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Original Research Article

STUDY OF VARIATIONS IN TALAR ARTICULAR FACETS OF HUMAN CALCANEI AND THEIR ASSOCIATION WITH CALCANEAL SPURS IN NORTH INDIAN POPULATION

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ABSTRACT

Background: Calcaneum is the largest tarsal bone of foot. The superior surface of calcaneum bears 3 articular facets anterior, middle and posterior for the talus. There are considerable variations in number and arrangement of these facets. Many times because of constant stress or calcium deposit, a bony deformity appears on it called calcaneal spur. Present study was done to determine pattern of the talar facets of calcanei and their clinical implication in North Indian population and association with calcaneal spur.

Materials and Methods: The present study was conducted in the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India in 600 dry calcanei of unknown sex and age. The superior, posterior and inferior surface of each calcaneum was carefully examined for various type of articulating facets for talus and presence or absence of calcaneal spur.

Results: According to types of talar facets, we classified calcanei into 5 Types.

Type I- Fusion of middle and anterior facets (73.9%). This group was further divided into Type Ia and Type Ib on the basis of constriction. **Type II**- The anterior and middle facets were separate (21.5%). This group was also divided into Type IIa, Type IIb and Type IIc on the basis of distance between anterior and middle facets. **Type III**- Absence of anterior facet (3.67%). **Type IV**- Fusion of all 3 facets i.e. anterior, middle and posterior (0.3%). **Type V**- Fusion of middle and posterior facets (0.6%). Type I was predominant followed by Type II. Total incidence of calcaneal spur was found to be 17.7% of which 35% were only dorsal spur, 60.4% only plantar spur while 4.7% bear both dorsal and plantar spurs. These spurs were found predominantly in Type I calcanei. Type III and IV didn't exhibited dorsal or plantar spurs.

Conclusion: The superior articular surface of calcanei shows racial and individual difference. There is dominance of Type I calcanei which is associated with spurs in Indians as compared to Europeans who commonly present Type II. This fact necessitates the orthopaedic surgeons in India to modify the surgical technique when they perform calcaneal osteotomy.

KEY WORDS: Calcaneum, Variations, Dorsal Spur, Plantar Spur, Articular Facets.

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INTRODUCTION

Calcaneum is the longest and largest weight bearing tarsal bone of proximal row. Its long axis is inclined upward and laterally. It forms the posterior pillar of the two longitudinal arches of the foot. It is the first tarsal bone to ossify. Calcaneal indexing is an effective method of surveying osteoporosis to predict the population at risk of sustain fractures [1]. Calcaneum is also a useful tool in determination of sex and its length being considered useful in stature estimation [2-4]. It articulates with overlying talus to form talocalcaneal joint which together with the talocalcaneo-navicular joint is referred to as subtalar joint [5]. Calcaneum has six surfaces i.e. dorsal, plantar, lateral, medial, anterior and posterior. There are three facets on the dorsal surface for synovial joints between calcaneum and talus i.e. anterior, middle and posterior. The anterior and posterior facets are situated on the body while middle is situated on sustentaculum tali. Anterior and middle facet articulates with the head of talus while posterior with the body of talus.

There is considerable variation in the number and arrangement of these facets. They are functionally important because they influence the subtalar stability. Calcaneum is the most frequently fractured tarsal bone with calcaneal fracture accounting for about 60% of all major tarsal injuries. The majority of fractures involve subtalar joint. Certain morphological variations of calcaneal facets for tali may predispose to the development of arthritic changes in subtalar joint [6]. Although a talocalcaneal coalition may occur at any of the three facets, the majority of osseous fusion involves the middle facet. Tarsal coalition is a frequent cause of painful flat foot [7].

