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Re-Modelling of North Indian Talus: A Pressure Effect of Squatting Position

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ABSTRACT

Background: Anatomical variations of the skeleton provide information on daily activities, living conditions, cultural behaviour and health problems of any society. Squatting is a good example of such behaviour/function producing skeletal markers due to remodelling, on the bones of lower limb by putting strong pressure and traction forces on the knee and ankle joints. It is associated with modifications of the neck of the talus (squatting facets) and its trochlear-malleolar surfaces (trochlear extensions). **Methods:** An observational analytical study was designed to observe anatomical variations in 616 dry, macerated human tali of both sides in north Indian population where squatting is a part of regular behaviour. Differences in the form and extent of this facet, trochlear extensions or articular (malleolar) extensions may be noted. **Results:** The frequency of occurrence of these facets and extensions has been found to vary considerably in different races. A much more pronounced forward prolongation has been found to be present in the north Indian talus in this series. A high frequency of forward prolongation of medial articular surface in Indian population suggests that, not only the squatting posture and habitual sartorial posture (palthi position/ tailor position) but the prevalence of walking for long distances may be responsible for this. **Conclusion:** The results provide an opportunity to study the relationship between past and modern population, and also describe the daily activity of life and cultural structure. Anatomical variations of the neck of the talus (squatting facets) and its trochlear- malleolar surfaces (trochlear extensions) can be of help in pathologies of foot for reconstruction and rehabilitation procedures. It will also provide ethnic data for anthropologists and forensic experts about talar variations and would be of direct relevance in anatomy teaching.

Keywords: Squatting facet, trochlear extension, malleolar extension.

INTRODUCTION

The structural changes that a function may bring about like morphological differences observed between bones of different populations are of much interest. Squatting is a good example of such behaviour/function producing skeletal markers on the bones. The squatting position puts strong pressure and traction forces on the knee and ankle joints, producing specific bone markers that reflect the remodelling of bone occurring in response to physical stress. These morphological changes are most pronounced in those races in which it is the customary mode of resting. Squatting is the position in which the legs are flexed upon the thigh and the thighs on the trunk. In this posture the back of the thighs rests upon the calf and the knee-joint is in a state of extreme flexion, associated with a certain degree of rotation of the leg upon the thigh. The heels are apart about the distance that separates the ischial tuberosities. The fronts of the ischial tuberosities are in close apposition with the heel; in fact the trunk weight is supported mostly by the heels and backs of the tibiae.

Habitual squatting alters the skeletal morphology of lower limb. It is associated with modifications of the neck of the talus (squatting facets) and its trochlear- malleolar surfaces (trochlear extensions). Thomson (1889) first described the presence of squatting facets on the anterior margin of the distal extremity of the tibia and the upper surface of the neck of the talus of Australian and Andamanese human specimen along with other primates.[1] Since then, these facets have been studied in different groups of populations in both ancient and present-day by various authors.[2-10] According to Barnett

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(1954) and Oygucu (1998),[2,3] a number of types of true squatting facets can be found on the neck of the talus. In addition, anterior extensions of the trochlear and malleolar surfaces of the talus that are continuous with the normal surfaces may be present.

Usually Indians assume squatting position conveniently during washing, cleaning, making pottery or handicrafts, working in fields, even resting. The Indian style toilets require to squat for defecating. This is not so in the western countries where squatting posture is not a part of their regular behaviour. The occurrence of talar modifications was therefore investigated in adult Indian talus.

MATERIALS AND METHODS

The observations presented in this study are based upon the critical analysis of 616 dry, macerated human tali, 308 of each side in north Indian population. All analysed samples were adult dry talus obtained from the collection of the Department of Anatomy of Moti Lal Nehru Medical College, Allahabad, India; Rajkiya Medical College, Jalaun, India and Hind Institute of Medical Sciences, Barabanki, India. The sex and ages of the tali were unknown but all were fully ossified without any congenital malformation, damage, fracture or apparent abnormalities. As it was not possible to assign individual right and left pairs of talus in this case of dry bone room specimens, symmetry of the sides could not be taken into account. But the tali presumably belonged to same group of cadavers.

