The Influence of Squatting Posture on the Calcaneus in the Japanese.*
Formation of the Forward Extension Complex of the Posterior Talar Articular Surface

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INTRODUCTION

Little comment has been made upon the influence of squatting posture on the calcaneus, although the squatting markings on the talus are described in detail in most anthropological works.

In a previous paper, it was pointed out that the constant eversion-abduction-dorsiflexion of the subtalar joint in the squatting posture gave rise to a forward extension on the antero-lateral side of the posterior talar articular surface of the calcaneus. The present investigation was designed to secure this information. It was concerned with two aspects of the problem: first, to define the various forward extensions that occurred at the antero-lateral corner of the posterior talar articular surface; secondly, to study their incidence in a series of adult and foetal Japanese calcanei.

MATERIALS AND METHODS

The adult bones studied were of two series. One of the adult series was composed of 104 cartilage-covered calcanei fresh from the feet of 54 Japanese cadavers within an age range of 19 to 90 years. The other adult series consisted of 137 cleaned calcanei obtained from 70 Japanese cadavers ranging between 18 and 79 years of age. In addition, 92 foetal calcanei removed from the feet of 46 Japanese foetuses of 5 to 9 months of foetal age were also examined.

In the determination of the forward extension complex of the posterior talar articular surface, the most antero-lateral point of the anterior talo-calcaneal ligament (Fick, 1904) was adopted as the landmark, because the anterior margin of the posterior talar articular surface running along the posterolateral surface of the anterior talo-calcaneal ligament was taking a sudden turn to the forward direction at the same point. That is, in the fresh adult and foetal calcanei the articular area before the imaginary straight line passing the most antero-lateral point of the anterior talo-calcaneal ligament at a right angle with the longitudinal axis of the calcaneus was regarded as the forward extension complex by the author. And when the anterior talo-calcaneal ligament was lacking, the forward extension complex was classified as type D (fig. 1). On the supposition that there was left the anterior talo-calcaneal ligament, this was also applied to the cleaned adult bones in the same way.

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Not only was morphological observation made upon the forward extension complex, but also topographical and mechanical considerations were given to that of both fresh adult and foetal calcanei.

With regard to the subtalar joint movement, modifying Hicks (1953), such a compound name as eversion-abduction-dorsiflexion or inversion-adduction-plantarflexion was used for the rotation about its oblique axis. Here the eversion or inversion was the meaning of rotation about an anterior-posterior axis, the abduction or adduction was that of rotation about a vertical axis, and the dorsiflexion or plantarflexion was that of rotation about a transverse axis.

**Findings**

Three types of the forward extension complex are represented and one additional type is added for comparison. Certain subdivisions of these main types are also present (figs. 1-5).

**Type A.** In this the antero-lateral margin of the posterior talar articular surface is a straight line ending level with the most antero-lateral point of the anterior talo-calcaneal ligament. Accordingly, no forward extension is present in this type.

**Type B.** Here there is a forward extension occurred at the antero-lateral corner of the posterior talar articular surface. OWING to differences in this antero-lateral forward extension, this type is subdivided into three subtypes. In B1, the antero-lateral forward extension is incompletely developed and does not reach the posterior surface of the intermediate root of the inferior extensor retinaculum (Smith, 1958). In B2, this extension is relatively wide and nearly uniform in width, and its anterior margin comes into contact with the whole breadth of the posterior surface of that of the retinaculum. In B3, this extension is relatively narrow and tapers anteriorly, and thus its anterior border comes into touch with only the medial part of the posterior surface of this retinaculum. The antero-lateral forward extensions of all three subtypes continue the line of curvature of the posterior talar articular surface and thus articulate with the posterior calcaneal articular surface of the talus.

