

## Variations in the Talar Articular Facets of the Calcaneum Bone in a Medical College of Rajasthan.

Dr. Parveen Ojha<sup>1</sup>, Dr. Rihab Moin Khan<sup>2</sup>, Dr. Sanjeev J Das<sup>3</sup>, Dr. Tiwari Pratiksha<sup>4</sup>, Dr. Nagda Anish<sup>5</sup>, Dr. Narendra Kumar<sup>6</sup>.

<sup>1</sup>(Professor & HOD, Department of Anatomy, RNT Medical College, Udaipur)

<sup>2</sup>(Post graduate resident, Department of Anatomy, RNT Medical College, Udaipur)

<sup>3</sup>(Post graduate resident, Department of Anatomy, RNT Medical College, Udaipur)

<sup>4</sup>(Post graduate resident, Department of Anatomy, RNT Medical College, Udaipur)

<sup>5</sup>(Post graduate resident, Department of Anatomy, RNT Medical College, Udaipur)

<sup>6</sup>(Post graduate resident, Department of Anatomy, RNT Medical College, Udaipur)

### Abstract:

**Background:** The posterior pillar is formed by the calcaneus, the major bone of the longitudinal arch. It is in charge of taking in and transferring the weight of the body to the plantar arch below. The three facets on the ventral surface—the anterior, middle (where the ant. facet extends), and posterior—articulate with the corresponding talus facets. The central facet is located on the upper surface of the sustentaculum tali, whereas the anterior and posterior facets are located on the body. Incidence in variations of these facets on calcaneum is seen quite often.<sup>7</sup>

**Materials and methods:** 100 whole dry calcanei of unknown gender were procured from the Department of Anatomy, RNT Medical College, Udaipur. They were classified as Type A (all separate facets), B (anterior and middle fused), C (all 3 facets fused to form one large facet) and D (absent anterior facet) according to Bunning & Barnett (1965). Types of articular facets were observed photographs were taken methodically.

**Results:** We found Type A in forty seven calcanei (22 right and 25 left), Type B in twenty seven (15 right and 12 left), Type C in sixteen (5 right and 11 left) and Type D in eight (2 right and 6 left) in the current study. On the other hand, we saw an additional facet in one right side bone, which we classified as Type F.

**Conclusion:** In conclusion, morphological analysis is important for both foot rehabilitation and reconstruction surgeries.

**Key word:** calcaneum, anatomy, sustentaculum tali, additional facet, facets, foot rehabilitation, foot surgeries.

Date of Submission: 24-06-2024

Date of Acceptance: 03-07-2024

### I. INTRODUCTION:

The largest tarsal bone, the calcaneum, extends posteriorly to the fibula and tibia, acting as a short lever for the calf muscles that are linked to it posteriorly. It has an uneven cuboidal shape, with an angled long axis directed laterally and upwards. The sustentaculum tali, a shelf like projection from the anteromedial surface is often divided into a middle and an anterior talar facet by a non-articular interval (the frequency of this division varies according to gender, race and occupation). In rare cases, all three facets are fused into an irregular area on the upper surface of the calcaneus.<sup>7</sup>The common variations in the talar facets on the calcaneus have been described in detail by Bunning & Barnett<sup>1</sup> (1965) in British, Nigerian and Indian subjects and by El-Eishi<sup>3</sup> (1974) in Egyptians. However the number of Indian<sup>1</sup> calcanei studied (78) was too small for detailed documentation of variations. Then in 1977 S. C. GUPTA et al<sup>4</sup> carried out a detailed analysis on patterns of anterior talar articular facets in a series of 401 Indian calcanei revealed four types. Type I (67%) showed one continuous facet on the sustentaculum extending to the distomedial calcaneal corner; type II (26%) presented two facets, one sustentacular and one distal calcaneal; type III (5%) possessed only a single sustentacular facet; and type IV (2%) showed confluent anterior and posterior facets.<sup>7</sup> Observing this significant difference we have decided to carry out the following study in our college setup among 100 dry calcanei procured from our college. Knowledge about variations in the talar facets of the calcanei is essential for orthopaedic surgeons while correcting foot deformities like pes planus.

