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Indian Journal of Clinical Anatomy and Physiology
Journal homepage: https://journals.ipinnovative.com/ijcap

Original Research Article

The anatomical variations of the calcaneal-talar facets in the Kongunadu population and their clinical implications

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Abstract

Introduction: The calcaneus is the largest among the tarsal bones. It is stressed, particularly when walking and running in weight-bearing situations. The morphometric parameters of the calcaneum play a vital role during orthopedic procedures. The study's principal goals are to detect various talar facet configurations on the calcaneum's superior surface and to establish how talar facet configuration and calcaneal spur are related.

Materials and Methods: A cross-sectional, retrospective, observational study was done between August 2024 and December 2025 on 76 dry calcaneum bones obtained from the Department of Anatomy and Forensic Medicine.

Results: We observed that out of 76 calcanei, 64.47% were of the Type I pattern with fused anterior and middle facets. 32.9% were of the Type II pattern with distinct anterior and middle facets. 2.6% of calcanei were of Type III, where there was an absence of anterior facets.

Conclusion: We observed that calcaneal spurs were related to the Type I pattern of facets in the highest frequency. Since calcaneal spurs are one of the most significant cofactors for heel pain, anatomical knowledge of the link between the calcaneal spurs and the pattern of calcaneal facets would be helpful in clinical treatment.

Keywords: Calcaneum facets, Calcaneal spurs, Heel pain.

Received: 15-04-2026 **Accepted:** 27-05-2026 **Available Online:** 30-06-2026

1. Introduction

The calcaneum, the biggest tarsal bone, serves as a brief lever for the calf muscles linked to its posterior aspect as it extends posteriorly to the tibia and fibula [1]. It has an upward slant and is oriented laterally and forward. It creates transverse tarsal joints and calcaneocuboid joints. The superior surface of the calcaneum has three facets where it articulates with the talus bone. They are facets that are anterior, middle, and posterior. The central facet is located on the sustentaculum tali, while the anterior and posterior facets are located on the body. There are significant differences in the quantity and configuration of these articular facets across different demographic groups.[2] The calcaneum's superior surface is separated into the following three regions. (a) The non-articular posterior third of the bone is rough and has a pad of fibrofatty tissue covering it that extends all the way to the tendocalcaneus. (b) A large oval facet—the posterior facet for the talus is seen in the middle third. (c) The middle and anterior facets for the talus are two articular facets that are present one-third more anteriorly.[3]

Researchers usually see changes in facet configuration as anatomical changes that have little functional impact. Bruckner (1987) asserts that subtalar joints produced by calcanei with pattern II facet configurations are less prone to arthritis and more stable.[4] There are two separate facets (anterior and middle) on the anterior third of the calcaneum, and the facets are configured using pattern II. Together with the posterior facet, the two facets form a "osseous tripod" that stabilizes the talus and limits the talar head's excessive mobility. By decreasing trauma and biomechanical stress on the subtalar joint, this tripod support lowers the risk of osteoarthritis, which is also less common in these situations. Because of their uneven weight distribution, unstable joints are more vulnerable to biomechanical stress, damage, and accidents.[5]. Since it is readily available and well-preserved, it is one of the bones utilized in forensic sciences.[6]

Solid, typically compact bones, the calcaneus and talus are commonly retrieved in circumstances where complete long bones may not be available.[7] The frequency of foot fractures is approximately two per 1,000 person-years for men and four per 1,000 person-years for women, making them the most common injury among people over 45.[8]

Calcaneal aspects might change as a result of heredity or postnatal variables, including gait and behaviors. The percentage distribution of the aspect's pattern varies by sex and race, as was previously mentioned. Orthopaedic surgeons must comprehend the differences in calcaneal articular facets because they affect the stability of the subtalar joint while fixing foot deformities and placing screws for fracture fixation.

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https://doi.org/10.18231/j.ijcap.16880.1779963712

2. Materials and Methods

A cross-sectional retrospective observational study was done between August 2024 and December 2025 in which 76 calcanei were obtained from the Department of Anatomy and Forensic Medicine, Coimbatore, after obtaining ethical clearance from the institution.

2.1. Inclusion criteria

Undamaged and non-pathological calcaneum bones

2.2. Exclusion criteria

Damaged bones and structurally deformed bones.

Types of articular facets on the calcaneus were observed and classified by incidence of various patterns in percentages. The findings of the present study were compared with available literature.

