THE BLOOD SUPPLY OF THE FEMORAL NECK AND HEAD
IN RELATION TO THE DAMAGING EFFECTS OF NAILS AND SCREWS

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Failures in the treatment of fractures of the femoral neck are caused by several factors. Some of these, such as avascular necrosis of the femoral head, cannot be avoided. Other factors, such as inaccurate reduction or imperfect fixation, can be partly controlled. The possibility has long been considered that the nail itself and the disturbance caused by its introduction might damage the blood vessels of the femoral head. Cedermark (1936) suspected this, and later the studies of Trueta and Harrison (1953) provided the anatomical basis for the clinical suspicions of Watson-Jones (1955) and Hulth (1956) that the nail might damage the vessels of the upper part of the head. In the present work an attempt has been made to determine how the nail or screws may damage the vessels of the femoral head and how the danger may be reduced by correct placing of the fixing agent.

METHODS AND MATERIAL

The vascular patterns described by Trueta and Harrison (1953) for the femoral head, and by Judet, Judet, Lagrange and Dunoyer (1955) for the femoral neck, were taken as the anatomical basis for the study.

Sixteen femoral heads and necks from eight cadavera of persons aged from sixty-two to seventy-six years were used. In addition we were able to study the material collected by Professor J. Trueta. A suspension of barium and Berlin blue (Harrison, Schajowicz and Trueta 1953) was injected into the abdominal aorta. The uppermost third of each femur was then removed and all the surrounding soft tissues were dissected away. Each specimen was radiographed. The specimens were fixed in a vice and a nail or a screw was inserted. These were inserted in different positions and sites: namely, varus (Fig. 1), valgus (Fig. 2) and along the centre of the femoral head and neck (Fig. 3). The last site is referred to as the "neutral zone." The whole specimen was fixed in formalin and the nail was removed. Slab sections approximately half a centimetre thick were then cut perpendicular to the axis of the femoral neck. The number of sections obtained in each case ranged from nine to twelve. The sections were decalcified and prepared by Spalteholz's method. Radiographs were then taken on films with a fine-grain emulsion, using a low voltage unit with a beryllium window. All the radiographs of the slab sections were taken with the medial face of the section towards the tube. The orientation of the specimens was thus kept constant so as to avoid confusion between specimens taken from the right or left femora.

Attempts to nail the femora before they had been injected and removed were abandoned because the profuse leakage from the site of exposure and from the bone itself produced unsatisfactory injections.

RESULTS

Anatomical arrangement of vessels—The vessels entering the femoral head through the round ligament were always found to be numerous (Figs. 4 and 7), and so too were the branches originating from them (Figs. 5 and 7). They were seen to supply the medial third of the femoral head.

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FIG. 1
Antero-posterior (left) and lateral (right) radiographs of right femoral head and neck after injection and insertion of nail in the varus position.

FIG. 2
Antero-posterior (left) and lateral (right) radiographs of right femoral head and neck after injection and insertion of screw in the valgus position. Note how in the antero-posterior projection the tip of the screw seems to cross the lateral epiphysial vessels. In the lateral projection it is seen to be in front of these vessels.
Fig. 3
Antero-posterior (left) and lateral (right) radiographs of left femoral head and neck after injection and insertion of screw in the "neutral zone."

Fig. 4
Figure 4—Slice 1. Showing the vessels entering the head through the round ligament.

Fig. 5
Figure 5—Slice 2. The rich network of branches arising from the vessels of the round ligament.

Fig. 6
Figure 6—Slice 3. Showing in the centre of the section the anastomoses between the vessels of the round ligament and the lateral epiphysial vessels.

Figs. 4 to 7
Sections through the medial part of a left femoral head after injection (slices 1, 2 and 3 as shown in Figure 7).
In all the sections of the femoral head the site and direction of the lateral epiphysial vessels was constant. They anastomosed with the vessels from the round ligament at a variable point which most often was near the junction of the medial and the central thirds of the femoral head (Figs. 6 and 7). These lateral epiphysial vessels cross the central and lateral thirds of the femoral head in its upper and posterior quadrant so that in sections of the right femur (Figs. 8 to 11) they are found on the right side above the centre of the section. In more medial sections they are closer to the centre and in more lateral ones closer to the periphery. In sections of the left femur (Figs. 12 to 15) they lie on the left. This path of the lateral epiphysial vessels was always observed in the sections of the lateral and central zones of the femoral head. They entered the head within an area one centimetre wide located between the cartilage of the head and the cortical bone of the neck. This site of entry is at the upper

border of the sections: on the right in the right femur (Figs. 10 and 11) and on the left in the left femur (Figs. 14 and 15). The entrance site was found in sections of the lateral part of the femoral head.

