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# THE ARTERIAL SUPPLY OF THE TALUS

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Fractures of the talus can cause a disrupture of the vascularization of this bone, which may become deprived of its blood supply to varying degrees. A necrosis may arise, the frequency of which varies with the type of fracture. The rate of necrosis in fractures of the neck and body of the talus combined with dislocation is 30–70 per cent and in undislocated fractures 0–10 per cent (McKeever 1943, Coltart 1952, Watson-Jones 1955, Sullivan & Jackson 1958, Larsson et al. 1961, Hawkins 1970, Kenwright & Taylor 1970).

In some instances there is a regression of the necrosis, but in others it persists and the talar dome collapses, especially when it is subjected to weight-bearing forces (Hawkins 1970). In cases of talar necrosis clinical improvement occurs in 80 per cent of the cases after treatment through non weight-bearing. With non weight-bearing the circulation may be sufficient to favour healing, but with the talus under stress it may become so insufficient that a regression of the necrosis is impeded (Coltart 1952, Hawkins 1970, Kenwright & Taylor 1970). It is suggested that clinical improvement is due to an increased osseous healing, secondary to an improved blood supply (Coltart 1952, Watson-Jones 1955, Hawkins 1970). New arterial pathways may be opened up, which are described in this investigation.

The object of this investigation has been to study the vascular sources, which contribute to the total vascularization of the talus. Special interest has been devoted to the arterial pathways running in the ligaments and joint capsules between the talus and surrounding bones.

In a later investigation it is intended to study the influence of experimentally produced talar fractures on the vascular supply of the talus.

## LITERATURE

In 1904 Lexer et al. published observations on the vessels of the talus. Contrast medium had been injected into the femoral artery. Standard X-rays showed a richness of vessels within the talus. The distribution within the bone was not described.

Sneed (1925) observed a small number of vessels within the talus, but did not describe any principal talar arteries.

In 1950 Wildenauer demonstrated a network of extraosseous talar vessels, which arose from the arteria dorsalis pedis, arteria tibialis posterior and arteria peronea. This network was the rete periostale, which covered all surfaces of the talus, excepting cartilage areas, ligamentous insertions and sulci for passing tendons. Wildenauer also described the tarsal canal to be limited by the talar and calcanear sulci. He described it as running in a posteromedial—anterolateral direction ending in the funnel-shaped sinus tarsi. In this canal he demonstrated an artery connecting the arteria tibialis posterior with the arteria sinus tarsi. This vessel was called the arteria canalis tarsi. Wildenauer ascribed to this artery great importance in the nutrition of the talus.

In 1958 Haliburton et al. published observations on the vascular supply of the talus. Their injection technique also involved a filling of the veins, which were difficult to distinguish from the arteries. Wildenauer's work on the extraosseous vascular supply was confirmed. In addition an intraosseous network was demonstrated, which arose from the extraosseous vessels.

In 1970 Mulfinger & Trueta described a technique, by which only the arterial supply was demonstrated. By injecting the vessels 36–48 hours post mortem—during which time the capillary bed is destroyed by autolysis—the contrast medium did not pass over to the veins. Intraosseous anastomoses in the talus were demonstrated between the three main arteries of the lower extremity. They concluded that the most important vascular supply to the talus was by the arteria canalis tarsi and arteria sinus tarsi. They showed, that the arteria canalis tarsi delivered a branch—ramus deltoideus—to the medial part of the corpus tali and they estimated that about ¼ of the body was supplied by this vessel. The head and neck of the talus received their vessels from the arteria dorsalis pedis, the arteria sinus tarsi and to some extent from the arteria canalis tarsi.

It has been mentioned that Haliburton et al. (1958) filled the venous system, but there was no information on its distribution. In 1967 Crock

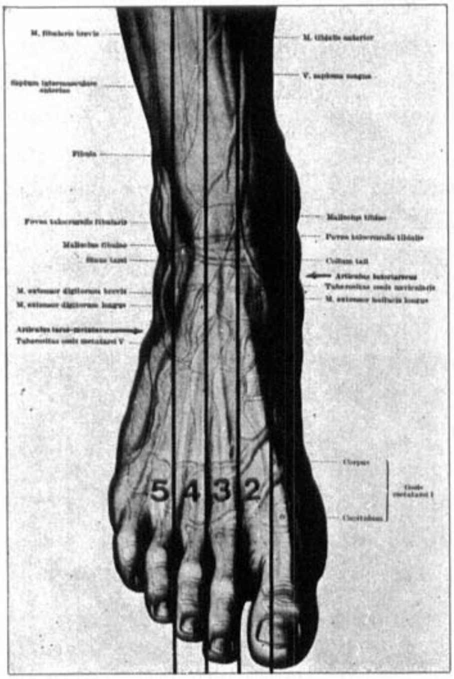


*Figure 1. Planes of sagittal sections in feet used for preparation according to the Spalteholtz method. Sections numerically indicated (From Lanz & Wachsmuth 1972).*

reported that the branches of the main veins followed the main arteries. In addition he demonstrated a subarticular collecting vein system beneath the anterior half of the trochlea surface.

