J. Anat. (1993) 183, pp. 631–634, with 2 figures Printed in Great Britain

Short Report

Arthritis of the subtalar joint associated with sustentaculum tali facet configuration

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(*Accepted 10 May 1993*)

ABSTRACT

The articular facets of the sustentaculum tali have a variety of configurations that are generally viewed as nonmetric traits of little functional significance. Bruckner (1987), in contrast, has hypothesised 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. Calcanei with 2 separate sustentaculum tali facets had a lower frequency of arthritic changes associated with joint instability than calcanei with other facet configurations. This finding supports Bruckner's hypothesis that subtalar joint facet configuration is a factor in foot mobility.

INTRODUCTION

Changes in the human foot associated with the evolution of bipedalism involved the elevation of the calcaneus which increased the inclination of the subtalar joint axis to approximately 42°. This elevation was crucial for the formation of the longitudinal arch. The sustentaculum tali is at the 'apex' of the longitudinal arch and thus occupies a key position in the subtalar joint. It functions as a bracket that supports the talar head and is responsible for transmission of force towards the lateral arch (Kapandji, 1970; Harris, 1983; Olson & Seidel, 1983; Lamy, 1986; Mann, 1991).

Variations in the articular facets of the sustentaculum tali have been described by many authors (Laidlaw, 1905; Bunning & Barnett, 1965; El-Eishi, 1974; Gupta et al. 1977; Bruckner, 1987; Campos & Pellico, 1989). Although these researchers use slightly different classificatory schemes, 3 distinct facet types are generally recognised: (1) 1 long continuous facet; (2) 2 separate facets; and (3) 1 medial facet only (Fig. 1). These facet configurations are present in fetal calcanei and are not developmental responses to physical activities (Bunning & Barnett, 1965).

Most researchers view these differences in facet configuration as anatomical variations of no functional significance. Bruckner (1987), in contrast, argues that the 2-facet configuration is more stable than the others. The 2-facet configuration is typically associated with a higher angled subtalar joint axis and a sharper intersecting angle of the anterior and medial facets. These characteristics, in conjunction with the posterior talocalcaneal facet, cause the talus to sit on an 'osseous tripod' and prevent excess motion of the talar head.

To evaluate the proposed relationship between subtalar joint morphology and joint stability, the frequency of osteoarthritic changes in talocalcaneal facet configurations was examined. Unstable joints are more likely to suffer trauma, accidents, or other biomechanical stress as a result of uneven weight distribution and excessive incremental motion which cause osteoarthritis (Harrington, 1982; Harris, 1983; Olson & Seidel, 1983; Schumacher et al. 1988; Bejjani, 1991; Massada, 1991; Sims & Cavanagh, 1991). If the 2-facet configuration is more stable, there should be less evidence of pathological changes associated with this configuration.

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MATERIALS AND METHODS

The calcanei used in this study are remains from Native Americans, obtained from 2 archeological sites in California (Sol-357 and SBa-60). The total sample consisted of 191 calcanei: 104 from Sol-357 and 87 from SBa-60. Age at death for the Sol-357 remains was determined using standard osteological criteria (Krogman & Iscan, 1986; Bass, 1987). The SBa-60 calcanei are not associated with other skeletal elements and as a result, age determinations could not be made for these individuals.

Observations were made on the left calcaneus when present. For Sol-357, the right calcaneus was used if the left calcaneus was not preserved. Since the right and left calcanei in the SBa-60 collection were not associated with specific individuals, only left calcanei were used.

For purposes of this study, sustentaculum tali facets were classified as follows: (1) long continuous facets: including all transitional 'figure-8' forms with fused anterior and medial facets; (2) sustentaculum tali with 2 facets, in which a distinct groove separates the anterior and medial facets; and (3) sustentaculum tali with a medial facet only and no anterior facet (Fig. 1). The configuration in which all talocalcaneal facets (the posterior and the sustentaculum tali facets) are fused into 1 large facet, was not observed.

