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TALAR DEFORMITY IN CONGENITAL CLUBFEET

An Anatomical and Functional Study with Special Reference to the Ankle Joint Mobility

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Dissection studies performed on foetuses and infants with congenital clubfeet have almost always shown deformities of the foot skeleton. The deformity has been most pronounced in the talus, in the form of a medial and plantar deviation of its neck and head (Adams 1866, Kocher 1879, Parker & Shattock 1884, Scudder 1887, Nichols 1897, Irani & Sherman 1963, Settle 1963, Reimann 1967, Fjeldborg 1971). Other less frequent changes have been a flattening of the trochlea, a reduction of the anterior part of its tibial articular surface as well as its lateral and medial articular facets.

Another fundamental part of the clubfoot deformity is a medial-plantar subluxation or luxation of the navicular bone with a consequent deformation of the articular facets of the talar head.

Dissecting two clubfeet with a pronounced deformation of the talus, we found that the deformity itself constituted a hindrance to the dorsiflexion of the foot. This functional hindrance could be forced by cutting tendons and ligaments, but then, instead, there appeared an incongruity in the ankle joint.

In this present study we have given emphasis to the ankle joint mobility which has not been closely examined in previous studies.

MATERIAL

Studies were performed on the feet of a three-day-old boy, deceased as a consequence of an atrial septal defect and atresia of the aorta. Both feet were fixed in a pronounced equino-varus-adductus position. No other skeletal deformities were observed. The feet were investigated by arthrography of the talocrural, talonavicular and subtalar joints after which they were dissected. Comparable material was

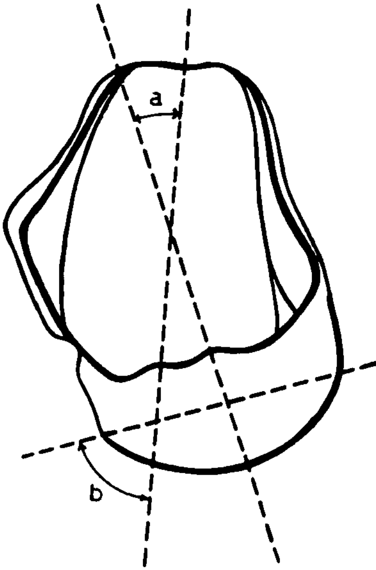

Figure 1 b. Drawing of a clubfoot specimen from above. Note that in this measuring the medial deviation of the talar neck by using the angle (a) between the axis of the trochlea and the neck. The medial deviation of the navicular joint facet is expressed as the angle (b) between the axis of the trochlea and the base line of the facet.

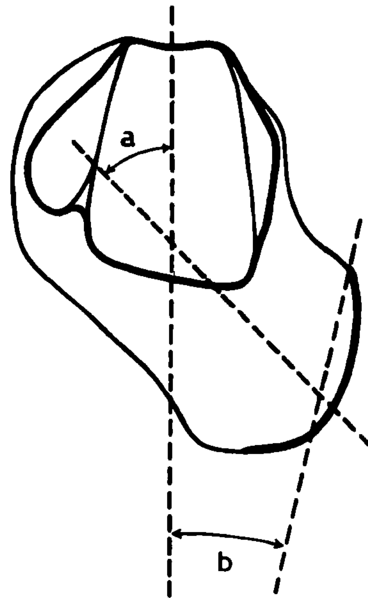

Figure 1 b. Drawing of a clubfoot specimen from above. Note that in this specimen the actual navicular facet is on the medial-plantar side of the head due to the dislocation of the navicular bone. Consequently the original facet is reduced both by compression and obliteration. The angle (b) is then expressed as the angle between the axis of the trochlea and the baseline of the actual navicular facet.

