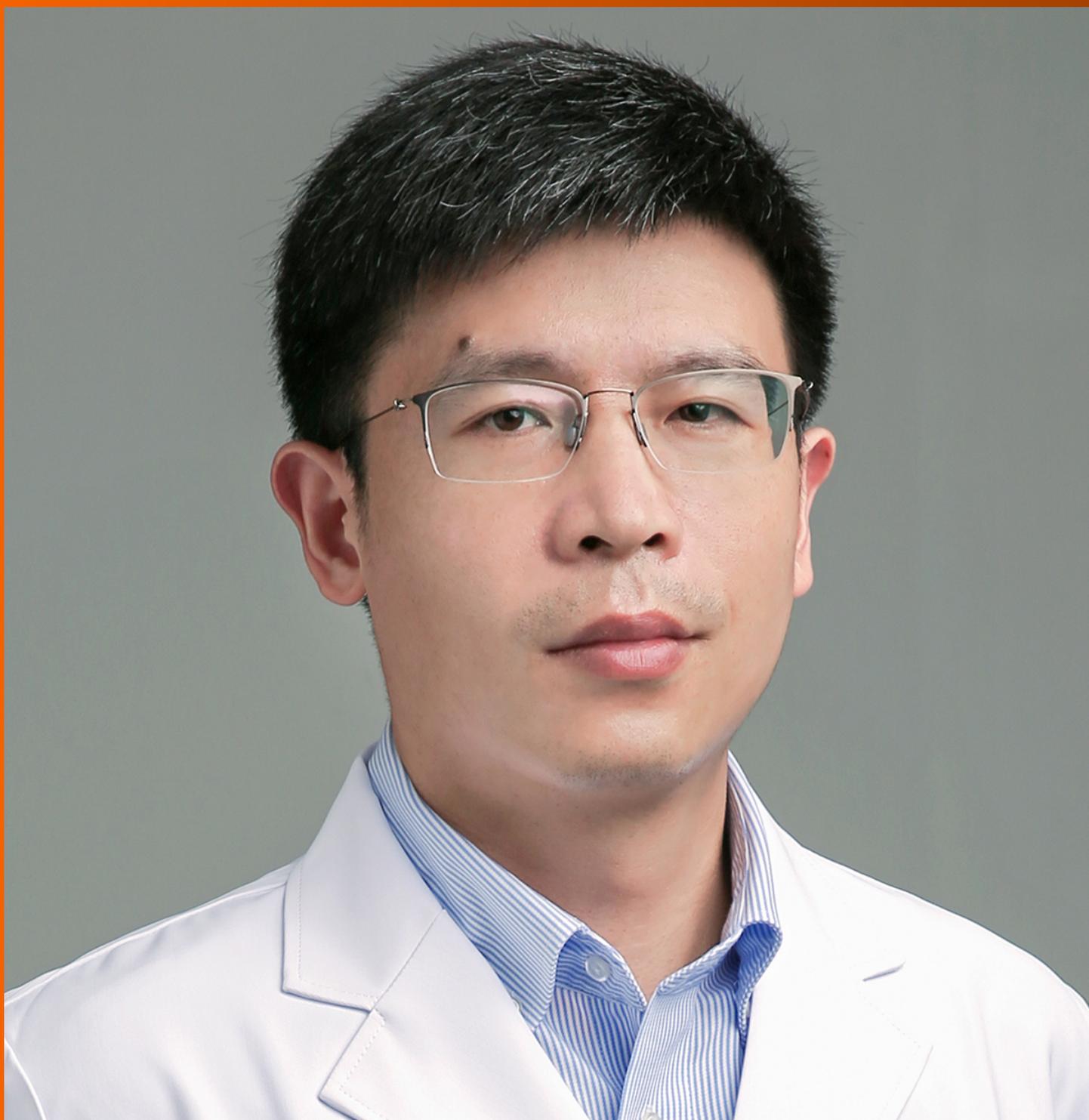


# World Journal of *Clinical Cases*

*World J Clin Cases* 2022 May 6; 10(13): 3969-4326



**REVIEW**

- 3969 COVID-19 and liver diseases, what we know so far  
*Elnaggar M, Abomhaya A, Elkhattib I, Dawoud N, Doshi R*

**MINIREVIEWS**

- 3981 Amputation stump management: A narrative review  
*Choo YJ, Kim DH, Chang MC*

**ORIGINAL ARTICLE****Clinical and Translational Research**

- 3989 Solute carrier family 2 members 1 and 2 as prognostic biomarkers in hepatocellular carcinoma associated with immune infiltration  
*Peng Q, Hao LY, Guo YL, Zhang ZQ, Ji JM, Xue Y, Liu YW, Lu JL, Li CG, Shi XL*

