Morphometric considerations of articular surfaces of calcaneum, occurrence of enthesophytes and evolutionary significance of cuboidal facet

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Abstract:

Introduction: Pattern of talar articular facets on the superior aspect of calcaneum significantly influence in causation of subtalar arthritis. Enthesophytes from calcaneum is a major cause of heel pain. Evolutionary modification of cuboidal facet on calcaneum is an important aspect of human bipedal gait. The objective of this study was to determine the incidence of calcaneal facet pattern and incidence of enthesophytes in calcaneum.

Methodology: Thirty-four dry human calcaneum were studied in Department of anatomy, Azeezia Institute of Medical Sciences, Kollam. All bones were examined for pattern of talar articular facets and classified accordingly. Meticulous examination was carried out to evaluate the incidence of enthesophytes. Morphometry of articular facet for cuboid and talar facets were carried out.

Results: Pattern I morphologic variant was the most frequently encountered type (25 out of 34). Pattern V not observed. Enthesophytes were observed in 21 (61.7%) bones, with medial predominant medial enthesophytes. One bone showed two enthesophytes. Mean cuboidal facet surface area was 386 (±46) square mm.

Conclusion: It was noted that pattern I was the most common morphological variant. Medial tubercular enthesophytes were most common type of abnormal bony outgrowths of calcaneum. The knowledge about variations in morphology is important for all surgeries in subtalar region.

Key words: Calcaneum, Talar articular facets, Cuboidal facet, Enthesophytes

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Introduction

Entheses is connective tissue between tendon or ligament and bone. Enthesophytes are abnormal bony projections at the attachment of a tendon or ligament. Plantar calcaneal enthesophytes are the bony outgrowths from calcaneum.[1] Osseous outgrowths at the plantar aspect of calcaneum was first reported in 1900 and were called Kalkaneussporn (calcaneal spur).[2] Such outgrowths are seen in 11-16% of general population. Nearly three fourth of patients with heel-pain have calcaneal spur.[1,3–5] Radiographs reveal a calcaneal spur in about 50% of patients, but the exact significance of this finding is uncertain.[6] The exact cause of formation of enthesophyte is poorly understood. According to longitudinal traction hypothesis, it is the constant wear and tear resulting from pull of flexor digitorum brevis and ossification of plantar fascia.[7,8] Calcaneal spurs are of two types: Dorsal/posterior spurs and plantar/inferior spurs. In this study, we have evaluated the incidence of enthesophytes in dry calcaneal bone.

Anterior, middle and posterior facets on the superior aspect of talus forms the joint with talus. Review of literature suggests that posterior facet is most constant among these facets, anterior and middle shows considerable variations.[5,9–13] Joint pathologies in subtalar region is more common in certain morphological varieties of facets.[14] Such variations influence subtalar joint stability and mobility.[4,15] During surgeries in subtalar region, operating surgeon needs to be aware of these morphological variations of calcaneal facets. This study addresses the variations of articular facets of calcaneum. Reported variations in south Indian population are minimal. The objective of this study was to evaluate the morphometry of articular facets, to find out facet variations, report the incidence of enthesophytes and to study the evolutionary significance of cuboidal facet of calcaneum.