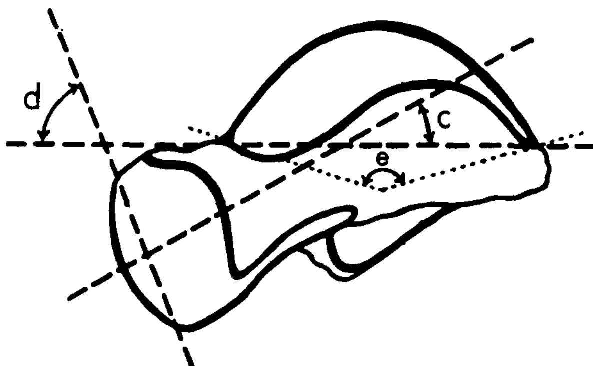

Figure 2 a. Drawing of a normal talus from the medial aspect illustrating the method of measuring the plantar deviation of the neck using the angle (c) between the base line of the trochlea and the axis of the neck. The plantar deviation of the navicular joint facet is measured by the angle (d) between the base line of the trochlea and the facet, respectively. The way of measuring the central angle (e) is shown.

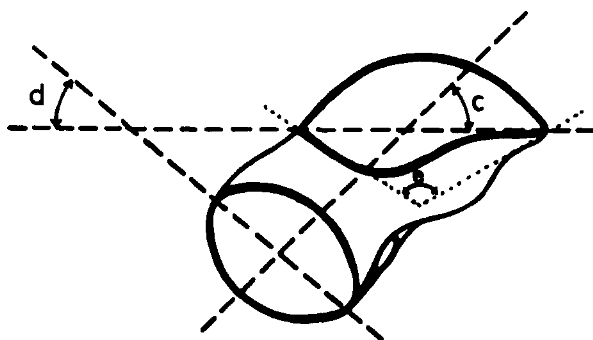

Figure 2 b. Drawing of a clubfoot specimen from the medial aspect. The plantar deviation (d) is difficult to measure with accuracy in clubfeet with pronounced medial deviation (figure) and impossible to measure if the medial deviation is extreme as in Figure 4 b.

obtained by a similar examination of 30 feet without deformities from children 2 days to 18 months of age.

RESULTS

The neck of the talus was short and wedgelike in both the preparations, lacking its normal "waist" and the little groove usually found on its dorsal side. The medial deviation of the long axis of the neck related to the long axis of the trochlea was 50° (normal value 28°±10°). The

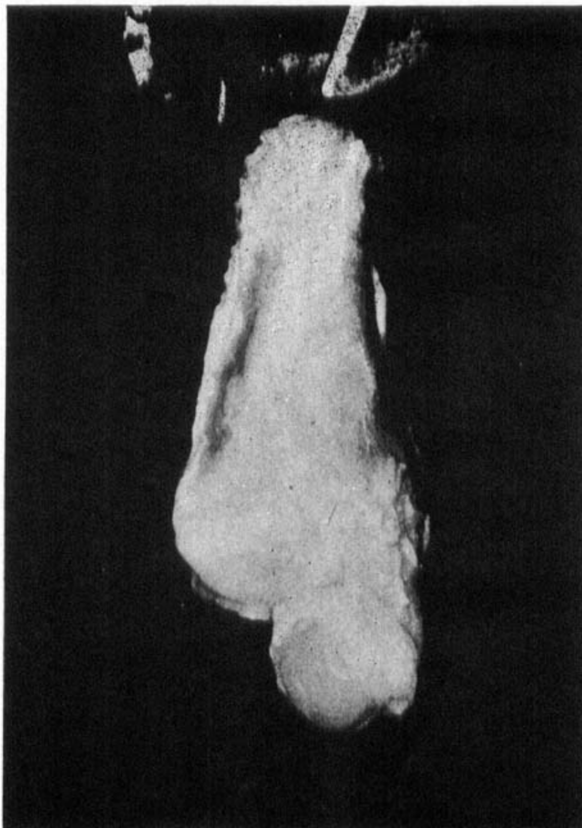

Figure 3 a. The medial aspect of the tibia and talus of a clubfoot specimen. The navicular and calcaneus bones have been removed. Note the pronounced medial and plantar deviation of the talar head and neck bringing the head in close contact with the tip of the internal malleolus.

plantar deviation of the collum was 50° (normally 27°±8°. See Figures 1 a, b, 2 a, b).