**Retrospective Cohort Study**

- 4020 Role of clinical data and multidetector computed tomography findings in acute superior mesenteric artery embolism  
*Yang JS, Xu ZY, Chen FX, Wang MR, Cong RC, Fan XL, He BS, Xing W*

**Retrospective Study**

- 4033 Effect of calcium supplementation on severe hypocalcemia in patients with secondary hyperparathyroidism after total parathyroidectomy  
*Liu J, Fan XF, Yang M, Huang LP, Zhang L*
- 4042 Comparison of clinical efficacy and postoperative inflammatory response between laparoscopic and open radical resection of colorectal cancer  
*He LH, Yang B, Su XQ, Zhou Y, Zhang Z*
- 4050 Three-dimensional echocardiographic assessment of left ventricular volume in different heart diseases using a fully automated quantification software  
*Pan CK, Zhao BW, Zhang XX, Pan M, Mao YK, Yang Y*
- 4064 Clinical effect of ultrasound-guided nerve block and dexmedetomidine anesthesia on lower extremity operative fracture reduction  
*Ao CB, Wu PL, Shao L, Yu JY, Wu WG*
- 4072 Correlation between thrombopoietin and inflammatory factors, platelet indices, and thrombosis in patients with sepsis: A retrospective study  
*Xu WH, Mo LC, Shi MH, Rao H, Zhan XY, Yang M*

**Observational Study**

- 4084 High plasma CD40 ligand level is associated with more advanced stages and worse prognosis in colorectal cancer

*Herold Z, Herold M, Herczeg G, Fodor A, Szasz AM, Dank M, Somogyi A*

- 4097 Metabolic dysfunction is associated with steatosis but no other histologic features in nonalcoholic fatty liver disease

*Dai YN, Xu CF, Pan HY, Huang HJ, Chen MJ, Li YM, Yu CH*

**Randomized Controlled Trial**

- 4110 Effect of Xuebijing injection on myocardium during cardiopulmonary bypass: A prospective, randomized, double blind trial

*Jin ZH, Zhao XQ, Sun HB, Zhu JL, Gao W*

**META-ANALYSIS**

- 4119 Perioperative respiratory muscle training improves respiratory muscle strength and physical activity of patients receiving lung surgery: A meta-analysis

*Yang MX, Wang J, Zhang X, Luo ZR, Yu PM*

**CASE REPORT**

- 4131 Delayed diffuse lamellar keratitis after small-incision lenticule extraction related to immunoglobulin A nephropathy: A case report

*Dan TT, Liu TX, Liao YL, Li ZZ*

- 4137 Large vessel vasculitis with rare presentation of acute rhabdomyolysis: A case report and review of literature

*Fu LJ, Hu SC, Zhang W, Ye LQ, Chen HB, Xiang XJ*

- 4145 Primitive neuroectodermal tumor of the prostate in a 58-year-old man: A case report

*Tian DW, Wang XC, Zhang H, Tan Y*

- 4153 Bilateral superficial cervical plexus block for parathyroidectomy during pregnancy: A case report

*Chung JY, Lee YS, Pyeon SY, Han SA, Huh H*

- 4161 Primary myelofibrosis with thrombophilia as first symptom combined with thalassemia and Gilbert syndrome: A case report

*Wufuer G, Wufuer K, Ba T, Cui T, Tao L, Fu L, Mao M, Duan MH*

- 4171 Late contralateral recurrence of retinal detachment in incontinentia pigmenti: A case report

*Cai YR, Liang Y, Zhong X*

- 4177 Pregnancy and delivery after augmentation cystoplasty: A case report and review of literature

*Ruan J, Zhang L, Duan MF, Luo DY*

- 4185 Acute pancreatitis as a rare complication of gastrointestinal endoscopy: A case report

