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ROTATIONAL DISPLACEMENT AFTER PERCUTANEOUS, INTRAMEDULLARY OSTEOSYNTHESIS OF FEMUR SHAFT FRACTURES

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In the Department of Surgery, intramedullary osteosynthesis, according to the specifications of Küntscher (1962), was the standard method of operative treatment of shaft fractures of the femur and the tibia. The displacement of the main fragments was readily reduced by stable, intramedullary osteosynthesis, except for the rotational displacement —*dislocatio ad periferiam*—especially when the osteosynthesis was done percutaneously in femur shaft fractures. The percutaneous, intramedullary osteosynthesis, as described by Küntscher (1962) and Müller et al. (1963), was practised more frequently when a roentgen television set became available in 1964.

The percutaneous method of osteosynthesis made an exact roentgenological method desirable for the calculation of the rotational dislocation. The anteversion angle (AV) of the left and the right neck of the femur is normally equal. Any obvious difference after a unilateral shaft fracture therefore indicates a rotational displacement of the main fragments (Müller 1967).

The present study was undertaken to establish a roentgenological method for the calculation of the AV angle of the neck of the femur and thereby the rotational displacement in unilateral femur shaft fractures. The method of Dunlap et al. (1953) modified by Rippstein (1957) was chosen for this purpose. The methods of Normann (1965) and Edholm (1966) were later also evaluated.

MATERIAL AND METHODS

Ten hospitalized patients with clinical and roentgenological normal hip joints and without any bone fracture were used as a reference for the roentgenological method.

Fourteen patients with unilateral femur shaft fractures treated by intramedullary clover-leaf nails were examined clinically and roentgenologically in 1967 and six of them roentgenologically one year later. The youngest patient was eight, the oldest 44 years of age, mean 17.9 years, SX ± 9.3. Ten patients had transverse, two longitudinal fractures in the middle third of the shaft and the adjoining part of the distal third. Two had comminuted fractures in the same parts of the shaft, making stable intramedullary osteosynthesis impossible. All fractures were closed with marked displacement, but without additional soft tissue damage. Eleven were nailed by percutaneous, three by open technique.

In all patients the AV angle of the neck of the femur was calculated in accordance with the specifications of Rippstein (1955). The apparent anteversion (AV') angles in the roentgenograms were measured with a roentgen-ischiometer in accordance with Müller (1957). The true AV angles were calculated from the apparent ones using the conversion table of Rippstein (1955). The roentgenological methods of Normann (1965) and Edholm (1966) were used in a few patients (not included in the present material).

RESULTS

The positioning stand and the roentgen-ischiometer (Protek AG, Bern, Switzerland) were easily adapted for routine work. The AV' angle of the neck of the femur was—for practical purposes—almost identical on the right and the left side in the ten patients without any fracture (Figure 1 a).

In the fracture patients some difference was found—indicating an uncorrected rotational displacement—between the calculated AV' angle of the fractured compared to the nonfractured side (Figure 1 b).

By repeated roentgenological examination after one year, practically no difference in the AV' angle was revealed in six fracture patients (Figure 2).

Only three patients—denoted by stars in Figure 2 b—had by clinical examination obvious rotational displacement of their shaft fractures. One had an internal, two an external rotational displacement and also a retroversion (RV) of the neck of the femur on the fractured side.

The first patient, coordinates (24) 40 in Figure 1 b, was a 16-year-old male. The transverse fracture had been nailed by the open method. Nevertheless the true internal rotational displacement was 21° roentgenologically.

The second patient, coordinates −6 (18), was a 15-year-old male with a comminuted shaft fracture. In order to correct angular and transverse displacement, a thin Küntscher nail was inserted percutaneously. The fracture had supplementary external fixation till it healed with considerable shortening. The true external rotational displacement was 26°.