When foot bone is exposed to constant stress, calcium deposits built up on the pattern of heel bone. However, repeated damage can cause these deposits to pile up on each other, causing a spur shaped deformity called calcaneal spur. Osseous spurring of the plantar aspect of the calcaneus was first documented in 1900 by German physician Plettner who coined the term Kalkaneussporn (calcaneal spur) [8]. Obese people, flat footed people and women who constantly wear high heeled shoes are more susceptible to heel spur. Calcaneal spur are of two types i.e. dorsal (posterior) spurs and plantar (inferior) spurs. The inferior spur is located on the inferior aspect of calcaneus and is typically a response to plantar fasciitis over a period, but may also be associated with ankylosing spondylitis. Posterior spur develops on the back of the heel at the insertion of Achilles tendon. Clinically, it may remain asymptomatic or produce disabling pain in heel [9]. The morphology of articular facets of calcaneus and spurs has been a subject of interest to anatomists and its anatomical information will be the baseline of advanced treatment procedure. In this study, we aimed to analyse the various pattern of talar articular facets on calcanei and to assess the incidence of calcaneal spurs associated with type of calcaneum in North Indian population.

MATERIALS AND METHODS

The present study was conducted in the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India. Six hundred calcanei without prominent pathology and unknown sex were included in the study. The superior surface of bones was carefully examined for the presence of talar articular facets while dorsal and plantar surfaces for calcaneal spurs. The calcanei were classified into 5 types on the basis of talar articular facets. The number of facets and incidence of calcaneal spurs were recorded and photographed. The sliding vernier calliper was used to measure the distance between the facets.

OBSERVATIONS AND RESULTS

Six hundred calcanei were classified into 5 types depending on the talar articular facets present on the superior surface (Table 1). Type I, showing the fusion of anterior and middle facets was found in 442 bones (73.9%) i.e. 240 right side and 202 left side (Fig. 1 & 2). Type II, in which the anterior and middle facets were separate, was found in 130 bones (21.5%) of which 48 were of right side and 82 were of left side (Fig. 3-5). Type III, categorized by the absence of anterior facet was found in 22 bones

(3.67%) i.e. 12 right sided and 10 left sided (Fig. 6). Type IV, in which there was fusion of anterior, middle and posterior facets, was found in 2 bones (0.3%) of right side only (Fig. 7). Type V, showing the fusion of middle and posterior facets was found in 4 bones (0.6%) i.e. 2 each of right and left side (Fig. 8).

Depending on the presence or absence of constriction of facet, type I was subdivided into Type Ia and Ib. Type Ia (Fig. 1) in which the facet was constricted was found in 352 bones (200 right and 152 left).Type Ib (Fig. 2) in which the facet was not constricted was found in 90 bones (40 right and 50 left).

Depending on the degree of separation between the anterior and middle facets, type II was subdivided into 3 varieties i.e. IIa with less than 5mm separation (Fig. 3) which was noted in 54 bones (20 right and 34 left), IIb with 5-10mm separation (Fig. 4) was observed in 68 bones (24 right and 44 left) and IIc with separation of more than 10mm (Fig. 5) was seen in 8 bones (4 right and 4 left).

The presence or absence of the calcaneal spurs on the posterior (dorsal) and inferior (plantar) surfaces were also studied in detail according to types of calcaneum (Table 2, Fig. 9). Total incidence of calcaneal spurs was found to be 17.7% (106 bones). The incidence of only dorsal spur was 35 %, being highest in Type I calcanei (27 bones) followed by Type II calcanei (10 bones) while only plantar spur was 60.4% being highest in Type I (56 bones) followed by Type II (6 bones) and Type IV (2 bones). Type III and IV didn't exhibited dorsal or plantar spur. Both dorsal and plantar spurs were encountered in 4.7% calcanei i.e. 4 bones in Type I and 1 bone in Type II. None of Type III, IV, V calcanei had both dorsal and plantar spur.

Table 1: Incidence of various types of calcanei on the basis of talar articular facets in North Indian population.

