ORIGINAL ARTICLE

Modifications on Dorsum of Neck of Talus (Squatting Facets and Trochlear Extensions) in Indians

Rohin Garg[1], Sushila Shekhawat[2], Khushboo Mogra[3], Santosh Kumar[4]

[1]Assistant Professor, Department of Anatomy, Teerthanker Mahaveer Medical College & Research Centre, Moradabad, Uttar Pradesh, India, [2]Senior Demonstrator, Department of Anatomy, JLN Medical College, Ajmer, Rajasthan, India, [3]Assistant Professor, Department of Anatomy, National Institute of Medical Sciences, Jaipur, Rajasthan, India, [4]Senior Lecturer, Department of Anatomy, Jaipur Dental College, Jaipur, Rajasthan, India

ABSTRACT

Objective: Habitual squatting in humans is associated with modifications of ankle especially the neck of the talus (squatting facets) and its trochlear surface (trochlear extensions) that characterize the strong pressure and traction forces on ankle joints in state of hyperdorsiflexion. Present study was done to find out variations and incidences of various types of modifications of neck of talus thoroughly and to determine regional peculiarities of these modifications in Indians. **Material and Methods:** 300 dry (150 right and 150 left) adult tali were taken for present study. Each talus was examined for the presence of various patterns of articular facets on neck of talus and extensions of its trochlear surface. Statistical analysis of data was performed by using Fisher exact test with 95% confidence limits. **Results:** Lateral squatting facet was found in 136 tali (45.3%). Incidences of medial, combined & continuous gutter like squatting facets were 7.7%, 3.3% & 4.3% respectively. Lateral and medial extensions of trochlear surface were found in 22.3% and 23.7% respectively. **Conclusions:** Modifications of the neck of talus (squatting facets and trochlear extensions) are result of prolonged squatting positions which is common habit of Indian population and incidences of these variations can be used as an anthropological marker for racial and regional differentiation of unidentified bones.

Keywords: Osteology, Posture, Squatting Facets, Talus, Trochlear extensions

INTRODUCTION

Bone- one of the strongest biological materials in existence, particularly in terms of bearing weight- is main supporting tissue of the body. Bone is virtually universal rigid underpinning of musculoskeletal system and must therefore routinely resist compression, tension, shear, bending and torsion during lifetime of an individual. Remodeling of bone occurs in response to physical stress.[1] Skeleton can undergo significant remodeling in response to normal or abnormal biomechanical stress.[2] Passive pressure on a bone can deform its shape in a surprisingly short space of time, especially in the young. Cranial deformations, sitting positions and load bearing can all resulting characteristic changes to bone forms and articular surfaces of the joints.[3] Habitual squatting has long been recognized to alter the skeletal morphology of the lower limb.[4]

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During locomotion the foot is rarely dorsiflexed sufficiently enough to bring the anterior border of distal end of tibia in contact with dorsum of neck of talus but squatting is a resting postural complex that involves hyperflexion at the hip and knee and hyperdorsiflexion at the ankle and subtalar joints.[5] Habitual squatting in humans is associated with modifications of ankle especially the neck of the talus (squatting facets) and its trochlear surface (trochlear extensions) that characterize the strong pressure and traction forces on ankle joints in state of hyperdorsiflexion.

Thomson (1889) first described the presence of squatting facets on the anterior margin of distal extremity of tibia and upper surface of neck of talus.[4] Barnett (1954) in addition found two facets (medial and lateral) on neck of talus. He also found lateral and medial extensions on the neck of talus which continue the line of curvature of the trochlea of the talus and which makes contact with the undersurface of tibia during dorsiflexion.[6] Since then various researchers have studied these

Corresponding Author:
Dr. Rohin Garg, A-409, Near JDA Nursery Circle, Vaishali Nagar, Jaipur, Rajasthan, India, PIN-302021. Phone no: 08192848265, 09414983161
Email: rohingarg99@yahoo.co.in

facets and trochlear extensions in different population groups. Morphometric values of tali are important for the science of Anatomy, Anthropology, treatment and diagnostic procedures on orthopedic surgery, kinesiology, physical treatment and rehabilitation sections. The racial and individual differences of the anatomic construction of the tali play a key role on static and kinetic dynamic on the foot. Present study was done to find out variations and incidences of various types of modifications of neck of talus thoroughly, relations of these modifications with side of body (Right/Left) and to determine regional peculiarities of these modifications in Indians.

