Observational Study

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A safe percutaneous technique for the reduction of irreducible femoral neck fractures using ultrasound localization of the femoral vascular and nervous structures at the hip

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Abstract

We present a safe percutaneous technique for the placement of Kirschner wires into the femoral head to assist in the reduction of irreducible femoral neck fractures using ultrasound to identify the vascular and nervous structures about the hip.

From January 2011 to June 2014, a total of 36 patients (25 males and 11 females) were enrolled in this study. Patients were placed on a fracture reduction table for limb traction. After 3 unsuccessful reductions with limb traction, ultrasound-guided localization of the patient's femoral artery, vein, and nerve at the hip was performed. These structures were marked on the overlying skin and then Kirschner wires were inserted into the femoral head avoiding these marked structures. After the surgery, the Kirschner wire insertions were routinely reviewed by ultrasound, the hip fracture reduction and the femoral nerve sensorimotor function were routinely examined as well.

All 36 patients with an irreducible variant of a femoral neck fracture showed anatomic reduction under C-arm fluoroscopy using ultrasound to avoid K wire injury to the femoral vascular structures and nerve. No major vascular injury during operation. In post-surgical ultrasound examination, local hematoma formation was not evident. There was normal function of the femoral nerve. On follow-up, there were no infections, wound problems, recurrence of fracture displacement, laxity, or implant breakage.

Preoperative ultrasonic localization of the femoral artery, vein, and femoral nerve safely allowed. Kirschner wire placement under C-arm fluoroscopy into the femoral head to assist in fracture reduction. This assisted reduction method for irreducible femoral neck fractures had a number of advantages, including closed anatomic reduction with minimal attempts, used simple equipment, and avoided further destruction of the blood supply to the femoral head.

Abbreviation: CT = computed tomography.

Keywords: closed reduction, femoral neck fractures, irreducible, Kirschner wire, ultrasound

1. Introduction

Femoral neck fractures in younger people are caused mostly by car collisions, falls from a height and other severe traumas. However, the majority of hip fractures happen to individuals over 60 years old who have osteoporotic bones. Femoral head osteonecrosis is the most common complication of a femoral neck fracture with an incidence as high as 20%.[1] Clinically, some femoral neck fractures are difficult to treat with closed reduction by traction bed, which is defined as conventionally closed reduction. Furthermore, conventionally closed reduction hardly ever achieves an anatomic reduction of the fracture.[2]

Some scholars have used Kirschner wires into the femoral head to control the displacement of the fracture and successfully reduced an irreducible femoral neck fracture.[3] However, when Kirschner wires are inserted to assist in closed reduction, there is a risk of injury to the femoral artery and vein, the femoral nerve, and lateral femoral cutaneous nerve of the thigh. Injury to the femoral artery may cause complications including life-threatening hemorrhage, hematoma, and pseudoaneurysm.[4] Injury to the femoral nerve and the lateral femoral cutaneous nerve of the thigh may result in diminished sensorimotor function in the involved area.[5,6] How to successfully avoid these complications is an issue that restricts this reduction adjunct. To this end, the author has proposed the use of ultrasound localization of these structures to allow the safe placement of Kirschner wires into the femoral head to assist in the reduction of irreducible femoral neck fractures. Ultrasound has its unique advantages in a clinic setting, such as no radiation, portability, and excellence in visualization of muscles and surrounding connective tissues.[7] Ultrasound-guided therapy has been widely used in clinical practice.[8,9] This

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All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethics Committee of the Second Affiliated Hospital of Anhui Medical University approved the study.

The authors have no conflicts of interest to declare.

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paper reports the initial experience using this ultrasonic localization of neurovascular structures about the hip to safely place Kirschner wires to assist in the reduction of irreducible femoral neck fractures.

2. Materials and methods

A total of 36 patients with irreducible femoral neck fractures between January 2011 and June 2014 underwent ultrasound localization of the femoral artery and femoral nerve at the hip followed by Kirschner wire insertion into the femoral head to assist in fracture reduction. (see Surgical Technique).(Fig. 1). An irreducible femoral neck fracture was defined as failure to achieve an anatomical reduction after 3 attempts using a fracture reduction table Intra-operative and post-operative surgical complications of vascular and nerve injury were assessed. The quality of the femoral neck reduction using Garden's criteria and position of the Kirschner wires were assessed radiographically.

2.1. Surgical technique

After the induction of general anesthesia, the patient was placed supine on the fracture reduction table. Conventional ultrasound was used to localize the femoral artery, vein, and nerve in the groin. The transducer was put along the horizontal plane above the inguinal ligament to visualize the blood vessels and nerve in the femoral triangle. Images were obtained using a linear probe of 5 to 12 MHz (EPIQ 5, Philips). The location of these structures was marked by Kirschner wire taped to the skin. Three millimeter Kirschner wires were placed percutaneously through stab incisions under the guidance of the C-arm, in the anterior-posterior direction into femoral head avoiding the blood vessels and nerves, marked by prior Kirschner wires When the bone of the femoral head was palpated, the Kirschner wires were hammered half (1/2) or two-thirds (2/3) into the femoral head and the position confirmed with the fluoroscopically.