Type	Subtype	Number of Bones		Total no. of bones	Percentage (%)
		Right	Left		
Type I	Ia	200	152	352	58.8
	Ib	40	50	90	15.1
Type II	II a	20	34	54	9
	II b	24	44	68	11.3
	II c	4	4	8	1.2
Type III	-	12	10	22	3.67
Type IV	-	2	0	2	0.3
Type V	-	1	1	2	0.6

Table 2: Incidence of calcaneal spurs according to calcaneal type.

Type of Calcanei	No. of calcanei showing spurs			Incidence of calcaneal spurs (%)
	Dorsal	Plantar	Both	
Type I	27	56	4	87(82%)
Type II	10	6	1	17(16%)
Type III	0	0	0	0(0%)
Type IV	0	2	0	2(1.9%)
Type V	0	0	0	0 (0%)
Total No. (%)	37 (35%)	64 (60.4%)	5 (4.7%)	106

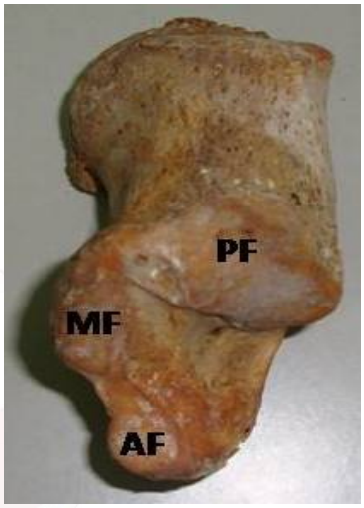

Fig. 1: Type Ia calcaneum (fusion of anterior facet-AF and middle facet-MF with constriction), PF-posterior facet.

Fig. 2: Type Ib calcaneum (fusion of anterior facet-AF and middle facet-MF without constriction).

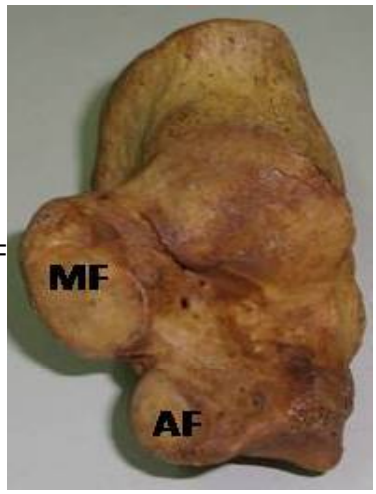

Fig. 3: Type IIa calcaneum (anterior facet- AF and middle facet-MF are separate with < 5mm distance).

Fig. 4: Type IIb calcaneum (anterior facet- AF and middle facet-MF are separate with 5-10mm distance).

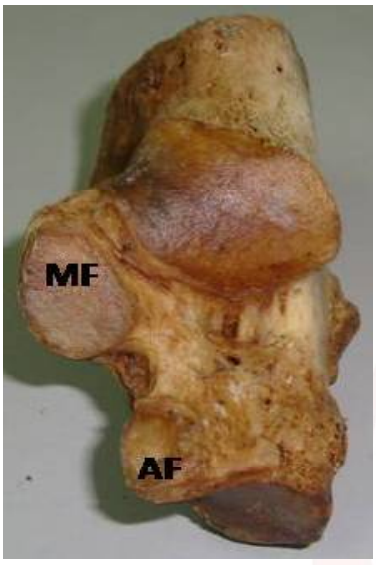

Fig. 5: Type IIc calcaneum (anterior facet- AF and middle facet-MF are separate with > 10mm distance).