The naviculer articular surface of the head normally shows a slight medial deviation and the angle between the base of its articular facet and the long axis of the trochlea normally is 74°±10°. In our clubfoot preparations the corresponding angle was about 10° (Figure 1 a, b). The plantar deviation of the head in the normal material was 70°±7° (Figure 2 a, b). In the clubfoot specimens the plantar deviation could not be measured with a satisfactory accuracy because of the simultaneous severe medial deviation. The navicular joint surface was reduced to less than half of its normal size by deformation and ob-

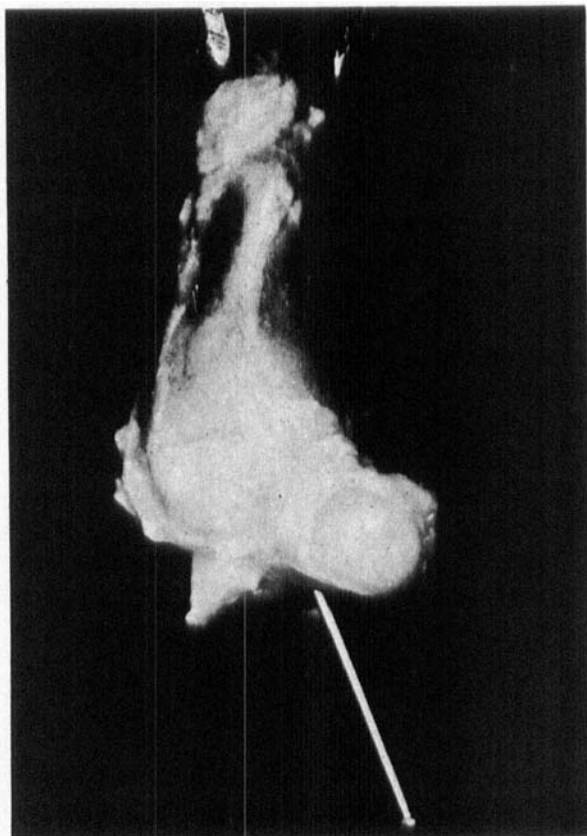

Figure 3 b. The same specimen after division of the talocrural joint capsule and ligaments. In dorsiflexion of the talus the head remained in close contact with the anterior margin of the malleolus. Being oblique, the latter forced the talar head laterally, thus causing a rotational movement of the talus around a vertical axis.

literation, and under the influence of the luxated navicular bone a new articular surface was formed on the medial-plantar side of the head. There was a moderate flattening of the trochlear articular surface. A reduction of the anterior part of the trochlear joint surface was also noted and this explains why the central angle (Figure 2 a, b) was only 125° (normally 160°). The recesses of the ankle joint were difficult to see directly. Arthrograms showed a small back recess, while the front recess seemed to be lacking or extremely compressed (Figure 4 b).

The navicular bone was luxated medially, articulating with the medio-plantar facet of the talar head. Its medial edge was situated close

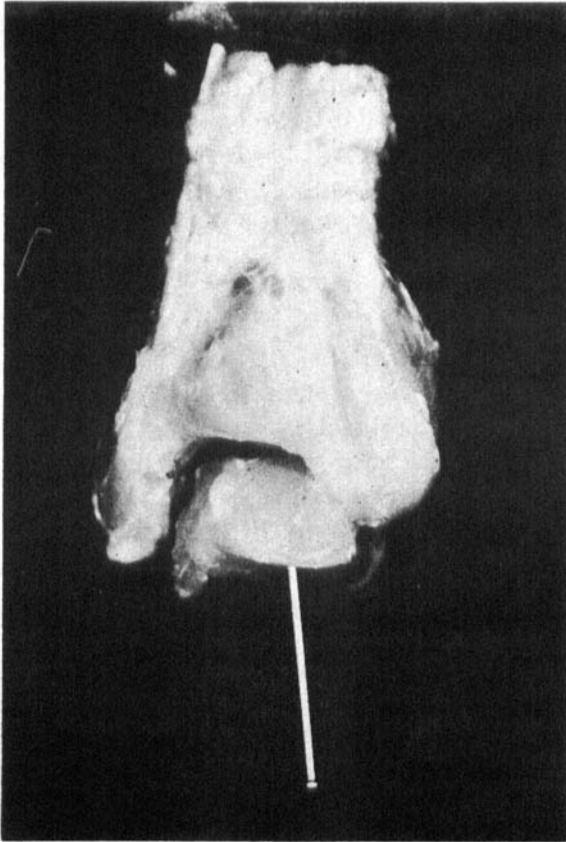

Figure 3 c. Posterior view of the specimen of Figure 3 b. Dorsiflexion of the talus has caused a rotational movement of the talus around a vertical axis, in turn causing an incongruence of the talocrural joint.

to the internal malleolus, fixed by a very short tibio-navicular ligament. It was difficult to determine if this ligament, or the other parts of the deltoid ligament, was thicker than normal.

