European Journal of Therapeutics
pISSN: 2564-7784
eISSN: 2564-7040

Eur J Ther. 2025;31(6):439-446.
https://doi.org/10.58600/eurjther2798

Original Research

Early Findings: Morphometric Evaluation and Articular Surfaces Classification of Talus and Calcaneus

Zekiye Karaca Bozdağ[1], Buse Naz Çandır Gürses[1], İlke Ali Gürses[2], Zafer Arı[1]

[1] Department of Anatomy, Faculty of Medicine, İstanbul Yeni Yüzyıl University, İstanbul, Türkiye
[2] Department of Anatomy, Faculty of Medicine, Koç University, İstanbul, Türkiye

Received: 2025-07-18 **Accepted:** 2025-10-01 **Published Online:** 2025-10-15

Corresponding Author
Zekiye Karaca Bozdağ, PhD
Address: Department of Anatomy, Faculty of Medicine, Istanbul Yeni Yuzyil University, Istanbul, Turkiye
E-mail: zekiye.karaca@yeniyuzyil.edu.tr

This study was presented as a poster presentation at the Anatomical Society Summer Meeting held in Edinburgh on 24-26 July 2024.

ABSTRACT

Objective: The aim was to establish an anthropometric standardisation by classifying the talocrural joint surfaces and bones.

Methods: The anteroposterior and transverse widths of 13 calcanei and 9 tali, and the length and width of the talar and calcaneal sulci were measured using digital calipers. The articular surfaces of the talus and calcaneus were divided into three subclasses according to the number of facets they bear (Type A with three facets: anterior, middle and posterior, Type B with two facets as a result of the fusion of the anterior and middle, Type C with a single facet as a result of the fusion of all articular surfaces).

Results: The mean anteroposterior length and transverse width of the calcaneus were 71.55±5.55 mm and 39.42±2.78 mm, respectively, and the mean anteroposterior length and transverse width of the talus were 53.64±2.36 mm and 38.72±3.07 mm, respectively. In addition, the mean calcaneal sulcus length and width were 19.27±3.87 mm and 5.99±0.85 mm, respectively, and the mean talar sulcus length and width were 23.43±2.91 and 6.71±1.06 mm, respectively. The length of the right calcaneal sulcus was found to be statistically greater (p=0.024). According to articular surface classification, 20% of the talus were type A and 80% were type B; 30.77% of the calcaneus were type A, 69.23% were type B. Type C was not found in either structure.

Conclusion: Knowledge of the shape of the talus and calcaneus bones is crucial for planning and performing orthopaedic surgery, selecting and placing the right size bone grafts, and choosing prostheses or implants. This study provides a reference for future applications. Larger studies are planned to validate and expand on these findings.

Keywords: calcaneus, calcaneal sulcus, morphometry, talar sulcus, talus

INTRODUCTION

The healthy functioning of the foot and ankle complex relies on the precise anatomical alignment of the bones, joints, and ligamentous structures within this region. Within this system, the talocalcaneonavicular (TCN) joint represents a structurally complex articulation that plays a critical role in load transmission, shock absorption, and maintaining postural balance. The TCN joint is located between the head of tali portion of the talus, the anterior and middle articular surfaces of the calcaneus, and the os naviculare. This joint, as part of both the subtalar and transverse tarsal joint complexes, enables multi-axial movements [1, 2].

The shape and size of these articular surfaces can vary a lot from person to person. These variations can directly affect the range of motion, stability, and load transfer of the TCN joint. Identifying these variations is super important for getting the right diagnosis and treatment plan, especially for conditions like subtalar instability, tarsal coalition, pes planus, and osteoarthritis [3, 4].

From a clinical perspective, a detailed understanding of the anatomy of this joint is of great importance in areas such as foot and ankle surgery, arthrodesis procedures, prosthesis design, biomechanical modelling, and the personalisation of foot orthoses. For example, in subtalar arthrodesis operations, a lack of knowledge about the morphology of the articular surfaces can lead to joint congruity issues, early failure, or postoperative complications [1, 5]. Likewise, if these variations are not taken into account during radiological assessments, this may lead to misinterpretation and errors in diagnosis [1, 3, 5].