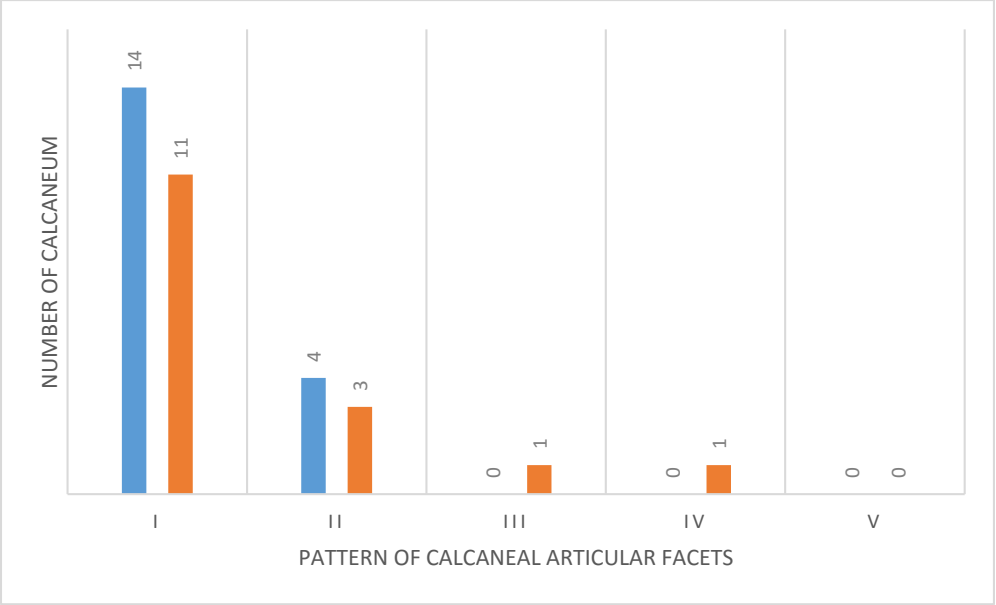
Methodology

The study was conducted in department of Anatomy, Azeezia Institute of Medical Sciences, Kollam using 34 dry calcaneum. Bones with developmental abnormalities and pathological changes including healed fractures were excluded. Each bone was observed for pattern of articular surfaces. Talar articular surface of each bone was photographed and were categorised into five patterns. Fusion of anterior and middle talar facets as pattern I; anterior and middle separate is pattern II; absence of anterior facet is pattern III; fusion of anterior, middle and posterior is pattern IV; and fusion of middle and posterior facet is pattern V. Minimum distance between anterior and middle facets in pattern II calcanei was measured and tabulated. Surface area of talar and

cuboid facets was measured using area calculation application. Left and right side values for all the parameters considered were tabulated separately. All calcanei bones were meticulously observed with hand-held magnifying glass for tubercles and incidence of enthesophytes were recorded.

Results

Out of 34 dry calcanei studied, 18 were right and 16 were left sided. Pattern I with fused middle and posterior facet was found in 25 bones, pattern II in 7. There was one bone with absent anterior facet and one with all facets fused. There was no pattern V bone. Wherever the distance between the facets were less than 0.1 mm and were connected by a bony bridge, it was considered to be fused. Sidewise pattern distribution is shown in graph 1.



Graph 1: Incidence of morphological patterns of calcaneal talar facets, blue bars - right calcaneum, red bars - left calcaneum. n=34

The average distance between middle and posterior facet in type I calcaneum was 0.48 (±0.02) mm. The average distance between anterior and middle facet in type II calcaneum was 0.26 (±0.04) mm and middle and posterior facet was 0.39 (0.01) mm. The mean surface area of anterior, middle and posterior facets in type II pattern calcaneum is given in table 1. Table 2 gives mean surface area of cuboidal facet of calcaneum.

Table 1: Surface area of individual facets of calcaneum in type II pattern (n= 7, values in square mm)

Facet	Right	Left	Mean
anterior	33.0	19.7	26.3
middle	53.3	27.3	40.3
posterior	449.7	299.3	374.5

Table 2: Tabulation of Mean surface area and perimeter of cuboidal facet for calcaneum, n=34, standard deviation in parenthesis

Cuboidal facet for calcaneum	Right	Left	Mean
Area (in square mm)	451.2 (±32)	320.3 (±48)	386 (±46)
Perimeter (in mm)	76.7 (±12)	67 (±8)	72.1 (±9)

Medial tubercle is the largest tubercle seen on all calcanei. Though all four anterior, medial, lateral and posterior tubercles were seen on all bones, one bone had no anterior tubercle. Enthesophytes are observed in 21 (61.7%) bones. It was more on right side. All values are tabulated in table 3. Medial enthesophytes were predominant (Figure 1). One bone even had two medial enthesophytes. Spurs varied in length and morphology and the details were not considered in present study. Out of these fourteen specimens with enthesophytes, ten were type I pattern and four were pattern II.

Table 3: Incidence of enthesophytes found in the study, n=34, percentages in parenthesis

	Right	Left	Total
Medial	8 (23.5%)	4 (11.7%)	12 (35.3%)
lateral	2 (5.9%)	0	2 (5.9%)
Posterior	4 (11.7%)	3 (8.8%)	7 (20.5%)

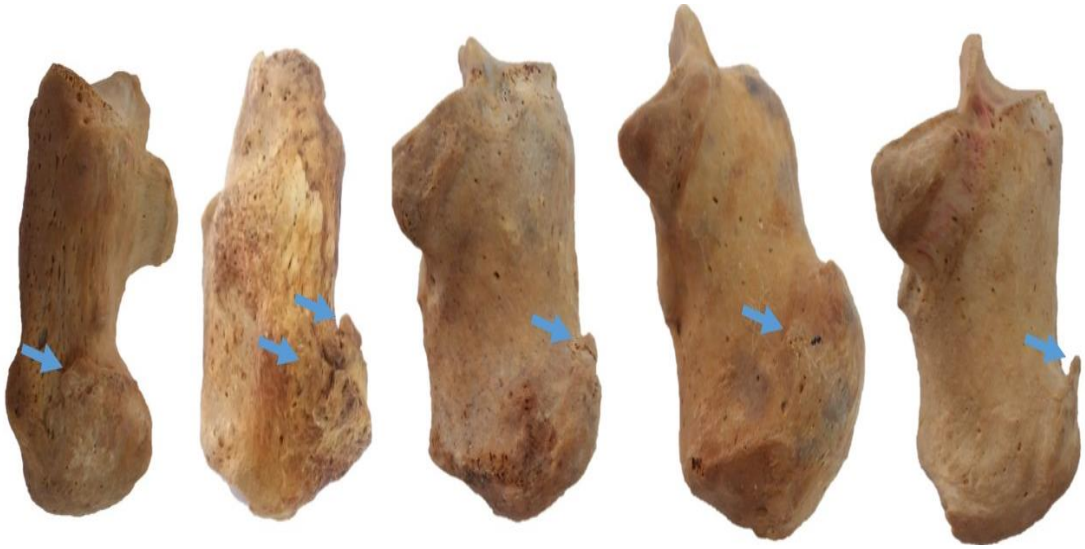


Figure 1: Enthesophytes documented in the study. (blue arrows)