So far we have been unable to find any references to the lymphatics around the talus.

In the present study we have concentrated our interest on the arterial supply.

## MATERIAL AND METHODS

The material consisted of 12 feet. Clinically there was no evidence of vascular disease, nor of metabolic disturbances, nor of any other illness which might influence the vascular tree. The reasons for amputation had been local bone and soft tissue tumours well away from the foot. The ages of patients varied from 13 to 63 years with two above 50 years of age, eight between 30 and 50 and two below 20 years of age.

The injection of contrast medium in the vascular tree was as a rule carried out 36 to 48 hours following amputation. In those instances, where it was impossible to carry out the injection within the time mentioned, the specimens were stored in a deep-freezer. When taken out of this the feet remained in room temperature for 48 hours. A catheter was introduced into the arteria tibialis posterior at about

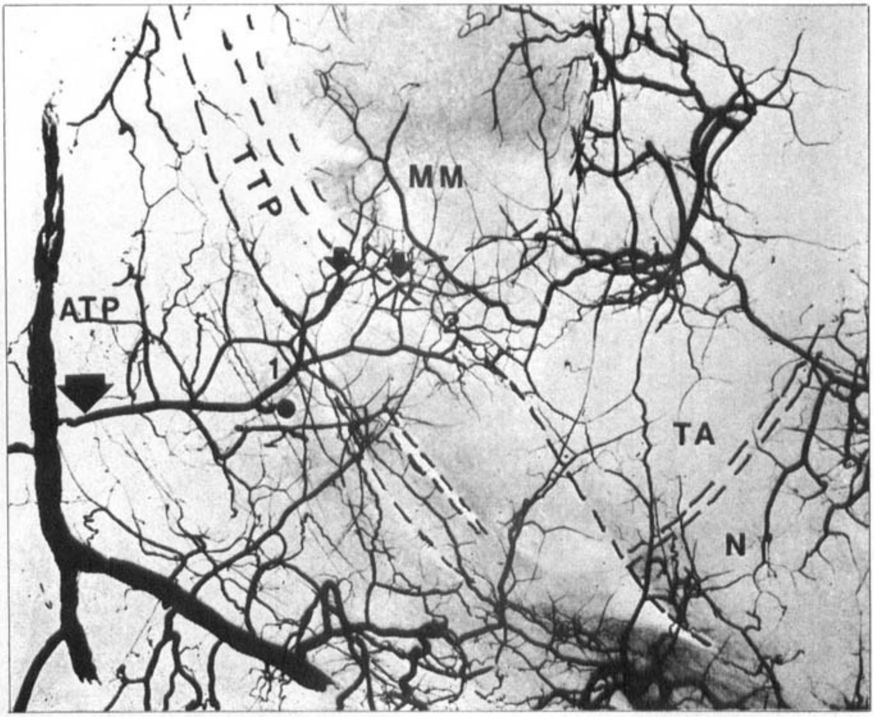


*Figure 2. Extraosseous arterial supply of the talus. Medial aspect of section 1 (cf. Figure 1) in left foot in 38-year-old woman (Spalteholz preparation). MM = medial malleolus; TA = talus; N = navicular bone; TTP = tendo m. tibialis posterior; large arrow = arteria canalis tarsi branching off arteria tibialis posterior (ATP); 1 = ramus deltoideus; small arrow to the left = branch penetrating deltoid ligament and entering talus; small arrow to the right = another branch from the ramus deltoideus penetrating to the talus. These latter branches correspond to those at small arrows in Figure 4. 2 = anastomotic network between the ramus deltoideus and the arteria tibialis anterior and arteria dorsalis pedis. Black dot at cut arteria canalis tarsi (cf. Figure 4).*

15 cm above the level of the malleoli, and the contrast medium, which consisted of one part micropaque mixed with two parts 10 per cent formaldehyde solution (formalin) was injected (it proved to be irrelevant which of the three main arteries was selected for injection). The contrast medium was injected under a constant pressure of 140 mmHg, and all vessels from which the contrast medium emerged were tied. When leakage no longer was evident, the foot was placed in a bath with 10 per cent formaldehyde solution and the infusion of contrast medium was carried on for 24 hours. A constant pressure of 140 mmHg was maintained by a manometer connected to a drip arrangement via a flask, which served as a pressure equilibrator. For each foot roughly 40–60 cc contrast medium was used for the initial filling. During the 24 hour infusion no more than approximately

