Original Article

Calcaneal Talar Facet Morphology of North Indian Population: Implications for Subtalar Joint Stability and Surgical Planning

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Abstract

Background: The subtalar joint, formed primarily by the talar facets on the calcaneum, is critical for foot biomechanics, providing stability, mobility, and shock absorption. Morphological variations of these facets—anterior, middle, and posterior—can influence subtalar joint function, predispose to instability, and have clinical implications in orthopedic surgery. The objective is to observe and classify the patterns of talar facets in adult human calcanei from the Uttar Pradesh population, assess their distribution, and evaluate potential functional and clinical significance. **Material and Methods:** Ninety adult dry calcanei from both sexes were examined in the Department of Anatomy, UPUMS, Saifai. Bones with deformities, fractures, or pathological changes were excluded. Facet patterns were observed visually, and inter-facet distances were measured using a sliding vernier caliper. Specimens were classified into five types: Type I (anterior and middle fused), Type II (anterior and middle separate), Type III (anterior absent), Type IV (all fused), and Type V (middle and posterior fused). Frequencies were analyzed and compared with existing literature. **Results:** Type I was the most common configuration, observed in 66.66% of calcanei (right: 15.55%, left: 51.11%), followed by Type II in 24.44% (right: 14.44%, left: 10%). Type II subtypes showed variability in inter-facet distances. Type III and IV were rare (6.66% and 2.22%, respectively), while Type V was absent. Statistically significant side-to-side differences were observed ($p = 0.0004$), indicating asymmetry in calcaneal facet morphology. **Conclusion:** The anterior-middle fused configuration (Type I) predominates in this population, with minor representation of other types. Knowledge of these variations is clinically relevant for orthopedic surgery, radiological interpretation, and biomechanical assessment of the subtalar joint. Awareness of population-specific anatomical patterns can enhance surgical planning, prosthetic design, and understanding of foot biomechanics.

Keywords: Calcaneus, Talar facets, Subtalar joint, Morphology, Anatomical variation, India.

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Introduction

The subtalar joint, formed primarily between the talar facets on the calcaneum and the inferior surface of the talus, plays a vital role in foot biomechanics, contributing to stability, mobility, and shock absorption during weight-bearing activities.[1]

The anatomical configuration of these talar facets — typically comprising the anterior, middle, and posterior facets—varies significantly among individuals and populations, with important clinical implications.[2,3]

Understanding the morphological variations in talar facets is essential for orthopedic surgeons, podiatrists, physical therapists, and radiologists, especially when addressing conditions such as subtalar joint instability, calcaneal fractures, arthritis, and planning reconstructive or arthrodesis surgeries.[4,5] These variations can alter joint congruency and load transmission, influencing foot alignment and gait mechanics.

Several classification systems have described distinct patterns of talar facet morphology on the calcaneum. In the present study, five patterns are considered:

- Type I: Anterior and middle facets fused
- Type II: Anterior and middle facets separate
- Type III: Anterior facet absent
- Type IV: All three facets fused (anterior, middle, posterior)
- Type V: Middle and posterior facets fused

Studies have shown that two-facet configurations (e.g., fused facets) may offer greater subtalar joint stability compared to configurations with three distinct facets.[6] Conversely, facet arrangements with less congruency may predispose individuals to joint instability, increasing susceptibility to trauma, biomechanical imbalance, and subsequent degenerative changes

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such as osteoarthritis.[7,8]

Furthermore, geographical and ethnic differences play a role in the prevalence of facet types, underscoring the need for regional anatomical data to guide clinical decision-making.[9] This observational study focuses on the calcanei from cadaveric specimens collected in Uttar Pradesh (UP), India, aiming to evaluate the distribution of talar facet types, assess their potential functional and clinical implications, and support surgical planning based on regional anatomical variation.