**Type C.** This type is characterized by an antero-lateral forward extension of the posterior talar articular surface and a concomitant facet situated on the posterolaterosuperior surface of the 'grande apophyse' to the medial side of the intermediate root of the inferior extensor retinaculum. The former is continuous an-
teriorly with the latter, although the former always makes an almost right angle with the latter. In a way this is a type B accompanied by the concomitant facet. The concomitant facet makes contact with, and acts as a “stop” for, a part of the facies externa accessoria corporis tali (Sewell, 1904) during eversion-abduction-dorsiflexion of the subtalar joint. In most cases, this concomitant facet owes its development to the destruction of the medial part of the intermediate root of the inferior extensor retinaculum caused by the pressure and rubbing of the facies externa accessoria corporis tali.

Type D. Here there is an antero-lateral forward extension of the posterior talar articular surface with another forward extension occurred along the supposed median sagittal line of this articular surface, the latter taking rise from the congenital absence or postnatal destruction of the anterior talo-calcaneal ligament. In a sense this is a type B accompanied by the median forward extension. Both median and antero-lateral forward extensions continue the line of curvature of the posterior talar articular surface and articulate with the posterior calcaneal articular surface. In the majority of the adult calcanei, these two extensions are continuous with each other and thus the antero-lateral margin of the posterior talar articular surface draws a large arc as a whole.

Examination of the distribution of the four types of the forward extension complex reveals that no similarity is found to exist between the adult and foetal series, while there is a close similarity between the fresh and cleaned adult series (table 1). It is seen that in the adult series the cases of types B2 and B3 are in general the most frequent, and those of type A the least frequent, whereas in the foetal series the cases of type A are the most frequent, those of type B1 the next, and those of types B2, B3, C and D lacking. This complementary distribution is of interest since it is in accord with the theory of pressure and rubbing which will be discussed later.

In addition, the anterior talo-calcaneal ligament is present 92.3% in the fresh adult series and 95.7% in the foetal series. The percentage of occurrence of the facies externa accessoria corporis tali in the fresh adult, cleaned adult and foetal series are 100.0, 97.1 and 100.0 respectively.

**DISCUSSION**

Concerning the subtalar joint, Fick (1911), modifying Düntz (1903), has stated that the movement is a single hinge movement rotating about a line passing obliquely from the dorso-medial side of the foot, plantarward, posteriorly and laterally to emerge at the lateral side of the heel. Thus, the subtalar joint, as has been noted...
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by Wiles (1934), Jones (1945) and Hicks (1953), provides for the rotation between the foot and the leg. In the squatting posture, the talus is tightly embraced by the medial and lateral malleoli, the extreme dorsiflexion (with slight abduction and eversion) of the talo-crusal joint allowing of this. The body weight thrown on the leg falls on the talus and produces such a torque about the oblique axis of the subtalar joint to evert-abduct-dorsiflex, because this (or its opposite) is the only movement of which the joint is capable (Hicks, 1953). This torque, in consequence, gives rise to the forward extension complex of the posterior talar articular surface which in turn receives the body weight transmitted to it by the superimposed talus. The eversion-abduction-dorsiflexion imposed on the subtalar joint is limited mostly by the facies extrema accessoria corporis tali abutting on the intermediate root of the inferior extensor retinaculum, the anterior and lateral talo-calcaneal ligaments and such a concomitant facet as is seen in the case of type C. Thus the subtalar joint comes to be much stabilized in the squatting posture. This makes us recall Wis-Brun (1951) who has noted that the linear contact of the 'vordere Kante der hinteren Taluskonkavität' with the calcaneal groove is conducive to the transverse stability of the foot. The attitude of the foetus in utero, however, has a false analogy with the posture squatting on the ground, because the body weight of the foetus does not fall on the foot, and because the position of the foot, according to Böhm (1935), is not in eversion-abduction-dorsiflexion, but in inversion-adduction-plantarflexion. Moreover, as shown in table 1, the cases of types B2, B3, C and D occupy in general a greater portion of the adult series, while the cases of type A form a large part of the foetal series. This seems to indicate that the forward extension complex of the posterior talar articular surface is caused by the pressure and rubbing of both posterior calcaneal articular surface and facies extrema accessoria corporis tali due to the constant eversion-abduction-dorsiflexion of the subtalar joint in the postnatal squatting posture. This exhibits a striking contrast to the result presented in the author's previous paper, that the facies extrema accessoria corporis tali observed on the talus of the Japanese foetus is subsequently perfected by the influence of squatting posture as the individual advances to maturity.