Main Points

- The articular surfaces of the talus and calcaneus were classified as Type A and Type B; no Type C was observed.
- A significant difference was found between right and left calcaneal sulcus lengths (p=0.024).
- Type B configuration was identified in 80% of tali and 69.23% of calcanei.
- The findings provide reference data for orthopaedic surgery and implant design.

The morphological classification and morphometric measurements of the joint surfaces forming the TCN joint are still in the developmental stage in the current literature. New studies in this field have the potential to make valuable contributions to both anatomy education and clinical practice. This study aims to provide a detailed classification of the anterior, middle, and posterior joint surfaces of the talus and calcaneus, to perform morphometric measurements of these surfaces, and to develop anthropometric standardisation based on the data obtained. It is expected that the results of this study will contribute to basic anatomical knowledge and serve as a reference source for improving diagnosis and treatment processes in clinical practice.

MATERIALS AND METHODS

A total of 22 dry foot bones (13 calcanei and 9 tali) from the Anatomy Laboratories of İstanbul Yeni Yüzyıl University and Koç University were analysed in this study. The age, gender, and side of the individuals to whom the bones belonged are unknown. Two anatomists measured all measurements twice in total. In all specimens, the anteroposterior and transverse diameters of the calcaneus and talus in the same plane were measured using digital callipers (0.01 mm accuracy). Length and width measurements of the sulcus tali and calcaneal sulcus structures in the talus and calcaneus were also taken in the same way. During these measurements, care was taken to fix each bone on a stable surface and to adjust the measurement directions according to the bone anatomy.

1. Morphometric Measurements

Calcaneus Measurements (Figure 1)

- **Antero-Posterior Length of Calcaneus (APLC):** The distance between the most anterior point on the anterior surface of the calcaneus and the most posterior point on the posterior surface was measured [8, 12, 13].
- **Transverse Width of Calcaneus (TWC):** The distance between the most medial point on the medial surface of the calcaneus and the most lateral point on the lateral surface was measured [8, 12, 13].
- **Calcaneal Sulcus Length (CSL):** Defined as the distance between the anterior and posterior borders of the calcaneal sulcus [8, 12, 13].
- **Calcaneal Sulcus Width (CSW):** The distance between the medial and lateral edges of the sulcus was measured [8, 12, 13].

Talus Measurements (Figure 2)

- **Antero-Posterior Length of Talus (APLT):** The distance between the most anterior point on the anterior surface and the most posterior point on the posterior surface of the talus [8, 12, 13].
- **Transverse Width of Calcaneus (TWC):** The distance between the most medial point on the medial surface and the most lateral point on the lateral surface of the talus was determined [8, 12, 13].
- **Sulcus Tali Length (STL):** The distance between the anterior and posterior borders of the sulcus tali was measured [8, 12, 13].
- **Sulcus Tali Width (STW):** The distance between the medial and lateral borders of the sulcus tali was measured [8, 12, 13].

2. Classification of Articular Surfaces (Facet Types)

The articular surfaces (facies articularis) on the talus and calcaneus were classified into three main categories, Type A, B, and C, according to the system defined by Bunning & Barnett [6]. This classification was performed separately for each bone. The classifications were conducted macroscopically by visual inspection, taking into account the boundaries of each facet, fusion lines, and surface morphology. The number of facets, whether they were separated or fused, and the distinctness of the transitions were considered as the main criteria (Figure 3).