## II. MATERIAL AND METHODS:

100 dry calcanei were procured from the Department of Anatomy, RNT Medical College, Udaipur.

All bones were of unknown gender and grossly normal without any physical damage. Types of articular facets were observed photographs were taken methodically.

Classification given by Bunning & Barnett<sup>3</sup> (1965) was followed in the present study. Accordingly, three types A, B, C & D were observed.

**Study Design-**Descriptive cross-sectional study design.

**Study Location:** This study was undertaken at Department of Anatomy set up under RNT medical college, Udaipur, Rajasthan.

**Study Duration:** February 2022 to July 2023 for a period of six months.

**Sample size:** 100 dry calcanei.

**Sample size calculation:** Maximum calcanei fulfilling the inclusion criterion were incorporated into the study.

**Selection Method:** 100 dry calcanei were procured from the Department of Anatomy, RNT Medical College, Udaipur and it was insured that all bones were grossly normal without any physical damage. These bones were taken at random were of unknown gender.

Classification given by Bunning & Barnett (1965) was followed in the present study. Accordingly, four types A, B, C & D were observed.

TYPE A- one continuous facet on sustentaculum tali.

TYPE B- 2 facets on sustentaculum tali i.e. anterior and middle facet.

TYPE C- only one single facet on sustentaculum tali.

TYPE D- single facet on sustentaculum tali continuous with the posterior facet.

Other types we found as study was carried out and classified them as follows:

TYPE E- all facets separate i.e. 2 facets (anterior and middle) on the sustentaculum tali and one separate posterior facet.

Type F- Extra facets on the anterior surface other than the 2 facets.

### INCLUSION CRITERIA:

Dry normal adult calcanei were taken for this study.

### EXCLUSION CRITERIA:

Any damaged or deformed bones were discarded.

**Procedure methodology:** 100 dry adult human calcanei were procured randomly from Department of Anatomy, RNT medical college, Udaipur for a period of 6 months. These were of unknown gender and both paired and unpaired. The talar articular facets on the superior surface of the calcaneum were observed.

The sustentaculum tali a shelf like projection protruding from the anteromedial surface can be seen. Its superior surface is the articular surface and has facet for corresponding facet of talus bone. This facet was observed to be either one continuous surface or was divided by a middle constriction or had a single facet only continuous with the posterior surface. The posterior facet can be seen caudal to the sustentaculum tali and is articular. These were then grouped under type A, B, C and D accordingly by following the Bunning & Barnett<sup>1</sup> (1965) classification.

In addition, we found two other variations in our study in which all three facets were completely separated, i.e. anterior, middle and posterior, and a rare finding was that one calcaneum had an additional facet next to the sustentaculum tali. These were grouped under type E and F.

Necessary photos were taken and the observations were tabulated accordingly. Non-probability convenience sampling technique was followed.

**Statistical Analysis:** The data was categorized according to different variables and further categorized data was entered on a master chart in MS Excel 2013 (office 365, Microsoft Company Ltd, USA). Coded data was analyzed using statistical software SPSS (earlier, Statistical product for social sciences; later, statistical Product and Service Solutions) version 16.0 [IBM SPSS Software, Chicago, IL, USA]. Proportions were calculated by statistical methods.

## III. RESULTS:

After careful observation all of our observations were tabulated as follows.

In table no.1 we have tabulated the additional types of facets found during the course of our study. Type E was observed only in 1 bone of the right side and type F where extra facet was observed in one bone of right side. Both highlighted by yellow.

Table no.2 shows the types of calcanei which have type A, B, C, and D of facets. Type A facets were observed in 47 calcanei i.e. 22 right and 25 left. Type B was observed in 27 bones i.e. 15 right and 12 left. Type C was observed

in 16 i.e. 5 right and 11 left. Type D seen in 8 i.e. 2 right and 6 left. According to Bunning & Barnett<sup>1</sup> (1965) classification these were grouped.

