INTRODUCTION
Avascular osteonecrosis is a well known complication after forefoot surgery and it may be related to iatrogenic disruption of the blood supply (1-2). A study with injection techniques about the blood supply of the first metatarsal has shown that the degree of vascular damage depends on the surgical technique. When the vascular anatomy is considered vascular damage can be prevented (3).

In contrast to the first (3) and the fifth (4) metatarsals the literature provides only little information about the nutrition of the lesser metatarsals II, II, and IV. Therefore, the purpose of this study was to demonstrate the extraosseous and intraosseous arterial blood supply of the lesser metatarsals in human cadavers.

MATERIAL AND METHODS
All cadavers with any link to a vascular disease were excluded from the study.

Epoxy resin injections: The femoral arteries of 10 limbs were injected with india ink gelatin solution under continuous manual pressure. The skin was removed and the specimen were placed in a 5% potassium chloride solution (K2OH) at 70°C to dissolve the soft tissues. Photographs and detailed notations were made during the dissolution process. The dorsalis pedis and posterior tibial vessels were identified and the branches were traced distally in each specimen to identify their location and course in relation to the lesser metatarsals. All arteries which did not contribute to the supply of the metatarsals were removed and photographs were taken.

After photographical documentation all metatarsals were coated with epoxy resin. After hardening of the resin the bones were divided longitudinally with an oscillating saw. Then the bone was macrocrated to demonstrate the intraosseous blood supply.

Spalteholz technique (5): The femoral arteries of 10 limbs were injected with india ink gelatin solution under continuous manual pressure. The injection pressure similar to the arterial blood pressure (120 mmHg) was controlled by a pressure gauge. For the gelatine injection the temperature of the cadaver limbs and of the injection medium was 40°C to prevent premature hardening of the gelatine solution. After the injection, all specimen used for the Spalteholz technique were fixed in 4% formaldehyde. For the investigation of the intraosseous perforating the metatarsals were decalcified in 10% EDTA, sectioned and prepared according to Spalteholz. The specimens were cut in three millimeter segments. The vascular patterns were evaluated grossly and by a low power lens.

RESULTS
All four lesser metatarsals had two distinct intraosseous vascular networks, one in the region of the diaphysis and one in the epiphysis. Diaphysis: The epoxy resin injections showed that the major arterial supply for the lesser metatarsal diaphysis arose from a nutrient vessel which divided from the plantar metatarsal artery in the region of the metatarsal base. This nutrient artery ran on the metatarsal cortex distally and traversed the cortex of the midshaft in a distal direction from the lateral aspect. Within the diaphysis the vessels divided both distally and proximally forming a dense intraosseous vascular network with numerous small anastomoses to the vessels of the periosteum. The periosteal vascular network is nourished by small branches which arose from the plantar and dorsal metatarsal arteries.

Epiphysis: The metatarsal heads had two main arterial sources: 1. The dorsal metatarsal arteries, and 2. The plantar metatarsal arteries which are branches of the posterior tibial artery. The dorsal metatarsal arteries divided from the A. arcuta in the region of the metatarsal base. They run distally within the intermetatarsal space dorsally to the corresponding interosseous muscle. At the metatarsalphalangeal joints they divided in dorsal digital branches for the adjoining toes. The plantar metatarsal arteries were provided by the plantar arch. They extended distally below the metatarsal diaphysis. The distance between the plantar metatarsal arteries and the cortex of the diaphysis varied between 4 and 2 mm. They divided into a lateral and a smaller medial branch in a distance between 8 and 12 mm from the articular cartilage. These branches provided the plantar digital arteries and a medial and lateral anastomosis to the adjoining dorsal metatarsal artery. The shortest distance between these vessels and the articular cartilage varied between 5mm and 12mm. These arteries provided an extensive extraosseous arterial network around the metatarsal heads with small arterial branches running distally on the cortex of the metatarsal to enter the bone of the metatarsal head.

The nutrient arteries for the metatarsal heads traversed the cortex of the metaphysis in the region of the capsular insertion at a distance between 2 an 7mm to the articular surface. There was a close relationship between these arteries to the origin of the medial and lateral collateral ligament. Within the bone the arteries run distally towards the subchondral bone and divided into a dense subchondral arterial network. The nutrient arteries of the metatarsal heads are terminal end arteries because there were only few thin anastomoses to the articular network of the diaphysis. There was no regional difference in the subchondral vascular density between the lesser metatarsal heads.

DISCUSSION
Distal osteotomies of the lesser metatarsals II-IV are frequently used to correct metatarsal overlength for the treatment of claw toe deformities and metatarsalgia (1). Complications of lesser metatarsal osteotomies, which include non-union, delayed union, and avascular osteonecrosis of the metatarsal head are attributed to iatrogenic disruption of the blood supply (2). The results of this cadaver study provide useful information to protect vessels at metatarsal surgery:

1. Care should be taken to protect the perforating arteries to the metatarsal heads because there were only few and thin anastomoses between head and diaphysis. Extensive soft tissue stripping during exposure should be avoided, as this may compromise the vessels which enter the head. Transsection of the ligaments and the capsule should be performed in a safe distance of 3-4mm from the insertions.

2. The power saw must be used carefully to prevent overpenetration of the proximal plantar cortex so to protect the plantar metatarsal arteries.

REFERENCES