MATERIAL AND METHODS

Material for the study comprised of 300 dry (150 right and 150 left) adult tali of unknown age and sex from bone banks of Department of Anatomy, Teerthanker Mahaveer Medical College & Research Centre, Moradabad (Uttar Pradesh) and S.M.S. Medical College, Jaipur (Rajasthan) [India]. As far as it could be ascertained samples were free of physical and pathological changes or anomalies. Each talus was examined for the presence of various patterns of articular facets on neck of talus and extensions of trochlear surface. All the 300 tali were numbered and photographed. Statistical analysis of data was performed by using Fisher exact test with 95% confidence limits.

Squatting facet (medial/lateral) was identified as articular/smooth area present on dorsum of neck which didn't follow line of curvature of trochlear surface and was either separated or not from this surface by a transverse ridge of bone not covered with articular cartilage. A true squatting facet faced upwards & slightly backwards as well as AP diameter facet was usually concave. Even if the squatting facets were continuous with trochlear surface, they could be identified by the fact that the concavity of facet changed abruptly to convexity of trochlear surface (Figures 1 and 2). Medial or lateral part of trochlear surface was often prolonged anteriorly on to the neck of talus, which always continued the AP curve (convexity) of trochlear surface. Prolongations of trochlear surface were defined as part of surface anterior to a line drawn across the head of talus perpendicular to long axis of foot, from superoanterior margin of the lateral malleolar to medial malleolar surface (Figure 3).[5,7]

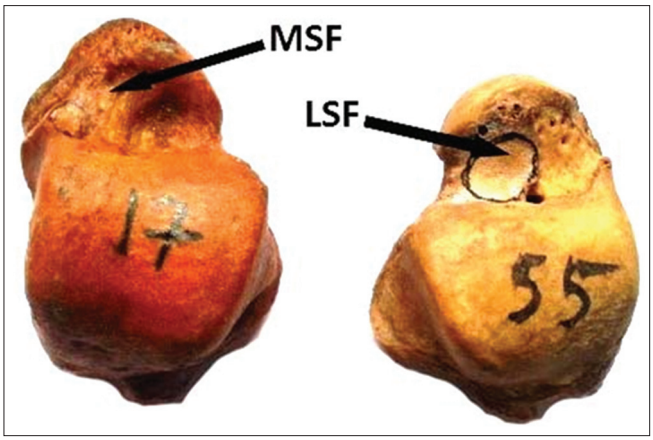

Figure 1: Medial (MSF) and lateral (LSF) Squatting facets on dorsum of neck of talus

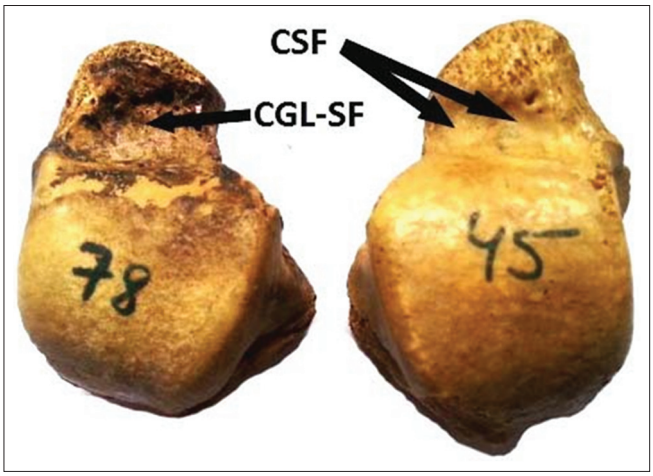

Figure 2: Combined (CSF) and continuous (Gutter like) (CGL-SF) Squatting facets

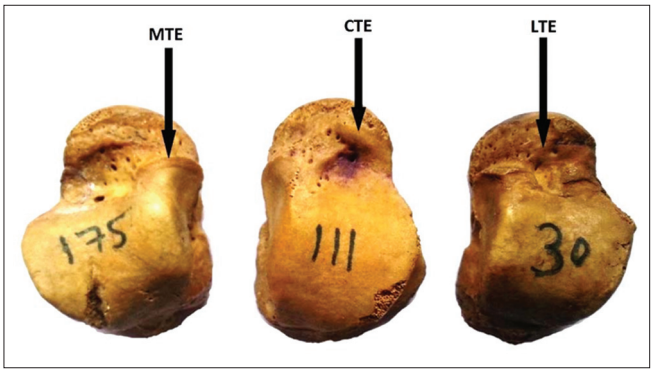

Figure 3: Medial (MTE), lateral (LTE) and combined (CTE) trochlear extensions on dorsum of neck of talus

