

Original article

Study of patterns of talar articular facets of human calcanei and their clinical implications in population of Rajasthan

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Abstract:

Introduction: There are three facets over upper side of talocalcaneal joint: anterior talar facet, middle and posterior. There is considerable variations in the number and arrangement of these facets. Present study was done to determine patterns of the talar facets of calcanei & their clinical implications in the population of Rajasthan and to find out association of patterns of the talar facets of calcanei with racial factors, if any.

Materials & methods: 310 adult dry calcaneal bones at SMS Medical College, Jaipur (Rajasthan) were studied. Each calcaneum was carefully examined for various patterns of articulating facets for talus. Where the anterior and middle facets were separated from each other (Pattern II), the distance between the two was measured.

Results: Pattern I with fused middle & anterior facets was predominant- found in 72.26%, followed by Pattern II in 24.52% of the bones. Pattern III, IV and V were found in 1.3%, 1.6% and 0.32% respectively. Subtypes in Pattern II: Subtype A with middle and anterior facet separation of (<2mm)-4.8%, Subtype B (2-5mm)-7.7%, Subtype C (>5 mm)-8.1%.

Conclusion: The articular facets of subtalar joint on calcanei show racial and individual differences. Study population may be at greater risk of developing subtalar arthritis due to predominant pattern I calcanei as compared to the Europeans who present pattern II commonly. This fact necessitates modifications of the western surgical techniques to suit the Indian scenario especially for orthopaedic surgeons in India when they perform calcaneal osteotomy.

Key words: Calcaneum, Articular facets, Pattern, Variation, Subtalar joint.

Introduction:

Calcaneum is the biggest and longest among the tarsal bones. It forms talocalcaneal joint with talus. This joint maintains eversion and inversion of foot and named as subtalar joint. There are three facets over upper side of talocalcaneal joint: anterior talar facet, middle and posterior. (1) The middle third of the superior surface of the calcaneus carries the posterior talar facet for articulation with the body of the talus. While a consensus exists in the anatomic literature about the morphology of the posterior facet, there are divergent descriptions of the anterior facet. In the anterior third of the calcaneus, distal and medial to

the sulcus calcanei, an articular area covers the sustentaculum tali. This facet articulates with the head of the talus, and may be divided in about half the cases by a non-articular zone creating middle and anterior talar facets the incidence of which varies with race and sex (2, 3).

The anterior and the posterior facets are situated on the body and the middle is situated on the sustentaculum tali. There is considerable variations in the number and arrangement of these facets. Using parameters such as degree of separation, fusion, and shape, several workers have described types and preponderance of articular facets on the anterior third of the calcaneus in

certain population groups like African, Indian, British, Egyptian, and Spanish. (4,5,6,7,8) Important race-related differences have emerged that seem to be genetically determined, possibly. Although these researchers use slightly different classificatory schemes:-

Bunning and Barnett (1963) have observed that there are three types of variations in the arrangement of facets. They have classified these variations as follows:

Type-A: There are three facets separated by variable intervals.

Type-B: There are two facets, anterior and middle which are either continuous or have a notch between them.

Type-C: There is only one facet i.e. the three form a continuum. (5)

Few Indian workers have also worked on this subject. Jha et al (1972) have reported that type-B calcanei are common amongst the population in Uttar Pradesh and also have classified type-B calcanei into four subgroups :

Group-1: Anterior and middle articular facets completely fused and form a single facet.

Group-2: Anterior and middle articular facets incompletely separated from each other by means of a notch.

Group-3: Anterior and middle articular facets separated from each other but with no non-articular area intervening.

Group-4: Absence of anterior articular facet. Only middle and posterior articular facets were being present. (9)

Most researchers view these differences in facet configuration as anatomical variations of no functional significance. Bruckner (1987) in contrast, argues that the subtalar joints formed by

calcanei which had the pattern II facet configuration were comparatively more stable and had less chances of developing arthritis. There are two separate facets, anterior and middle, in the anterior 1/3 rd of the calcaneum with the pattern II facet configuration. These two facets along with the posterior facet provide an 'osseous tripod' for the talus to sit on and to prevent excess motion of the talar head. Thus, the subtalar joint with this tripod support is less likely to suffer trauma or biomechanical stress and the incidence of osteoarthritis is also less in such cases. Unstable joints are more likely to suffer trauma, accidents or other biomechanical stress as a result of uneven weight distribution. (10)