Materials and Methods

Study Setting and Sample Size

The present study was conducted in the Department of Anatomy, Uttar Pradesh University of Medical Sciences (UPUMS), Saifai, Etawah, Uttar Pradesh. A total of ninety ossified adult calcanei were collected and studied, including specimens from both male and female cadavers. All specimens were carefully examined to ensure they were free from pathological changes, deformities, fractures, or any congenital anomalies, to maintain uniformity and reliability of the data.

Inclusion Criteria

- Adult human dry calcanei obtained from the osteology collection of the department.
- Bones with well-preserved and clearly distinguishable anterior, middle, and posterior articular facets.
- Both right and left-sided calcanei, irrespective of sex.
- Specimens showing no signs of deformity or damage.

Exclusion Criteria

- Calcanei that were broken, eroded, or showed postmortem damage affecting the articular surfaces.
- Bones with congenital anomalies, pathological deformities, or evidence of fractures.
- Immature or pediatric bones identified by smaller size and incomplete ossification.

Method of Observation and Measurement

The pattern of articulating facets on each calcaneus was observed visually with the naked eye for both the right and left sides. Special attention was given to the posterior, middle, and anterior facets, noting their number, shape, and configuration. To ensure precision in morphometric data, a sliding vernier caliper was employed to measure the inter-facet distances, including distances between anterior, middle, and posterior facets. Each measurement was taken twice, and the mean values were calculated to minimize errors and increase accuracy.

Classification and Data Analysis

After completing all observations and measurements, the types of calcaneal facet patterns were classified according to established criteria from previous anatomical studies. The frequency and distribution of each type were recorded and subsequently compared with data reported in available international and national literature. This comparison helped in identifying variations and patterns specific to the studied population, providing insights into anatomical diversity and potential clinical significance, particularly for orthopedic surgeries, radiological interpretation, and biomechanical assessments of the subtalar joint.

Results

Table 1: Distribution of Different Patterns of Calcanear Articulat Facet On the Talar Surface of Calacanei

Types of pattern of calcaneal facets	Numbers of bones	%	Right calcaneum facet		Left calcaneum facet	
			Total Number	%	Total number	%
Type I (Anterior and Middle fused	60	66.66%	14	15.55%	46	51.11%
Type II (Anterior and Middle facet separate	22	24.44%	13	14.44%	9	10%
Type III (Anterior facet absent)	6	6.66%	5	5.55%	1	1.11%
Type IV (Anterior, Middle and Posterior facet fused)	2	2.22%	2	2.22%	0	0%
Type V (Middle and Posterior facet fused)	0	O%	0	0%	0	0%

The present study analysed ninety adult calcanei from both sexes to observe the patterns of articular facets. Five distinct types of calcaneal facet configurations were identified, and their distribution was carefully recorded for both the right and left sides.

1. Type I (Anterior and Middle facets fused): This pattern was the most common, observed in 66.66% of all calcanei. On the right side, it accounted for 15.55%, whereas it was more prevalent on the left side, constituting 51.11%. The predominance of Type I suggests that fusion of anterior and middle facets is a common anatomical variation in this population, which may have implications for subtalar joint stability and surgicalplanning.
2. Type II (Anterior and Middle facets separate): Present in 24.44% of specimens, with 14.44% on the right side and 10% on the left. To further characterize the variability, Type II was divided into three subtypes based on the inter-facet distance:
   a) Subtype a: Separation of less than 5 mm, observed in 72 bones, indicating that minor separation is the most common variant within Type II.
   b) Subtype b: Separation of 5–10 mm, seen in 13 bones, representing a moderate degree of separation.
   c) Subtype c: Separation of more than 10 mm, present in 5 bones, representing a rare but significant anatomical variation.

These subtypes highlight the wide variability in anterior-middle facet separation, which is important for orthopedic and radiological assessments, as even small differences in facet spacing may affect joint biomechanics.

3. Type III (Anterior facet absent): Observed in 6.66% of the calcanei, with a higher incidence on the right (5.55%) than on the left (1.11%). This rare variation indicates absence of the anterior facet and may influence subtalar motion and susceptibility to certain injuries.