Discussion

In parlance to our objectives, we have determined the incidence of patterns of talar articular facets and occurrence enthesophytes. In this study, the most frequently found pattern is type I and in this pattern calcaneum, enthesophytes were encountered maximum. Our study goes according to many of the previous workers.[4,5,9–11,15,16] Incidence of enthesophytes is considerably higher in comparison to many of the previous reports. Our results are similar to previous studies by Bassiouni[17] and Banadda[16] et al, where they have studied calcaneum of older people. Thus, the higher incidence of enthesophytes in this study, may be due to considering calcaneum of older people. Similar higher incidence is reported in many of MR radiographic studies.[6,18] These enthesophytes arise from attachment of one of plantar aponeurosis and plantar muscles, like flexor digitorum brevis, abductor hallucis and adductor digiti minimi. Since many of the spurs were from medial tubercle, it is suggested that out of these structures, attachment of plantar aponeurosis and flexor digitorum brevis plays a crucial role in formation of enthesophytes.

There are reports that subtalar arthritis is most common in type I pattern.[17] So, this study shows light on possible role of pattern of calcaneal articular facet in occurrence of arthritis in a particular locality. Despite many uncertainty regarding pathogenesis of enthesophytes, many of modalities of treatment has been recommended ranging from simple excision to more recently developed techniques such as endoscopic excision.[2] Most of the techniques involve release of plantar aponeurosis.

Evolutionary significance: Arboreal heritage is well marked in human foot. It is shown by its primary grasping nature. It is indicated by well developed platar aponeurosis, strong plantar ligaments and longitudinal arches. Comparison of chimpanzee and human allows us to understand the footsteps of evolution. Primates have significantly elongated calcaneus in comparison to many non-primates.[19] Calcaneal elongation can be understood as a mechanism to replace loss of foot leverage that resulted with acquired grasping hallucal metatarsal joint. This has shifted the fulcrum of distal limb segment from the metatarsal heads to tarso-metatarsal joint.[20] The cuboid articular facet is the most distinctive feature of human foot[21]. In humans, the cuboid articular facet on calcaneum is asymmetrical. Superior part of this articular facet projects more anteriorly than the inferior part (figure 2). The facet only assumes a more longitudinal orientation in relation to the ground when the anterior aspect of articular facet is raised as it would be normally arched foot[22]. There is a deeper concavity on the medical aspect of the facet, which articulates with the beak like projection of the cuboid. This arrangement makes calcaneum a 'keystone' in lateral longitudinal arch of foot. The complex nature of this articular facet combined with reciprocal architecture of cuboid allows distinctive lateral swing of human calcaneocuboid joint. This brings the joint into closed packed position during stance phase of the bipedal locomotor gait[23].

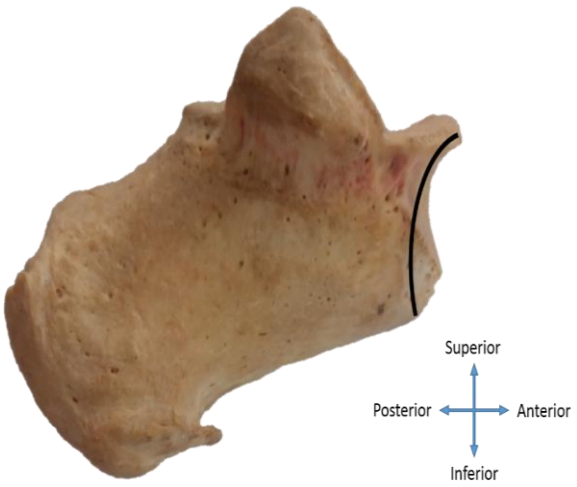


Figure 2: Side view of right calcaneum showing projection of superior part more anteriorly than the inferior part, black line shows the direction of projection.

In contrast, many of the other primates including chimpanzees, gorillas lack this anterolateral projection of cuboid articular facet on calcaneum[24]. This does not permit locking of calcaneocuboid joint. Absence of such close packing during locomotion results in 'midtarsal break' in stance phase of ape locomotor cycle[23].

Conclusion

Thirty four human dry calcaneum morphometry, pattern of articular facet and enthesophytes were studied. It was noted that pattern I was the most common morphological variant. Medial tubercular enthesophytes were most common type of abnormal bony outgrowths of calcaneum. The knowledge about variations in morphology is important for all surgeries in subtalar region.

Conflict of Interest: None
Source of Support: Nil

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