The vessels in the femoral neck were constantly situated at its periphery, arising from the cortical shell of the neck and forming a rich network inside the periphery of the femoral neck (Figs. 16 and 20). Anastomoses were less dense and less constant as the centre of the neck was approached (Figs. 17 to 20).

Effect of the position of the nail or screw—The liability to vascular damage by the nail or screw was studied in each of the three positions.

The varus position—A nail or screw inserted in this position seems at first sight likely to cut off the lateral epiphysial vessels, but in these experiments this was never observed. This was because in the varus position the nail tended to be placed in the anterior part of the femoral head—a region not occupied by the lateral epiphysial vessels (Figs. 21 to 23).

The valgus position—This position (Fig. 24) was found to be the one in which interference
Figs. 12 to 15
Sections through the middle and lateral zones of a left femoral head after injection (slices 5, 6 and 7 as shown in Figure 15). The track of a screw inserted in the "neutral zone" is clearly seen in each section. Figures 12 and 13—Slices 5 and 6. The lateral epiphysial vessels are shown coming from the left in the upper half of the sections. Figure 14—Slice 7. In the left upper zone of the section the entrance of the lateral epiphysial vessels into the head is shown.

Figs. 16 to 20
Sections through a right femoral neck after injection (slices 7 to 10 as shown in Figure 20). The track of the nail is shown in all four sections. Figure 16—Slice 7. Showing the peripheral vascular network of the neck. Figures 17 to 19—Some of the anastomotic branches crossing the neck have been cut by the nail.
Sections through the lateral zone of a right femoral head after injection (slices 4 and 5 as shown in Figure 22). A nail has been inserted in the varus position; its track is clearly visible. Figure 21—Slice 4. The nail has passed in front of the lateral epiphysial vessels. Figure 23—Slice 5. There is even more clearance between the nail and the vessels, which are now more peripherally placed.

Antero-posterior (left) and lateral (right) radiographs of left femoral head and neck after injection and the insertion of a nail in the valgus position. The tip of the nail is in relation to the lateral epiphysial vessels.
Section from specimen shown in Figure 24 (slice 5 as shown in Figure 25). Some of the branches of the lateral epiphysial vessels have been broken by the nail.

Section from the right femoral head (slice 5 as shown in Figure 27) of the same individual. The intact lateral epiphysial vessels are well shown, and the extent of the damage caused by the nail can readily be assessed.

Sections through the middle and lateral zones of two left femoral heads after injection (slices 3 to 6 in Figure 30 replaced in correct relationship). Figure 29—A screw has been inserted. It has largely avoided damaging the vessels (compare Figure 31). Figure 31—A nail has been inserted. It has damaged several vessels (compare Figure 29).
with the lateral epiphysial vessels was most likely (Figs. 25 to 28). It was the only one in which interference with some of their branches was observed, although in this position too, if the nail were placed anteriorly in the femoral head, the vessels could not be reached (Fig. 2). The neutral position—A nail or screw placed in this position could not reach the lateral epiphysial vessels (Figs. 12 to 15), although in some specimens a few anastomoses in the neck were seen to be cut. However, the severing of these anastomoses, which are not constant in any case, seems of secondary importance because of the richness of the peripheral vascular network in the femoral neck.

DISCUSSION

Although the possibility that the nail or screw used in the internal fixation of fractures of the femoral neck may interfere with the blood supply is rather slight, an ideal position for the fixing agent does exist. The possibility of damaging the vessels can be entirely avoided by placing the nail in the zone of the femoral head and neck away from the main vessels responsible for their blood supply. The less favourable zones—the upper and posterior quadrant of the head and the periphery of the neck—should be avoided.

The nearer the nail is placed to the central zone of the femoral head and neck the less will it interfere with the capital blood vessels. This does not apply to the medial third of the head where the vessels coming from the round ligament anastomose with the lateral epiphysial vessels. In this area the vascular anastomoses are so numerous that it is unlikely that the nail however placed could seriously interfere with the blood supply of the femoral head.

No great difference in damage potential between screws and nails was found, although it seems that the screw may be less harmful to the vessels than the three-flanged nail because of its spiral shape and narrower diameter (Figs. 29 to 31).

SUMMARY AND CONCLUSIONS

1. Sixteen injected specimens of human femoral heads and necks, in which a nail or screw had been inserted, were examined.
2. The possibility exists that the fixing agent may interfere with the blood supply of the femoral head. The likelihood of this occurrence is not great.
3. The position of the fixing agent in which vascular damage is least likely is the central area or "neutral zone" of the femoral neck and head.

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REFERENCES

Cedermark, J. (1936): Om caputnekroser vid collumfrakturer i spikade fall. Nordisk Medicinsk Tidskrift, 11, 1,044.