4. Type IV (Anterior, Middle, and Posterior facets fused): This configuration was extremely rare, found in only 2.22% of specimens, exclusively on the right side, and absent on the left. Complete fusion of all three facets may reduce subtalar joint mobility, which could be clinically significant in foot biomechanics and surgical interventions.
5. Type V (Middle and Posterior facets fused): This pattern was not observed in any specimen, suggesting that fusion of the middle and posterior facets is an uncommon anatomical variant in this population.

The statistical analysis demonstrated a highly significant difference in the distribution of calcaneal facet patterns between the right and left sides ($p = 0.0004$). This asymmetry suggests that calcaneal facet morphology is not bilaterally identical in all individuals, highlighting the inherent anatomical variability in the subtalar joint.

Overall, the data demonstrate that Type I is the most prevalent pattern, followed by Type II and Type III, while Types IV and V are rare or absent. The detailed assessment of Type II subtypes provides additional insight into the range of anatomical variability, which can guide radiologists, orthopedic surgeons, and anatomists in understanding normal and variant calcaneal morphology.

These findings also provide a basis for comparison with other populations, highlighting ethnic and regional differences in facet patterns. Importantly, the significant side-to-side differences observed in our study indicate that reliance on contralateral imaging for preoperative planning may not always represent the true configuration of the affected side. Variations in facet arrangement influence subtalar joint stability, load distribution, and range of motion, thereby impacting outcomes of procedures such as subtalar arthrodesis, calcaneal fracture fixation, and corrective osteotomies. This underscores the need for individualized assessment through imaging and emphasizes the importance of regional anatomical data in surgical planning.