Using Barnett's nomenclature, each talus was thoroughly inspected for the presence of squatting facet and extensions of trochlear and articular (malleolar) surface. Trochlear extensions were defined as prolongations of the trochlear surface anterior to a line drawn across the body of the talus perpendicular to the long axis of the foot, from the superoanterior margin of the lateral malleolar surface to the medial malleolar surface [Figure 1A]. The part of medial articular facet extending on the neck of the talus with respect to the total length of medial articular facet was measured with the help of Vernier caliper accurate up to 0.02 mm [Figure 1B]. All data were recorded and calculated for their prevalence in percentage followed by their comparison with the available data of previous studies. “Two sample t-test between percents” and “chi-square” tests were used to test the statistical significance (P value less than or equal to 0.05) of the findings.

RESULTS

Various talar modifications were frequently found to be present on critical analyses of 616 dry tali of Indians. The medial surface of the neck of talus showed forward extension of the medial articular surface (articular extension), and superior surface showed trochlear extensions (medial, lateral and central) and squatting facets. However any extensions or variations in the lateral articular surface were conspicuously absent.

1. Articular (malleolar) Extensions:-The comma shaped medial articular surface of talus which articulates with medial malleolus of tibia shows forward prolongation on the neck of talus. The forward prolongation has been measured numerically in the form of percentage of anteroposterior diameter of medial articular facet extending on the neck of talus, beyond the anterior margin of the superomedial border of trochlea [Table 1]. This forward prolongation of medial articular surface on the neck of talus was found to be present in all the 616 talus studied, ranging from 28-92% of the anteroposterior diameter of the medial articular facet [Figure 1].
2. Trochlear extensions: - Trochlear extensions are forward prolongation of the superior trochlear surface. Small degree of trochlear extensions appears as a sinuous anterior edge of superior trochlear surface. Large medial and lateral trochlear extensions are usually quadrilateral in shape and follow the curvature of superior trochlear surface, being convex anteroposteriorly, and facing upward and forward [Figure 2A, 2B & 3B]. Total 266 tali (160 right; 106 left side) showed medial trochlear extension and 436 tali (199 right; 237 left) showed lateral trochlear extension. The trochlear extensions were not just limited to medial and lateral sides, occasionally the central portion also showed extensions. A total of 5 talus showed central extensions, among these 2 were associated with both lateral and medial extensions, 1 with lateral extension and 2 were only central extensions which tapered sharply towards the sides [Figure 3A]. Out of all trochlear extensions, lateral trochlear extension had maximal prevalence. Lateral trochlear extensions were found to be common on left side while medial trochlear extensions were common on right side and this difference was statistically highly significant (chi=14.24, df= 1, $p<0.001$) [Table 2].
3. Squatting facets-: Among 616 tali, 270 tali (157 right; 113 left side) showed no squatting facets (Fig. 4A).Lateral facet was found to be present on 313 tali (128 right;185 left side), usually separated from trochlear surface by a ridge [Figure 4B] or a groove/non articular strip [Figure 4C]. The surface of the facets were usually found to be concave when present on the neck in proximity to the body of the talus, while the facets present near the head (articular surface for talonavicular joint) were more or less convex.

Though the lateral squatting facets were found on the lateral side of the superior surface of neck of talus, they varied in shape, size and their proximity

to trochlear surface or the head. Few tali had large lateral facet covering the central portion of the superior surface of the neck of talus [Figure 4B], we found 19 such talus, all on left talus. In 33 tali (14 right and 19 left side) lateral facet reached up to the head [Figure 4D], while in some talus the facet was very small lying midway on the neck and away from both the trochlear surface proximally and head distally. Occasionally, the facet on the superior surface of the neck of the talus was found to be in close proximity with the head being continuous with articular surface for talonavicular joint, as if the articular facet for talonavicular joint has upturned over the adjoining portion of the neck on the superolateral side. Two of the talus, one from each side showed such variation [Figure 5B].

