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ORIGINAL ARTICLE

# Femoral neck fractures: prognosis based on a new classification after superselective angiography

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**Abstract**

*Background* Vascular injury after femoral neck fracture can determine its prognosis. This study aimed to determine methods of evaluating femoral neck fracture and accurately predicting the prognosis.

*Methods* Forty-five patients with a single femoral neck fracture all underwent digital subtraction angiography (DSA) and were divided into three types by DSA. DSA showing three to six supporting band vascular images crossing the fracture line was classified as type I. DSA showing one to two supporting band vascular images crossing the fracture line was classified as type II. When DSA did not show vascular images crossing the fracture line, it was classified as type III. The 45 patients were divided according to age into elderly, middle-aged and youth groups. All cases were given internal fixation operations by a hollow screw under a C-brachial machine. After a follow-up of 6–60 months, avascular necrosis of the femoral head (ANFH) and fracture healing of different type and different ages of patients were evaluated according to symptoms and imaging examinations.

*Results* (1) For DSA types I, II and III, the rates of ANFH were 0, 7.14 and 100 %, respectively, and the rates of fracture disunion were 13.3, 7.15 and 0 %, respectively. Therefore, the rate of ANFH is negatively related to the visible supporting band vascular amount on DSA. (2) In the young group, the proportions of types I, II and III were 6.7, 26.67 and 66.7 %, respectively, 18.18, 36.36 and 45.45 % in the middle-aged group and 63.16, 31.58 and 5.27 % in the elderly group. The rates of necrosis for elderly, middle-aged and youth were 10.53, 45.45 and 66.67 %, respectively, and the rates of fracture disunion were 0, 0 and 6.67 %, respectively. So we can draw the conclusion that the amount of supporting band vascular images is inversely proportional to age and the union is directly related to age, but independent of the supporting band vascular amount of DSA showing.

*Conclusion* The new classification after superselective angiography is valuable for predicting the prognosis of femoral neck fractures.

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## Introduction

For proximal femoral fractures, femoral neck fractures account for 53 %. For femoral neck fractures, nondisplacement fractures (including impacted fractures) account for 37 %, and displacement fractures account for 67 %. Femoral neck fractures occur most often in the elderly. Although the treatment methods are abundant, curative effects vary greatly [1–3]. Therefore, the treatment of femoral neck fractures is controversial.

Currently, femoral neck fracture classification is carried out by using X-ray. There are many types of classifications, summarized as follows: anatomic sites, direction of the fracture line (Pauwel's classification) [4] and fracture displacement degree (Garden classification) [5]. Anatomic site classification, which relies more on X-ray projection angles, is currently not used very often. Pauwel's classification is based on the angle of the fracture line and the horizontal line. The bigger the angle is, the bigger the shear force of the fracture site and the more unstable the fracture. However, this classification has two problems. First, there is overreliance on the X-ray projection angle. The fractured neck has to be parallel to the X-ray image. This is difficult to achieve because a femoral neck fracture is always at abduction. Second, some investigators consider that Pauwel's classification shows no relationship to femoral neck fracture disunion and avascular necrosis of the femoral head (ANFH) [6, 7]. The Garden classification is one of the most widely used methods for classifying femoral neck fractures, and it is divided into types I–IV. It gradually increases from types I to IV with the fracture union rate and with the rate of ANFH. However, determination of displacement is closely related to subjective factors because classification coincidence is very low when different doctors classify one X-ray image [8]. These classification methods are subjective and blinded concerning judgment of femoral neck fracture outcome, and they are limited for guiding femoral neck fracture treatment.

Some investigators have used digital subtraction angiography (DSA) to examine changes in blood flow of the femoral head for determining the gold standard of classification after femoral neck fractures [9–11]. Since April 2004, we have used high selectivity vascular angiography for classification according to the amount of supporting band vascular images from DSA. We predicted the prognosis from the classification and obtained objective evidence from images for choosing treatment methods.

## Materials and methods

### Materials

Forty-five patients, 26 males and 19 females, all had unilateral femoral neck fractures. Fifteen patients were aged from 26 to 44 years, 11 patients were aged from 45 to 55 years, and 19 patients were aged from 56 to 65 years. The mean age was 45.4 years (45.4 $\pm$ 14.2). Twenty-two patients had a fracture on the left side, and 23 had a fracture on the right side. Considering external force, 15 patients had a slight external force and 30 had a violence force. According to the Garden classification, 20 cases were classified as types I and II and 24 as types III and IV. The time from fracture to DSA was 6–18 h. The mean time was 12.7 $\pm$ 3.2 h. DSA has a certain operation risk, and this increases treatment fees. DSA was carried out after obtaining patients' informed consents and signed agreements, and institutional review board (IRB) approval from the Institute Research Committee of our University was obtained. The patients were informed that data from the case would be submitted for publication and gave their consent.

### DSA methods

We applied a GE INNOVA 2100 digital broad angiography machine to investigate cardiac, hepatic and renal function, and an iodine allergy test was routinely performed preoperatively. Under local anesthesia, catheterization was performed through a femoral artery in a normal limb by using Seldinger technology; the medial and lateral femoral circumflex arteries in the affected limb were examined by DSA. A 5F Yasiro tube was implanted, allowing selective entry to the medial and lateral femoral circumflex arteries. Angiography was then performed in a tension-free neutral position. The injection rate was 6 ml/s in the femoral circumflex artery (the total amount was 10–15 ml) and 1 ml/s in the retinacular artery (total amount was 1–2 ml). The capture rate was 6, 3 and 2 frames/s in an artery, capillary and vein, respectively. The display time was 2 s, and the capture time was 5, 10 and 15 s in an artery, capillary and vein, respectively, to dynamically observe the retinacular artery of the femoral neck.

### Count of the retinacular artery

Femoral head blood supply is mainly derived from the retinacular artery, which arises from the medial and lateral circumflex femoral artery, especially the medial circumflex femoral artery. The retinacular artery courses along the intertrochanteric line, through the hip joint capsule and the synovial fold of the femoral neck, and mainly divides into three groups: the posterior superior retinacular artery, the posterior inferior retinacular artery and the anterior retinacular artery.

The posterior superior retinacular artery, which arises from the medial circumflex femoral artery and courses through the femoral head outside the junction of the femoral head and neck, supplies blood to the femoral head of the lateral 2/3–3/4. The posterior inferior retinacular artery, which arises from the medial circumflex femoral artery and courses through the femoral head along the lower edge of the femoral head cartilage, supplies 1/4–1/2 of the area under the femoral head. The anterior retinacular artery, which arises from the lateral circumflex femoral artery, does not always exist and only supplies a little blood to the femoral head. In this experiment, we mainly dynamically counted the posterior superior and inferior retinacular artery passing through the fracture line by DSA.

Intraobserver analysis of retinacular artery counting: At three different time points (interval >3 days), Dr. Yuan Xi repeatedly counted the number of retinacular arteries