Acta orthop. scand. 45, 564–571, 1974

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DEVITALIZATION OF THE FEMORAL HEAD AFTER MEDIAL FRACTURE OF THE FEMORAL NECK

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Accepted 3.xii.73

Nutrition of the femoral head is impaired after medial fracture of the neck of the femur. The blood supply to the femoral head via the cancellous bone is always affected by the fracture itself; in severely displaced fractures damage to the epiphyseal arteries in the joint capsule further reduces the circulation in the femoral head. The blood vessels of the ligamentum teres are of minor importance in the nutrition of the femoral head (Sevitt & Thompson 1965, Wertheimer & Lopes 1971). As a result of the altered nutritive conditions, bone necrosis can be observed histologically in more than ⅔ of patients with medial femoral neck fractures (Phemister 1934, Sevitt 1964, Bohr & Larsen 1965, Catto 1965 a, Sevitt & Thompson 1965).

Assessment of the viability of the femoral head after medial fracture of the femoral neck is clinically difficult (Hulth 1965). Attempts to evaluate the blood supply of the femoral head have been made pre- and peroperatively by arteriography (e. g. Rook 1953, Hipp 1962, Müssbichler 1970), by venography (e.g. Hulth 1956, Hulth & Johansson 1962, Eberle 1971) and isotope techniques (e.g. Tucker 1950, Boyd et al. 1955, Eegholm 1970, McNeur 1970). Interpretation of the results is difficult, however, and none of these methods has gained any wide clinical acceptance.

In this study the viability of the femoral head was examined by the tetracycline labelling method. Tetracyclines are deposited in the growth areas of living bone and in newly-formed bone in callus tissue formed during fracture repair. Tetracycline uptake in the bone can be traced by fluorescence microscopy. Experimental studies in the rabbit have shown that an avascular femoral head does not display tetracycline fluorescence (Rokkanen et al. 1965).

MATERIAL AND METHODS

The series comprises 70 patients with medial fracture of the neck of the femur treated at the Department of Orthopaedics and Traumatology, University Central Hospital, Helsinki and at the Central Hospital, Vaasa. In all cases the injured femoral head was removed and replaced by an endoprosthesis. Sixty-one femoral heads were removed in connection with a primary prosthetic arthroplasty, while 9 heads were excised on account of unsatisfactory healing several months after primary nailing of the fracture.

The patients received 250 mg oxytetracycline (OTC) intramuscularly twice a day for two days before the operation. The femoral head and the base of the femoral neck lateral to the fracture were taken for further examination. The samples were bisected in the frontal plane; one half of the sample was fixed in neutral 10 per cent formalin for histological examination and the other half in absolute alcohol for fluorescence microscopy. Paraffin-embedded sections were stained with Weigert-van Gieson's haematoxylin, and methylmethacrylate embedded specimens were ground to a thickness of 100 μ prior to microscopic examination.

RESULTS

On the basis of the histological pattern and the occurrence of OTC-uptake in the femoral head and femoral neck the material was classified into three groups as follows:

1) *No uptake of fluorescent material.* In 47 femoral heads no OTC-uptake could be demonstrated (Figure 1). All these specimens were obtained in cases of recent fracture. However, fluorescence was regularly observed in samples taken from the base of the femoral neck.

2) *Subchondral uptake of fluorescent material.* In 14 femoral heads fluorescence was seen subchondrally at different sites around the circumference of the femoral head. The fluorescence occurred as sickle-shaped, thin bands immediately under the articular cartilage (Figure 2).

3) *Irregular uptake of fluorescent material in inveterate fractures.* In 9 old inveterate fractures, nailed before endoprosthethic replacement was performed, fluorescence was seen in the bone trabeculae of the femoral head (Figure 3). The fluorescence predominantly occurred along the previous nail track and in the callus tissue around the femoral neck.

OTC-uptake was irregular and corresponded in the histological sections to the granulation tissue and new bone invading these areas. In the femoral heads signs of creeping substitution of necrotic bone areas were observed as the process of repair advanced from the femoral neck towards the femoral head.

