*FROM THE KRONPRINSESSE MÄRTHAS INSTITUTT, OSLO*
*(HEAD: H. S. NISEEN-LIE, M.D.)*

# THE AXIS OF THE ANKLE JOINT AND ITS IMPORTANCE IN SUBTALAR ARTHRODESIS[1]

*By*

THOMAS WYLLER

The direction of the axis of the ankle joint is described somewhat variously in the literature but generally it is described as almost entirely transverse in relation to the sagittal plane of the normal foot.

*Barnett, Napier & Hicks* examined the axis of the ankle joint in greater detail. *Barnett & Napier* examined 152 cartilage-covered talus bones and found that the medial profile of the trochlea is composed of an anterior arc with a small radius and a posterior arc with a large radius, while the lateral profile consists of a single arc with a medium sized radius. (Fig. 1).

In moving the foot dorsally to the O-position (both in the dorsal and plantar direction in this dorsal area of movement), it is the anterior part of the trochlea with the sharp medial arc which is in contact with the tibia. From this *Barnett & Napier* concluded that these movements must occur around an axis which is higher medially than laterally. (Fig. 1 a). The reverse in the case with movements plantar to the O-position (both in the plantar and dorsal direction in this plantar area of movement): now it is the posterior part of the trochlea with the slack medial arc which is in contact with the tibia. These movements must therefore occur around an axis which is lower medially than laterally. (Fig. 1 b).

The oblique position of both axes in relation to the horizontal plane varies amongst individuals.

The extent of the variation in breadth is not stated directly in *Barnett & Napier*'s work, but from graphs it appears that the obliquity of the axis for the plantar area varied from 0° to 16°, and that the obliquity

[1] Reprinted after correction from The Proceedings of the Nordisk Orthopedisk Förenings 30th Assembly in Oslo where the article contained some confusing errors.

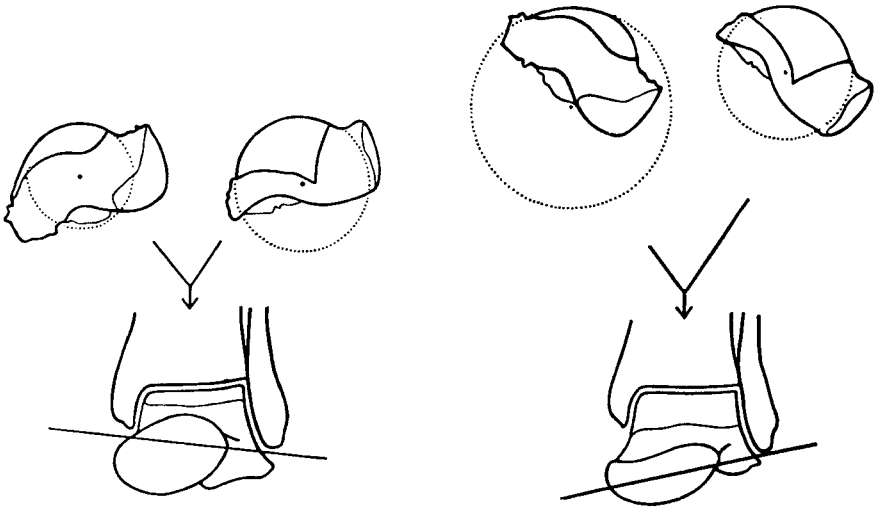

*Fig. 1 A.* *Fig. 1 B.*

*Figs. 1 A and B.*
The medial profile of the trochlea tali is composed of an anterior curve with a small radius and a posterior curve with a large radius. The lateral profile consists of a single curve of medium sized radius. Movements of the foot dorsally to the O-position therefore occur about an axis that is higher medially than laterally (1 A), and movements plantar to the O-position occur about an axis that is lower medially than laterally (1 B). For clarity the lateral side of (the left) talus is given in mirror reflection. (*Barnett & Napier* 1952. Reproduced from the Journal of Anatomy with kind permission of the editors and of the authors.)

of the axis for the dorsal area in selected groups totalling 83 bones varied from 0° to 14°.