*Dai MG, Li LF, Cheng HY, Wang JB, Ye B, He FY*

- 4190** Paraneoplastic neurological syndrome with positive anti-Hu and anti-Yo antibodies: A case report  
*Li ZC, Cai HB, Fan ZZ, Zhai XB, Ge ZM*
- 4196** Primary pulmonary meningioma: A case report and review of the literature  
*Zhang DB, Chen T*
- 4207** Anesthesia of a patient with congenital cataract, facial dysmorphism, and neuropathy syndrome for posterior scoliosis: A case report  
*Hudec J, Kosinova M, Prokopova T, Filipovic M, Repko M, Stourac P*
- 4214** Extensive myocardial calcification in critically ill patients receiving extracorporeal membrane oxygenation: A case report  
*Sui ML, Wu CJ, Yang YD, Xia DM, Xu TJ, Tang WB*
- 4220** Trigeminal extracranial thermocoagulation along with patient-controlled analgesia with esketamine for refractory postherpetic neuralgia after herpes zoster ophthalmicus: A case report  
*Tao JC, Huang B, Luo G, Zhang ZQ, Xin BY, Yao M*
- 4226** Thrombotic pulmonary embolism of inferior vena cava during caesarean section: A case report and review of the literature  
*Jiang L, Liang WX, Yan Y, Wang SP, Dai L, Chen DJ*
- 4236** EchoNavigator virtual marker and Agilis NxT steerable introducer facilitate transseptal transcatheter closure of mitral paravalvular leak  
*Hsu JC, Khoi CS, Huang SH, Chang YY, Chen SL, Wu YW*
- 4242** Primary isolated central nervous system acute lymphoblastic leukemia with *BCR-ABL1* rearrangement: A case report  
*Chen Y, Lu QY, Lu JY, Hong XL*
- 4249** Coexistence of meningioma and other intracranial benign tumors in non-neurofibromatosis type 2 patients: A case report and review of literature  
*Hu TH, Wang R, Wang HY, Song YF, Yu JH, Wang ZX, Duan YZ, Liu T, Han S*
- 4264** Treatment of condylar osteophyte in temporomandibular joint osteoarthritis with muscle balance occlusal splint and long-term follow-up: A case report  
*Lan KW, Chen JM, Jiang LL, Feng YF, Yan Y*
- 4273** Hepatic perivascular epithelioid cell tumor: A case report  
*Li YF, Wang L, Xie YJ*
- 4280** Multiple stress fractures of unilateral femur: A case report  
*Tang MT, Liu CF, Liu JL, Saijilafu, Wang Z*
- 4288** Enigmatic rapid organization of subdural hematoma in a patient with epilepsy: A case report  
*Lv HT, Zhang LY, Wang XT*

- 4294 Spinal canal decompression for hypertrophic neuropathy of the cauda equina with chronic inflammatory demyelinating polyradiculoneuropathy: A case report  
*Ye L, Yu W, Liang NZ, Sun Y, Duan LF*
- 4301 Primary intracranial extraskeletal myxoid chondrosarcoma: A case report and review of literature  
*Zhu ZY, Wang YB, Li HY, Wu XM*
- 4314 Mass brain tissue lost after decompressive craniectomy: A case report  
*Li GG, Zhang ZQ, Mi YH*

**LETTER TO THE EDITOR**

- 4321 Improving outcomes in geriatric surgery: Is there more to the equation?  
*Goh SSN, Chia CL*
- 4324 Capillary leak syndrome: A rare cause of acute respiratory distress syndrome  
*Juneja D, Kataria S*

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## Multiple stress fractures of unilateral femur: A case report

Mao-Ting Tang, Chun-Feng Liu, Jin-Lian Liu, Saijilafu, Zhen Wang

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### Abstract

#### BACKGROUND

Stress fractures of the femoral neck are not common in clinical practice, and simultaneous stress fractures of the femoral neck and proximal femur of the unilateral femur are even more rare. We introduce a case of this type of fracture that was treated in our department, analyze the causes, and review similar stress fractures reported in the literature to provide references for the diagnosis and treatment of such conditions.

#### CASE SUMMARY

A 62-year-old female, with a free medical history, was admitted to the hospital mainly due to pain in the right hip and worsening pain in the right thigh. The patient had no obvious history of trauma. X-ray and computed tomography showed fracture of the femoral neck and proximal femur. The patient had undergone surgery 1 year prior to address a fracture of the left proximal femur that had occurred in a traffic accident. Our first consideration was stress fracture of the femoral neck; however, simultaneous stress fractures of the femoral neck and proximal femur of the unilateral femur were seen. The femoral neck stress fracture was a tension fracture, with obvious displacement and varus deformity of the hip. Considering that the patient was an elderly female, we performed total hip arthroplasty. Follow-up X-rays showed that the stress fracture of the proximal femur had mostly healed after 3 mo.

#### CONCLUSION

Muscle fatigue and hip varus deformity provide an anatomical basis for the occurrence of femoral neck stress fractures.