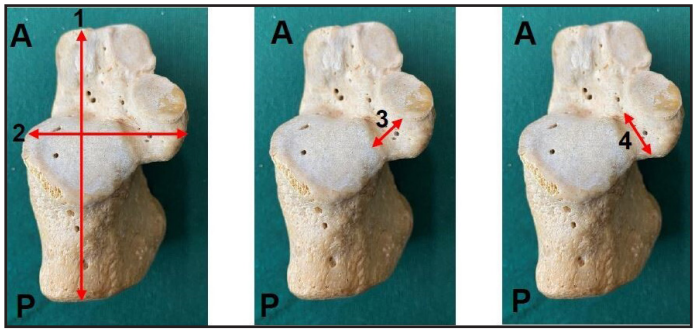

Figure 1. Morphometric description of the calcaneus

Abbreviations: A: Anterior, P: Posterior, 1-APLC 2-TWC 3-CSL 4-CSW

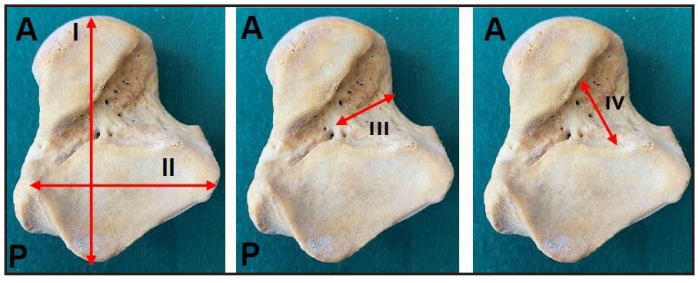

Figure 2. Morphometric description of the talus

Abbreviations: A: Anterior, P: Posterior, I-APLT II-TWT III-STL IV-STW

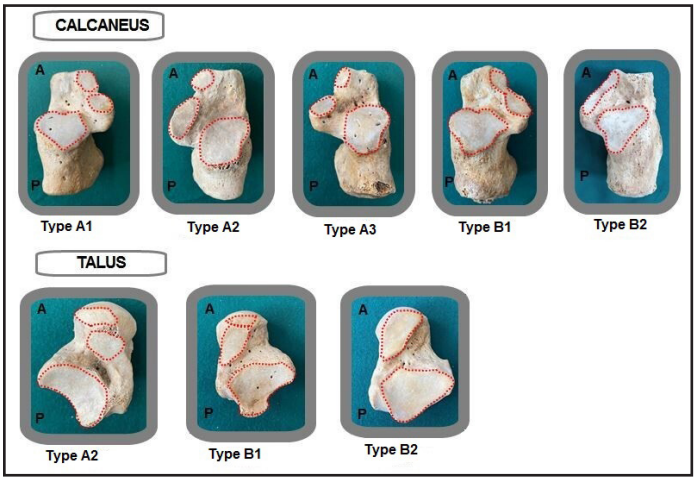

Figure 3. Classification of Talus and Calcaneus according to articular facets.

For the Calcaneus:

- **Type A:** Characterized by three separate facets: anterior, middle, and posterior [6].

  A1: The distance between the anterior and middle facets is less than 2 mm [6].

  A2: The distance between the anterior and middle facets is between 2 and 5 mm [6].

  A3: The distance between the anterior and middle facets is greater than 5 mm [6].
- **Type B:** The anterior and middle facets are fused, while the posterior facet remains separate [6].

  B1: The fusion line between the anterior and middle facets is distinguishable [6].

  B2: The boundary between the anterior and middle facets is unclear, and the surface appears as a single unit [6].
- **Type C:** The anterior, middle, and posterior facets are completely fused, forming a single continuous articular surface [6].

For the Talus:

- **Type A:** The anterior, middle, and posterior facets articulating with the calcaneus can be identified separately [6].

  A1: The distance between the anterior and middle facets is less than 2 mm [6].

  A2: The distance between the anterior and middle facets is between 2 and 5 mm [6].

  A3: The distance between the anterior and middle facets is

greater than 5 mm [6].

- **Type B:** The anterior and middle facets are fused, while the posterior facet is separate [6].
  B1: The fusion line is observable [6].
  B2: The fusion line between the anterior and middle facets is completely obliterated [6].
- **Type C:** All facets are fused into a single continuous articular surface [6].