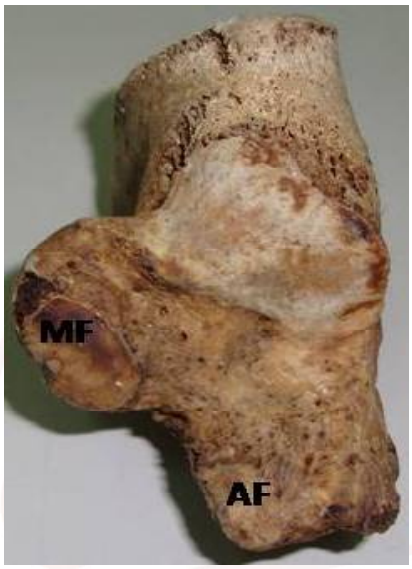

Fig. 6: Type III calcaneum (absence of anterior facet), MF-middle facet, PF-posterior Facet.

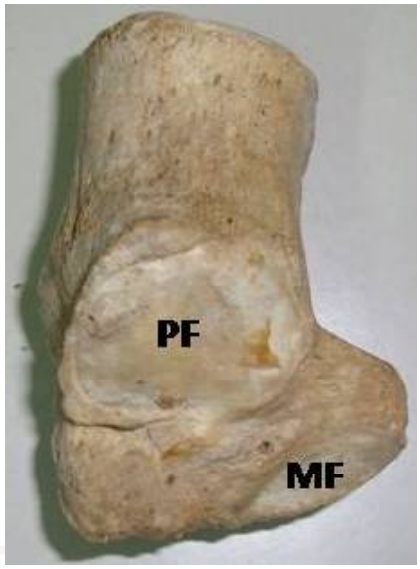

Fig. 7: Type IV calcaneum (fusion of anterior facet-AF, middle facet-MF and posterior facet-PF).

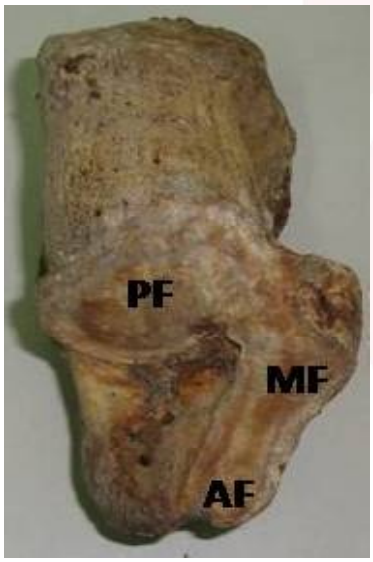

Fig. 8: Type V calcaneum (fusion of middle facet-MF and posterior facet-PF), AF-anterior facet.

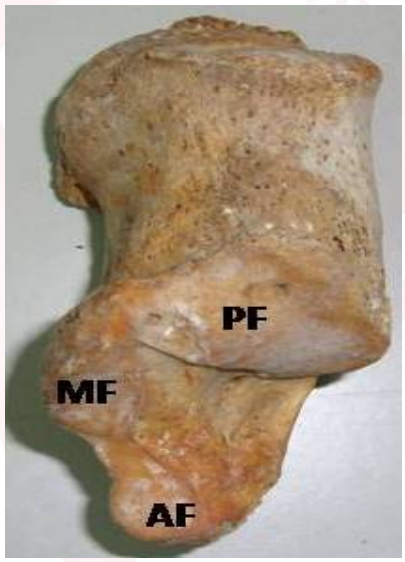

Fig. 9: Dorsal spur (DS) and Plantar spur (PS).

DISCUSSION

The results of the present study are consistent with the studies done previously. In the present study Type I calcanei were found maximum (73.9%) followed by Type II (21.5%). Studies done in various parts of India by Muthukumaravel et al. (2011) in South Indians (Tamilnadu) and Patel et al. (2013) in Western Indians (Gujarat) also found predominance of Type I calcanei i.e. 65.82% and 64.88% respectively followed by Type II i.e. 33.33% and 28.78% respectively but in both the studies separation between anterior and middle facets in Type II was less than 5mm while we noted maximum bones with 5-10 mm separation [10, 11]. The number and arrangement of articular facets on the superior surface of calcaneum and incidence of calcaneal spurs have been described by different authors (Table 3 & 4).