The third patient, coordinates (9)–13, was a 25-year-old female, also with a

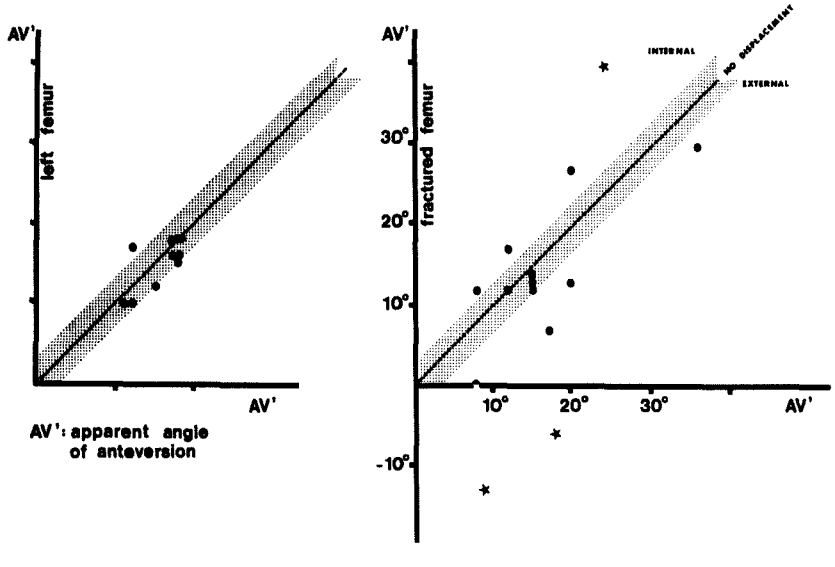

Figure 1 a. Normal group *(10 patients). The apparent angle of anteversion (AV') of the left (ordinate) and the right neck of the femur (abscissa) gives the patient's coordinates in the scatter diagram. The distance from the 45° axis gives the difference in the measured AV' angle between the two contralateral sides. One measurement only reveals a larger difference than ± 3° between the left and the right side.*

Figure 1 b. Fracture group *(14 patients). The AV' angle of the fractured (ordinate) and of the non-fractured side (abscissa) gives the patient's coordinates. By selecting the patients' coordinates, as shown in the scatter diagram, all patients with internal rotational displacement are found over, and all with external displacement under the 45° axis. External displacement was most often found. Few had a larger displacement than ± 10° (apparent). Three patients with larger rotational displacement—denoted by stars—are especially commented on in the text.*

retroversion of the neck of the femur on the fractured side. This was due to a true external displacement of 25°. Painful muscular strain developed in the hip region on the same side postoperatively. The pain became worse with increasing weight-bearing. The Trendelenburg sign was positive on the affected side. The proximal end of the nail protruded somewhat over the medial side of the greater trochanter. Five months after the operation roentgenograms demonstrated absorption around the perifery of the nail in the distal fragment indicating instability.

The patient's complaints were ascribed to the instability of the fracture and the protruding end of the nail. The patient was therefore reoperated by percutaneous technique. The rotational displacement could not be successfully reduced by this approach. The transverse fracture healed after the rigid reosteosynthesis, but the patient experienced—as before—low grade pain in the medial side of the affected thigh toward the knee. The leg and the foot had a tendency of outward rotation when walking.

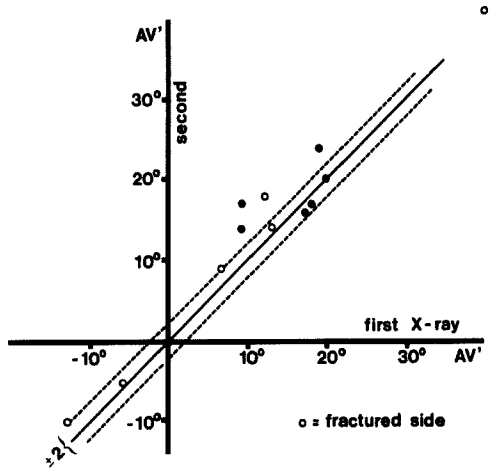

Figure 2. The reliability of the AV' angle measurements of six of the patients in the fracture group is shown in this scatter diagram. The AV' angle measured on the first roentgenogram (abscissa) and the same angle measured on another roentgenogram of the same neck of the femur one year later (ordinate) gives its coordinates. The diagram reveals some small systematic error of measurement, probably due to replacement of the "homemade" positioning apparatus by one of industrial designs.