**Key Words:** Femoral neck fracture; Femoral fracture; Stress fracture; Fatigue fracture; Hip pain; Case report

**Core Tip:** Stress fractures of the femoral neck are not common in clinical practice. Additionally, simultaneous stress fractures of the femoral neck and proximal femur of the unilateral femur are even more rare and have not been reported in the literature. We found that varus deformity of the hip provides an anatomical basis for the occurrence of stress fractures of the proximal femur. Early diagnosis is very important for the treatment of femoral neck stress fractures. The classification of femoral neck stress fractures guides the treatment options.

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## INTRODUCTION

Stress fractures of the femoral neck are not common in clinical practice. They were first reported by Ernst[1] in 1936 and account for about 11% of all stress fractures[2]. Additionally, simultaneous stress fractures of the femoral neck and proximal femur of the unilateral femur are even more rare and have not been reported in the literature. This article introduces a case of unilateral femoral neck and proximal femur stress fractures that were diagnosed and treated in our department, analyzes the causes, and reviews the literature to provide references for the diagnosis and treatment of these injuries.

## CASE PRESENTATION

### **Chief complaints**

The patient was a 62-year-old female who was admitted to our hospital mainly due to pain in the right hip for 4 mo and worsening pain in the right thigh for 1 mo. At 4 mo before admission, the patient had no history of trauma. Initially, the pain in the right hip and groin slightly improved after rest but worsened after exercise. The symptoms recurred. In the month prior to admission, the patient felt pain in the right thigh, which had prompted her to visit our clinic.

### **History of present illness**

The patient had undergone an open reduction and internal fixation for a fracture of the left proximal femur 1 year prior (Figure 1A), to address the injury sustained in a traffic accident. Due to the delayed union of the left femoral fracture, the patient supported the right limb with crutches on the ground to perform functional exercises.

### **History of past illness**

The patient had no history of osteoporosis or other trauma, no metabolic diseases (*e.g.*, diabetes or kidney disease), no immune diseases (*e.g.*, rheumatism), did not smoke tobacco or drink alcohol, and had no history of hormone and bisphosphonate usage.

### **Personal and family history**

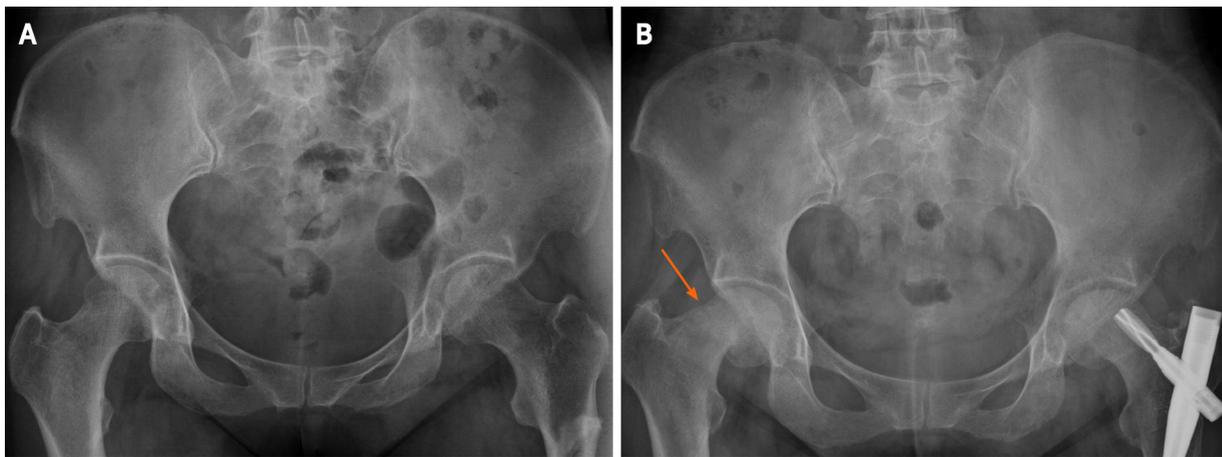
The patient weighed 60 kg and had a height of 165 cm. Her body mass index was 22 kg/m<sup>2</sup>. She reported having no bad personal habits nor customs, as well as no family history of cardiovascular, respiratory or gastrointestinal diseases.

### **Physical examination**

No obvious deformity of the left hip, local redness, pigmentation, nor swollen blood vessels were observed. Tenderness at the midpoint of the left groin, tenderness on the lateral side of the femur, missing inguinal lymph nodes, positive percussion test, good passive movement of the right hip joint, and good distal blood supply were found.