It is interesting to note here that there is a difference between the percentage of absence of the anterior talo-calcaneal ligament and that of occurrence of the case of type D in the foetal series, while this is just the same with that in the adult series. It seems to indicate that whether the anterior talo-calcaneal ligament may be present or absent, the median forward extension which distinguishes type D from the others does not occur in the foetal stage, where the subtalar joint of the foetus neither receives the body weight nor is always in the position of eversion-abduction-dorsiflexion.

As mentioned above, all four types of the forward extension complex of the posterior talar articular surface are closely associated with the squatting posture. But, the reason why there are present different types of the forward extension complex is still uncertain. Apart from the strength of the anterior talo-calcaneal ligament and that of the intermediate root of the inferior extensor retinaculum, these variations seem to depend upon not only the structural configuration of the calcaneus, but also the 'interlocking' nature of the talus and calcaneus. The investigation of this possibility must be the subject of future research.
Summary

1. Three hundred and thirty-three fresh and cleaned adult and foetal Japanese calcanei were observed for the forward extension complex of the posterior talar articular surface.

2. Three types of the forward extension complex were represented and one additional type is added for comparison.

3. The forward extension complex was in general markedly developed in the adult calcanei, whereas it was absent or incompletely developed in the foetal ones.

4. From the anatomical, topographical and mechanical points of view, the cause of the forward extension complex was to be sought in pressure and rubbing of both posterior talar articular surface and facies externa accessoria corporis tali during such eversion-abduction-dorsiflexion of the subtalar joint as secured the stability of the foot in the postnatal squatting posture.

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EXPLANATION OF FIGURES

2 A case of type A in a foetal calcaneus (left side). No. F-130, female, 7 foetal months.
3 A case of type B in a cleaned adult calcaneus (left side). No. 105, male, 19 years of age.
4 A case of type C in a fresh adult calcaneus (left side). No. 5713, male, 79 years of age.
Note that the anterior talo-calcaneal ligament (Fick) has been destroyed by the pressure
and rubbing of the facies externa accessoria corporis tali (Sewell) during eversion-
abduction-dorsiflexion of the subtalar joint in the squatting posture.
5 A case of type C in a cleaned adult calcaneus (right side). No. 97, male, 66 years of age.
日本人蹠骨におよぼす踵趾位の影響
——後距骨関節面の前方伸展について——

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日本人成人ならびに胎児の新鮮蹠骨・洗浄蹠骨計333個を対象とし、後距骨関節面の前外側隅に生ずる関節面の前方伸展について観察した。

前方伸展は次の諸型に分類される。A型（基本型）は前方伸展を欠くもの。B型は後距骨関節前の前外側隅に関節面の前方伸展が見られるものの。さらにB型は発達の不完全なB₁亜型と、よく発達したB₂亜型・B₃亜型とに分けられる。C型はB型の前方伸展の前方にこれと直交して距骨骨板外面（SEWELL）と関節する小関節面を伴うもの。D型はB型の前方伸展の内側に、前距関節帯（FICK）断裂の結果生じた別の前方伸展を伴うもの。

成人ではB₂亜型およびB₃亜型が全例の75％以上を占め、C型およびD型もそれぞれ10％前後見られるが、胎児ではA型が全例の約70％を占め、B₁亜型がこれに次ぎ、B₂亜型・B₃亜型・C型・D型は見られない。

前方伸展の成因は生後の踵趾位と関係がある。踵趾位をとると距骨下関節は内側・外側・背屈され、足は安定する。その際、距骨の後距骨関節面と距骨骨板外面の圧迫によって前方伸展が生ずるものと考えられる。

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