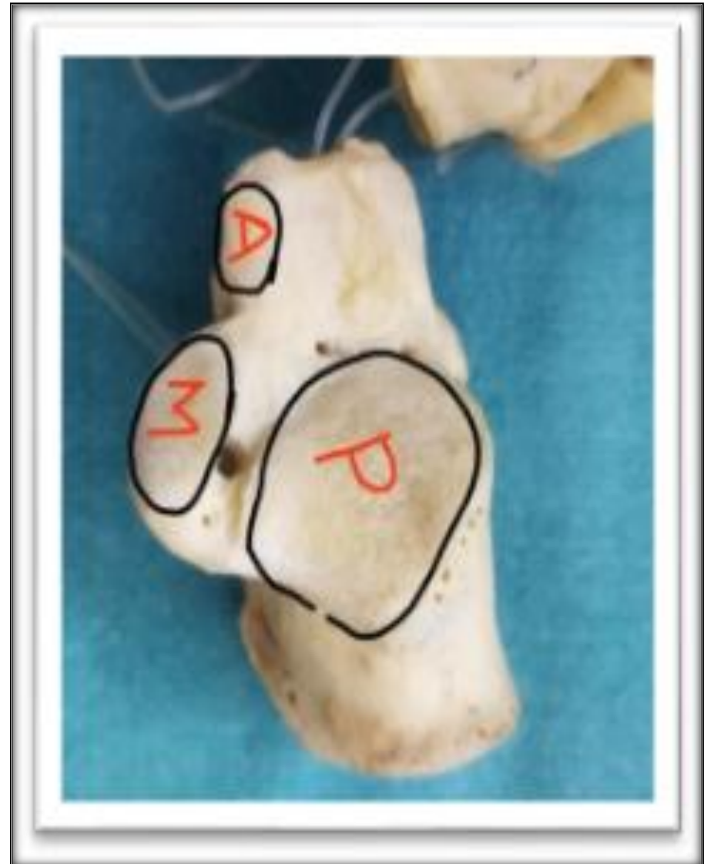

Figure 2: Anterior and Middle facet separate

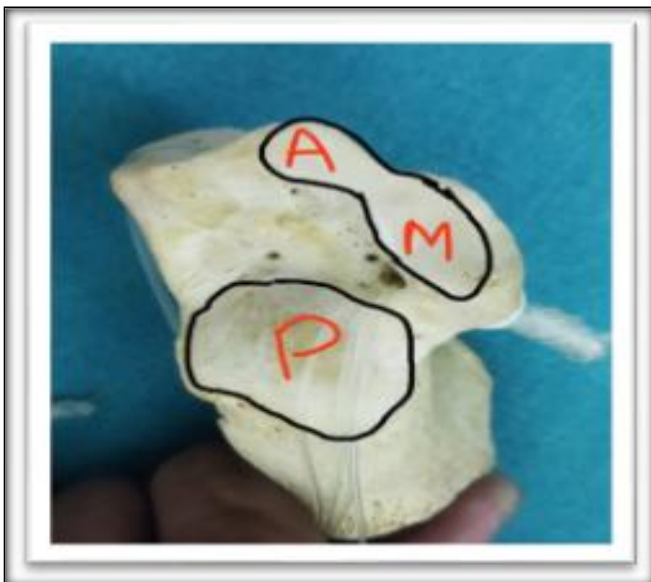

Figure 1: Anterior and Middle fused

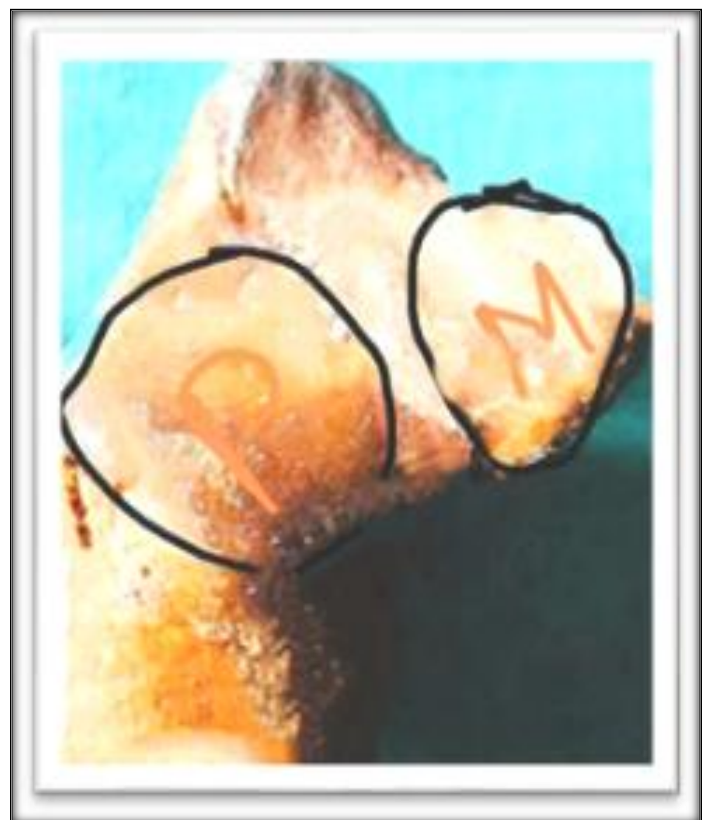

Figure 3: Anterior facet absent

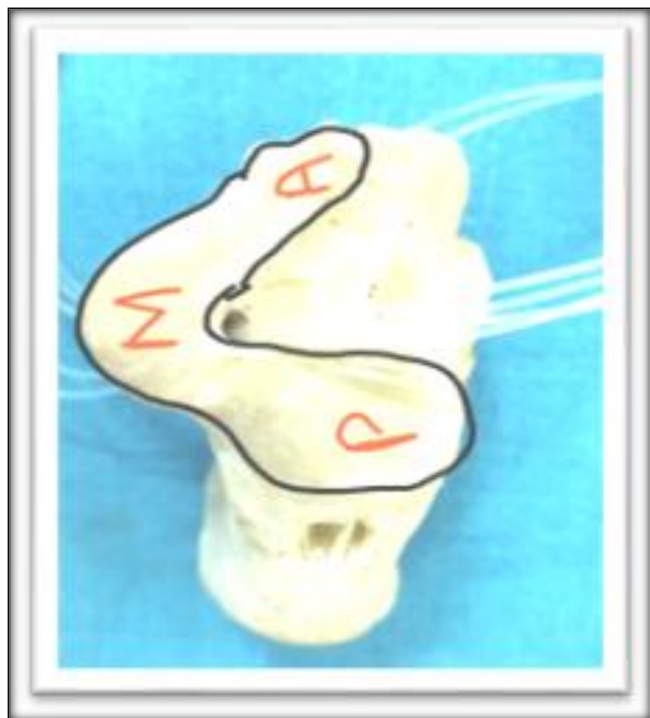

Figure 4: Anterior, Middle and Posterior facet fused

Discussion

In the present study, Type I configuration, where the anterior and middle calcaneal facets are fused, was the most commonly observed pattern (66.66%). This closely matches the findings of Kaur et al. (2012),[10] who reported a 66.3% prevalence of the same type in their study on 300 calcanei. Type II (anterior and middle separate) was the second most common in our study (24.44%), which also aligns with Kaur et al.'s data (26.7%). Regarding the rarer types, our study showed 6.66% for Type III, 2.22% for Type IV, and absence of Type V, compared to Kaur et al.'s 2%, 3%, and 2% respectively. The similarities suggest a strong agreement between both studies, though minor variations, especially in Type III and V, could be due to population or sample size differences.

When compared with Jha et al. (2013),[11] who conducted a study on 100 calcanei, the current findings are largely consistent. Jha et al. reported Type I as the most common configuration (65%), which is nearly identical to our observation of 66.66%. Type II was noted in 23% of their specimens, closely corresponding with the 24.44% found in our study. In terms of less common types, our study recorded 6.66% for Type III and 2.22% for Type IV, whereas Jha et al. collectively reported approximately 12% for Types III–V, though specific percentages were not detailed. Notably, neither study observed a significant incidence of Type V. These similarities reinforce the general distribution trend of calcaneal facet patterns in the Indian population.