Further we compared our present study with the other studies done in India and globally to find any association with race and origin in table 3 & 4.

**TABLE NO. 1**

TYPE A: ONE CONTINUOUS FACET ON ST.	TYPE B: TWO FACETS ON ST i.e. ANTERIOR AND MIDDLE.	TYPE C: SINGLE FACET ON ST.	TYPE D: SINGLE FACET ON ST CONTINUOUS WITH POSTERIOR FACET.	TYPE E: ABSENT ANTERIOR FACET.	TYPE F: EXTRA FACET	TOTAL
47 (22 right & 25 left)	27 (15 right & 12 left)	16 (5 right & 11 left)	8 (2 right and 6 left)	1 (right side)	1 (right side)	100

**TABLE NO. 2**

BUNNING & BARNETT CLASSIFICATION (1965)			
TYPE A	TYPE B	TYPE C	TYPE D
ONE CONTINUOUS FACET ON ST.	TWO FACETS ON ST i.e. ANTERIOR AND MIDDLE.	SINGLE FACET ON ST.	SINGLE FACET ON ST CONTINUOUS WITH POSTERIOR FACET.
47 (22 right & 25 left)	27 (15 right & 12 left)	16 (5 right & 11 left)	8 (2 right and 6 left)

\*ST- Sustentaculum Tali.

**TYPE A (fig. 1 & 2) - one continuous facet on sustentaculum tali.**

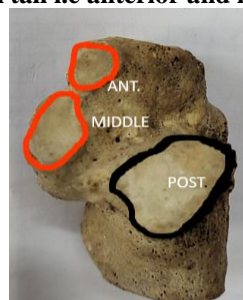


**FIG. 1**



**FIG. 2**

**TYPE B (fig. 3)-2 facets on sustentaculum tali i.e anterior and middle facet.**

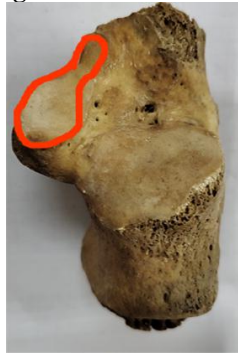


**FIG. 3**

**TYPE C (fig. 4 &5) - only one single facet on sustentaculum tali.**

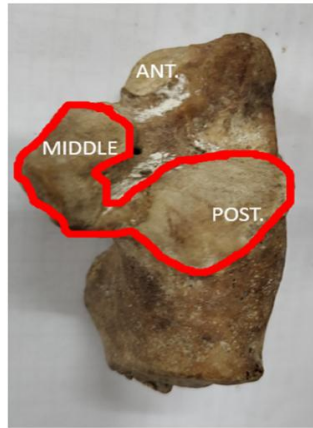


**FIG. 4**



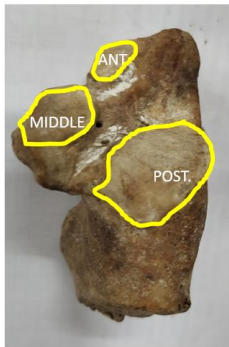
**FIG. 5**

**TYPE D (fig. 6) - single facet on sustentaculum tali continuous posteriorly.**



**FIG. 6**

**TYPE E (fig. 7 & 8) - all facets separate**

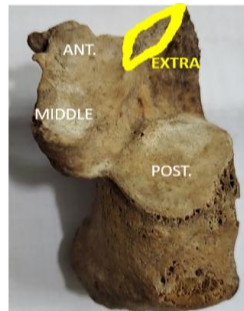


**FIG. 7**



**FIG. 8**

**TYPE F (fig. 9) - Extra facets on the anterior surface other than the 2 facets.**



**FIG. 9**

TABLE NO. 3 -STUDIES DONE IN INDIA.