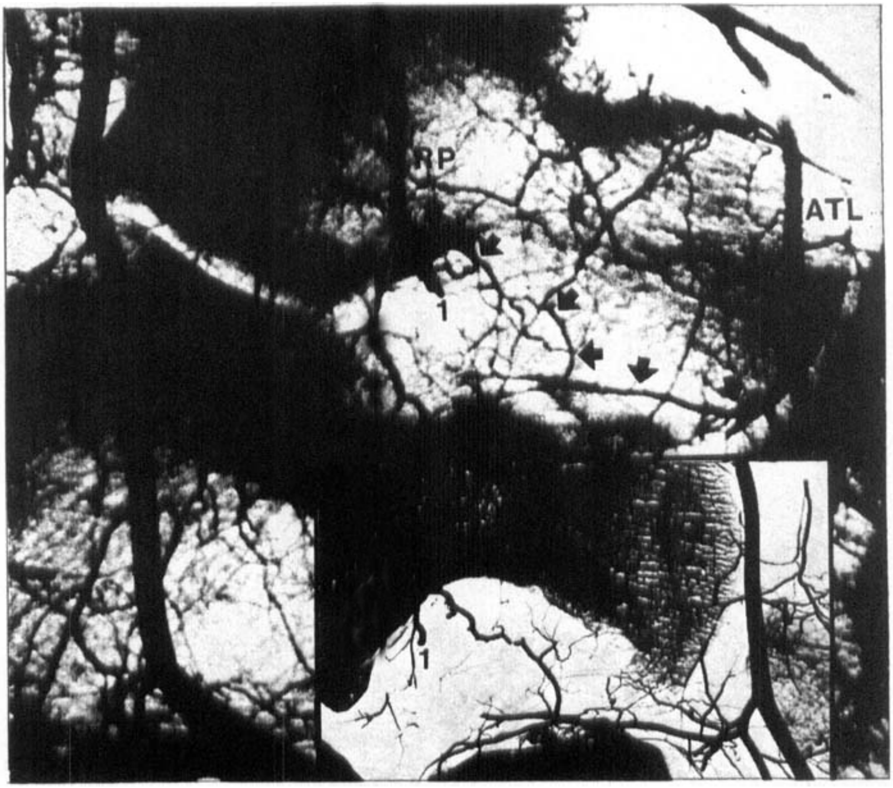


*Figure 3. Lateral aspect of right foot in 44-year-old man. The arteria tarsea lateralis (ATL) gives off an anastomotic branch, which connects (arrows) with branches from ramus perforans (RP) of the arteria peronea. Arteria sinus tarsi (1) is given off from this anastomosis. It is better demonstrated in the inset (section 4, cf. Figure 1).*

5 cc contrast was instilled. With this arrangement it became apparent that a good filling of the vascular tree was achieved.

Each foot was X-rayed in anteroposterior and lateral views. Stereograms of the whole foot were made in the lateral view. Following X-ray the specimens were deep frozen and sectioned in 1 cm thick slices in sagittal planes (Figure 1). (Sections in the frontal planes were made in some cases, but no additional information was gained.) Each slice was later thawed and X-rayed, this time by a soft tissue technique utilized for mammary X-ray (Senographe CGR). Film-focal distance 30–35 cm; exposure 25 kV, 30 mA, 1.5–6 seconds. Kodak film (Crystallex®) was used.

Following the X-ray procedure all slices were treated by the Spalteholtz technique (1914), by which the tissues become translucent and demonstration of the contrast medium filled vessels is facilitated. Following the clearing procedure a new series of X-rays according to the above standards was taken.

Areas of special interest were studied with higher resolution. The angiograms were exposed with a Machlett OEG-centitube at a focus-film distance of 15–25 cm; 20 kV, 10 mA, 20–60 seconds, on Ilford dental X-ray film or Gaevert dentus rapid-film. The films were developed on glass plates, one representing each section. This permitted an analysis of the course of vessels as by placing one plate on the top of the other the direction of any particular vessel could easily be followed (see three consecutive sections of one specimen, Figures 2, 4 and 5).

The whole clearing and examining procedure took approximately 8 weeks for each specimen.

## RESULTS

### *Extraosseous supply*

There are three main arteries to the foot: arteria tibialis posterior, arteria tibialis anterior and arteria peronea.