Morphometric values of calcaneum are important for the science of anatomy, treatment and diagnostic procedures on orthopaedic surgery, kinesiology, physical treatment and rehabilitation sections. The racial and individual differences of the anatomic construction of the calcaneum play a key role on static and kinetic dynamic on the foot. During the treatment period of the congenital club foot, talocalcaneal coalition, severe pronation cases, valgus deformities, subtalar instability and development of subtalar implants talus-calcaneum relation should be well defined. (4,11,12)

However, this subject is interesting but comparing the larger population of the Indian subcontinent, the amount of study carried on the variation of facets is much less. Similar study in the population of Rajasthan has not yet been undertaken so far. The present study was planned to determine patterns of the talar facets of calcanei & their clinical implications in the population of Rajasthan and to find out association of patterns of

the talar facets of calcanei with racial factors, if any.

Materials & methods

Study was conducted by utilizing 310 adult dry calcaneal bones from bone bank of department of Anatomy, Sawai Man Singh Medical College, Jaipur (Rajasthan). As far as it could be ascertained, the specimens were free of pathological changes or anomalies. Sexual dimorphism was not considered. Each calcaneum

was carefully examined for various patterns of articulating facets for talus. Articular margin of facets was marked with black fine tipped sketch pen and each calcaneum was numbered and photographed. A sliding vernier calliper was used to measure the separation between the facets. All observations and measurements were made twice. Incidence of various patterns was calculated and compared with available literature. Classification used in present study were:-

Table 1: Classification of calcaneal articular facets.

Pattern	Feature
I.	Middle & Anterior facet fused, Two facets on calcaneum
II.	Middle & Anterior facet separate, Three facets on calcaneum
III.	Anterior facet absent, Two facets on calcaneum
IV.	Anterior, Middle & Posterior facets fused, Only one facet on calcaneum
V.	Middle & Posterior facets fused, Two facets on calcaneum

Where the anterior and the middle facets were separated from each other (Pattern II), the distance between the two was measured with the help of the blunt pointers of the sliding calliper. The posterior most part of the anterior facet was taken as the anterior point and the anterior most

part of the middle facet was taken as the posterior point. Depending upon degree of separation between middle & anterior facets, pattern II was divided into three subtypes. Subtype A with middle and anterior facet separation of less than 2mm. Subtype B:-2-5mm. Subtype C:-more than 5 mm.

Results:



Photograph : Showing various patterns of calcaneal articular facets.

Pattern I - Middle & Anterior facet fused, Two facets on calcaneum

Pattern II - Middle & Anterior facet separate, Three facets on calcaneum

Pattern III - Anterior facet absent, Two facets on calcaneum

Pattern IV - Anterior , Middle & Posterior facets fused, Only one facet on calcaneum

Pattern V - Middle & Posterior facets fused, Two facets on calcaneum

Table 2: Incidence of calcaneal articular facets in present study.

S. no.	PATTERN	PRESENT IN (TOTAL=310)	PERCENTAGE %
1.	I. M & A fused	224	72.26
2.	II. M & A SEPARATE	76	24.52
3.	III. A FACET ABSENT	4	1.3
4.	IV. A& M& P FUSED	5	1.6
5	V. M & P FUSED	1	0.32

M-Middle, A-Anterior, P-Posterior calcaneal facets.

Pattern I with fused middle & anterior facets was predominant- found in 224 bones (72.26%), followed by Pattern II in 24.52% of the bones. Cases of pattern III and IV were found in 1.3%, 1.6% respectively. Pattern V with fused middle & posterior facets was found in only one bone (0.32%).[Table-2]

Subtypes in Pattern II: Subtype A with middle and anterior facet separation of less than 2mm was seen in 15 bones (4.8%). Subtype B (2-5mm) was seen in 24 bones (7.7%). Subtype C (more than 5 mm) was seen in 25 bones (8.1%).

Discussion:

Table 3: Comparison of results of different calcaneal studies including the present study.