### **Laboratory examinations**

Blood biochemistry was normal. Urinalysis was unremarkable. Electrocardiogram, chest X-ray, arterial blood gas, and levels of bone turnover markers and vitamin D were normal. Specific findings from



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**Figure 1** X-ray of the pelvis 1 yr prior to and before surgery. A: Fracture of the left proximal femur and good continuity of the right femur neck. At that time, the patient had no clinical symptoms in the right hip; B: Fracture line at the upper end of the right femoral neck (orange arrow) and varus deformity of the hip.

laboratory tests were serum calcium level of 2.26 mmol/L (range: 2.02–2.7 mmol/L), parathyroid hormone level of 42 pg/mL (range: 15–65 pg/mL) and 25-hydroxyvitamin D level of 13.83 µg/L (range: 11.1–42.9 µg/L).

### Imaging examinations

X-ray of the right hip in the anterior-posterior and lateral views showed right femoral neck and proximal femur cortical discontinuity, and varus deformity of the right hip joint (Figures 1B and 2). Computed tomography (CT) of the right hip showed that the upper cortex of the left femoral neck was discontinuous, and the fractured end was displaced (Figure 3). Bone mineral density (lumbar spine and proximal femur) was normal (T value: 0.36).

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## FINAL DIAGNOSIS

Stress fracture of the right femoral neck and proximal femur and postoperative fracture of the left proximal femur.

---

## TREATMENT

According to the classification, the stress fracture of the femoral neck in the patient was a tension fracture, with obvious displacement of the fracture end and varus deformity of the hip, which had surgical indications. Considering that the patient was an elderly female, we performed total hip arthroplasty (THA). Because of the stress fractures of the proximal femur, we chose a longer femoral prosthesis (*i.e.* extended stem), and the fracture end was first fixed with a wire to prevent intraoperative fractures when the femoral stem prosthesis would be subsequently installed (Figure 4A and B). After the patient was admitted to the hospital, the examination was completed and there was no contraindication to the operation.

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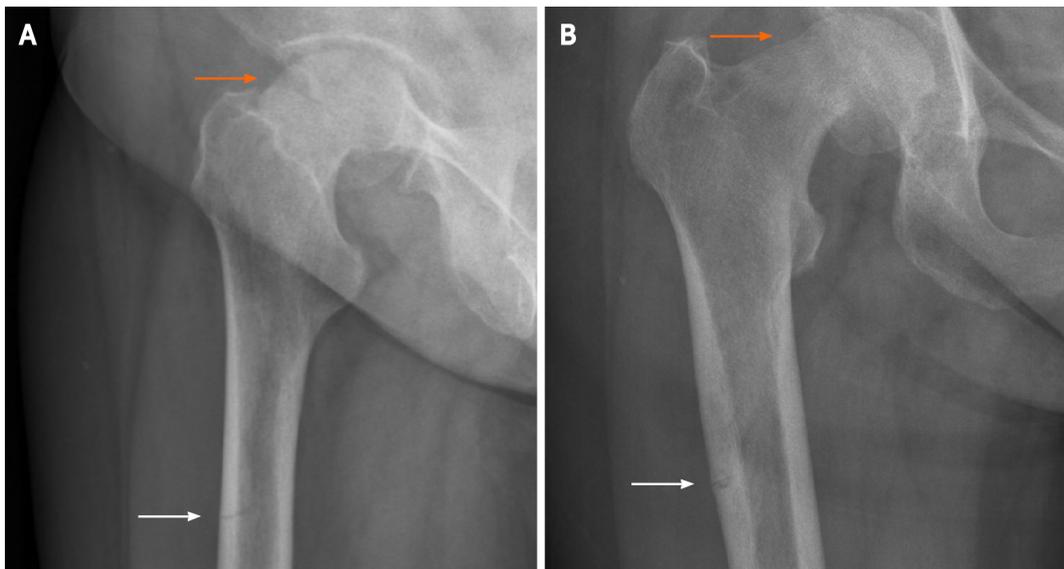
## OUTCOME AND FOLLOW-UP

After the operation, the patient was able to move around immediately. Follow-up X-rays (after 3 mo) showed that the stress fracture of the proximal femur had mostly healed (Figure 4C and D).