The findings of our study also show considerable resemblance to those reported by Singh et al. (2014),[12] who studied 200 calcanei. They found Type I in 60% of cases, slightly lower than our 66.66%, while Type II accounted for 30%, slightly higher than our 24.44%. Singh et al. observed Type III in 5% and Types IV and V in 2.5% each. Comparatively, our study showed a slightly higher percentage of Type III (6.66%) and Type IV (2.22%), with Type V being absent. Overall, the distribution trend is similar, supporting the predominance of Type I and the relative rarity of other types, with minor differences likely due to inter-population variability. In contrast to our study, Muthukumar et al,[13] (2016) found Type II to be the most common pattern (54%) in their analysis of 150 bones, followed by Type I (36%). This distribution is notably different from our findings, where Type I was dominant (66.66%) and Type II was less frequent (24.44%). Our study reported 6.66% for Type III and 2.22% for Type IV, while Muthukumar et al. reported 6%, 2%, and 2% for Types III, IV, and V respectively. The reversal in the most common type suggests potential regional or genetic variation, indicating that facet morphology might not be universally consistent across different Indian populations.

Agarwal et al,[14] (2017) observed a distribution pattern that aligns closely with our findings. In their study of 100 calcanei, they found Type I in 62% of bones, which is similar to our 66.66%. Type II accounted for 30%, slightly higher than our 24.44%. Type III and IV were found in 5% and 2% of their specimens, respectively, while Type V was seen in 1%. Our study reported similar values for Type III (6.66%) and Type IV (2.22%), but no cases of Type V were observed. The close match in the frequencies of Types I–IV further supports a general anatomical pattern across studies, with the variation in Type V potentially due to smaller sample size or population differences.

