus longus tendon with fracture of the os peroneum. J Foot Surg. 1988;27(4):328-333.
25. Stockton KG and Brodsky JW. Peroneus longus tears associated with pathology of the os peroneum. Foot Ankle Int. 2014;35(4):346-352.
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JRC- Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, data collection, manuscript preparation; **LA-** Coordination, manuscript revision; **GVL-** Coordination, manuscript revision; **NKR-** Data analysis and interpretation, manuscript preparation, editing, preparation of figures, and manuscript revision, submission of article.

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