3. Results

In the present study, 76 calcanei were studied based on gross features & classified into types and subtypes. Of the total 76 calcanei that were used for the study, 37 (48.68%) were right-sided and 39 (51.3%) were left-sided. Incidences of Types I, II, and III were shown in Tables 1 and 2. Type IV and V patterns were absent in the present study. Subtypes in Pattern I: Subtype A with fused middle and anterior facets are non-constricted (IA) in 25 bones and were found with a higher percentage (32.9%) compared to constricted (IB) in 24 bones (31.6%). The interfacet distance was measured using sliding calipers. The interesting finding of this study is the predominance of Type IA. In type II, subtype A with a narrow interfacet distance (< 2 mm) was found with 5.3%; subtype IIB (2-5 mm interfacet distance) was found with the highest (22.3%), and subtype IIC (> 5 mm interfacet distance) was found with the least percentage of about 7.9%.

Table 1. *Classification of calcaneal articular facets*

Pattern	Feature	Right	Left	Percentage
I	Middle and anterior facets fused	22	27	64. 47 %
II	Middle and anterior facets are separate.	14	11	32.9 %
III	Anterior facet Absent	1	1	2.6%
IV	Anterior, middle & posterior facets fused	-	-	Nil
V	Middle & posterior facets fused	-	-	

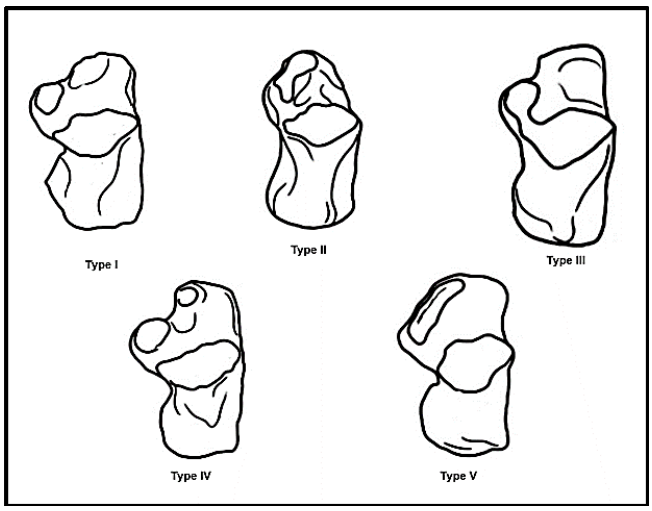

Figure 1: *Schematic illustration of calcaneal articular facets*

Table 2. *Percentage incidence of subtypes of Type I and Type II Calcaneum*

Subtypes of calcaneum	No. of bones	Percentage
Type IA	25	32.9%
Type IB	24	31.6%
Type II A	4	5. 3 %
Type II B	17	2 2 .3%
Type II C	6	7.9%

Table 3. *Comparative incidence of types of calcanei with Indian studies*

Study/ year	Country/n=sample size	Pattern I (%)	Pattern II (%)	Pattern III (%)	Pattern IV (%)	Pattern (V)
Bunning and Barnett 1984 [9]	British /194	33%	67%	-	-	-
Campos et al., 1989 [17]	Spanish/176	53%	46%	-	-	-
Verhagen 1993 [18]	USA/ 191	54.45%	26.7%	18.85%	-	-
G.S.Gindha et al., 2014 [14]	North India /325	69.5%	29.8%	-	0.6%	-
Dahkal Arun et al., 2018 [16]	Nepal/142	56.34%	42.25%	-	1.41%	-
Dang B et al., 2023 [13]	North-west India/100	83%	16%	-	1%	-
Jyotsna et al., 2022 [15]	South india / 98	80.61%	19%	-	-	-
Present study 2024	Kongu nadu population/76	64. 47 %	32.9%	2.6%	-	-

Table 4. *Distribution of calcaneal spurs*

Type of Calcanei	No. of calcanei showing spurs			Incidence of calcaneal spurs (%)
	plantar	Dorsal	Both	
Type I	7	5	3	15 (19.7%)
Type II	1	0	1	2 (2.6%)
Type III	-	-	-	-

Table 4. *Distribution of calcaneal spurs (continued)*

Type of Calcanei	No. of calcanei showing spurs			Incidence of calcaneal spurs (%)
Type IV	-	-	-	-
Type V	-	-	-	-
Total no in (%)	8 (10.5%	5 (6.5%)	4 (5.2%)	17(22%)