*Hicks* examined the movements in the ankle joint by means of 5 presumably normal preparations. The soft tissue of the preparations was preserved up to 4 cms. above the ankle joint. The movements were produced by pulling on the tendons, both with and without weight-bearing by the foot.

*Hicks* also found 2 axes, one for the dorsal and another for the plantar area of movement. The axes had the same direction of inclination relative to the horizontal plane as *Barnett & Napier* had calculated. Moreover, *Hicks* found that both axes passed obliquely in relation to the frontal plane of the foot, as the medial end of both axes pointed somewhat ventrally. On *Hicks'* illustration (Fig. 2) I have measured the horizontal projection of the divergency of the axes from the frontal plane and found it to be 14° and 17°. (The frontal plane is thought to be at right angles to the longitudinal axis of the foot. On Fig. 2 the

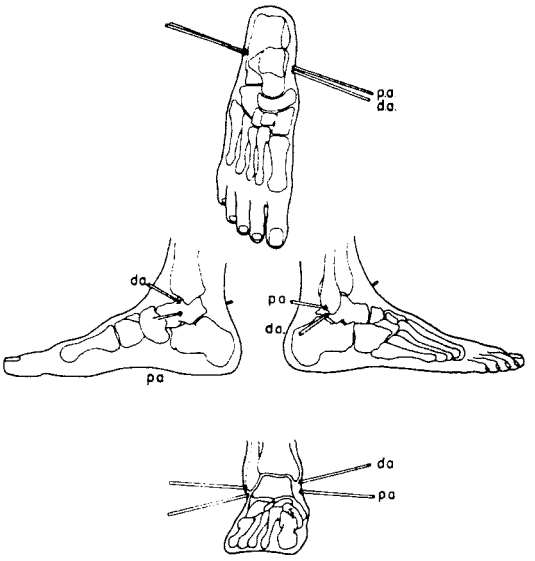


*Fig. 2.*
Axes of ankle joint. p.a. = axis of movements plantar to O-position. d.a. = axis of movements dorsal to O-position. (*Hicks* 1953. Redrawn from the Journal of Anatomy with kind permission of the editors and the authors.)

horizontal projection of the foot is shown in slight abduction, so the oblique position of the ankle axes appears larger still.)

As clinical landmarks *Hicks* states that the axis of the dorsal area of movement passes from a point 1½ cms. in front of the tip of the medial malleolus to a point ½ cm. below the tip of the lateral malleolus, and that the axis of the plantar area passes from a point 1½ cms. in front of the tip of the medial malleolus and 1 cm. below it to a point ½ cm. above the tip of the lateral malleolus.

The fact that the ankle axis passes obliquely instead of at right angles to the sagittal plane of the foot means that the foot moves in the ankle joint like a badly mounted wheel. If we imagine the sagittal plane of the foot to be a round disc with the ankle joint in its centre and the ankle axis mounted obliquely the disc will wobble from side to side in its movements around the axis. (Fig. 3). If we regard the tip of the foot we call this swerve abduction/adduction, if we regard the heel (represented by a cranio-caudal line of direction) we call this swerve valgus/varus. A model like that in Fig. 3 wobbles regularly. The swerve of the foot becomes irregular because the ankle axis changes direction when the O-position is passed.