*Arteria tibialis posterior:* Before and after its passage under the medial malleolus, branches are given off which anastomose with branches from the arteria tibialis anterior and arteria peronea. About 2 cm distal to the medial malleolus the arteria tibialis posterior gives off a branch, the arteria canalis tarsi (large arrow in Figure 2), which enters the tarsal canal and runs in a posteromedial-anterolateral direction. Before entering the tarsal canal the arteria canalis tarsi gives off a branch, ramus deltoideus (1 in Figure 2), running upward on the deltoid ligament dividing into two branches. One of them penetrates the deltoid ligament and enters the medial part of the corpus tali (left small arrow in Figure 2; cf. Figure 4). The other branch continues in a forward direction and divides into a number of branches, one of which penetrates the talus (right small arrow in Figure 2; cf. Figure 4); others form an anastomotic network with vessels from the arteria tibialis anterior and arteria dorsalis pedis.

Posteriorly a network is formed by branches from the arteria tibialis posterior and arteria peronea. From this network branches arise, which run to the processus posterior tali and enter the bone. Other branches run more distally to enter the calcaneus.

*Arteria tibialis anterior and arteria dorsalis pedis:* Medially two branches are given off, which run down towards the medial malleolus and join in the anastomotic network with the branches from the ramus deltoideus of the arteria canalis tarsi. Laterally two branches are given off, which run down to the lateral malleolus. The distal lateral branch, the arteria tarsea lateralis (ATL in Figure 3), originates from the arteria dorsalis pedis. It anastomoses (arrows in Figure 3) with the ramus perforans (RP in Figure 3), which originates from the arteria

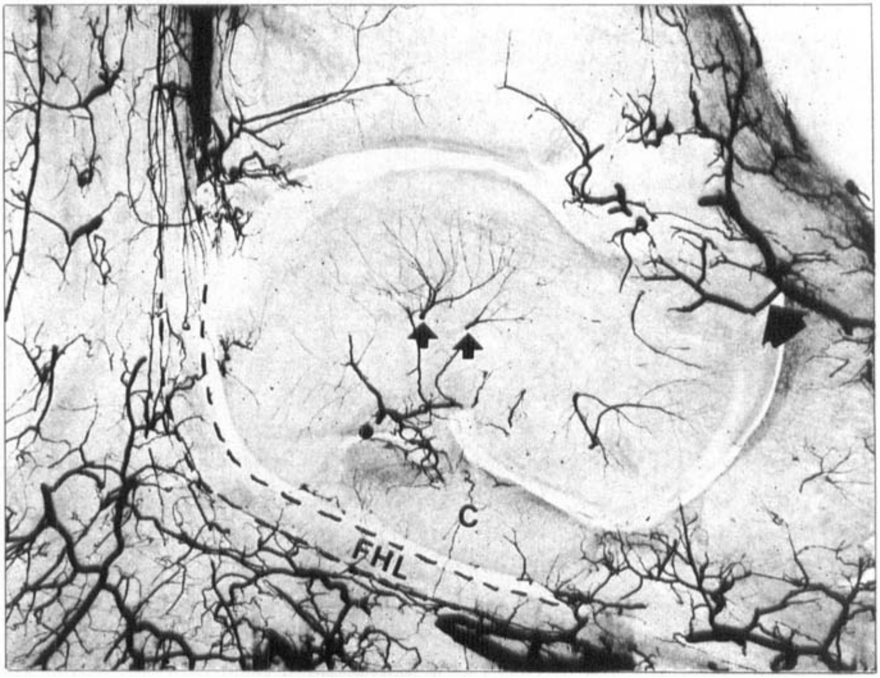


*Figure 4. Intraosseous vascularization of the talus and interosseous anastomoses. Medial aspect of section 2 (cf. Figure 1) in left foot in 38-year-old woman (same as Figure 2). The contour of the calcaneus (C) is partly obliterated by the tendon of the flexor hallucis longus (FHL). Large arrow indicates branch from the arteria dorsalis pedis entering the talus. Small arrows indicate the continuation of the penetrating branches from the ramus deltoideus (small arrows in Figure 2). Black dot at cut arteria canalis tarsi (cf. Figure 2).*

peronea and runs through the membrana interossea between the tibia and fibula. It is from this anastomosis that the arteria sinus tarsi (1 in Figure 3) arises and then runs in a medial direction straight into the sinus tarsi. From the arteria dorsalis pedis branches are given off, which run straight down into the neck of the talus through the foramina nutriciae (large arrow in Figure 4).