Notable was the strong fibrous connection between the inside of the internal malleolus and the medial side of the trochlea. These fibres occupied the larger part of the medial surface of the trochlea, leaving only a small area as a normal articulating surface.

There were both anterior and posterior subtalar joints, but they were smaller than normal and somewhat deformed. The posterior subtalar joint recess extended backwards between the almost vertical tuber calcanei and the back of the tibia and the fibula.

The tuber calcanei was bent medially like the distal part of the corpus. The sustentaculum tali was fairly well preserved. The cuboid was in good contact with the articular facet of the calcaneus even if there was a slight rotation and dislocation medially.

No abnormal insertions of the tendons were observed. The course of the tendons was somewhat changed, but this seemed to be just an adaptation to the skeletal deformities. The ligament, too, showed a similar adaptation.

Function study

Having removed all the soft tissues except the ligaments, we could with redression obtain only a slight correction of the equinus deformity and the navicular luxation. Not even after removal of the calcaneus, navicular and cuboid bones could the talus be dorsiflexed notably. This can be explained in three ways:

1) The ligaments have lost their elasticity which can depend either on pre- or postmortem changes.
2) The joint capsule is tight because of a partial obliteration of the recesses of the talocrural joint.
3) the head of the talus deviates medially and protrudes in front of the internal malleolus which like the medially dislocated navicular bone locks the talus in a plantarly flexed position (Figure 3 a).

After division of the capsule and the ligaments of the talocrural joint, we could study how dorsiflexion of the talus was influenced by the talar deformity itself.

Dorsiflexion proved to be possible only if

1) the talar head was dislocated laterally losing its contact with the front rand of the medial malleolus. This, however, causes a corresponding medial rotation of the back part of the trochlea giving an incongruity in the ankle joint (Figure 3 b and c).
2) the talar head remained in close contact with the oblique front edge of the malleolus during dorsiflexion. The talus then naturally dislocates slightly forward, which again gives an incongruity in the talocrural joint.

The lack of the dorsal groove of the talar neck also decreases the range of dorsiflexion.

Radiographic findings

Arthrograms of the talocrural, talonavicular and subtalar joints enabled a determination of the relationships between the articular sur-