The angle formed by the intersection of the medial and anterior facets of the sustentaculum tali, was determined using the following procedure. The calcaneus was placed on its medial side on a piece of paper so that the medial border of the sustentaculum tali facets contacted the paper and the planes of the facets were perpendicular to the surface of the paper. The contour of the facets was traced with a pencil and the angle measured with a protractor. Repeated observations made on the same series of bones indicated that the average error of this measurement is about 2°.

The presence of arthritis was determined by visual inspection of the articular surfaces. Arthritic changes consisted of periarticular remodelling (lipping), subchondral sclerosis and eburnation. Arthritis was scored as present if any of these osseous changes was found on the sustentaculum tali facets, posterior talocalcaneal facet or tarsal canal.

RESULTS

Of 191 individuals, 54.5% had the long continuous facet, 26.7% the 2-facet configuration and 18.8% had 1 medial facet only (see Table). The average intersecting angle was 149.1° for the long continuous facet, 127.8° for the 2-facet configuration, and 136° for the medial facet only type (Fig. 2).

Lipping or other stress-related arthritic changes were present in 65.4% of calcanei with the long continuous facet, in 35.3% of calcanei with 2 facets, and in 50% of calcanei with a medial facet only (Table). A χ^2 test for an association between the presence of lipping and facet configuration was highly significant ($\chi^2 = 12.85$, $P < 0.002$; Table). Statistical

Table. *Total number and percentages of facet types, arthritic lipping, degrees of intersecting angles, and average ages of individuals with arthritis*

Facet type	Long facet	Two facets	Medial facet only
n = 191	104	51	36
% of total	54.45	26.7	18.85
Intersecting angle			
average	149.1	127.8	136.05
minimum	128.5	107	113
maximum	161.5	146	157.5
S.D.	8.59	10.06	11.15
Arthritic lipping			
n = 104	68	18	18
%	65.38	35.29	50
Average ages of individuals with arthritis			
n = 42	32	6	4
average age	34.8	39.8	41.5

n, sample size.

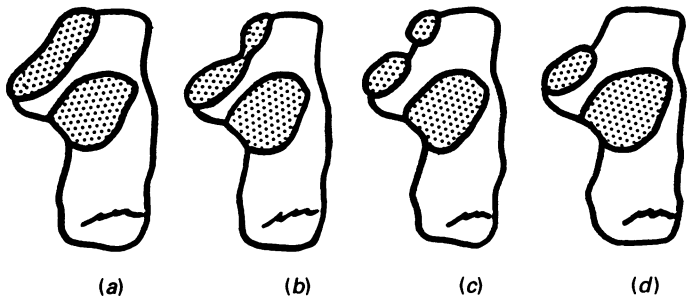

Fig. 1. (*a*) Long continuous facet; (*b*) continuous figure-8 facet; (*c*) 2 separate facets; (*d*) medial facet only.

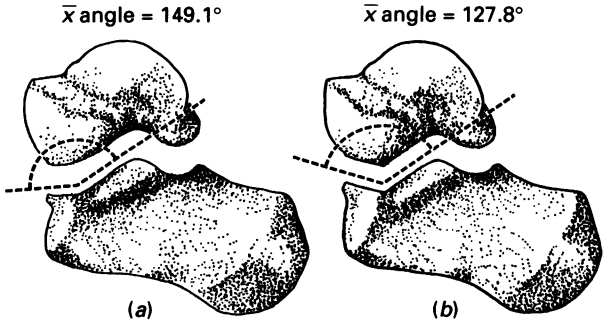

Fig. 2. Degrees of intersecting angles: (*a*) continuous facet configuration; (*b*) 2-facet configuration.

analysis also showed that calcanei with evidence of arthritis had significantly larger sustentaculum tali facet angles than calcanei with a smaller angle ($t = 3.23$ with 238 d.f., $P < 0.001$).

This striking difference in the frequency of arthritis between the facet types cannot be explained by age differences. Average ages for individuals with arthritic changes were 39.8 y for the 2-facet, 34.8 y for the long continuous facet, and 41.5 y for the medial facet only configurations.