AUTHOR (INDIAN)	TYPES OF CALCANEI			
	TYPE A	TYPE B	TYPE C	TYPE D
1. Gupta et al, 1976, UP, (n*=401) <sup>4</sup>	104	269	8	20
2. Rangnath et al, 2006, South India, (n=71)	17	48	NIL	6
3. Patel et al, 2011, Western India, (n=205)	59	133	4	8
4. Garg et al, 2013, Jaipur, (n=310)	224	76	1	5
5. Anjaneyulu et al, 2014, North-East India,(n=100)	31	62	2	5
6. Seema et al, 2012, North India, (n=300)	126	168	6	NIL
PRESENT STUDY (n=100)	47	27	16	18

\*Where n is total number of bones.

TABLE NO. 4- GLOBALLY

AUTHOR (GLOBALLY)	TYPE OF CALCANEUM (%)			
	TYPE A	TYPE B	TYPE C	TYPE D
Bunning et al, 1965, INDIAN, n=78.	61	17	NIL	NIL
Bunning et al, 1965, VEDDAH, n=10	0	6	4	0
Bunning et al, 1965, BRITISH, n=194.	64	130	NIL	NIL
Bunning et al, 1965, NIGERIAN, n=492.	312	176	NIL	4
El-Eishi et al, 1974, EGYPTIAN, n=200.	80	98	NIL	22
Campos et al, 1989, SPANISH, n=176.	46	53	NIL	NIL
Drayer Verhagen et al, 1993, USA, n= 191	51	104	NIL	36
Hussain et al, 2010, PAKISTAN, n=350.	28.6	62.9	NIL	8.6
PRESENT STUDY, n=100.	47	27	16	8

From the **Table 3** we understand that type A and B are predominantly seen in the Indian population. Type C & D though not seen commonly in previous studies but in this present study we were able to appreciate in many calcanei. Our study shares similarities with findings in western Indian regions (Patel M et al).<sup>8</sup> From the **Table 4** we have compared our study with other studies done at a global level to see any similarities between different races and regions. It is clear that type A & B are predominantly seen globally but among many races.<sup>3, 4, 6,9,10,11,12,13</sup> Type C & D is more common among Indian race<sup>9, 10,11,12,13</sup> and not seen in any of the other races.

#### IV. DISCUSSION:

In the present study, Type A which was a single articular facet on the sustentaculum tali was consistent with the findings of Gupta S, Garg SC and Seema et al.<sup>4,10,11</sup> In fact our studies have quite similar results to those of Garg S C et al<sup>4</sup> in Jaipur, Rajasthan. However, we did not find any missing anterior facet (type E) as in this study.

In the present study, we encountered two new types of specimens in which all three facets were separated and a single bone had an additional facet next to the sustentaculum tali, which we termed Types E and F.

The pattern according to Type A was found to dominate in present study. Our results confirm the observations from other Indian studies. Pattern A was also common in African studies when compared globally.<sup>1</sup> However, in Europeans<sup>1</sup>, Type B was predominant, while in Americans, pattern A with fused anterior and medial facets was more common than pattern B. The samples of Egyptians<sup>3</sup>(El-Eishi H et al) and Africans<sup>1</sup> strongly agree with those of Indians, with Type A being by far the most common and Type B being second. All these findings indicated that there was a correlation between the calcaneal facet pattern and race. Present study has established the fact that the joint facets on calcanei which articulate with talus show racial and individual differences.

A comparison of the heel bones of adult Africans, Indians and Europeans by Bunning and Barnett<sup>1</sup> revealed a clear racial difference for which no functional explanation can be offered. The racial differences observed in the adult bones were also present in the foetal calcanei, suggesting that they are probably genetic and not developmental responses to physical activity. Thus, the link between genetic factors and variations in calcaneal facets was indirectly demonstrated. Although it is necessary for many branches of science to define and appreciate these differences in order to make an accurate diagnosis and carry out treatment, there is no detailed knowledge that identifies these differences.<sup>11</sup>

Knowledge of the talar facets of the calcaneus is essential for orthopaedic surgeons who perform 'Lengthening-distraction wedge calcaneal osteotomy and interpositional bone grafting' to correct pes planus deformities. In this procedure, determining the interval between the anterior and middle facet is important for the exact placement of the retractor, as the osteotomy line usually runs through the same interval.<sup>5</sup> Calcaneus Type A predominates in Indians compared to Europeans, who often have pattern B. This fact makes it necessary for the orthopedic surgeons in India to modify the surgical techniques in calcaneal osteotomy. As not many studies have been done in the state of Rajasthan we have hence made aware that they may be at a greater risk of developing subtalar arthritis due to the dominance of Type A calcanei.