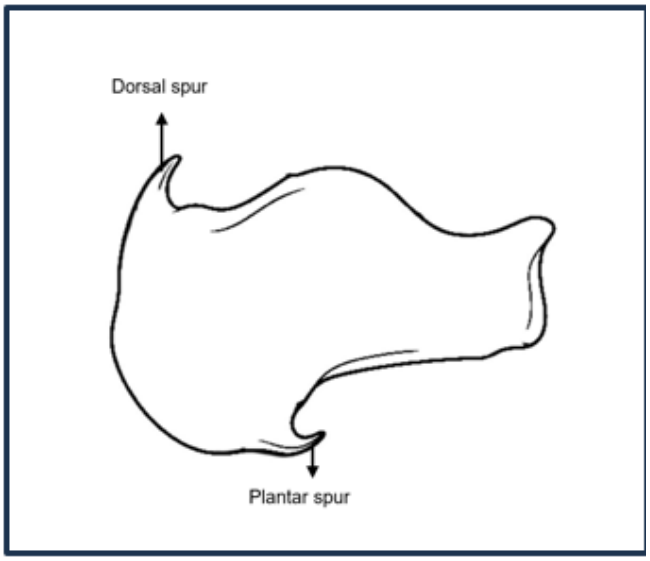

Figure 2: *Schematic illustration of calcaneal spurs*

4. Discussion

Bunning & Barnett classified calcanei with 3 facets as type A, those with 2 facets as type B, and those with a single facet as type C. They noted that calcanei with 3 facets were predominant in European races, whereas Africans and Asians have calcanei with 2 facets. Racial differences and sexual dimorphism were identified in a fetal series, showing that they are most likely genetically determined. The same observations in the fetuses indicate genetic predisposition rather than the influence of walking patterns.[9] The observed ethnic differences may have a genetic or developmental basis because prenatal investigations have shown comparable talocalcaneal facet patterns. The biomechanical stressors and degenerative alterations observed in adults may also be influenced by functional factors including gait and weight-bearing patterns.[9] When comparing our findings with Bunning and Barnett, the present study observed 2 facets predominantly in type I A. The contrast may be because of racial differences. Gupta et al. classified the calcanei's facets into four classes. They discovered a prevalence of type I with nonconstricted facets (39%) in the Indian population.[10]

Sarvaiya et al. reported non-constricted facets due to the union of the anterior and middle facets to be observed in the majority (26% of calcanei) and the existence of a single joint facet to be the least (0.4%) [11]. Phunchago et al. investigated the articular facets on the calcanei in the Thai population and observed that the calcanei with a fusion of the anterior with the middle facet were present in the majority of continuous non-constricted facets in 35% and constricted facets in 33% of calcanei.[12] The current study's findings were similar to those of Gupta et al. and Sarvaiya et al., both of which studied the Asian population. However, Phunchago et al.'s findings are not identical to our study, which could be due to ethnic differences.

Based on the presence of talar facets on their superior surface, the calcanei have been divided into five categories. Numerous scholars have examined the prevalence of these categories in diverse populations. Of the 76 calcanei, we found that only 32.9% had a distinct anterior and middle facet and were of type II. Type I facets with merged anterior and middle facets were present in 64.47% of calcanei. Type III, or the lack of an anterior facet, is present in 2.6% of calcanei. According to Dang B et al. (2023), 16% of calcaneum out of 100 have a type II facet, whereas 83% have a type I facet, and 1% have a type III aspect.[13] The Type I facet outnumbered the Type II facet. Studies on the Indian race by G. S. Gindha et al. and Jyotsna et al.[14,15] and populations in Nepal, Spain, and the United States by Dhakal Arun et al., Campos F et al., and Verhagen FD are comparable.[16–18] Compared to Type I, which had a population of 37% and 25%, Type II had a higher population of Americans and Belgians (46% and 64%, respectively). Our study's findings are comparable to those of Dang B et al.'s study on the Indian population, which found 1% type III calcaneum.[13]

A number of authors study the calcanei in order to see the articular facet pattern. The talus's articular facets were divided into four groups by Bruckner: A (three facets), B (transitional two facets), C (simple two facets), and D (special two facets). The talus and calcaneus move more easily and in unison when there are two facets instead of three. The stiff foot that results from the three-facet shape is more prone to subtalar joint disorders. Those with two facets benefit more from physiotherapy than those with three.[4] This study shows that the number of subtalar joint facets affects foot mobility to the extent that osseous factors indicate joint range of motion. A continuous or single medial facet raises the risk of developing subtalar arthritis, according to Drayer-Verhagen.[18] These characteristics cause ligaments to become loose and joints to become unstable.

