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Cheryl Marise Peilin Tan
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Hsieh En Chua
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Alvin Chin Kwong Tan
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Derek Howard Park
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Antony Xavier Rex Premchand
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Corresponding Author:
Cheryl Marise Peilin Tan
Department of Orthopaedic Surgery, Khoo Teck Puat Hospital, Singapore 90 Yishun Central, Singapore

Segmental neck of femur fractures: Early recognition and appropriate treatment to prevent fixation failure: A case series

Cheryl Marise Peilin Tan, Hsieh En Chua, Alvin Chin Kwong Tan, Derek Howard Park and Antony Xavier Rex Premchand

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Abstract
Introduction: Segmental fractures of the neck of femur (SFNOF) are rare injuries that should be recognized early.
Case Presentation: We present a series of two cases with SFNOF who initially underwent surgical fixation with a femoral intra-medullary nail. Both cases had complications of fracture non-union, femoral intra-medullary nail failure and migration, and had to undergo revision surgery with a hip arthroplasty.
Results and Conclusion: A discussion of similar cases in the literature is presented. We highlight the importance of early recognition and appropriate further imaging such as computed tomography (CT) scanning and consideration of arthroplasty options.

Keywords: Segmental fractures of neck of femur; early recognition; revision arthroplasty; computed tomography imaging

Introduction
Epidemiological data [1] have estimated that there will be 6.26 million hip fractures in year 2050, and that 70% of these hip fractures will be from Asia, Latin America, the Middle East and Africa. In Singapore, 402 out of 100,000 females have a hip fracture per year [2]. This is expected to increase with the ageing population and increased incidence of osteoporosis locally.
Segmental fractures of the neck of femur (SFNOF) are rare injuries with a bimodal distribution. These injuries can occur in the young following high energy traumatic injuries such as road traffic accidents, or in low energy injuries in the elderly – such as the earliest cases described by Pemberton et al. [3] and An et al. [4] A high index of suspicion is important for early recognition of such fractures and to avoid morbidity. There is a high risk of avascular necrosis (AVN) [5] with SFNOF, due to the greater extent of disruption of the blood supply, which may involve the extracapsular arterial ring formed by the medial and lateral circumflex femoral arteries and trochanteric anastomosis.
SFNOF are not always identified on initial plain radiographs, and the diagnosis may be delayed or missed. Early recognition by advanced imaging is important for surgical planning.

Materials and Methods
Case 1
A 90-year old lady with good pre-morbid status (community ambulant with quad stick), presented to the Emergency Department with right hip pain after sustaining a low energy fall. She had a past medical history of hypertension, hyperlipidemia, and a right corona radiata infarct eight years prior. On examination, her right lower limb was shortened, and externally rotated, distal neurovascular status was intact. Plain radiographs of the pelvis and right hip revealed a concomitant right sub-capital neck of femur fracture and four-part intertrochanteric fracture (Fig 1).