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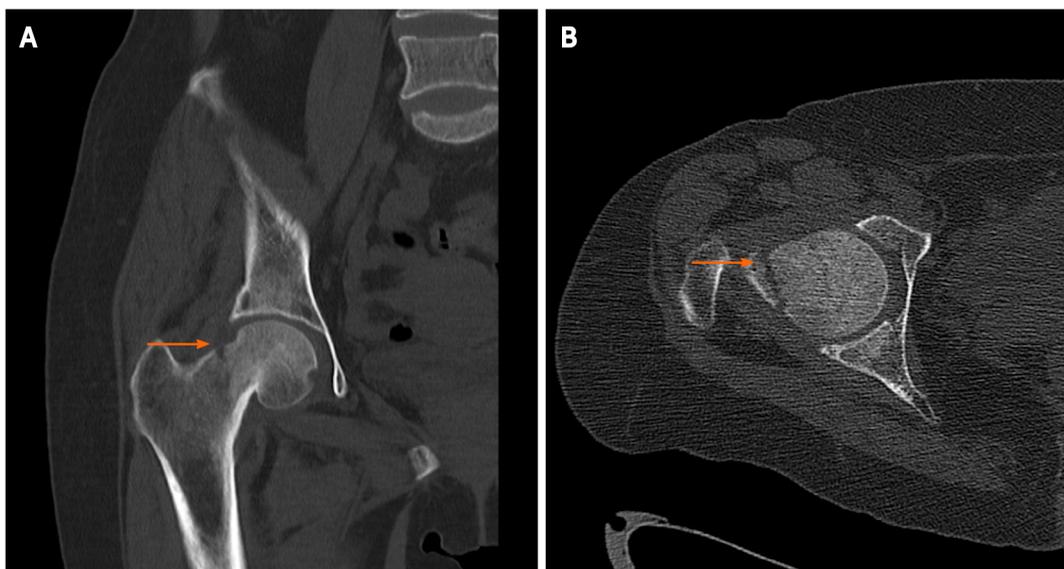
## DISCUSSION

Stress fractures were first reported in the middle of the 19<sup>th</sup> century. Femoral neck stress fractures are not common and are generally found in populations including military recruits, ballet dancers, and distance runners. Stress fractures are not easy to diagnose early, as they are difficult to see on X-rays



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**Figure 2 Plain radiograph of the hip joint before an operation.** A: Lateral view; B: Anterior-posterior view. Both show the fracture line at the upper end of the right femoral neck (orange arrow), displacement of the fracture end, varus deformity of the hip, and proximal femur cortical discontinuity (white arrow).



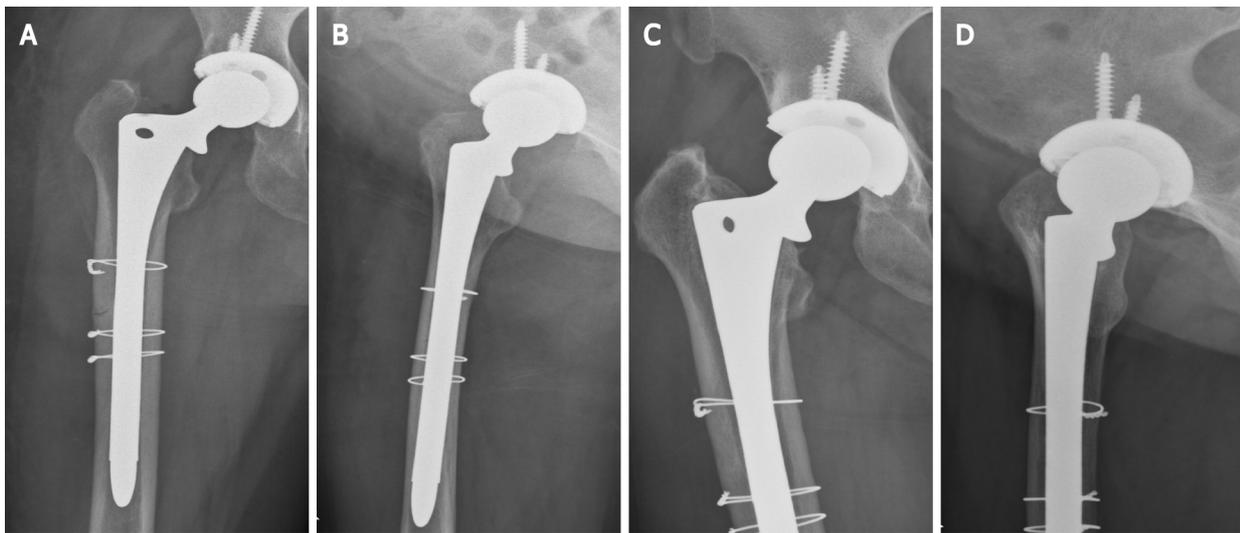
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**Figure 3 Preoperative computed tomography of the hip joint.** A: Coronal scan; B: Axial scan. Both scans show the fracture line above the femoral neck (arrow), obvious displacement of the fracture end, and varus deformity of the hip.

immediately following the injury. Delayed diagnosis often results in fracture displacement, nonunion, and femoral head necrosis. Here, we reported a case of simultaneous unilateral femoral neck and proximal femur stress fractures. There have been previous reports of bilateral femoral neck stress fractures[3-7], but to the best of our knowledge, this is the first report on unilateral femoral stress fractures.