Table 1: Forward prolongation of medial articular (malleolar) surface of talus.

Forward prolongation of medial articular surface extending beyond front of trochlear surface	Number of tali			Percentage
	Right	Left	Total	
0% -10%	0	0	0	0%
>10% -20%	0	0	0	0%
>20% -30%	0	1	1	0.16%
>30% -40%	0	1	1	0.16%
>40% -50%	5	9	14	2.27%
>50% -60%	57	89	146	23.7%
>60% -70%	66	84	150	24.35%
>70% -80%	158	110	268	43.51%
>80% -90%	18	11	29	4.71%
>90% -100%	4	3	7	1.14%
Total	308	308	616	

Table 2: Trochlear extensions of talus

Type of extension	Number of talus			Percentage
	Right	Left	Total	
No trochlear extension	54	39	93	15.1%
Medial trochlear extension only	54	31	85	13.79%
Lateral trochlear extension only	92	162	254	41.23%
Central trochlear extension only	1	1	2	0.32%
Medial and lateral trochlear extension both	105	74	179	29.05%
Central extension with Lateral trochlear extension	1	0	1	0.16%
Central extension with medial and lateral trochlear extensions (continuous extension)	1	1	2	0.32%

None of the tali showed a definite medial articular facet. But I am doubtful about 11 talus (8 right and 3 left side) whose medial trochlear extension was not in smooth continuity with the trochlear surface, it was separated partially (on the lateral side) by a ridge from the trochlear surface [Figure 5C].

Table 3: Prevalence of medial and lateral squatting facets in different populations

Population	Researcher	Total number of talus	Medial facet	Lateral facet
European	Thomson	25		1 (4%)
	Pfitzner	840		1
	Barnett	100	0	2 (2%)
Egyptian	Sewell	1006	189 (19%)	86 (8.6%)
Australian	Thomson	11		7 (63.6%) +4doubtful
	Inkster	150		45 (30%) +10doubtful
	Rao	238	3 (1.2%)	80 (33.6%)
Byzantine	Oygucu	175	1 (0.6%)	66 (37.7%)
Andaman	Thomson	24		12 (50%) +7doubtful
Indian	Charles	53	25	34 (64%) +6doubtful
	Singh	300	0-1 (doubtful) (0-0.33%)	86 (28.6%)
	Present study	616	11 (doubtful) (1.79%)	313 (50.81%)

Table 4: Prevalence of medial and lateral trochlear extensions in different populations

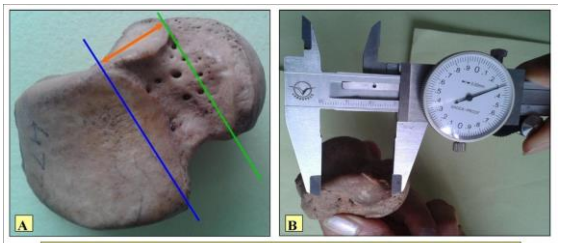
Population	Author	Total number of talus	Medial extension		Lateral extension	
European	Barnett	100	11	11%	17	17%
Byzantine	Oygucu	175	19	10.9 %	14	8%
Indian	I.B.Singh	300	165	55%	164	54.6 %
	Present study	616	266	43.18 %	436	70.78 %

Another feature which we came across was an elevated area of smoothness parallel to the articular surface for talonavicular joint near the head, more towards the lateral side, sometimes in the form of comma/ L shape [Figure 5A]. There were 28 tali (13 right and 15 of left side) with such comma shaped smooth area. Occasionally we found a well marked crest/spike with a rough surface (as if any ossified ligament? talo-navicular ligament?) on the superior surface of talus adjoining the head, more towards lateral side. There were 9 tali, 4 of right side and 5 left side, showing such variation [Figure 6]. This condition was first described by Hyrtl

(1860),[11] who obtained a single specimen and gave to it the name of the processes trochlearis. Sewell (1905) had,[4] however found the condition occurring in 9 cases. He regarded this process as merely an abnormal development of the external portion of the ridge, which, runs across the upper aspect of the neck. In a series of bones one can trace the gradual development of the small tubercle on the external border of the neck into, first, a low crest occupying the outer half of the superior surface, and continuous with the ridge internally, being separated from the articular surface of the head by a smooth interval, and finally into a well-marked crest which completely obliterates the region of the neck in front of it.