Statistical Analysis

The Shapiro-Wilk test was used to assess whether the variables follow a normal distribution. Continuous variables were presented as mean±standard deviation values. Categorical variables were reported as n (%). According to the normality test results, an Independent samples t-test was used in comparison between the two groups. Inter-observer reliability was assessed using the ICC (Interclass Correlation Coefficient) test. SPSS (IBM Corp., Released 2012. IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY: IBM Corp.) was used for statistical analysis, and a p value <0.05 was considered statistically significant.

RESULTS

Statistically, when inter-observer agreement was examined, it was determined that the consistency values between measurements varied between 0.926 and 0.999 and that all measurements were highly reliable (p<0.001).

The typing of the articular faces of the calcaneus and talus is summarised in Table 1. In the calcaneus, the Type A rate was 30.77% (7.69% Type A1; 15.38% Type A2; 7.69% Type A3), and the Type B rate was 69.23% (46.15% Type B1; 23.08% Type B2). In the talus, Type A was found to be 20% (Type A2), and Type B was found to be 80% (40% Type B1; 40% Type B2). Type C was not found in either bone.

The mean APLC of the calcaneus was 70.56±3.79 mm on the right side and 72.71±7.33 mm on the left side, the mean TWC was 39.69±2.34 mm on the right side and 39.11±3.44 mm on the left side, and there was no difference between the sides (p<0.05). There was a difference in the mean calcaneal sulcus values between the sides (p=0.024). The mean CSL was 21.41±4.06 mm on the right side and 16.78±1.54 mm on the left side, and it was determined that the length of the right side was higher. The mean CSW was 6.36±0.99 mm on the right side and 5.54±0.37 mm on the left side, and there was no significant difference between the sides (p<0.05) (Table 2).

The mean APLT was 54.80±0.59 mm on the right side and 52.48±2.97 mm on the left side, the mean TWT was 38.49±3.22 mm on the right side and 38.94±3.28 mm on the left side, and there was no difference between the sides. The mean STL was 24.15±2.19 mm on the right side and 22.71±3.60 mm on the left side, the mean STW was 6.28±0.89 mm on the right side and 7.13±1.14 mm on the left side, and there was no difference between the sides (Table 3).

Table 1. Number and percentage of joint face types observed in Talus and Calcaneus

Types	Calcaneus		Talus	
	n	%	n	%
Type A1	1	7.69	0	0
Type A2	2	15.38	2	20
Type A3	1	7.69	0	0
Type B1	6	46.15	4	40
Type B2	3	23.08	4	40
Type C	0	0	0	0
TOTAL	13	100	10	100

Table 2. Mean values comparisons of morphometric features of the calcaneus by side

Parameters	Side	Number	Mean±Std (mm)	p-value
APLC (mm)	Right	7	70.56±3.79	0.537[a]
	Left	6	72.71±7.33	
TWC (mm)	Right	7	39.69±2.34	0.726[a]
	Left	6	39.11±3.44	
CSL (mm)	Right	7	21.41±4.06	**0.024**[a]
	Left	6	16.78±1.54	
CSW (mm)	Right	7	6.36±0.99	0.082[a]
	Left	6	5.54±0.37	

a: Independent Sample t Test

Abbreviations: A: Anterior, P: Posterior, 1-APLC: anteroposterior length of the calcaneus, 2-TWC: transverse width of the calcaneus, 3-CSL: calcaneal sulcus length, 4-CSW: calcaneal sulcus width.