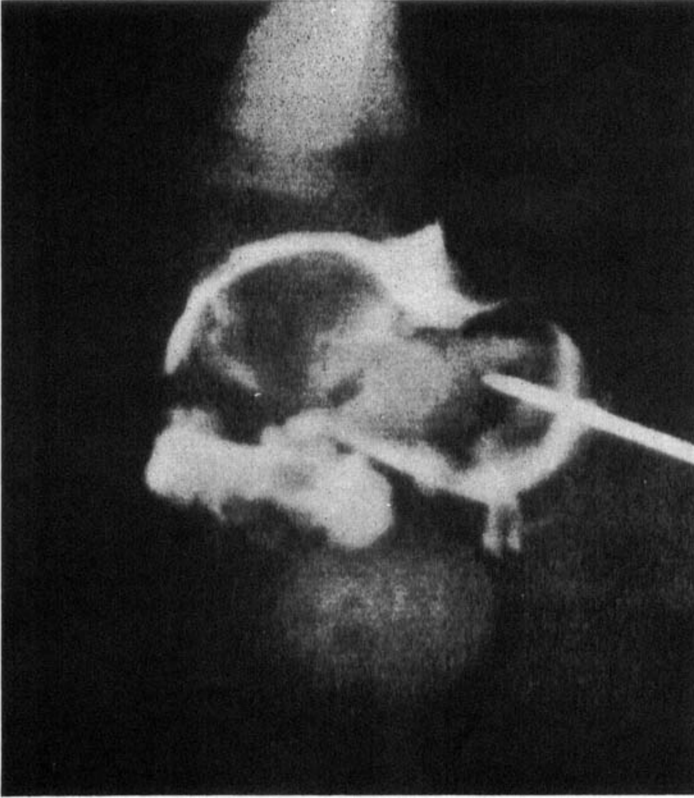

Figure 4 a. Arthrogram of the lateral aspect of the talocrural, talonavicular and posterior subtalar joints of a normal specimen. The needle is left in the talonavicular joint to prevent contrast leakage. The trochlear articular surface approximates an arc of a circle. The contrast in the anterior recess of the ankle joint outlines the small groove on the dorsal side of the talar neck. The dorsal recess is compressed due to the slight dorsiflexion of the joint.

faces and an approximation of the shape of the talus. The results are in good agreement with the anatomical findings. The radiographic method also allows an estimation of the size of the recesses of the joints, which can be difficult to evaluate by dissection. Arthrograms of the clubfoot specimens showed a partial obliteration of the recesses of the ankle and talonavicular joints (Figure 4 a, b).

DISCUSSION

Anatomical findings

Previous investigations (Adams 1854–1855, 1866, Kocher 1879, Parker & Shattock 1884, Scudder 1887, Bissel 1888, Burrell 1893, Nichols

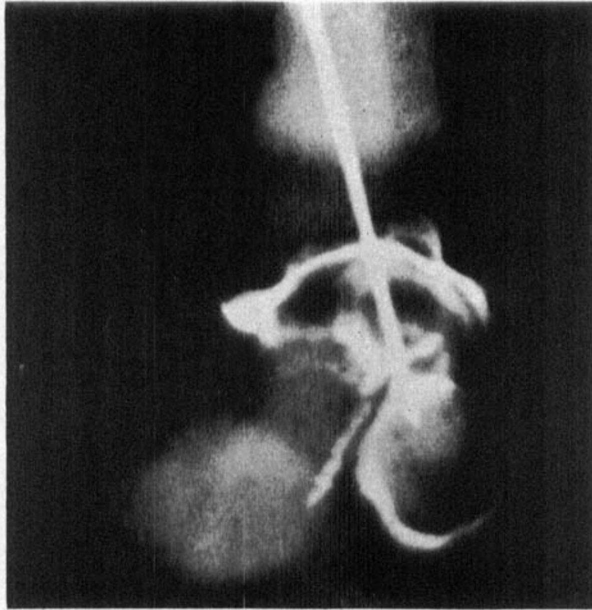

Figure 4 b. Arthrogram of the lateral aspect of the talocrural and talonavicular joints of a clubfoot specimen. There is some flattening of the trochlea and its articular surface is insignificantly longer than that of the tibia. There is a small posterior recess while the anterior recess is absent. The trochlea is seen in profile while the talar head is seen en face *due to its pronounced medial deviation. Note the plantar position of the talar head, which is also positioned behind the frontal border of the trochlea due to the shortness of the talar neck.*

1897, Bechtol & Mossman 1950, Bernbeck 1950, Irani & Sherman 1963, Settle 1963, Reimann 1967, Fjeldborg 1971) have shown a varying degree of skeletal deformity in clubfeet. However, if the deformity varies in its degree, this does not seem to be the case concerning its type. Thus, the trochlea of the talus may have an apparently normal form but also be flattened and show a reduction of the front part of its tibial articular surface as well as a reduction of its malleolar articular facets. The most pronounced deformity, however, concerns the head and the neck of the talus, which to a varying extent deviate medially and plantarly. The more or less deformed navicular bone is subluxated medially-plantarly with a corresponding deformation of the articular facet of the talar head. The cuboid is often subluxated but only in exceptional cases fully luxated. The calcaneus is bent with its concavity turned medially and the sustentaculum tali is often poorly developed.

Our preparations demonstrate a pronounced deformity of the described type, although they do not belong to the most extreme cases described previously in the literature.

Concerning the soft tissues, we, as with previous investigators have found only an adaptation to prevailing skeletal deformities, but no changes concerning the insertions of the tendons. Histological examination of the soft tissues has not been performed.