Table 5: Forward prolongation of the medial articular surface of the talus

Percentage of the antero-posterior diameter of the medial articular surface extending beyond the anterior margin of the trochlea	Percentage of European tali (Barnett) n= 100	Percentage of Indian tali (I. B. Singh) n= 300	Percentage of Indian tali (present study) n= 616
0-10 %	48	7	0
11-20 %	34	15.5	0
21-30 %	17	31	0.16
31-40 %	1	34	0.16
41-50 %	0	12	2.27
Above 50 %	0	0.5	97.41



A= "Blue" line denotes anterior margin of the superomedial border of trochlea
"Green" line denotes the anterior most extent of medial articular extension.
"Orange" line denotes medial articular extension on the neck of talus.

B= Measurement of medial articular facet using vernier caliper

Figure-1 Medial articular extension of talus

Figure-2 (A) Lateral trochlear extension (yellow arrow)
(B) Medial and lateral trochlear extension(orange and yellow arrow)

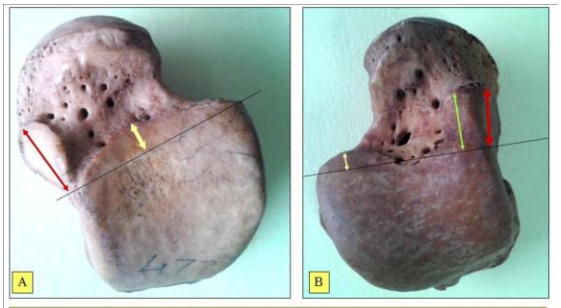


Figure-3 (A) Central trochlear extensions of talus (yellow arrow)along with medial articular extension (red arrow)
(B) Medial and lateral trochlear extension (yellow and green arrow) along with medial articular extension (red arrow)

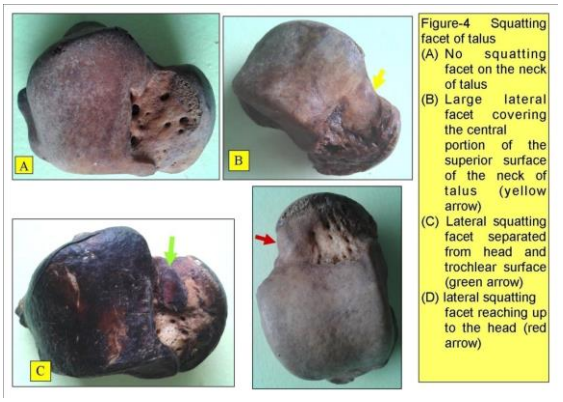


Figure-4 Squatting facet of talus
(A) No squatting facet on the neck of talus
(B) Large lateral facet covering the central portion of the superior surface of the neck of talus (yellow arrow)
(C) Lateral squatting facet separated from head and trochlear surface (green arrow)
(D) lateral squatting facet reaching up to the head (red arrow)

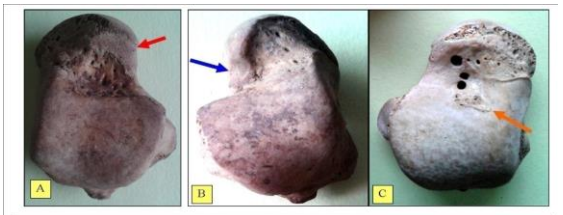


Figure-5 Squatting facet of talus
(A) Lateral facet continued into a smooth area near the articular surface on the head for talonavicular joint forming a comma shaped facet (red arrow)
(B) Lateral squatting facet is in close proximity with the head being continuous with articular surface for talonavicular joint (blue arrow)
(C) Medial trochlear extension is separated from trochlear surface (on the lateral side) by a ridge (orange arrow)