STUDY	YEAR	COUNTRY	n*	I (%)	II (%)	III(%)	IV(%)	V (%)
Burning & Barnett ⁽⁶⁾	1965	Britain	194	33	67	---	00	---
	1965	Veddah	10	60	00	---	40	---
	1965	Indian	78	78	22	---	00	---
	1965	African	492	63	36	---	1	---
Gupta SC et al ⁽⁸⁾	1977	India	401	67	26	5	2	---
Campos&Pellicio ⁽⁴⁾	1989	Spain	176	53.41	39.77	6.82	00	---
Verhagen FD ⁽¹³⁾	1993	USA	191	54.45	26.7	18.85	---	---
Saadeh FA et al ⁽¹⁴⁾	2000	Egypt	300	63	30.3	4.7	2	---
Barbaix E et al ⁽¹⁵⁾	2000	Belgium	134	25	64	11	00	---
Ragab A et al ⁽¹⁶⁾	2003	American	--	46	25	12	0.2	---
Priya R et al ⁽¹⁷⁾	2006	South India	71	67.6	25.35	7.04	---	---
Madhvi C et al ⁽¹⁸⁾	2008	South India	222	72.1	19.4	6.8	1.3	0.4
Mujde Vuygur etal ⁽¹⁾	2009	Turkish race	221	58.37	34.39	4.98	2.2	---
MuthukumarNetal ⁽¹⁹⁾	2011	South India	237	65.82	33.33	---	0.42	0.42
Shahabpowr etal ⁽²⁰⁾	2011	Belgium	49	44.9	44.9	10.2	00	---
Mini Mol P et al. ⁽³⁾	2012	India(Mumbai)	50	74	26	00	00	---
Present Study	2012	India(Rajasthan)	310	72.26	24.52	1.3	1.6	0.32

*Total number of calcaneal bones studied.

Pattern I calcaneal type was found to be dominant in the present study. Our findings confirmed the observations of other Indian studies (3,8,17,18,19). In African studies (6,14) also, Pattern I was common. But pattern II was predominant in Europeans (6, 8), whereas in Americans, pattern I with fused anterior and middle facets was commoner than pattern II (13). There is a strong correspondence in Egyptians & Africans sample and those for Indians with type I being the most frequent by far, and type II in second place. All these findings indicated that there was a correlation

between the calcaneal facet pattern and race. [Table-3/Figure]

The rare pattern IV which was found in other studies was also found in the present study in 5 bones (1.6%). But the unusual feature of the present study was the finding of one calcaneum with the pattern V talar facet (0.32%), which was the rarest pattern which has been rarely reported in the literature. In pattern V, the middle and the posterior facets are fused and a distinct anterior facet is seen. [Table-2,3/Figure]

Table 4: Comparison of incidence of subtypes (pattern II) with other studies.

Study	Year	Country	n*	Subtypes Pattern II		
				A**	B [†]	C [‡]
Gupta SC etal ⁽⁸⁾	1977	India	401	09	04	13
Camposs & Pellicio ⁽⁴⁾	1989	Spain	176	2.84	21.02	15.91
Saadeh FA etal. ⁽¹⁴⁾	2000	Egypt	300	-	6.7	23.7
Mujde Uygur etal ⁽¹⁾	2009	Turkey	221	4.08	13.12	17.19
MuthukumaravelNetal ⁽¹⁹⁾	2011	South India	237	-	27	6.32
Mini Mol P etal ⁽³⁾	2012	India(Mumbai)	50	22	02	02
Present study	2012	India(Rajasthan)	310	4.8	7.7	8.1

*Total number of calcaneal bones studied. **less than 2mm, †2-5mm, ‡more than 5 mm.

In the present study, in pattern II, the subtype C (>5mm) was the commonest one (8.1%). This finding coincided with the findings of Gupta SC et al.(8) Similar findings were also observed in Egyptian population (14) and Turkish population (1), while in south Indians, subtype B was common (19) and in Mumbai population, subtype A was found to be most frequent in occurrence. (3)[Table-4]

foetal calcanei, thus indicating that they were probably genetically determined and were not developmental responses to physical activities. Thus, the association of genetic factors with

A comparison of the adult African, Indian and European calcaneal bones by Bunning and Barnett (6) revealed a distinct racial difference for which no functional explanation can readily be offered. These findings were compared with those which were derived from the study of the corresponding foetal calcaneal bones of African, Indian and European populations. The racial differences which were observed in adult bones were also present in variations of the calcaneal facets were indirectly established. Present study has established the fact that the joint facets on calcanei which articulate with talus show racial and individual differences.