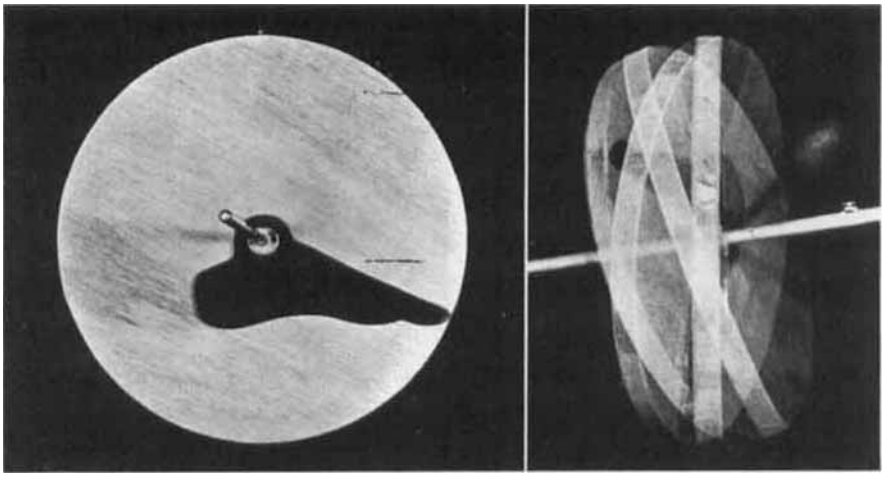

*Fig. 3 A.* *Fig. 3 B.*

*Figs. 3 A and B.*

The sagittal plane of the foot may be regarded as a round disc with the ankle joint in the centre and the axis of the joint oblique (3 A). On movement about its axis the disc will wobble like a poorly mounted wheel (3 B).

Normally the swerve of the ankle joint is compensated as required by opposing movements in the talo-tarsal joints, so that the swerve is difficult to detect. When subtalar arthrodesis has been performed, however, this compensation mechanism is annulled and the swerve comes to light. This means that the foot after performance of subtalar arthrodesis places itself in different degrees of varus or valgus according to the different degrees of height of the shoe's heel.

The extent of the swerve normally varies according to the individual. In a pathological series, which feet with subtalar arthrodesis certainly form, the variation must be assumed to be larger than normal. This must already be accepted for the reason that even if the axis passes normally in relation to the malleoli and the talus, then a malposition of the heel will produce an abnormal position between the axis and the median plane of the heel with a consequent abnormal swerve of the heel.

Figs. 4–11 show some examples of how 4 cms. lift of the heel influences the valgus/varus position of the heel when subtalar arthrodesis has been carried out. The individual variation is, as can be seen, considerable, from no swerve (Fig. 8) to considerable swerve in the varus direction (Fig. 5). None of the examples show swerve in the valgus direction nor can I remember seeing such a swerve at any time in

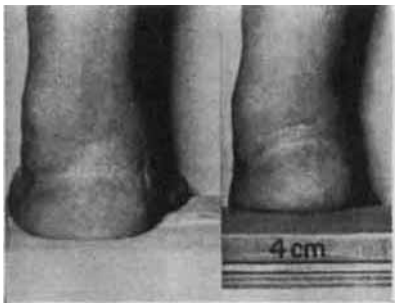


*Fig. 4.*
Man, aged 48. Left foot. He had had poliomyelitis as a child and triple-arthrodesis as an adult. The slight varus position with a support of 4 cms. under the heel made the foot so unsteady that he could not use this height of heel, which would have been desirable because of shortening of the leg.

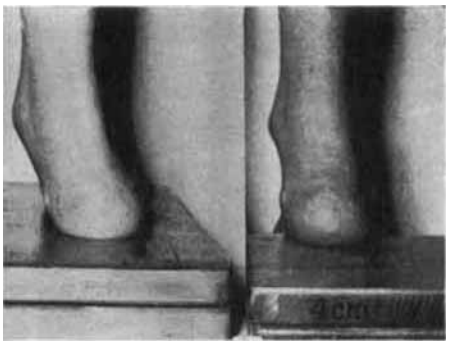

*Fig. 5.*
Girl, aged 12. Right foot. Poliomyelitis, arthrodesis a.m. Grice. Shortening of the leg made a 4 cms. heel desirable, so that the arthrodesis may be regarded as being in ideal position despite considerable valgus barefooted.

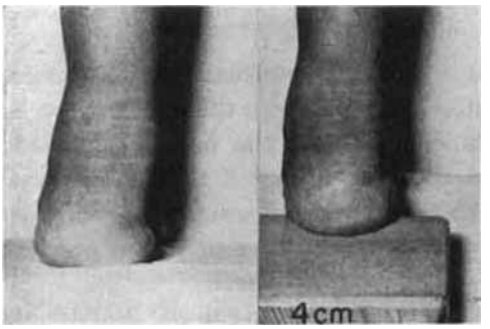


*Fig. 6.*
Girl, aged 13. Left foot. Poliomyelitis, arthrodesis a.m. Grice.