Figure-6 Processes trochlearis (Green arrow)

DISCUSSION

In squatting position the ankle joint is in a state of extreme flexion and there is an actual contact of the neck of the talus with the anterior border of the lower portion of the tibia. The neck of talus shows transitions in the development of a facet, from the

condition in which the neck is rough and non-articular, intermediate forms with smoothing of the bone along the outer part of the superior surface of neck to that in which there is a clearly defined facet with well-marked margin on the non-articular part of the neck. Differences in the form and extent of this facet and trochlear or articular extensions may be noted. The frequency of lateral squatting facets [Table 3] has been found to vary very considerably in different races, being least in Europeans and also in Egyptians.[1,2,4] The incidence of lateral facet in north Indian population in the present study is comparable to those of Andamanese and Australian population.[1,5] Prevalence of lateral squatting facet in our study showed highly significant differences with the studies in European population,[2] Australian population,[6,7] Egyptians,[4] Indian population and in Byzantine population.[3,8]

Similarly the occurrence of trochlear extensions has been found to be significantly higher in the present study in north Indian population than the studies in Europeans and Byzantine population [Table 4].[2,3]

It should be noted here that in some studies the term facets also includes trochlear extensions [Table 3]. Thomson (1889),[1] Charles (1893) and Sewell(1905) had considered trochlear extensions and facets as same entity.[3,5] It was after the study of Barnett (1954) who found that these extensions continue the antero-posterior curve of the trochlea and makes contact with the inferior surface of tibia during dorsiflexion and since these extensions are not associated with modifications of the anterior margin of the distal tibia,[2] they may be products of dorsiflexion at the ankle joint rather than that of squatting.

Medial squatting facet has been rarely seen to be present except in the studies of Sewell (1905) and Charles (1893),[4,5] who may have considered medial trochlear extension as medial squatting facet. A striking contrast has been seen in the study of Morimoto (1960) who found concave medial squatting facet and the absence of lateral squatting in Japanese tali.[9]

A much more pronounced forward prolongation has been found to be present in the north Indian talus in this series as compared to the studies of Barnett(1954) and Singh I B(1959) [Table 5].[2,8] In about 92 percent of the talus 50-80% of the anteroposterior diameter of medial articular surface was prolonged forward on to the neck of the talus. It was noteworthy that ≥70% prolongation of medial articular surface of talus showed high propensity on the right side while <70% prolongation of medial articular surface of talus showed high propensity on the left side, and this difference was found statistically highly significant (chi=20.27, df= 1, $p<0.001$).

A high frequency of forward prolongation of medial articular surface in Indian population suggests that, not only the squatting posture and the prevalence of habitual sartorial posture (palthi position/ tailor position) but walking for long distances may be responsible for this. Most of the talus samples were of unclaimed bodies of poor labours that probably travelled a lot on foot for their livelihood. Walking might not be in completely symmetrical gait, producing greater degree of prolongation of medial articular facet on right side than left side.

1) As individual sets of bones were not available, random samples were taken, limiting the study to comment upon the unilateral and bilateral prevalence of the talar modifications.

CONCLUSION

The figures or pictures of talus given in standard textbooks of anatomy showing that the superior articular surface of trochlea bounded anteriorly by a more or less definite transverse line, and presenting a rough neck anteriorly does not holds well with respect to the talus in Indians. The results indicate that Indian population is engaged in a squatting posture as a regular behaviour, and the talar modifications show the intensity and regularity of the posture. Talar modifications are so common in many populations; it is suggested to include it in standard textbooks of anatomy and osteology to aid in teaching. Anatomical variations of the neck of the talus (squatting facets) and its trochlear- malleolar surfaces (trochlear extensions) can be of help in pathologies of foot for reconstruction and rehabilitation procedures. It will also provide ethnic data for anthropologists and forensic experts about talar variations and would be of direct relevance in anatomy teaching.

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