Table 3. Mean values and comparisons of morphometric features of the talus by side

Parameters	Side	Number	Mean±Std (mm)	p-value
APLT (mm)	**Right**	**5**	**54.80±0.59**	**0.124**[a]
	Left	**5**	**52.48±2.97**	
TWT (mm)	**Right**	**5**	**38.49±3.22**	**0.832**[a]
	Left	**5**	**38.94±3.28**	
STL (mm)	**Right**	**5**	**24.15±2.19**	**0.471**[a]
	Left	**5**	**22.71±3.60**	
STW (mm)	**Right**	**5**	**6.28±0.89**	**0.230**[a]
	Left	**5**	**7.13±1.14**	

a: Independent Sample t Test

Abbreviations: A: Anterior, P: Posterior, I-APLT: anteroposterior length of the talus, II-TWT: transverse width of the talus, III-STL: sulcus tali length, IV-STW: sulcus tali width

DISCUSSION

The morphometric data and articular surface typing obtained in this study were evaluated to understand the anatomical importance and clinical implications of the talus and calcaneus bones in the ankle complex. The findings are discussed in the light of studies conducted both in the Anatolian population and in different geographical regions.

The mean APLC was measured as 70.56±3.79 mm on the right side and 72.71±7.33 mm on the left side in our study. These values are lower than the value of 75.49±6.00 mm reported by Dursun et al. [7]. Boyan et al. [8] similarly reported 76.07±5.44 mm. These differences may be explained by individual differences such as sample size, measurement technique, age, and gender. The mean length value of 78 mm reported by Garg et al. [9] from India also underlines the variation among populations.

In this study, the mean APLT was measured as 54.80±0.59 mm on the right and 52.48±2.97 mm on the left, and these values are very similar to the data of Dursun et al. [7] (55.34±5.49 mm). Forriol Campos & Gomez Pellico [10] emphasised that the measurement values may vary in European populations, especially the variations of the posterior articular surface, which have significant ethnic differences.

A significant difference between the sides was shown by CSL in our study (p=0.024). It was measured as 21.41±4.06 mm on the right side and 16.78±1.54 mm on the left side. This result may

be explained by the exposure of the dominant side to repetitive loading. Boyan et al. [8] reported this value as 32.42±3.23 mm on the right and 31.85±2.76 mm on the left. Jung et al. [11] reported that the calcaneal sulcus and sulcus tali depth are associated with subtalar joint stability and may cause sinus tarsi syndrome.

The typology of Bunning & Barnett [6] was taken as a basis for the classification of articular surface types. In our study, Type B1 (46.15%) and B2 (23.08%) were the most common types in the calcaneus, while B1 and B2 were equally common in the talus (40%). Type A variant was found in 30.77% and 20% of both bones, while Type C was not found. These findings coincide with the observations of Dursun et al. [7] and Boyan et al. [8]. Similarly, Ipek et al. [12] reported type B2 as the most common variant with a rate of 69.1% in the talus and type A1 as the most common variant with 40.3% in the calcaneus. On the other hand, Lee et al. [13] reported that Type A was more common in the Korean population. This suggests that geographical and ethnic origin are determining factors in articular surface variations.

It was emphasised in the study of Boyan et al. [8] that A3 and C types are rare and B types are predominant. This suggests that the load-bearing and balance functions of the subtalar joint with larger contact surfaces are preserved in the population. In addition, Linklater et al. [14] stated that type B variants have a lower risk of coalition; in contrast, fused articular surfaces, such as Type C, increase the risk of coalition and the possibility of movement limitation. The fact that Type C was not found in our study supports that this variant is rare in the Anatolian population.

The clinical importance of these variations is due to the biomechanical properties of the subtalar and talocalcaneonavicular joints. Anjaneyulu et al. [15] reported that subtalar movement limitations, instability, and postural disorders are observed more frequently in B2 types in which the anterior and medial surfaces are united. It has also been reported that these types predispose to pathologies such as tarsal coalition, pes planus, and arthritis.