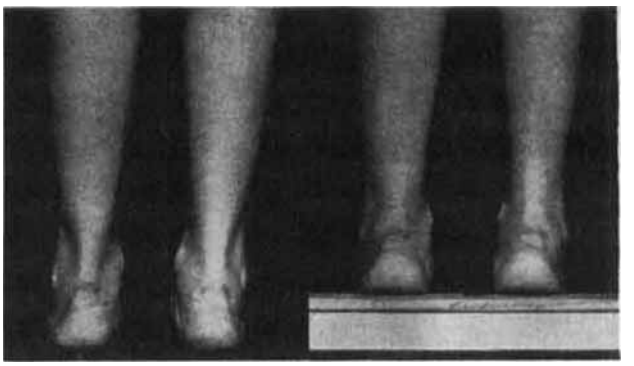

*Fig. 7.*
Girl, aged 10, bilateral idiopathic pes planovalgus, bilateral arthrodesis a.m. Grice.

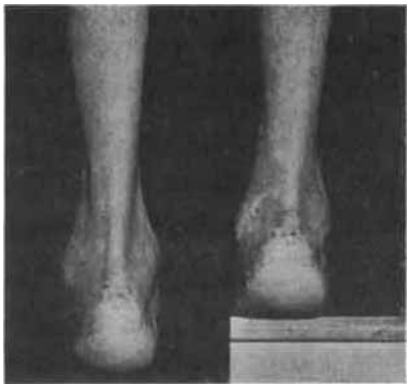

*Fig. 8.*
Man, aged 43. Left foot. Cavo-varus, triple-arthrodesis.
No appreciable swerve.

*Fig. 9.*
Woman, aged 48. Left foot. Calcaneus fracture, triple-arthrodesis.

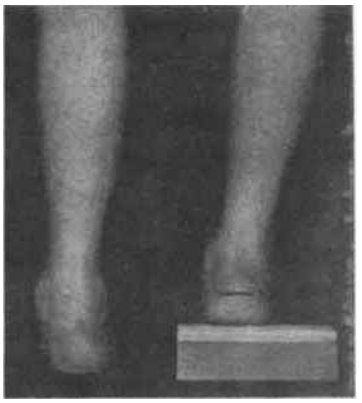

*Fig. 10.*
Boy, aged 11 years. Right foot. Pes valgus after division of tendon of anterior tibial muscle, arthrodesis a.m. Grice.

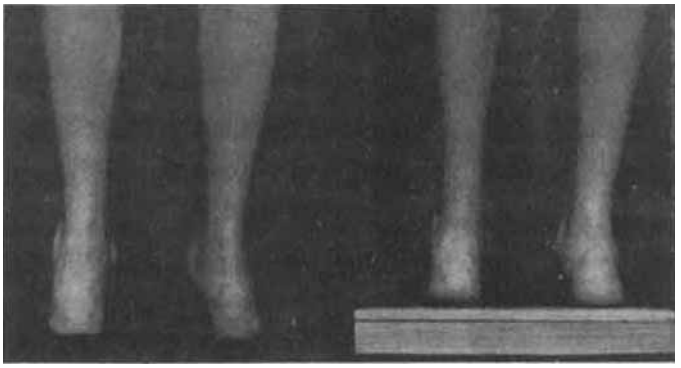

*Fig. 11.*
Boy, aged 13 years. Charcot-Marie-Tooth's disease, bilateral triple-arthrodesis.

plantar flexion. The swerve seems to be particularly prominent in patients who had polio as children. (Figs. 4, 5, 6).

Now it is the case that the varus position is endured much less easily than the valgus position, not least by polio patients.

*The conclusion* is therefore that in the adjustment of a subtalar arthrodesis on the operation table consideration must be given to the degree of plantar flexion which it is desirable for the patient to carry out without the foot assuming a varus position. In other words consideration must be given to the height of heel which the patient will require in his footwear after the operation, with a slight addition for walking down hills. The height of the heel may be determined by cosmetic wishes or by shortening of the extremity.

Allowance for the height of the heel is most simply achieved by undertaking the adjustment of the arthrodesis with the ankle joint in the pointed foot position which the desired heel height requires and not at right angles between leg and sole of foot.