DISCUSSION

Arthritic lipping was found to be significantly less common in sustentaculum tali with 2 separate facets than in the other configurations (Table). This suggests that sustentacula tali facet morphology is an important factor in subtalar joint stability and is consistent with Bruckner's (1987) hypothesis, that joints with the 2-facet configuration are comparatively more stable.

The facets of the sustentaculum tali are reflected in the morphology of the talar head. In the 2-facet configuration, the talus and calcaneus articulate at 2 discrete locations within the anterior subtalar joint capsule. These articular surfaces are sharply divided by a groove and form a V-shaped articular surface with an average angle of 127.8°, constraining the talar head and limiting medial rotation of the talus that occurs during heel strike. This contrasts with the comparatively smooth and flat articular surface of calcanei with continuous facets. These form an average angle of 149.1°. This large angle presents less of an impediment to the medial rotation of the talar head than the relatively acute angle of calcanei with the 2-facet configuration.

Bruckner likened the lack of talar head constraint found in individuals with continuous facets to a 'stripped bolt' (Bruckner, 1987). Eventually, this configuration can cause ligamentous laxity because it allows the talar head to exert continuous and excessive pressure on the spring ligament which connects the sustentaculum tali to the navicular. Laxity of ligaments and muscles is thought to be responsible for mobile or unstable feet (Kapandji, 1970; Harrington, 1982; Rose, 1991).

Stability of the subtalar joint also depends on the height of the longitudinal arch, which is determined by the inclination of the subtalar joint axis (Perry, 1983; Mann, 1991). A high arch represents a more stable structure and is commonly referred to as a 'rigid' or cavus foot (Norkin, 1983; Glancy, 1984; Bruckner, 1987). Bruckner measured inclinations of subtalar joints, and found that joints with the 2-facet configuration have a higher subtalar joint axis than the other configurations (Bruckner, 1987). Analysis of the intersecting angle formed by the sustentaculum tali surface provides a possible explanation. Relative to the rounded, continuous facet, the 2-facet configuration has an anterior facet that is slanted upwards and raises the total subtalar joint axis. On the other hand, the continuous facet is horizontally inclined, which results in a lower arch and a less stable foot (Kapandji, 1970; Samilson & Dillin, 1983, Bruckner, 1987).

In her study, Bruckner included 'medial facet only' calcanei with the long continuous facet type. I treated this configuration separately and found that angles and lipping are intermediate, between the 2-facet and long facet configurations (Table).

Sustentacula tali with only a medial facet have inadequate talar head support which allows excessive anterior and inferior rotation of the talus during weight bearing. This results in a valgus position of the calcaneus and a downward tilt of the talar head. (Kapandji, 1970; Norkin, 1983). The vastly increased pressure on the anterior subtalar joint capsule causes ligamentous laxity (Rose, 1991). CT scans show that the planus foot (hypermobile or flat foot) has no anterior sustentaculum tali facet (Smith, 1991). This suggests that this configuration is characteristic of a planus foot. However, in my sample, some individuals had pseudo facets for the talus on the superior body of the calcaneus, indicative of a more lateral orientation of the talar head. The orientation of the talar head axis in a medial facet only configuration, may therefore be the deciding factor in a planus foot condition (Rose, 1991).

Conclusions

The data presented here show that certain morphological variations of the sustentaculum tali may predispose people to joint instability, ligamentous laxity and the development of arthritic changes in the subtalar joint. People with the long continuous facet and medial facet only configurations of the sustentaculum tali may be at a greater risk for subtalar joint instability than individuals with the 2-facet configuration.

ACKNOWLEDGEMENTS

I extend my sincere appreciation to Dr Phillip Walker for critical assessment of an earlier draft and continuing encouragement and to Charles Slaymaker and Suzanne Griset of Slaymaker & Associates and Mary Norton of the Patwin Tribe for allowing me to study

the Sol-357 remains. I also thank Dr David Schiff, Dr Lewis Cozen, Dr Jan Bruckner and Patricia Lambert for helpful comments on the manuscript, and Mark and Jessica Drayer for support when needed.

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