Variations in the articular surfaces of the talus and calcaneus bones are of great importance not only in orthopaedic practice, but also in radiological diagnoses, medico-legal sex estimation, and anthropological classifications. These variations reflect interindividual and interpopulation differences and are used in various clinical and forensic applications. The morphometric properties of the calcaneus and talus bones are particularly important for subtalar joint stability and ankle biomechanics. Consideration should be given to variations in these bones when performing surgical procedures such as implant selection and osteotomy planning [7, 12]. Vučinić et al. [16] reported in another study that morphological variations in calcaneal facets may affect subtalar joint stability and are therefore important in surgical planning. Radiological imaging techniques are used to evaluate variations in the articular surfaces of the talus and calcaneus bones. It is important to note that these variations play an important role in the diagnosis and treatment planning of subtalar joint pathologies. In addition, the shape and size of the joint surfaces in the subtalar joint can affect joint stability and range of motion. Determining gender is possible by studying the dimensional characteristics of the talus and calcaneus bones [8, 17]. Moreover, a study by Ouamthong et al. [18] on a Thai population revealed that measuring the calcaneus and talus bones offered precise results for sex estimation. The demonstration in this study is of the reliability of morphometric analysis of these bones as a method for the estimation of sex. Anthropologists can use morphological variations of the talus and calcaneus bones in classifications by comparing different populations. The existence of these variations may be a reflection of genetic and environmental differences between populations. An investigation by Vučinić et al. [16] on the Serbian population examined variations in calcaneal facets and reported that these variations reflect inter-population differences.

Limitations

The limitations of the study are the small sample size and the use of only two-dimensional measurements. These variations should be evaluated in future studies with larger samples about factors such as sex, age, and loading patterns, and the findings should be correlated with clinical scenarios. Furthermore, using three-dimensional imaging and volume analysis could facilitate a more objective evaluation of articular surface areas.

CONCLUSION

In conclusion, this study not only details the morphometric characteristics of the talus and calcaneus, but also evaluates the types and distribution of variations in the joint surfaces. So, what we have found is in line with what other studies have found, but there are some unique differences too, which add to the info we already have about the area. The different shapes of the surfaces of the talus and calcaneus are very important in many areas of science. These areas include orthopedic surgery, radiological

diagnosis, forensic sex estimation, and anthropological classifications. Comprehending these differences might lead to more precise results in personalised treatment planning and forensic applications. We believe that our data will serve as a valuable reference for orthopaedic surgeons, radiologists, and anatomists, and will also provide a foundation for future comparative studies.

This study was presented as a poster presentation at the Anatomical Society Summer Meeting held in Edinburgh on 24-26 July 2024.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: None.

Informed Consent: Not applicable.

Ethical Approval: This study was obtained from Istanbul Yeni Yüzyıl University Science and Health Sciences Research Ethics Committee with decision number 2025/06-1577 (Date: 2025-06-17).

Author Contributions: Conception: ZKB, BNÇG, İAG - Design: ZKB, BNÇG - Supervision: İAG, ZA - Materials: ZKB, BNÇG - Data Collection and/or Processing: ZKB, BNÇG, İAG – Analysis and/or Interpretation: ZKB, BNÇG - Literature: ZKB, BNÇG - Review: ZKB, BNÇG - Writing: ZKB - Critical Review: ZKB, BNÇG, İAG, ZA

REFERENCES

[1] Sammarco VJ (2004) The talonavicular and calcaneocuboid joints: anatomy, biomechanics, and clinical management of the transverse tarsal joint. Foot Ankle Clin 9(1):127-45. https://doi.org/10.1016/S1083-7515(03)00152-9

[2] Krähenbühl N, Horn-Lang T, Hintermann B, Knupp M (2017) The subtalar joint: A complex mechanism. EFORT Open Rev 6;2(7):309-316. https://doi.org/10.1302/2058-5241.2.160050

[3] Barbaix E, Van Roy P, Clarys JP (2000) Variations of anatomical elements contributing to subtalar joint stability: intrinsic risk factors for post-traumatic lateral instability of the ankle? Ergonomics 43(10):1718-25. https://doi.org/10.1080/001401300750004122

[4] Agarwal S, Garg S, Vasudeva N (2016) 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 1;10(9):AC05-AC09. https://doi.org/10.7860/JCDR/2016/20216.8444