In our study, the total incidence of spurs was 17.7% in North Indians but Menz et al. (2008) reported 55.1% in Australia while Perumal and Anand (2013) noted 56% in Tamilnadu, India [12, 13]. The incidence of plantar spurs found in the present study was 60.4% which is much more as compared to 16% observed by Resnick et al. (1977) [14]. The dorsal spurs varied in height and were always directed superiorly due to the pull of tendocalcaneus. Plantar spurs also

Table 3: Comparative incidence of types of calcanei with previous studies.

Author	Year	Country	n*	Type of calcanei (%)								
				I	Ia	Ib	II	IIa	IIb	IIc	III	IV	V
Bunning and Barnett [22]	1965	European	194	33	-	-	67	-	-	-	-	0	-
	1965	Veddah	10	60	-	-	0	-	-	-	-	40	-
	1965	Indian	78	78	-	-	22	-	-	-	-	0	-
	1965	African	492	63	-	-	36	-	-	-	-	1	-
Jha & Singh [25]	1972	Indian	294	504	-	-	294	-	-	-	-	2	-
Gupta et al [21]	1977	Indian	401	67	28	39	26	9	4	15	5	2	-
Forriol & Gomez [27]	1989	Spanish	176	54	29	25	42	5	21	16	4	-	-
Boonruangsri et al. [29]	1992	Thai	230	59	90	40	40	10	22	8	0.57	0.43	-
Verhagen [6]	1993	American	191	54.4	-	-	26.7	-	-	-	18.8	-	-
Saadeh et al. [26]	2000	Egypt	300	63	-	-	30.3	-	-	-	4.7	2	-
Uygur et al. [28]	2009	Turkish	221	58	-	-	39.8	-	-	-	-	-	-
Mini et al. [24]	2012	Indian	50	74	-	-	26	-	-	-1	0	0	-
Present study	**2015**	Indian	600	73.9	58.8	15.1	21.5	9	11.3	1.2	3.6	0.3	0.6

n*: No. of calcaneum studied

Table 4: Comparison of incidence of calcaneal spurs with previous studies.

Author	Year	n*	Total spurs (%)	Plantar spurs (%)	Dorsal spurs (%)	Both spurs (%)
Resnick et al. [14]	1977	-	22	16	11	4
Prichssuk and Subhadrabandhu [18]	1994	-	15.5	-	-	-
Riepert et al. [17]	1995	-	15.7	11.2	9.3	-
Menz et al. [12]	2008	216	55.1	55	48	-
Perumal and Anand [13]	2013	218	56	-	-	-
Present study	**2015**	600	17.7	60.3	35	4.7

n*: No. of calcaneum studied

varied in length, but were always directed anteriorly due to traction of plantar fascia. Previous studies stated that these spurs have some relation with age, sex, obesity, race and type of calcanei. Bassiouni (1965) found that frequency of calcaneal spurs increased with age in patients with osteoarthritis and rheumatoid arthritis than controls [15]. Banadda et al. (1992) reported 50% prevalence of calcaneal spurs in Zimbabwean hospital patients aged over 51 year [16]. Riepert et al. (1995) found that plantar spurs were more in females [17]. Menz et al. (2008) found that obese people are more prone to develop spur [12]. The high incidence of plantar calcaneal spur was found in Victoria, Australia, while fewer incidences were seen in Thailand and Caucasian population [12,17,18]. Li and Muehleman (2007) found that stress lead to the formation of spur [19]. Bassiouni (1965) found that 81% patients of osteoarthritis had calcaneal spur as compared with 21% of rheumatoid arthritis and 16.1% of control patients [15]. Williams et al (1987) suggested it to be one of the causes of heel pain [20]. The incidence of calcaneal spur has been directly linked to type of calcanei. According to present study, spurs are frequently associated with Type I (82%) followed by Type II (16%).These findings are consistent with Gupta et al. (1977), Bunning and Barnet (1963, 1965), Mini et al. (2012), Jha and Singh (1972) who reported that the incidence of Type I was significantly higher than Type II in Indians [21-25]. It was also common in American, African, Egyptian, Spanish, Turkish and

Thai studies [6,22,23, 26-29]. But Type II is predominant in European population [23]. These findings indicate that there is a correlation between the calcaneal facet type and race. A comparison of the adult African, Indian and European calcaneal bones by Bunning and Barnett (1965) revealed a distinct racial difference [23].