Thus our dissection study confirms previous observations concerning the skeletal deformities.

However, attention can be directed to the fact that in our preparations the articular surface of the trochlea did not extend as far forwards on the neck of the talus as normally noted. This means that the articular surface of the trochlea in a sagittal direction extended only slightly beyond the corresponding articular surface of the tibia. Another observation, that has not been pointed out by previous investigators, except Kocher (1879), is that either one or both of the recesses of the ankle joint can be obliterated. The back recess of the subtalar joint in our preparations formed a false joint between the tuber of the calcaneus and the tibia.

Functional study

Tight muscles and ligaments as obstacles to the correction of clubfeet deformity have been carefully examined and discussed by previous authors. The skeletal deformity itself, however, as an obstacle to correction and to joint mobility has been a matter of controversy, and this to some extent is due to the variation of the deformities.

Our study shows that the talar deformity itself can be a hindrance to dorsiflexion of the foot. After cutting the tendons, ligaments and capsule, dorsiflexion was possible only by a rotational or forward movement of the talus, in both cases giving an incongruity in the ankle joint (Figure 3 b, c). Contrary to this finding, Parker & Shattock (1884), as well as Irani & Sherman (1963), have stated that talar deformation does not change the mobility of the ankle joint. Fjeldborg (1971) describes an incongruity of the talonavicular and talocalcanear joints after correction but does not mention the ankle joint.

Bissel on the other hand wrote in 1888: "In both my specimens it was still impossible to dorsiflex the foot after removal of the muscles and tendons even after devision of the whole of the internal ligament without separating some of the articulating surfaces".

A solution of this problem may be as difficult as with the Gordian knot. Thus, Nichols as early as 1897 proposed a corrective osteotomy through the talus and the calcaneus. However, it is not yet known if this may be done without sometimes causing serious damage to the vascular supply of the talar head and the trochlea.

Other anatomical changes of the clubfoot talus, decreasing the ankle joint mobility, are

1) a reduction of the articular surface of the trochlea
2) a flattening of the trochlea
3) lack of the small groove on the dorsal side of the talar neck that fits into the anterior rim of the tibia on dorsiflexion of the foot.

A soft tissue change influencing the ankle joint mobility is, as also mentioned by Kocher (1879), a partial or total obliteration of the recesses. There is probably no completely satisfactory solution to this latter problem. In any case, a posterior capsulotomy will be futile if there is an obliteration of the anterior recess, especially if it is combined with a shortening of the frontal part of the trochlear articular surface.

The deformation of the talar head and its articular surfaces explains the difficulty of reposition of the navicular bone as well as the problems of preserving its proper alignment.

CONCLUSIONS

1) The skeletal deformities found in our preparations agree with what many previous investigators have found in pronounced pes equinovarus.

2) In addition we have found a partial obliteration of the recesses of the ankle joint, a finding which is also confirmed by arthrography in clinical cases. This means that not only tight ligaments, but also the capsule itself may constitute a hindrance to dorsiflexion of the talus.

3) A reduction of the articular surface of the trochlea, the lack of the dorsal groove of the talar neck and flattening of the trochlea cause limitation of the mobility of the ankle joint.

4) If muscles, ligaments and the capsule are eliminated as obstacles for dorsiflexion of the talus, this movement can be performed, but then an incongruity of the talocrural joint arises. It should be emphasized that this is true only in cases with a severe talar deformity.

5) Due to the deformation of the articular facets of the talar head

the navicular bone may, after reposition, have only a very small supporting area with a consequent great risk for reluxation.

6) Obliteration of the recesses of the talonavicular joint has been found and may be a hindrance to reposition of the navicular bone.

SUMMARY

Two clubfeet from a new-born boy were studied by arthrography and dissection. The skeletal deformities agree well with many previous descriptions. However, the importance of partial obliteration of the ankle and talonavicular joint recesses as well as the deformation and reduction of the articular surfaces is discussed.

A function study shows that when muscles, ligaments and capsule have been eliminated as obstacles to the ankle joint mobility, dorsiflexion will be possible but only at the expense of an incongruity in the ankle joint. This is true, however, only in cases with a pronounced talar deformity. The mechanism is discussed.

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