In textbooks, anterior and posterior facets are mentioned separately while the middle one is defined as the continuation of the anterior facet.

Although it is necessary to define and appreciate these differences for many science branches to make accurate diagnosis and the treatment, there is no detailed knowledge indicating these differences. The articular facets of the sustentaculum tali have a variety of configurations that are generally viewed as nonmetric traits of little functional significance. Buckner (10), stated that sustentaculum tali facet variations are functionally important because they influence subtalar joint stability; to test this hypothesis, 191 calcanei were analysed for correlations between sustentaculum tali facet morphology and osteoarthritis of the subtalar joint by Verhagen FD (13). Calcanei with two separate sustentaculum tali facets had a lower frequency of arthritic changes associated with joint instability than calcanei with other facet configurations. This finding supports Buckner's hypothesis that subtalar joint facet configuration is a factor in foot mobility.

It is well known that the treatment choices of the complex foot deformity are osteotomy, anatomic reduction, and relaxation of the soft tissue to obtain a normal-sized, painless and functional foot. It would be helpful to know the pathological and clinical anatomy of the deformed foot so that some structurally based treatment plan could be formulated.

Knowledge of the talar facets of the calcaneum is essential for the orthopaedic surgeons who perform 'Lengthening-distraction wedge calcaneal osteotomy and interposition bone graft', to correct the deformities in Pes planus. In this procedure, the identification of the interval between

the anterior and the middle facets is important for the exact placement of the retractor, since the line of osteotomy usually passes through the same interval (21). This technique is suitable for Europeans who predominantly have calcanei with pattern II facets for the tali (with separate middle and anterior facets). Since pattern I calcanei (with fused middle and anterior facets) are found to be dominant in study population (Indians), the surgeons here have to be careful while applying this technique or a suitable modification may be required. It establishes that the awareness about the variations in the talar facets of the calcaneum is vital in the surgical management of foot deformities. (19)

In many diseases of foot, such as the talocalcaneal arthritis and coalition, intraarticular fractures and congenital dysmorphology, flatfoot, valgus deformities: the size and shape of the bones, the relationships of the talus and calcaneus with each other and other bones of the foot must be considered for the internal and external fixation and surgical procedures. There is a dominance of pattern I calcanei in Indians as compared to the Europeans who present pattern II commonly. This fact necessitates the orthopaedic surgeons in India to modify the surgical techniques when they perform calcaneal osteotomy. Indians (Rajasthanis) may be at a greater risk of developing subtalar arthritis due to the dominance of Pattern I calcanei. Today with the aid of the improvement of the technology there has been a great development of the subtalar implants, the flaps and prosthesis for the foot. Detailed anatomic information will be baseline for advanced treatment procedures.

Calcaneal articular surface characteristics and sex difference were not taken in account during

present study. Future studies taking care of these factors and by using imaging modalities have been recommended. Three-dimensional computerized imaging techniques may present facet surfaces of talus and calcaneus. So, in talocalcaneal subluxation, coalition and many dysmorphologies, success rate of diagnosis and treatment will increase and talocalcaneal joint implants and prosthesis may be developed.

Conclusion:

- The joint facets on calcanei which articulate with talus show racial and individual differences.
- There is a dominance of pattern I calcanei in study population (Rajasthanis) as compared to the Europeans who present pattern II commonly. This fact necessitates the orthopaedic surgeons in

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India to modify the surgical techniques when they perform calcaneal osteotomy.

- Study population may be at greater risk of developing subtalar arthritis due to their dominance of pattern I calcanei.
- These anatomic variants exist from earliest days of life without causing any trouble, but initiation of complaints like pain or instability of ankle should be analysed in detail to verify about pre-existing anatomic variations.
- Racial differences in the facet pattern of calcanei necessitate modifications of the western surgical techniques to suit the Indian scenario.

Conflict of interest: Nil.

Source of support: Self financing.

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Date of submission: 28 January 2013
Date of Provisional acceptance: 17 March 2013
Date of Final acceptance: 28 April 2013
Date of Publication: 03 June 2013
Source of Support: Nil ; Conflict of Interest: Nil