Structural Changes of the Femoral Head in Cases of Non-Union of the Femoral Neck

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Prognostic tests in femoral neck fractures using intraosseous phlebogram (Hult, 1956) or radioactive iodine (Johansson, 1964) have demonstrated a good correlation between avascularity and non-union. Thus non-union should be looked upon as an avascular complication. The femoral head often shows a normal structure on roentgenograms in cases with non-union, but mottled appearance, diffusely increased density, or deformity may be seen. Therefore some authors state that there are two types of non-union — with or without necrosis of the femoral head — which can be differentiated in standard roentgenograms.

The roentgenological changes of necrosis can only occur after at least partial revascularization. If the teres vessels are inadequate or missing and the synovial bridges around the neck are torn, the head fragment is left as a loose body in the joint. It will keep its original structure for an indefinite period of time. The role of the revascularization in creating the roentgenological picture of femoral head necrosis was demonstrated by Hult 1961. He compared the roentgenograms with microradiograms and histological slides in four cases of healed femoral neck fractures with subsequent necrosis. As the roentgenological diagnosis of necrosis was ascertained a greater part of the femoral head was already rebuilt after revascularization, sometimes with the exception of a sequestration of a portion of the healing head at the superior pole. The sclerotic parts represented areas with broad bone trabeculae, consisting of newly formed bone apposited on the old bony framework.

In order to put further light on the structural changes that appear in cases of non-union we have studied 15 cases representing different types with none, slight or massive roentgenological changes of the head fragment.

Material and Methods

The femoral heads in this study were specimens obtained during operative procedures either for replacement with a prosthesis or simple removal in cases of non-union with severe clinical symptoms.

The patients had been referred to the orthopaedic or surgical clinic in Uppsala from several different hospitals. In some cases a prognostic test had been performed at the time of nailing. Different types of nails had been used.

Roentgenograms were taken of the head fragment before and after sawing it sagitally in 5–10 mm thick sections. Of the two central sections one was used for histological studies after fixation in formaldehyde and decalcification in nitric acid. It was embedded in paraffin and slides measuring 10 μ were obtained. The other central section was fixed in alcohol and embedded in methyl metacrylate. After polymerization the block was sawed into thinner laminae and these were sanded until they had a thickness of approximately 150 μ. Microradiographic studies were then carried out using a Philips's diffraction unit with a Cu anode.
Classification of femoral head fragments was done after roentgenological appearance into three groups:

I. no structural changes (5 cases),

II. structural changes with normal contour (6 cases),

III. structural changes with contour deformity (4 cases).

Results

I. Non-Union without Structural Changes

Case 1, male 93 years. At osteosynthesis the $^{131}$I-test (JOHANSSON) had suggested a totally interrupted blood supply to the femoral head. 13 months later nails were removed and the femoral head taken out due to pseudarthrosis. Microradiogram showed normal bone trabeculae throughout. Histologically the cartilage had normal height but showed cavities and a frayed surface. The bone trabeculae were slender and the osteocytes lacked nuclei. The marrow contained no stainable cells; only at the base a sparse collagen tissue was seen. Although standard roentgenographic and microradiographic studies showed normal pattern the histological slides confirmed the fact that the whole femoral head was non-viable.

Case 2, female 81 years. $^{131}$I-test showed partial vascular damage to the head fragment,redislocation 2 months after nailing, head fragment then removed. It looked macroscopically normal with intact cartilage. Microradiogram: mostly broad trabeculae. Near the fovea newly formed bone possibly in a nail channel was seen. Here the cavities between the broad trabeculae were cored with thinner trabeculae with a lesser degree of mineralization. Histologically in most parts necrotic marrow and bone. A non-viable fragment with signs of revascularization from the fovea giving rise to the formation of new bone in this region.

Case 6, female 66 years. The fracture was not nailed due to medical complications. At operation after 4 months a phlebogram (HULTH) was positive. A prosthetic replacement was then performed. Roentgenogram showed normal structure in the head fragment as a whole though in pictures of the sawed sections there were zones of diminished density centrally and at the base. In microradiograms cavities filled with newly formed slender bone trabeculae were seen. Histologically most of the bone was necrotic with formation of dense connective tissue subchondrally. Basally there were zones of new bone formation in more vascularized connective tissue. This was a primarily non-viable femoral head with starting revascularization and regeneration. The positive venogram was probably a result of reestablished vascular channels at the time of operation.

Case 11, female 68 years. Venogram and $^{131}$I-test indicated avascularity. Nails slipped after 6 months and then a prosthesis was inserted. The head fragment macroscopically and roentgenologically normal (Fig. 1a). Roentgenogram of a section showed somewhat increased density at the base. Microradiogram showed intensive new bone formation, especially in and around nail channels (Fig. 1b). Histologically mostly dead bone and marrow. Primarily this was a non-viable fragment with signs of regeneration especially along nail channels.

Case 17, female 64 years. Redislocation 5 months after nailing necessitating a prosthetic replacement. The head fragment appeared grossly normal with intact cartilage. Microradiogram showed varying density and newly formed bone in scattered areas. Histologically the cartilage was vital and so were the bone trabeculae with granulation tissue in the marrow cavities rich in vessels. This seemed to be a vital head fragment with no signs of bone necrosis.

Summary of group I cases: Four out of five cases of non-union with no structural changes on clinical roentgenograms showed head fragments which were almost totally necrotic. In three of these there were signs of starting reorganization. In the fifth case only the head fragment was viable throughout.

II. Non-Union with Structural Changes in the Femoral Head, with Normal Roentgenologic Contour

Case 2, female 61 years. 21 months after osteosynthesis there was a small dense head fragment and a fracture line was located within the base of the head, possibly a "Wanderungs-pseudarthrose" (ENDER). Roentgenogram of a central section of the head showed marked...