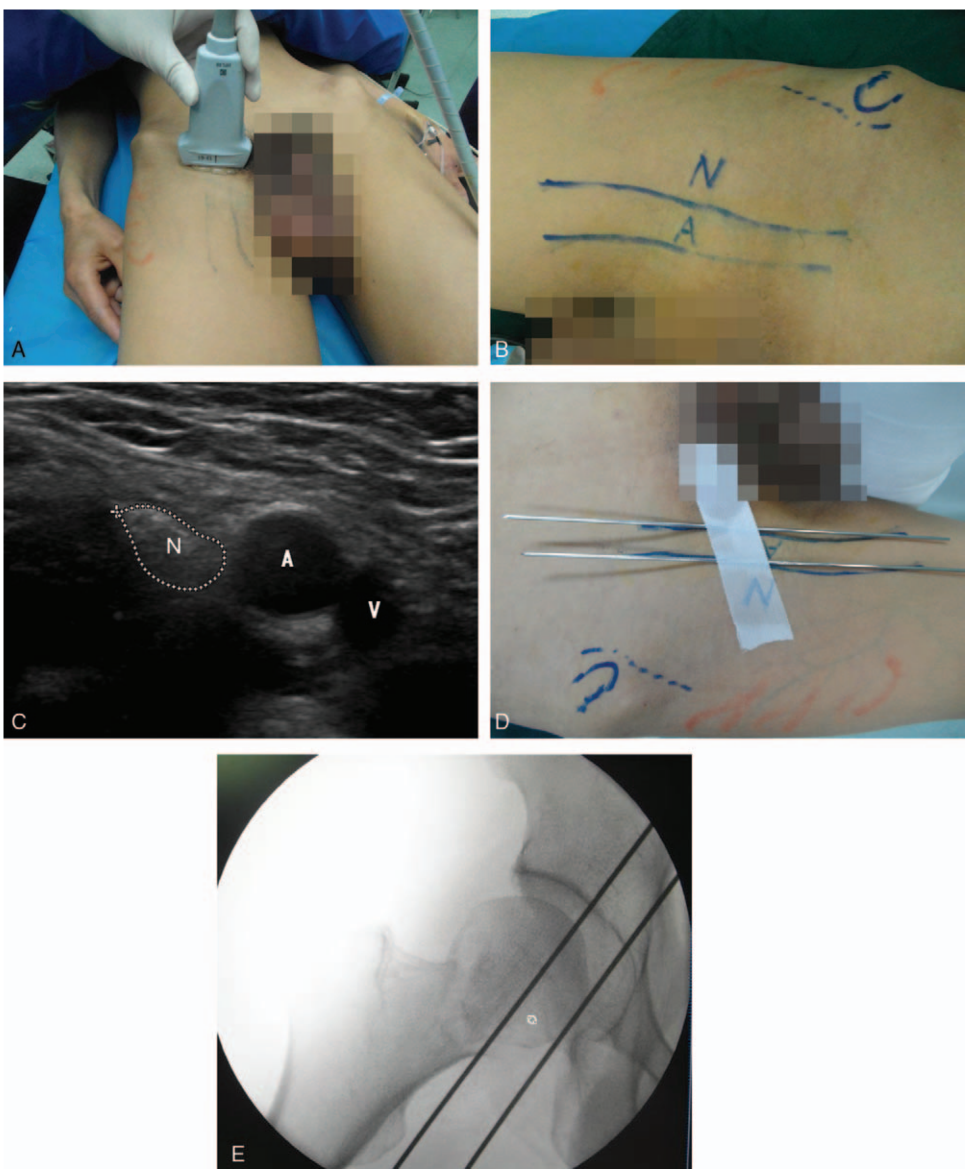

Figure 1. (A) Ultrasound localization; (B) Surface labeling; (C) Ultrasound shows femoral artery and femoral vein;(A: arteria femoralis, V: femoral vein, N: nervus femoralis) (D) Fix the Kirschner wire in the marked position; (E) The vertical projection position of the femoral vein under the perspective of the C-arm.

Traction was then applied followed by internal and external rotation of the leg while the position of the femoral head was controlled by the Kirschner wires. Using Kirschner wires in the femoral head, the proximal part of the fracture was fitted to the distal part of the fracture to reduce the fracture which previously had been difficult to reduce. Fracture reduction was acceptable when the Garden criteria were fulfilled. The neck shaft angle on the AP radiograph was 135 degrees and on the lateral radiograph, the neck and head axes were co-linear. The assistant immediately placed the guide wire through the fracture site (medullary cavity) drilling open with 1 screw into the matching length of the cannulated screws (Fig. 2).