Four classes of articular facets are included in the Type A categorization.

- A1: Less than 2 mm separates the anterior and middle articular facets.
- A2: There is a 2–5 mm gap between the anterior and middle articular surfaces.

The distance between the anterior and middle articular facets in A3 is greater than 5mm.

One joint facet is referred to as the anterior talar facet (A4). Type B combines the anterior and middle characteristics of two types (B1 and B2. The anterior and center sides of B1 were found to be constricted. B2: The middle and anterior aspects are not constricted.

C:When all three facets are combined, a single aspect is produced.Combining the anterior, middle, and posterior facets.Type A is related to type II, type C to type IV, and type B to type I.[9,19]

In the present, we observed that among type I articular facets, subtype IIB was the most prevalent, with an interfacet distance of 25 mm. These results align with those of Kullar et al. and Muthukumaravel et al. in the Indian population [20,21]. Type I individuals with fused anterior and middle facets may have a higher risk of developing subtalar arthritis.[22]

Dogan anatomic reduction, soft tissue relaxation, and osteotomy are the most successful for complicated foot abnormalities. Restoring a normal-sized, pain-free, and functional foot is the main aim. A sound treatment strategy can be developed with an understanding of the anatomy of the foot. The triple arthrodesis method requires meticulous examination of the calcaneum's articular configuration in order to restore the flat foot. This guarantees the complete removal of cartilage from the subtalar joint surfaces.[23] Advancements in subtalar implants, flaps, and foot prostheses have been made possible by technology. The treatment procedures will be built upon comprehensive anatomical data.[24] The facet surfaces of the talus and calcaneus can be seen using 3D digital imaging. The diagnosis and treatment of coalition, talocalcaneal subluxation,and other dysmorphologies would be more successful as a result. Furthermore, joint implants and prosthetics may be created.

The incidence of calcaneal spurs was 22% in the present study, which is greater than Kori et al.[25] in Uttar Pradesh but comparable to Biswal R. et al.[26] Because the fused surface modifies normal subtalar joint mechanics, the type I calcaneal facet pattern, in which the anterior and middle facets are fused, may enhance the production of calcaneal spurs. During walking and standing, this fusion concentrates compressive stresses on the calcaneus and lessens independent movement across aspects. Calcaneal spurs are more common as a result of reactive bone growth at the calcaneal attachment sites brought on by increased stress and plantar fascial tension.[27] Last but not least, plantar spurs were more common in Type I calcanei (4%) and Type II calcanei (2.5%), with a total incidence of 6.5%,according to Kullar et al.[20]. Type III and IV calcanei showed no signs of plantar spurs (Tables 4, 5, Figure. 1).

Table 5. *Comparative incidence of distribution of calcaneal spurs with Indian studies*

Study / year	No. of calcanei studied	Plantar spurs (%)	Dorsal spurs (%)	Both spurs (%)	Total spurs (%)
Kull a r et al. (2013) [20]	200	6.5 %	15.5 %	4.5 %	26.5 %
Kori et al. (2016) [25]	600	60.4%	35 %	4.7 %	17.7 %
Biswal R et al., (2017) [26]	107	18.7 %	10.28 %	4.7 %	33.68%
Present study (2024)	76	10.5 %	6.5 %	5.2 %	22 %

5. Conclusion

Fused talar facets may change subtalar biomechanics and increase vertical compressive stress on the heel, as indicated by the greater frequency of plantar calcaneal spurs in Type I calcanei. Therefore, rather than being exclusively a result of plantar fascial tension, calcaneal spurs may be an adaptive reaction to persistent mechanical pressure. The clinical assessment and treatment of heel pain may benefit from an understanding of the connection between calcaneal facet morphology and spur development.

6. Limitations

Compared to bigger Indian investigations, the study was constrained by a rather small sample size (n=76). Evaluation of sexual dimorphism and age-related changes was also hindered by the dried calcanei's lack of age and sex information.

7. Acknowledgement

We sincerely acknowledge the contribution of Kirthi Sankar M., a Phase III, Part 1 student, who assisted in preparing the anatomical illustrations and diagrams used in this paper. Her effort and support greatly enhanced the visual presentation of the study.

8. Source of Funding

None.

9. Conflict of Interest

None.

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Cite this article: Priya P, Daliparthi GA, Vijaianand M. The anatomical variations of the calcaneal-talar facets in the Kongunadu population and their clinical implications. *Indian J Clin Anat Physiol.*. 2026;13(2):57-61.