[5] Shahabpour M, Devillé A, Van Roy P, Vaes P, De Mey J, De Maeseneer M (2011) Magnetic resonance imaging of anatomical variants of the subtalar joint. Surg Radiol Anat 33(7):623-30. https://doi.org/10.1007/s00276-011-0788-8

[6] Bunning PS & Barnett CH (1965) A comparison of adult and foetal talocalcaneal articulations. J Anat. 99(1):71–76. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1261461/

[7] Dursun A, Yılmaz V, Kastamoni Y, Öztürk K, Albay S (2021) Anadolu Popülasyonunda Talus ile Calcaneus'un Morfometrik Özellikleri ve Ortak Eklem Yüzlerinin Tiplendirilmesi. SDÜ. 12(3):351-363. https://doi.org/10.22312/sdusbed.961431

[8] Boyan N, Ozsahin E, Kizilkanat E, Soames R, Oguz O (2016) Morphometric measurement and types of articular facets on the talus and calcaneus in an Anatolian population. Int. J. Morphol. 34(4):1378-1385. https://www.scielo.cl/pdf/ijmorphol/v34n4/art33.pdf

[9] Garg R, Dagal N, Kumar S, Shekhawat S (2013) Study of patterns of talar articular facets of human calcanei and their clinical implications in population of Rajasthan. IJBAMR 2(7):643–650.

[10] Forriol Campos F, Gómez Pellico L (1989) Talar articular facets (facies articulares talares) in human calcanei. Acta Anatomica 134(2):124–127. https://doi.org/10.1159/000146675

[11] Jung MH, Choi BY, Lee JY, Han CS, Lee JS, Yang YC, Cho BP (2015) Types of subtalar joint facets. Surg Radiol Anat 37(6):629-638. https://doi.org/10.1007/s00276-015-1472-1

[12] İpek ED, Gümüş C, Akdoğan İ (2025) Talus ve calcaneus'un morfometrik analizi, talar ve calcaneal eklem yüzü tipleri. KÜ Tıp Fakültesi Dergisi 27(1):1-7. https://doi.org/10.24938/kutfd.1498683

[13] Lee JY, Jung MH, Lee JS, Choi BY, Cho BP (2012) Types of Calcaneal Articular Facets of the Talus in Korean. Korean J Phys Anthropol 25(4):185-192. http://doi.org/10.11637/

kjpa.2012.25.4.185

[14] Linklater JM, Hayter CL, Vu D, Tse K (2009) Anatomy of the subtalar joint and imaging of talo-calcaneal coalition. Skeletal Radiol. 38(5):437–449. https://doi.org/10.1007/s00256-008-0615-4

[15] Anjaneyulu K, Philips C, Tamang BK, Kumar A (2014) Patterns of talar articulating facets in adult human calcanei from North-East India and their clinical correlation. AJMS 5(4):89–93. https://doi.org/10.3126/ajms.v5i4.9486

[16] Vučinić D, Blagojević Z, Vučinić V (2020) Morphological types of calcaneal articular facets and clinical implications: A study of subtalar joint stability. PLOS ONE 15(10):e0240818. https://doi.org/10.1371/journal.pone.0240818

[17] Kavya S, Sowmya SS, Sharmada KL (2019) Sex determination by talus: A comparative study. IJCAP 6(4): 484–487. https://doi.org/10.18231/j.ijcap.2019.106

[18] Ouamthong R, Aunhachoke K, Chaiyamoon A, Duangto P (2023) Sex Determination Using Morphometry of Talus and Calcaneus in a Thai Population. Int. J. Morphol. 41(1): 268–273. https://doi.org/10.4067/S0717-95022023000100268

How to Cite;

Karaca Bozdag Z, Candir Gurses BN, Gurses IA, Ari Z (2025) Early Findings: Morphometric Evaluation and Articular Surfaces Classification of Talus and Calcaneus. Eur J Ther. 31(6):439-446. https://doi.org/10.58600/eurjther2798