RESULTS

Tables 1 and 2 shows incidences of different modifications on neck of talus that occur due to hyperdorsiflexion during squatting posture. Lateral squatting facet was found in 136 tali (45.3%). Significant difference was found in frequency of lateral squatting facet with relation to side of body (Right Left) [p-Value=0.037]. Lateral squatting facets was more on left side (51.3%) as compared to right side (39.3%). Incidences of medial, combined and continuous gutter like squatting facets were very low as compared to lateral squatting facets. Incidences of medial, combined & continuous gutter like squatting facets were 7.7%, 3.3% & 4.3% respectively (Figures 1 and 2, Table 1). No significant difference was found with relation to side

Table 1: Incidence of squatting facets in present study population

Squatting facets	Rt+Lt*/total (300) (%)	Rt/total Rt (150) (%)	Lt/total Lt (150) (%)	p-value**
Lateral	136 (45.3)	59 (39.3)	77 (51.3)	0.037***
Medial	23 (7.7)	15 (10.7)	7 (4.7)	0.119
Combined	10 (3.3)	6 (4)	4 (2.7)	0.749
Gutter	13 (4.3)	6 (4%)	7 (4.7)	1

*Rt=Right side, Lt=Left side, **Significance level at 0.05, ***Significant

Table 2: Incidence of Trochlear extensions in present study population

Trochlear extension	Rt+Lt*/total (300) (%)	Rt/total Rt (150) (%)	Lt/total Lt (150) (%)	p-value**
Lateral	67 (22.3)	38 (25.3)	29 (19.3)	0.267
Medial	71 (23.7)	35 (23.3)	36 (24)	1
Continuous	11 (3.7)	9 (6)	2 (1.3)	0.061

*Rt=Right Side, Lt=Left Side, **Significance level at 0.05

of body for medial, combined & continuous gutter like squatting facets.

Lateral extension of trochlear surface on dorsum of neck of talus was found in 67 tali (22.3%) more so towards right side (25.3%) as compared to left side (19.3%). Extension of medial surface was found in 71 tali (23.7%). Incidence was nearly similar on both sides (23.3% right and 24% left side). A continuous (lateral/central/medial) extension was found in 16.3% (49 tali) (Figure 3 and Table 2). Incidence of lateral squatting facet was highest among all modification on dorsum of neck of talus (45.3%). No significant difference was found with relation to side of body for trochlear extensions.

DISCUSSION

Unlike the weight bearing articular facets at the pelvis, femur and tibia: the talar articular facets are very small in relation to the loading environment and their ability to remain morphologically plastic during ontogeny represents an adaptation that is integral to our ability to cope with the substantial gains in body weight that occur during our developmental period.[16] Modification of the talus indicative of habitual squatting has been reported to occur in hominids since at least the Pleistocene era.[5] Modification of talus observed in present study is consistent with prolonged extreme dorsiflexion at ankle joint during squatting, an activity compatible with lifestyle of Indian population.

Lateral squatting facet showed highest incidence (45.3%) in present study and this observation was in accordance to studies done by Das[12] in U.P (Indians)-40.5%, Jeyasingh[13] in Agra (Indians)-43.5%, Pandey & Singh[8] on U.P. & Bihar (Indians)-83.2%, Oygucu et al.[5] (late Byzantine males)-37.7%, Shilpi G et al.[7] (North Indians)-65.9% and Baykara et al.[14] on eastern Antonia population. These studies also reported highest incidence of lateral squatting facets among all modifications that occur on dorsum of neck of talus due to squatting posture. Lower incidences were reported by Sewell[10]-8.6%, Barnett[6]-2% on Egyptian and European population respectively and it shows that Indian population exhibits higher incidence as compared to Egyptians and Europeans (Table 3).

Much higher figures was reported by Thomson[4]-63.6% on Australian population, Charles[9]-64% and Pandey& Singh[8]-83.2% and Shilpi G et al.[7]-65.9% on Indian population. In present study frequency of occurrence of lateral squatting facets was higher (45.3%) compared to medial (7.7%), combined (3.3%), continuous gutter like (4.3%) on neck of talus (Table 3). Much higher incidence of lateral squatting facets in samples can be attributed to unequal distribution of body weight mainly towards lateral side of foot due to different life conditions, habitual activities and postures.