Yadav et al,[15] (2019) reported Type I as the most prevalent (68%), which is consistent with our finding of 66.66%. They observed Type II in 22% of their cases, which also aligns well with our 24.44%. For the less frequent types, they found Type III in 6%, and Types IV and V each in 2%, while our study showed similar results for Type III (6.66%) and Type IV (2.22%), but no instance of Type V. The similarities in percentage distribution across both studies highlight a shared anatomical pattern in the Indian population and further validate the predominance of Type I calcaneal facet configuration.

In our study, Type I calcaneal facet configuration (anterior and middle facets fused) was the most frequent, found in 66.66% of cases. This is slightly higher than the findings reported by Pratap et al,[16] who observed Type I in 60% of their sample. Type II was found in 24.44% of our cases, which is somewhat lower than Pratap et al.'s report of 30%. For the less common types, our study recorded Type III in 6.66%, Type IV in 2.22%, and no cases of Type V, whereas Pratap et al. documented Type III in 5%, Type IV in 3%, and Type V in 2%. Although there is general agreement in the pattern distribution, the absence of Type V in our sample and the slightly higher Type I percentage may reflect differences in the studied populations or sample size.

The current study's findings also show similarity with those of Garg et al., who reported Type I as the most predominant configuration at 65%, closely comparable to our 66.66%. Garg et al. found Type II in 25% of specimens, which nearly matches our 24.44%. Regarding the less frequent types, Garg et al,[17] documented 5% for Type III, 3% for Type IV, and 2% for Type V, whereas our study found 6.66% for Type III, 2.22% for Type IV, and no incidence of Type V. The pattern suggests a consistent dominance of Type I across both studies, with slight variations in

the rare types, possibly attributable to ethnic, regional, or environmental factors.

Conclusion

The present study highlights that the most common calcaneal facet configuration in the studied population was Type I, where the anterior and middle facets are fused. The distribution of other types showed minor variations, reinforcing the anatomical diversity among individuals. Knowledge of these variations holds substantial clinical relevance. The configuration of the calcaneal facets plays a critical role in the stability and movement of the subtalar joint, and understanding these patterns can assist orthopedic surgeons during surgical procedures like subtalar arthrodesis, calcaneal fracture fixation, and corrective osteotomies. It also aids radiologists in accurate interpretation of imaging and helps biomechanical engineers in the design of foot prostheses and orthotics. Therefore, awareness of these facet patterns is essential for improving surgical outcomes and understanding the functional biomechanics of the foot.

Limitations: The present study was conducted on a limited sample size of ninety dry adult calcanei from an osteology collection, which may not fully represent the broader population. The sex and age of the specimens could not be confirmed, potentially limiting the scope of demographic correlations. Since only dry bones were studied, soft tissue relationships and dynamic functional aspects of the subtalar joint could not be assessed. Additionally, the study was restricted to a single institution, which may introduce regional bias. Future studies with larger, demographically diverse samples and radiological correlation are recommended for more comprehensive anatomical and clinical insights.

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Conflicts of interest

There are no conflicts of interest.