With this procedure one does not need to know how large or small is the patient's swerve in the ankle joint. If the swerve is large the foot places itself in a deformning valgus position when walking barefoot (Fig. 5), but this must be said to be of minor importance in this connection. It is the price the patient must pay to walk comfortably and neatly with shoes on. If the swerve is small, the fact that the subtalar adjustment is undertaken with the ankle in the pointed foot position will not very much affect the position of the foot when walking barefoot. (Fig. 8). It may be accepted that this procedure is more reliable than, with the ankle at right angles, the haphazard adjustment of the arthrodesis to some degree of valgus position, in order to compensate for the unknown large swerve in the varus direction caused by the shoe heel.

## SUMMARY

*Barnett, Napier & Hicks* showed that the axis of the ankle joint passes obliquely in relation to the sagittal plane of the foot. This means that the foot moves in the ankle joint like a poorly mounted wheel, it swerves from side to side. Normally the swerve is compensated for in the talotarsal joints, but when subtalar arthrodesis has been performed there is no compensation. The size and variability of the lateral swerve of the heel in a plantar flexion corresponding to a shoe heel of 4 cms. is demonstrated. In all the cases demonstrated the heel swerves in the varus direction on such plantar flexion, if it does swerve at all.

Varus is endured less easily than valgus. The conclusion therefore is that in adjusting a subtalar arthrodesis on the operating table consideration must be given to the height of the heel the patient is to use (e.g. owing to shortening of the extremity). This is done by adjusting the subtalar arthrodesis with the ankle joint in the pointed foot position which the height of the heel requires, and not at right angles between leg and sole of foot.

RESUME

*Barnett, Napier & Hicks* ont montré que l'axe de l'articulation de la cheville est incliné par rapport au plan sagittal du pied. Cela signifie que le pied se meut dans l'articulation de la cheville comme une roue mal montée qui est « projetée » d'un côte à l'autre. Normalement, la projection est compensée dans les articulations talotarsiennes mais dans l'arthrodèse sous-astragalienne, elle n'est pas compensée. Il est fait la démonstration de l'importance et de la variabilité de la projection de côté du talon lorsque la flexion plantaire correspond à un talon de chaussure de 4 cm de hauteur. Dans tous les cas indiqués, le talon est projeté en direction varus à cette flexion plantaire, s'il est projeté.

On supporte moins bien la position varus que valgus. C'est pourquoi on en conclut qu'au moment d'établir l'arthrodèse sous-astragalienne sur la table d'opération, il convient de tenir compte de la hauteur du talon que portera le malade (par ex. par suite d'un raccourcissement de l'extrémité). On le fait en adaptant l'arthrodèse sous-astragalienne à l'articulation de la cheville dans la position du pied indiquée par la hauteur du talon de la chaussure et non à angle droit entre la jambe et la plante du pied.

ZUSAMMENFASSUNG

*Barnett, Napier & Hicks* haben nachgewiesen, dass die Achse des Knöchelgelenkes im Verhältnis zur Sagittalebene des Fusses schräg verläuft. Das bedeutet, dass der Fuss sich im Knöchelgelenk wie ein schlecht montiertes Rad bewegt, er „wirft" sich von Seite zu Seite. Normalerweise wird dieses „Werfen" in den Talotarsalgelenken kompensiert, aber nach einer subtalaren Arthrodese geht keine Kompensation vor sich. – Die Grösse und Variation der Fersenablenkung bei einer Plantarflexion, die einer Absatzhöhe von 4 cm entspricht, wird demonstriert. In allen den vorgezeigten Fällen wird die Ferse bei einer solchen Plantarflexion in der Varusrichtung abgelenkt, wenn eine Ablenkung überhaupt stattfindet.

Eine Varusstellung wird schlechter vertagen als eine Valgusstellung. Man schliesst daher, dass man bei der Anpassung einer subtalaren Arthrodese am Operationstische Rücksicht auf die Absatzhöhe nehmen muss, die der Patient späterhin brauchen soll (z. Bsp. wegen Gliedmassenverkürzung). Das geschieht indem man die Subtalararthrodese mit dem Knöchelgelenk in der Spitzfussstellung zusammenpasst, die die Absatzhöhe erfordert, und nicht im rechten Winkel zwischen Unterschenkel und Fusssohle.

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