The racial differences which were observed in adult bones were also present in foetal calcanei. Thus, indicating that they were probably genetically determined. Some authors are in opinion of that when 3 facets (anterior, middle and posterior) are present on the superior surface of calcaneum, they can be due to high heeled foot wearing. As the high heel transmits the weight of body anteriorly, it will give rise to formation of anterior facet on the superior surface of distal part of calcaneum. In flat foot because of loose calcaneonavicular ligament and spring ligament, the anterior part of head of talus will rest on superior surface of distal part of calcaneum which also results in formation of anterior facet [22, 23].The findings of Verhagen (1993) suggested that the talar facet morphology of calcaneum is an important factor in subtalar joint stability [6]. This finding is consistent with the hypothesis of Bruckner (1987), who stated that the subtalar joints formed by calcanei having 3 facets i.e. anterior, middle and posterior were comparatively more stable and have less chances of developing arthritis [30].

All 3 facets when separated provide an 'osseous tripod' for the talus to sit on and to prevent excess motion of talar head. Thus, the subtalar joint, with this tripod support, is less likely to suffer trauma or biomechanical stress and incidence of osteoarthritis is also less in such cases. According to Verhagen (1993), arthritic changes were present only in 35.29% of calcanei with Type II facet. But the same changes were present in 65.38% of calcanei with Type I facet and in 50% of the calcanei with Type III facet. He also supported another theory which explained the increased mobility of talar head in the subtalar joints formed by calcanei with fused anterior and middle facet, so that the articular surface is continuous, flat and smooth giving fewer impediments to the medial rotation of talar head. This type can cause laxity of spring ligament and other supporting muscles due to continuous and excessive pressure which is exerted by talar head. This laxity of ligament and muscle is thought to be responsible for the unstable subtalar joints, thus leading to osteoarthritis [6]. These theories imply that Indians may be at greater risk of developing arthritis since they predominantly have Type I calcanei as again proved in our study. Stability of subtalar joint also depends on the height of longitudinal arch, which is determined by the inclination of subtalar joint axis. High arch represents a more stable structure and is commonly referred to as a 'rigid' or 'canvas foot' [26,27]. Many factors such as wearing shoes, squatting habits, genetic and racial differences are the probable reasons for the variations in the facets on the calcanei in the western and Indian population.

Knowledge of talar articular facets of calcaneum is essential for orthopaedic surgeons who perform 'lengthening-distraction' wedge calcaneal osteotomy, interposition bone graft and triple arthrodesis procedure to correct the deformities in pes planus in which measurement of anterior and middle facet is important. This technique is suitable for Europeans who predominantly have calcanei with Type II facet. Since Type I calcanei are found to be dominant in Indians. So, it is important for Indian surgeons to have the detailed anatomical information to modify the surgical techniques for advanced treatment procedures.

CONCLUSION

The variations in difference between various types of facets on calcanei can result from difference in race, gait and habit of shoe wearing. In the present study, Type I calcanei was dominant in Indians with increase incidence of calcaneal spur. Other factors which increase the incidence of spurs are increasing age, weight, concurrent orthopaedic disease and heel pain. Calcaneal spur may be one of the causes of heel pain. Our population may be at greater risk of developing subtalar arthritis due to dominance of Type I calcanei. These facets show racial difference as Europeans present Type II commonly. Therefore, there is need of

modification of present surgical techniques to suit the Indian scenario.

Conflicts of Interests: None

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