References

1. Bhandare, Vrushali Sachin; Methepatil, Supriya Sarjerao1. A Descriptive Study on the Morphometric Aspects of the Articular Facets for the Talus in the Human Calcanei. National Journal of Clinical Anatomy 13(1):p 36-40, Jan–Mar 2024. | DOI: 10.4103/NJCA.NJCA_6_24
2. Anbumani TL , Sridharan R , Thamarai Selvi A ., AN ANATOMICAL STUDY OF MORPHOLOGY AND MORPHOMETRIC ANALYSIS OF CALCANEUM AND ITS TALAR ARTICULAR SURFACES, International Journal of Anatomy and Research, Int J Anat Res 2017, Vol 5(3.2):4223-29. ISSN 2321-4287.
3. N.Bhanu Sudha Parimala , D. Suma Devi , S. Muralidhar Reddy, A STUDY OF MORPHOLOGY AND TYPES OF TALAR ARTICULAR FACETS IN ADULT HUMAN CALCANEII OF ANDHRA REGION, International Journal of Anatomy and Research, Int J Anat Res 2016, Vol 4(4):3209-14. ISSN 2321-4287
4. ANWESA PAL, ANANYA BISWAS, HIRONMOY ROY, INDRA DATTA, Calcaneal Facet of Talus: An Osseo-morphological Study in the Population of West Bengal, India, International Journal of Anatomy, Radiology and Surgery. 2022 Jul, Vol-11(3): AO05-AO08
5. Rani, Anita. "Variations in Talar Articular Facets of Calcaneum in UP Region and Its Clinical Correlation." International Journal of Scientific Research, 2017.
6. Kleipool RP, Vuurberg G, Stufkens SAS, van der Merwe AE, Oostra RJ. Bilateral symmetry of the subtalar joint facets and the relationship between the morphology and osteoarthritic changes. Clin Anat. 2020 Oct;33(7):997-1006. doi: 10.1002/ca.23525. Epub 2019 Dec 6. PMID: 31749217; PMCID: PMC7540665.
7. Agarwal S, Garg S, Vasudeva N. Subtalar Joint Instability and Calcaneal Spurs Associated with the Configuration of the Articular Facets of Adult Human Calcaneum in Indian Population. J Clin Diagn Res. 2016 Sep;10(9):AC05-AC09. doi: 10.7860/JCDR/2016/20216.8444. Epub 2016 Sep 1. PMID: 27790414; PMCID: PMC5071914.
8. Yang Y, Cheng HW, Xiong ZR, Liu N, Liu Y, Wang Y, Zeng Y, Fu SJ, Zhang L. Classification and Morphological Parameters of the Calcaneal Talar Facet: Which Type Is More Likely to Cause Osteoarthritis in Chinese Population? Biomed Res Int. 2019 Apr 4;2019:6095315. doi: 10.1155/2019/6095315. PMID: 31080826; PMCID: PMC6475557.
9. Yamamoto T, Paulus P, Setliff JC, Hogan MV, Anderst WJ. Influence of Talar and Calcaneal Morphology on Subtalar Kinematics During Walking. Foot Ankle Int. 2024 Jun;45(6):632-640. doi: 10.1177/10711007241231981. Epub 2024 Mar 15. PMID: 38491768; PMCID: PMC11164638.
10. Bunning PSC, Barnett CH. A comparison of adult and foetal talocalcaneal articulations. Journal of Anatomy 1965; 99(1):71-6. 7)
11. SC, Gupta CD, Arora AK. Pattern of the talar articular facets in Indian calcanei. Journal of Anatomy 1977;124(3):651-55. 5)
12. Harrington IJ. Biomechanics of joint injuries. In Bio-mechanics of Musculoskeletal Injury. Baltimore: Williams & Wilkins 1982:31-69. 4)
13. Saadeh FA et al. Patterns of the talar articular facets of Egyptian calcanei. Journal of Anatomical Society of India 2000;49(1):6-8. 9)
14. Muthukumaravel N et al. Human calcaneal facets for the talus: Patterns and Clinical Implications. Journal of Clinical and Diagnostic Research. 2011;5(4):791-4. 6)
15. Yadav N, Nimje D, Patil K. Variation in talus facets on calcaneum and their clinical implications. International Journal of Anatomy Physiology and Biochemistry 2015; 2(7): 1-5.
16. Pratap S, Chopra J, Rani A, Variations in Talar Articular Facets of Calcaneum in UP Region and its Clinical Correlation. International Journal of science research. Volume-6 | Issue-2 | February-2017 ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46.
17. Garg R, Dagal N, Kumar S, Shekhawat S. Study of patterns of talar articular facets of human calcanei and their clinical implications in population of Rajasthan. Indian Journal of Basic & Applied Medical Research; June 2013: Issue-7, Vol.-2, P. 643-650.