In present study incidences of lateral squatting facets showed significant differences with relation to side. Lateral squatting facets was more on left side (51.3%) as compared to right side (39.3%). Although for other modifications (Medial/combined/gutter like squatting facets and trochlear extensions), findings showed no significant differences with relation to side of body. Previous studies done by Shilpi G[7], Oygucu et al.[5], Baykara et al.[14] observed no evidence of side morphism for modifications.

Much lower incidence of medial squatting facet was observed (7.7%) in present study compared to lateral squatting facet, findings were similar to Shilpi G[7]-8.2%, JeyaSingh[13]-8.6%, Das[12]-4% in similar population and Baykara[14]-5% in eastern Antonian population. Higher figures were observed by Pandey & Singh[8] in Indian population while Barnett[6] did not observe this type of variation in European population (Table 3).

Lateral trochlear extension was reported in 22.3% of tali investigated. Similar frequency was observed by Singh[11]-24.3% and Das[12]-24.5%. Slightly higher frequency was observed by Shilpi G[7]-32.7% and much higher figures was observed by JeyaSingh et al.[13]-71.6% and Pandey & Singh[8]-90.8% in Indian populations while Barnett[6]-17% and Oygucu[5]-8% reported lower frequency. Khadija et al.[15] reported 58% in Pakistani population. Incidence of medial trochlear extension was 23.7% in present study which was similar to Shilpi G[7]-27.2%, Singh[11]-24.6%, Das[12]-25.5% and slightly higher by JeyaSingh[13]-37% on Indian population. Khadija[15] reported 34% in Pakistanis which is comparable. Much higher incidence was reported by Pandey & Singh[8] 60.3% and Charles[9]-47.2%. Frequency was very low in European (11%) and Egyptian (19%) by Sewell[10] (Table 3).

Table 3: Comparison of results of different studies on modifications of dorsum of neck of Talus including the present study

Study	Year	Population	Squatting facets (%)				Trochlear extension (%)		
			Lateral	Medial	Combined	Gutter	Lateral	Medial	Continuous
Thombson[4]	1889	Australian	63.6	-	-	-	-	-	-
Charles[9]	1894	Indian (Punjab)	34 (64)	-	-	-	-	25 (47.2)	-
Sewell[10]	1905	Egyptian	86 (8.6)	-	-	-	-	189 (19)	-
Barnett[7]	1954	European	2 (2)	0	-	-	17 (17)	11 (11)	-
Singh[11]	1959	Indian	86 (28.6)	0	-	-	73 (24.3)	74 (24.6)	91 (30.3)
Das[12]	1959	Indian (U.P.)	40.5	8 (4)	3	13	49 (24.5)	51 (25.5)	45 (22.5)
Jeya singh[13]	1979	Indian (Agra)	43.5	8.6	-	-	71.6	37	-
Panday & singh[8]	1990	Indian (U.P., Bihar)	218 (83.2)	46 (17.6)	31 (11.8)	28 (10.7)	238 (90.8)	158 (60.3)	152 (58.0)
Oygucu[6]	1998	Late Byzantine	66 (37.7)	1 (0.6)	1 (0.6)	1 (0.6)	14 (8.0)	19 (10.9)	8 (4.6)
Shilpi G[14]	2009	North Indian	65.9	8.2	2.04	4.1	32.7	27.2	4.7
Baykara[15]	2010	DK	72.1(F) 51.3(M)	- 5 (M)	-	-	-	-	-
		EVS	91.2(F) 83.7(M)	-	-	-	-	-	-
Khadija[16]	2012	Pakistan	-	-	-	-	58	34	8
Present study	2014	Indian	136 (45.3)	23 (7.7)	10 (3.3)	13 (4.3)	67 (22.3)	71 (23.7)	11 (3.7)

Thomson[4] (1889) who first described the presence of squatting facets on the anterior margin of distal extremity of tibia and upper surface of neck of talus, stated that the facet as a smooth cartilage covered area on the upper surface of the neck of the talus articulating in full dorsiflexion with a facet on the anterior margin of the lower extremity of tibia.