### **Pathogenesis**

The pathogenesis of stress fractures remains a subject of debate. At present, there are two theories. One is that repeated stress stimulation leads to accelerated bone remodeling and bone resorption is greater than bone formation, leading to stress fractures. The other is that loss of muscle function around the injured area leads to abnormal bone bearing, causing the fracture. The simultaneous action of internal and external factors cause stress fractures[8]; however, other factors are also involved, such as genetic factors, endocrine and metabolic diseases, vitamin D deficiency, osteoporosis, sex-related factors, ethnicity, and mental factors[4,5,9].



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**Figure 4** X-rays of hip joint after the operation and 3 mo after the operation. A: Anterior-posterior view; B: Lateral view. Both views show that, after total hip arthroplasty, the prosthesis was in a good position and the proximal femur was fixed with steel wires to prevent intraoperative fracture; C: Anterior-posterior view; D: Lateral view. Both views show that the right artificial hip prosthesis was in a good position, the fracture line of the right proximal femur disappeared, and the bone fracture healed well.

The patient in this case report shifted her body weight to the right lower limb because of the fracture of the left proximal femur, which is considered to be the main cause of right femoral neck stress fractures. Patel *et al*[10] reported a case of an elderly patient with a bilateral femoral neck stress fracture. The right femoral neck pressure fracture occurred first, and the left tension fracture occurred after 3 mo. We considered the mechanism similar to that in our patient, who had stress fractures in the femoral neck and proximal femur of the unilateral femur. It is an extremely rare case, and the order of occurrence of stress fractures in the femoral neck and proximal femur is difficult to determine. The patient complained of pain in the right inguinal area and hip for 4 mo, and pain in the proximal thigh for nearly 1 mo. According to her medical history, the femoral neck stress fracture occurred first, followed by the proximal femoral stress fracture.

The cause of stress fractures of the proximal femur was initially thought to be caused by muscle fatigue. The muscle fatigue injury theory refers to the fact that bone stress is correlated with the functional state of the muscle joints, and the muscle-joint unit acts as a stress attenuator. Tensile stress caused by uncoordinated muscle contraction and muscle fatigue loss to protect the bones is the cause of stress fractures. After repeated weight bearing, the patient's right hip abductors fatigue, resulting in accelerated bone reconstruction at the proximal and lateral sides of the femoral neck, leading to tension fractures above the femoral neck. The pain gradually improves after rest, as the weight on it has been reduced.

After a fracture of the right femoral neck, the fractured end is hardened and coxa varus deformity occurs. After varus deformity of the hip, the right hip muscles and lateral hip muscles are further misused, leading to the disappearance of lateral tension resistance and loss of the protective effect on the bone, which further lead to stress fractures of the lateral cortex of the proximal femur. Therefore, varus deformity of the hip provides an anatomical basis for the occurrence of stress fractures of the proximal femur. When walking and running, femoral neck stress is about 3-5 times the body weight. When there is hip varus, the stress on it further increases. Consistent with earlier reports in the literature, there is a significant correlation between hip varus deformity and stress fractures of the proximal femur[11-13].

There have also been reports in the literature that the difference in angle of the femoral neck shaft and curvature of the femoral shaft affects the distribution of lateral femur tension, leading to concentrated stress distribution in the proximal one-third of the femur and the occurrence of stress fractures of the proximal femur[14,15]. Our literature review also found cases of bilateral hip varus deformity in patients with bilateral femoral neck stress fracture[16]. Although the authors did not discuss it, hip varus deformity is another cause of stress fractures. It has also been reported that most patients with femoral neck stress fractures have radiographic signs of acetabular impingement[17]. However, further research is needed to confirm whether these signs are correlated with stress fracture.

### Classification

There are many classifications of femoral stress fractures, which guide treatment strategies. Stress fractures are divided into fatigue fractures and insufficiency fractures. Insufficiency stress fractures usually have abnormal bone quality and structure, resulting in fractures that cannot withstand conven-

tional stress. Fatigue fractures are caused by normal bone under long-term repeated stress stimulation, resulting in decreased bone production and increased bone resorption. Blickenstaff and Morris[18] divided femoral neck stress fractures into three types. Type I fractures are periosteal reactions or callus formation on the medial side of the femoral neck, with no obvious fracture lines. Type II is a visible femoral neck fracture line with no significant displacement of the fracture end. Type III is a completely displaced femoral neck fracture. According to the mechanism underlying femoral neck stress fractures, Fullerton and Snowdy[19] divided them into the following three types: Tension fracture, pressure fracture, and displacement fracture. Tension fractures occur outside and above the femoral neck, and the fracture ends are often displaced. Compression fractures are mostly fractures in the lower part of the femoral neck, which are stable fractures and are not prone to displacement of the fracture end.