Postoperative passive rotary shoe brake was encouraged in patients with muscle contraction to prevent the formation of deep venous thrombosis of the lower extremity. The use of subcutaneous injection of low molecular weight heparin and 12 to 24 hours of cefazolin was routinely used for prophylaxis of thromboembolic disease and surgical site infection.

3. Results

There were 36 patients (25 males and 11 females) ranging in age from 23 to 60 years old (average age of 41.5 years) who were enrolled in the study. The time from injury to operation was 4 to 72 hours, with an average of 28 hours. According to the Garden Classification of femoral neck fractures, there were 4 cases of type II, 21 cases of type III, and 11 cases of type VI with irreducible femoral neck fracture that received assisted reduction using Kirschner wires. Among them, 6 patients had a femoral neck combined with a femoral shaft fracture. The etiology of the

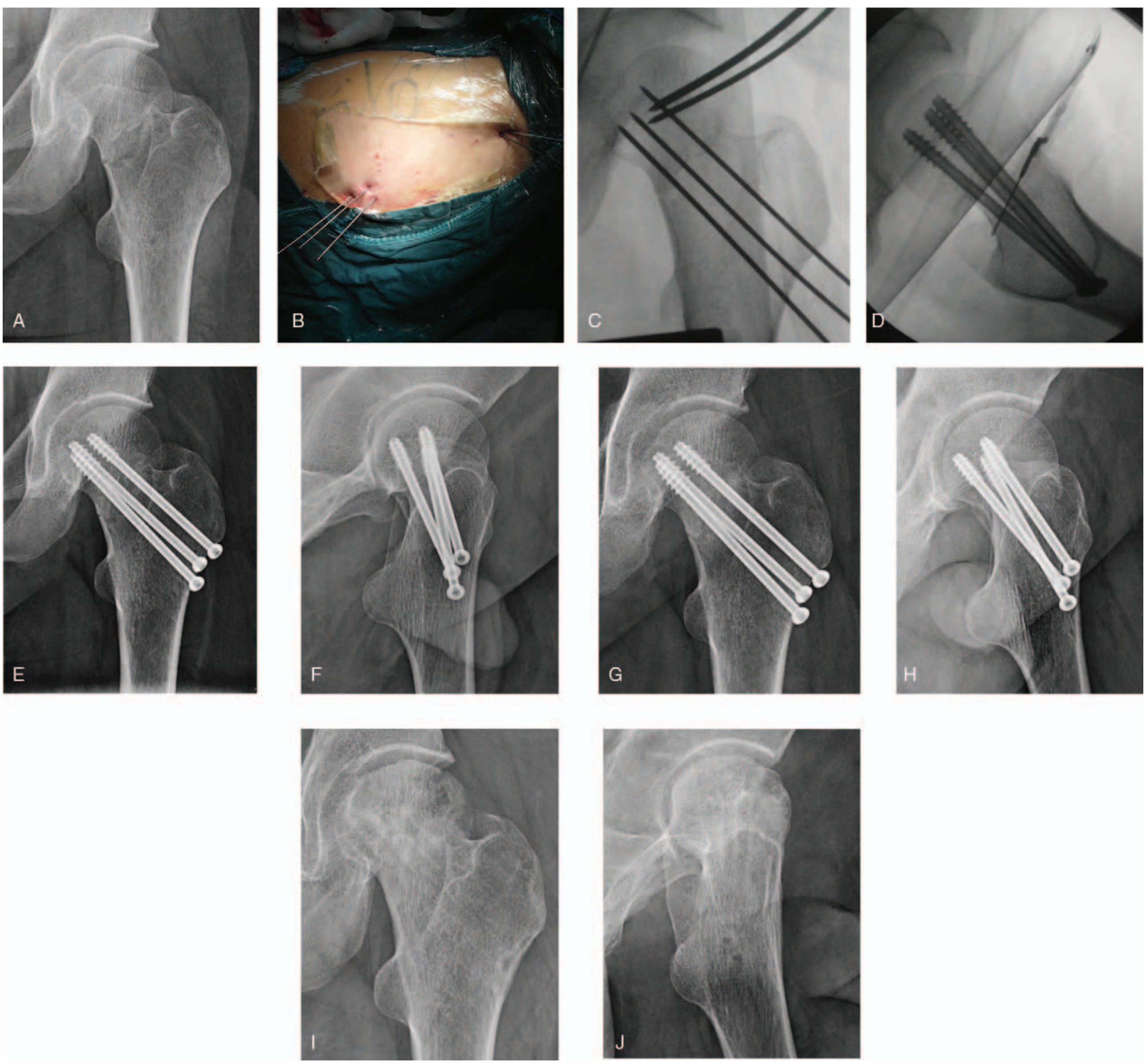

Figure 2. A 35-year-old male suffered a left femoral neck fracture from a traffic accident. (A)The anteroposterior radiograph; (B) The entity figure after inserting the Kirschner wire; (C) Percutaneous reduction by leverage; (D) Implant 3 hollow screws; (E) and (F)Two days after surgery, the anteroposterior radiograph and the lateral radiograph, respectively; (G) and (H) Three months after surgery, the fracture line had blurred in the anteroposterior radiograph and the lateral radiograph, respectively; (I) and (J)The fracture had healed well after removal of the internal fixation in the anteroposterior radiograph and the lateral radiograph, respectively.

fractures was: 17 traffic collisions, 7 falls, and 9 injuries by slipping. With regard to the hip functional outcome assessment, all 36 patients stated that they were highly satisfied. This group of 36 cases of femoral neck fracture was treated with Kirschner wire support reduction and C-arm fluoroscopy and cancellous screw fixation. The reduction time was 45 to 90 minutes (average 60 min). Post-surgical Garden Index evaluation showed that 36 patients achieved an anatomic reduction. No cases of vascular or nerve injury were reported from the surgery. No local hematomas were found in the patients. No patient had deep venous thrombosis of the lower limb. All cases were followed for 2 to 4 years (average 2.8 years). There was 1 case of each of the following: femoral head osteonecrosis, planned total hip replacement, screw displacement, and internal fixation loosening.

4. Discussion

A femoral neck fracture is a common hip fracture with a high incidence rate, high disability rate, and high mortality rate.[10–12] Due to these factors, a femoral neck fracture in both the young adult and the elderly is always a clinical challenge for the orthopedic surgeon. The incidence of femoral neck fractures is increasing dramatically due to the increasing mean age of the population.[13]

Clinical studies have been directed toward avoiding the occurrence of femoral head osteonecrosis.[14–17] Diagnosis using 3-dimensional computed tomography (CT) examination provides guidance for the reduction and judges the prognosis. Treatments include femoramuscle flap transplantation and pedicled free fibula transplantation where specific results have been achieved.[18–20] However, the most critical factor in determining necrosis of the femoral head is the fracture type and the quality of the fracture reduction.