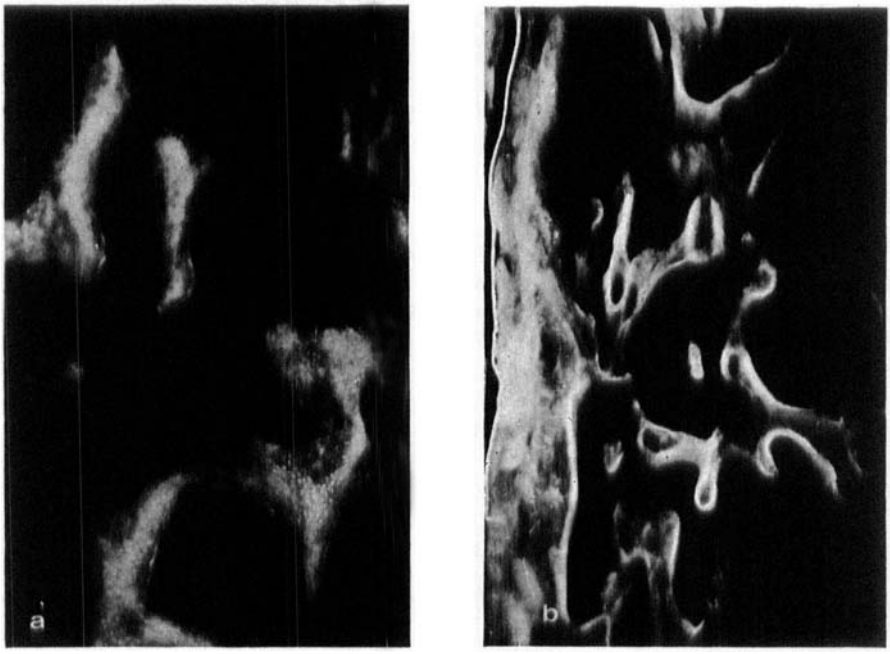

Figure 1 a. Fluorescence micrograph of the femoral head in a 69-year-old woman. The femoral head was extirpated 17 days after fracture of the neck of the femur in connection with the application of an endoprosthesis. No fluorescence is seen in the trabeculae.

Figure 1 b. Fluorescence is observed in the femoral neck distal to the fracture.

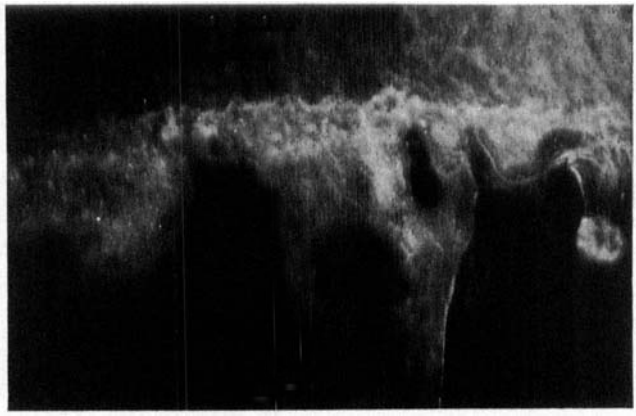

Figure 2. Fluorescence micrograph of the subchondral part of the femoral head after recent fracture of the neck of the femur in a 78-year-old woman. Fluorescence is seen subchondrally.

Figure 3. Fluorescence micrograph of the femoral head in a 68-year-old woman. The femoral head was extirpated 2 years after a fracture of the neck of the femur, which was nailed 11 days after injury. Fluorescence is seen in the trabeculae as a sign of regenerative new bone formation.

DISCUSSION AND CONCLUSIONS

It emerges from this study that after a recent medial fracture of the femoral neck, OTC uptake in the femoral head does not occur or is present only in the subchondral area, whereas OTC fluorescence is abundant at the base of the femoral neck, lateral to and in close proximity to the fracture. This indicates that the nutrition of the cancellous bone in the femoral head is markedly impaired, and that subsequent ischaemic changes in the femoral head are apt to occur in all cases of medial fracture of the neck of the femur. The results corroborate previous reports of a high incidence of bone necrosis after medial fracture of the femoral neck (Sevitt 1964, Bohr & Larsen 1965), but they also show that after this type of trauma nutrition of the femoral head is more constantly and severely impaired than has previously been assumed.