Finally as we concluded the study we shed some light on the limitations of the study which predominantly is inability to determine the gender of the bones we had procured as this would also have greatly helped in establishing gender differences and also helped to determine which diseases or pathologies are common in males and in females and if females are more prone to disease more than males with advancing age.

Also the best method to visualize these facets and the talocalcaneal joint in detail is which is in fact gold standard MRI or x-rays at base level. We have but attempted to aid anatomically in the better understanding of this joints. These imaging modalities are gold standard and hence used to develop implants and prosthesis. Another limitation is our sample size which was limited to a hundred.

## V. CONCLUSION:

- The articular facets on the calcanei that articulate with the talus show racial and individual differences.
- In our study we saw rare observations like extra facet near to the sustentaculum tali.
- In the study population (Rajasthanis), Type A calcanei predominate compared to Europeans, who frequently exhibit Type B. This fact necessitates that the orthopedic surgeons in India to modify the surgical techniques in calcaneal osteotomy and also they are at a greater risk of developing subtalar arthritis.

## REFERENCES:

- [1]. Bunning PSC, Barnett CH. Variations in the talocalcaneal articulations. *Journal of Anatomy* 1963; 97(5): 643.
- [2]. Bunning PS, Barnett C. A comparison of adult and foetal talocalcaneal articulations. *J Anat.* 1965; 99(Pt 1):71-6.
- [3]. El-Eishi H. Variations in the talar articular facets in Egyptian calcanei. *Acta Anat (Basel).* 1974; 89(1):134-8.
- [4]. Gupta SC, Gupta C, Arora A. Pattern of talar articular facets in Indian calcanei. *J Anat.* 1977; 124(Pt 3):651-5.
- [5]. Greer Richardson E. Pes Planus. In: S Terry Canale, editor. *Campbell's Operative Orthopaedics*. 9th ed. St. Louis: Mosby – Year Book, Inc., 1998; pp. 1720-1725.
- [6]. Rangnath P, Manjunath KY, Balasubramanyam V. Variations of the talar articular facets of the calcaneus in South Indians. *South Asian Anthropologist.* 2006; 6(1): 69-71.
- [7]. Susan S, Neel A, Rolfe B, Patricia C, Alan R, Michael G, et al. "Gray's Anatomy-Anatomical Basis of Clinical Practice." 40th Edition. 2008; 84 (9):1437-38.
- [8]. Patel M. Foam posturography: standing on foam is not equivalent to standing with decreased rapidly adapting mechanoreceptive sensation. *Experimental Brain Research.* 2011; 208(4): 8.
- [9]. Nagar SK, Ojaswini M, Dharati K, Gosai SR, Andani RH, Bhaskar P. Types of talar articular facets and morphometric measurements of the human calcaneus bone. *Natl J Med Res.* 2012; 2(2):128-32.
- [10]. Seema, Maninder S, Anupam M, Gandhi DK. Variation in Calcaneal Articular Facets in North Indian Population and its Clinical Implications. *Global Journal of Medicine and Public Health.* 2012; 1(1): 24-26.
- [11]. 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.
- [12]. Anjaneyulu K, Chandira Philips, Tamang BK, Kumar A. Pattern of articulating facets in adult human Calcanei from north-east India and their clinical correlation. *Asian journal of medical science.* 2014; 5(4): 89-93.
- [13]. Jyotsna, Anuradha Mamidi. The morphometric analysis of calcaneus and its articular facets. *Indian Journal of Clinical Anatomy and Physiology* 2022; 9(1):22-24.