DISCUSSION

Femur shaft fractures can more easily be aligned by open intramedullary osteosynthesis than by percutaneous approach. The open method thus simplifies the operative procedure and requires less instruments than the closed, percutaneous method. It also gives the choice, during the operation, of using the internal appliance, which gives the best possible internal fixation.

The open method usually imposes a larger operation on the patient. It always makes a closed fracture open with the risk of infection and additional soft tissue and periosteal damage, which may give delayed union and sequelae.

Percutaneous intramedullary osteosynthesis is advocated by several authors (Küntscher 1962, McDonald 1968, Böhler 1968, Rokkanen et al. 1969). As the fracture is not directly exposed, there is much less risk of infection, even if the fracture is open (Böhler 1968). By this method the operative trauma ought to be at a minimum, leading to a more rapid and uneventful recovery (Rokkanen et al. 1969).

However, the percutaneous method imposes several difficulties, partly on the technical equipment, partly on the more precise and stereog-

nostic use of these. Without a minimum of instruments, including a roentgen television set, the percutaneous method cannot be done safely.

The choice of internal appliance is usually restricted to the intramedullary nail, which can only give a rigid osteosynthesis in the middle part of the shaft in fractures with no tendency of shortening. Lastly, reducing the rotational displacement, *ad integrum*, is unlikely.

Some *rotational displacement* is usually well tolerated after femur shaft fractures. In our selected material only one patient had complaints. Weigert et al. (1968) report more disabling sequelae. The degree of rotational displacement, however, is lacking in their report. The late effect of rotational displacement after femur shaft fractures is discussed by Müller (1967).

By roentgenological appraisal of the fracture itself, Neer et al. (1957) claim that some spontaneous correction of the rotational displacement may be anticipated in children. It is usually claimed that spontaneous correction of the rotational displacement is non-existent in adults. Operative correction may then be necessary to eliminate pain and, if possible, to prevent late disability. The rotational displacement can and should be calculated.

The trigonometric, roentgenological method of measuring the anteversion angle (Rippstein 1955) should be accurate enough for the purpose of the present study—even if the error of calculation (mostly systematic) reported by Brattström (1962) is not taken into account. The method required only one roentgen film for the qualitative evaluation of the rotational displacement (see Figure 2 b). Two films were sufficient for the calculation of the exact degree of displacement and several other data of the hip joints. The methods of Normann (1965) and Edholm (1966) required more roentgen films and are not considered so convenient for routine work.

The conversion formulae in Rippstein's paper (1955) contain some grave typographical errors. The conversion table in the same report, according to Grote (1964), also contains small typographical errors. These have been reprinted by Müller (1957).

External rotational displacement was most often found in our cases. This is in agreement with the findings of Weigert et al. (1968). They claim that this is due to the internal rotational effect of the iliopsoas muscle on the proximal fragment in the flexed hip during the osteosynthesis.

A torsional load is naturally less well tolerated than a bending one by an osteosynthesis done with the Küntscher clover-leaf type nail

(Allen et al. 1968). Some authors therefore claim that rotational displacement may develop postoperatively before the fracture is healed. This *may* be the cause in two of our patients with comminuted fractures.

However, it seems unlikely that rotational displacement may develop postoperatively when a stable osteosynthesis is achieved. It is therefore essential that the rotational displacement also be reduced and roentgenologically controlled before the operation is completed—even if the osteosynthesis is done by open technique.

SUMMARY

The preference for percutaneous versus open intramedullary osteosynthesis of femur shaft fractures entailed the evaluation of a trigonometric, roentgenological method for the calculation of any uncorrected rotational displacement.

The roentgenological method was considered accurate enough for this purpose. In the small, selected group of patients used for the evaluation of the method, a rotational displacement mostly less than 10° was found in the healed fractures. One patient only was handicapped due to an unreduced external displacement of 25°. The advantages and the difficulties of the percutaneous, intramedullary osteosynthesis are mentioned.

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