At present, femoral neck fractures are treated by open and closed reduction techniques; the decision regarding the type of surgical procedure is based on many factors.[21] Tension fractures are potentially unstable and may require surgical stabilization. Non-displaced femoral neck fractures may need to be stabilized with multiple parallel lag screws or pins. We know that the hip has a complex anatomical structure that includes the anterior femoral arteries and veins and its branches, the femoral nerve, and the lateral femoral cutaneous nerve of the thigh.[22] The blood supply to the femoral head can be disturbed by a femoral neck fracture due to anatomical characteristics, and this is considered as a major cause of non-union or osteonecrosis of the femoral head.[23,24]

The mainstream of femoral neck fracture reduction in clinical practice is closed and performed under traction Some orthopedists use Kirschner wires to fix the femoral head and control the reduction of the fracture to achieve good results.[2] Fixing Kirschner wires in the bone stock is a challenge. Ultrasound is a non-invasive and low-cost technique which has been employed more and more wildly in clinic. Intravascular ultrasound is utilized to diagnose and treat cardiovascular disease.[25] Ultrasound imaging has been frequently applied to examine carotid intima-media thickness.[26] In addition to its cardiovascular applications, ultrasound is used widely in orthopedics, including in the diagnosis of soft tissue diseases and in the treatment delayed fracture healing. The reduction of femoral neck fractures with the placement of proximal Kirschner wires assisted by ultrasound location of the femoral artery, vein, and nerve is recommended because of the non-invasiveness.[27–29] However, this use of ultrasound localization of neurovascular structures to assist in placement of reduction adjuncts has not been reported before. We have combined ultrasound with irreducible femoral neck fractures to achieve zero injuries of the vascular structures and nerve with closed reduction. This technique is time effective and is safe for surgeons to easily operate. The major advantages of this technique are its non-invasive examination, repeatability, and operability.

The deficiencies of this study are that the patient number was small and the follow-up time was short. There may have been some errors in ultrasonic localization and the sample of data was insufficient to support division of the femoral artery and vein, and femoral nerve projection in the femoral head. Fixation was also relatively simple: both anterior and posterior fixation.

5. Conclusion

It is not always easy to achieve anatomic reduction of irreducible femoral neck fractures. However, the use of ultrasound to safely position Kirschner wires into the femoral head to assist in reduction in the treatment of irreducible femoral neck fracture is a simple highly reproducible technique. It avoids important blood vessels and nerves when the Kirschner wires are being inserted reducing iatrogenic injury.

Author contributions

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