Reduced nutrition of the femoral head affects the healing conditions of these fractures, and the choice of treatment is an intricate problem to the clinician. Repair of a medial fracture of the femoral neck largely depends on a close and undisturbed contact between the cancellous fragments.

The process of repair advances from the vascularized femoral neck towards the poorly vascularized or avascular femoral head and ultimately leads to healing of the fracture as well as revascularization of the femoral head. Poor contact between the fragments is detrimental to fracture healing and often results in a progressive shortening of the femoral neck due to resorption of bone at the borderline between the advancing regenerating tissue and the avascular cancellous bone. A necrotic femoral head is slowly replaced by regenerating tissue, and as new bone is laid down on the old trabecular lattice-work, the radiographic density of the femoral head gradually increases. Revascularization of the femoral head causes softening, often leading to flattening. Restoration of the cancellous blood flow is essential to the process of repair. Consolidation of the fracture and maintained viability of the femoral head can be expected only when the fragments are well reduced and rigidly fixed by nailing (Garden 1971) or impacted (Bentley 1968).

The high incidence of nutritive disturbances of the femoral head after medial fracture of the femoral neck speaks indirectly in favour of routine application of an endoprosthesis in the treatment of these fractures. On the other hand, the ischaemic femoral head has a great loading tolerance (Sevitt & Thompson 1965): if the fracture is well reduced and rigidly secured, the femoral head will act as a biological endoprosthesis. The problem is that the inadequacy of the present nailing technique and the continuous remodelling of the necrotic bone make most osteosynthetic methods unreliable. Various compression techniques have been developed to aid the osteosynthesis of fractures of the neck of the femur (Brown & Abrami 1964, Rydell 1964, Müller et al. 1965). The results so far reported are promising, but it should be noted that collapse of the femoral head also may occur after stable osteosynthesis in the late phase of repair, when revascularization has advanced into the weightbearing area of the necrotic femoral head (Catto 1965 b). Moreover, continuous pressure on a poorly vascularized femoral head regularly results in flattening and derangement of the trabecular structure, as has been observed in rabbits (Rokkanen et al. 1965, Slätis & Rokkanen 1966). Similar observations were reported by Charnley (1961), who used compression osteosynthesis in the treatment of fractures of the neck of the femur.

Subchondral OTC uptake in the femoral head is an interesting phenomenon, previously observed in experimental studies in the rabbit (Slätis & Rokkanen 1966). It seems to indicate that subchondral can-

cellous bone can be nourished by the synovial fluid through the articular cartilage. However, nutrition by this route is limited to a narrow area of cancellous bone and cannot prevent aseptic necrosis of the femoral head after medial fracture of the femoral neck.

It may be concluded that after medial fracture of the femoral neck the nutrition of the femoral head regularly deteriorates so much that healing conditions become extremely unfavourable. From the clinician's point of view, time-consuming and often unspecific determinations of the viability of the femoral head may not seem to be indicated under these circumstances. The present findings constitute evidence in favour of the use of primary replacement arthroplasty in the treatment of medial fractures of the neck of the femur.

SUMMARY

Seventy patients with fractures of the neck of the femur received oxytetracycline preoperatively for fluorescence microscopy of the bone. Sixty-one patients had a recent fracture; nine had inveterate, non-united fractures of the femoral neck. In all cases the femoral head was replaced by an endoprosthesis. Fluorescence microscopy of the femoral head revealed no fluorescence centrally in the femoral head after a recent fracture of the neck of the femur, whereas fluorescence could regularly be seen at the base of the femoral neck. In 14 cases fluorescence was observed subchondrally in the femoral head, indicating scanty nutrition of the juxtachondral cancellous bone through the articular cartilage. Irregular fluorescence was observed in the trabeculae of the femoral head in inveterate cases as a sign of bone regeneration.

The results indicate that severe nutritional disturbances regularly occur in the femoral head after medial fracture of the neck of the femur and speak in favour of the application of an endoprosthesis in the treatment of severely displaced fractures.

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