Charles[9] (1894) suggested that the presence of squatting facets on the dorsal surface of the neck of the talus in the fetus as well as in adults of oriental races provides evidence for the inheritance of acquired characters. However, squatting facets were also present in European fetuses[6,10] and these facets are more prevalent in European fetuses than in adults. Singh[11] provided evidence that the Indian fetus inherits no greater expression of squatting facets than the European fetus. Sewell[10] expressed that fetal presence of these features is due to the fact that during intra uterine life, the lower extremities of the fetus are in the position most favorable for the formation of such articular surfaces viz. one of the extreme dorsiflexion and inversion. The persistence of these features in adult depended upon the type of life adopted by them. Singh[11] stated that modification of talus due to squatting are more common in European fetus than Indian and more common in Indian adult than European adult as these features can undergo further development in Indian adults because squatting postures are maintained by Indian for considerable periods. Many of the European possessed these facets at birth but the lack of subsequent pressure (such as would occur during squatting) allowed the attachment of the capsule to encroach upon and obliterate them.[11]

The incidence of squatting facets and trochlear extensions in the present study were in consonance with the previous studies done on Australians and byzantine males and also with some Indians. These were consistent with prolonged extreme dorsiflexion of tali during squatting, an activity compatible with life style of these populations (farming). Prolonged periods of squatting are very commonly endured by farmers in tropical countries like in Indians during harvesting seasons[12] and also most people in the Indian subcontinent are still accustomed to perform their morning rituals in the toilet in squatting posture.

Oygucu et al. stated that squatting facets in Byzantine males were present almost entirely on the lateral aspect of neck of talus. On investigation pes valgus deformity was present in them which were perhaps due to prolonged standing and walking on hard surface (consistent with lifestyle of Byzantine farmer). It resulted in outward deviation of the foot at the talo-calcaneal joint bringing the lateral surface of the talus into contact with the anterolateral margin of inferior end of tibia suggesting that extreme dorsiflexion was perhaps not the only reason for the modification of upper surface of the neck of talus.[5]

Thomson gave a phylogenetic view to his study by including tali of gorillas, orangs, baboons and chimpanzees also. He observed the squatting facets well marked on orangs, baboons and in few gorilla but absent in chimpanzees. He stated that although the cause of presence of facet was the same that is extreme dorsiflexion of ankle but the difference was due to different use of the foot as anthropoids did not squat like man. They didn't rest the weight of the body on the sole of the foot but when they use their foot for climbing, weight of the body was sustained by foot with hyperdorsiflexed ankle. Therefore, facets were well developed in orangs (expert climbers).[4,7]

From the clinical point of view, study of squatting posture now a days is important as prolonged squatting was found to be a strong risk factor for tibio-femoral knee osteoarthritis in elderly[18] as well as a major cause of common peroneal nerve palsy not only unilateral even bilateral peroneal nerve palsy is known to occur after prolonged squatting.[17,19] Marya KM et al. reported case of acute popliteal artery occlusion in a young male farmer as a result of prolonged squatting and advised that farmers especially of tropical countries who engage in manual harvesting practices should be made aware of this potentially disastrous complication and advised to intermittently extend their knees while harvesting so that such situations can be averted.[17]

Most people in Indian subcontinent still accustomed to perform their morning rituals in toilet in squatting posture and there are reported evidences of rise in systolic blood pressure of 10 mm of Hg or more (highest 34 mmHg) occurred on squatting. This have clinical significance in hypertensive subjects as one third of strokes occur in early morning hours and in the toilets.[20]

Also, reliable estimation of race from skeleton by using various criteria is important while dealing with undocumented skeletal material whether; it is in the field of medicine or work with prehistoric osteological collections. Therefore these facets can be useful in forensic science for identification of race of unidentified bone.[7] To summarize, modifications of the neck of talus (squatting facets and trochlear extensions) are result of prolonged squatting positions which is common habit of Indian population and incidences of these variations can be used as an anthropological marker for racial and regional differentiation of unidentified bones.

KEY POINTS

- Interpretation of activities of individuals depends upon objective reconstruction of the biomechanical anatomy of the signs imprinted on the bones of individuals. Effects of squatting stress may induce bone remodeling. In present study incidence of various modifications on the dorsum of neck of talus produced due to squatting posture was studied.
- Different incidences of these modifications on dorsum of neck of talus reflect life style of population and different factors can be invoked to explain these modifications. Much higher incidence of lateral squatting facets in samples can be attributed to unequal distribution of body weight mainly towards lateral side of foot due to different life conditions, habitual activities and postures.
- These modifications offer an opportunity to study the relationship between past and modern population and also describes the daily activity of life and cultural structure.
- Incidences of these variations can be used as an anthropological marker for racial and regional differentiation of unidentified bones. Further studies on other populations groups are indicated using larger sample size to make comparative studies more meaningful.

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