*Arteria peronea:* From this artery the ramus perforans branches off through the membrana interossea as already described. Furthermore a number of small vessels branch off in a posterior direction to anastomose with the branches from the arteria tibialis posterior. With our technique we have not been able to detect any further branches from this artery of any importance to the talus.


*Figure 5. Intraosseous vascularization of the talus and interosseous anastomoses. Medial aspect of section 3 (cf. Figure 1) in left foot in 38-year-old woman (same as Figures 2 and 4). Arrow at arteria canalis tarsi. C = calcaneus; N = navicular bone; T = tibia.*

### *Intraosseous vascularization*

As for the intraosseous vessels they form a richly interconnected system of branches, whose main supply is from the arteria canalis tarsi (Figures 4 and 5). The arborization has a direction from the canalis tarsi upward posteriorly and anteriorly, i.e. towards the trochlea and collum tali. The main vascular supply of the caput tali is from the arteria sinus tarsi and the aforementioned branches from the arteria dorsalis pedis. The interconnection of the intraosseous vessels is distributed in a way, which gives no impression of segmental delineation based on the source, from which the anastomotic vessels arise.

### *Interosseous anastomoses*

The talus has rich vascular connections with the os naviculare and calcaneus by way of the interosseous ligaments and capsules (Figures 4 and 5).

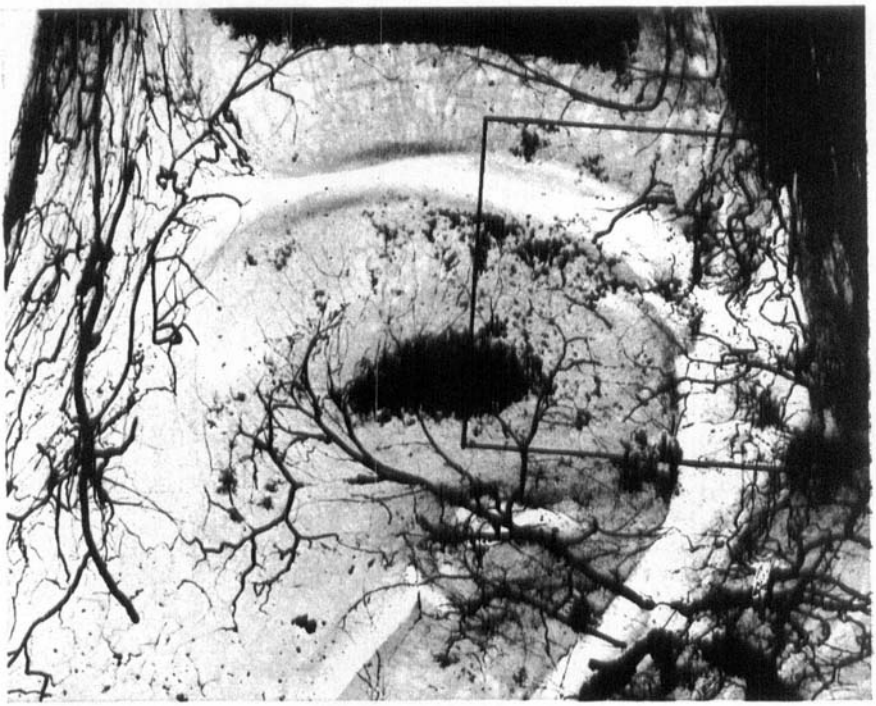

*Figure 6. Medial aspect of right talo-crural joint in 13-year-old girl. Section 2 (cf. Figure 1). Rich anastomotic vascular network in anterior and posterior ligaments and joint capsule between tibia and talus. Marked area enlarged in Figure 7. The darker areas in the tibia and the talus are due to insufficient decalcification.*

Another feature—not previously described—is the numerous vascular connections between the tibia and the talus. These vessels reach the talus by way of the articular capsule and ligaments (Figure 6). In other words there is a direct vascular connection between the tibial and the talar marrow spaces.

The angiographic studies with higher resolution have been concentrated to the regions of attachment of the joint capsule to the tibia and the talus respectively. The course of the vessels through the capsular insertion into the bone has been demonstrated (Figure 7).

## SUMMARY

In this investigation we have limited our studies to the arterial supply of the talus. We have been able to confirm all that has been described previously.


*Figure 7. Angiography with higher resolution of marked area in Figure 6. Vascular connections between the tibia (T) and the talus (TA) via the ligaments and the joint capsule.*

An additional observation, however, is the presence of rich vascular connections between the tibial and the talar marrow spaces by way of the interconnecting capsule and ligaments. The talus thus receives a great amount of vessels from many different sources and appears to be in a centre of a large vascular network.

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