Stress fractures of the proximal femur are not common, and are usually called atypical femoral fractures. In recent years, it has been reported that atypical fractures of the proximal femur may be caused by the inhibition of bone transformation caused by long-term use of bisphosphonates. However, it has also been postulated that the abnormal morphology of the femur is a main reason for proximal femur stress fractures[20-22].

### **Radiographic evaluation**

According to the literature[3], early diagnosis plays a key role in the treatment of femoral stress fractures, especially femoral neck stress fractures, and can prevent femoral head necrosis, nonunion, and hip deformities caused by misdiagnosis and delayed diagnosis. Patel *et al*[10] also proposed that early diagnosis is very important for the treatment of femoral neck stress fractures, and sometimes more radical treatments can be applied clinically to prevent serious adverse complications caused by fracture progression. Although early diagnosis is extremely important for femoral neck stress fractures, clinically, the early missed diagnosis rate of femoral neck stress fractures has reached 75%[16]. A systematic review of the literature on 48 cases of femoral head stress fractures among exercisers found that the average delay in diagnosis is 57 d.

The early diagnosis of femoral stress fractures is difficult. Most patients go to the doctor mainly because of hip and groin discomfort, which worsens after fatigue and can be relieved by rest. Radiography is the first choice for early examination but there are usually no abnormal findings. The radiographical sensitivity is about 10%, and the missed diagnosis rate is 75%[16,23]. Early diagnosis mainly relies on magnetic resonance imaging (MRI) and bone scan, with sensitivities of 100% and 85%, respectively. MRI shows the early edema reaction of the femoral neck, with visible or invisible fracture lines. After the stress fracture occurs, radiographs and CT show clear fracture lines, with or without sclerosis of the fracture end and callus formation. Although MRI is considered the gold standard for diagnosing stress fractures, if MRI exams for hip pain are routinely used, they will not only lead to a waste of medical resources but the expensive costs will increase the burden on patients and lead to conflicts between doctors and patients. For patients with pain and discomfort in the groin area and thigh and recent repetitive stress irritation, stress fractures should be suspected. If necessary, in addition to normal radiography, MRI or bone scan should be considered.

### **Treatment strategy**

The classification of femoral neck stress fractures guides the treatment options. The most important thing in the treatment of femoral neck stress fractures is early diagnosis, which can prevent displacement of the fracture end caused by delayed or missed diagnosis, leading to further adverse complications. For non-displaced femoral neck fractures and proximal femoral fractures, a conservative treatment approach can be used (*e.g.*, bed rest, local treatment) in addition to regular radiograph review. Generally, these fractures can be treated; for example, shock wave therapy can be used to treat stress fractures by promoting fracture healing[24,25]. Displaced femoral neck stress fractures usually require surgical intervention. For younger patients, physicians can choose hollow nail internal fixation and non-weight bearing functional exercises. For elderly patients with fracture end displacement, THA can be used. Displaced proximal femoral fractures are mostly treated with femoral intramedullary nails. This patient had a tension fracture of the femoral neck, with obvious displacement of the fracture end and varus deformity of the hip. Considering the patient's age, the first choice was THA. The patient had a stress fracture of the proximal femur on the same side, but there was no significant displacement of the fractured end. Therefore, the prosthesis of the femoral end used an extended stem. Simultaneously, we pre-installed a wire fixation to prevent fracture displacement during the subsequent reaming and installing of the prosthesis.

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## **CONCLUSION**

Although femoral stress fractures are not common, patients with a history of exercise, or hip joint, groin or thigh pain should be vigilant, and femoral stress fractures should be considered. X-ray examination should be performed routinely, and if necessary, MRI exams to achieve early diagnosis and avoid adverse consequences caused by delayed diagnosis.

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## FOOTNOTES

**Author contributions:** Tang MT reviewed the literature and contributed to drafting the manuscript; Liu CF reviewed the literature and followed up with the patient; Liu JL reviewed the literature and performed the operation; Saijilafu made important intellectual contributions to the revision of the manuscript for publication; Wang Z reviewed the literature and helped revise the manuscript; all authors issued final approval for the version to be submitted.

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