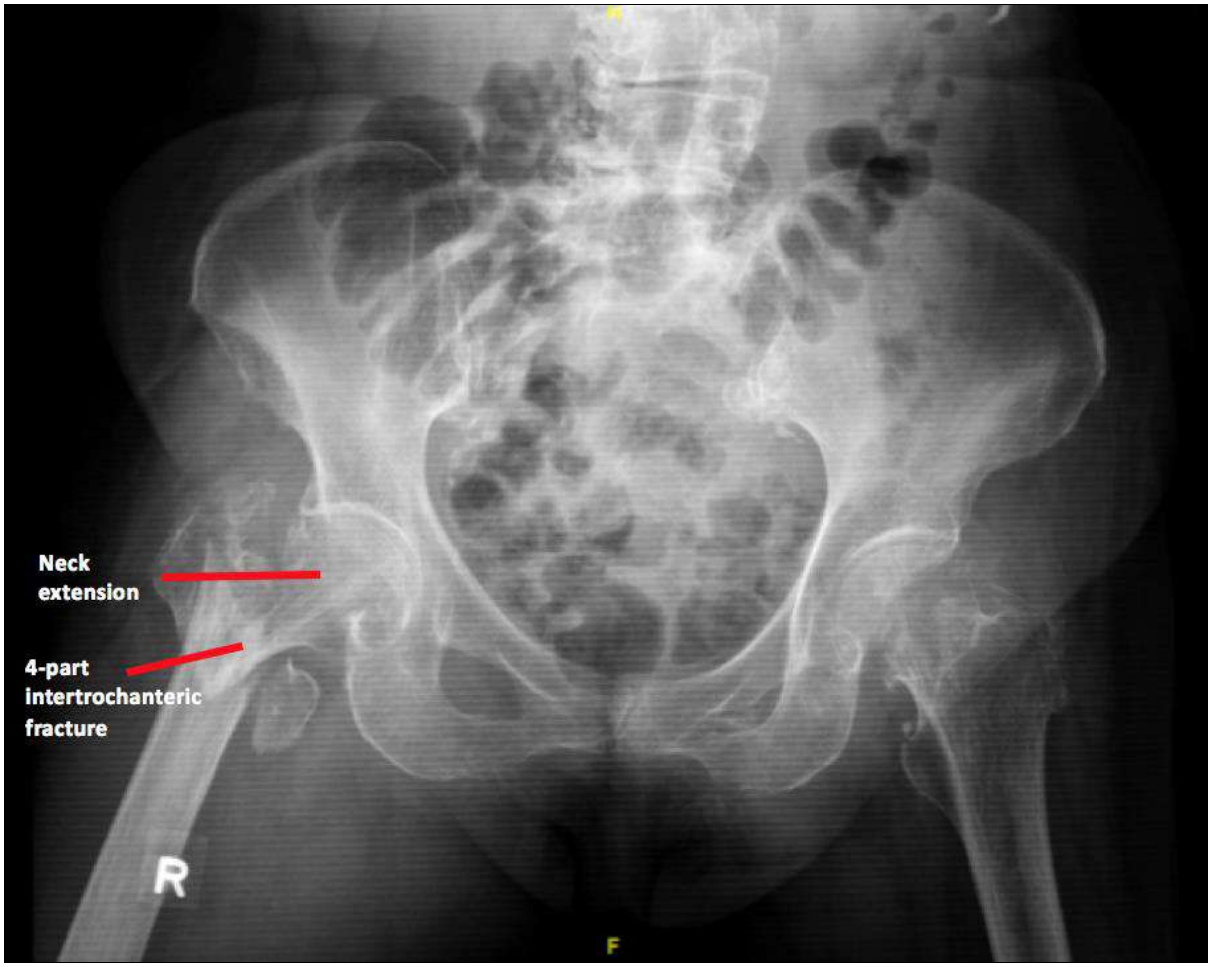

Fig 1: Pre-operative X-ray of antero-posterior view of pelvis showing a concomitant right sub-capital neck of femur fracture and four-part intertrochanteric fracture

After patient optimization, fixation with a long proximal femoral antirotation nail (PFNA) was done. Post-operative plain radiographs of the right hip post fixation showed good reduction and alignment of the fracture (Fig 2).

Fig 2: Post-operative X-ray antero-posterior view of right hip post insertion of PFNA

The patient continued to have poor pain control despite non-weight bearing restrictions. XR images done one-month post operation showed non-union of the fracture, fracture site displacement and PFNA cut out (Fig 3).

Fig 3: X-ray of the right hip antero-posterior view one month post-operatively showing non-union of the fracture with PFNA cut out

Infection as a cause for non-union and implant failure was ruled out. Intra-operatively, there was no sign of infection, and cultures showed no bacterial growth. The patient underwent revision total hip replacement, with a constrained liner. Post-operative plain radiographs are shown in Fig 4.

Fig 4: X-ray of pelvis antero-posterior view immediately post total hip arthroplasty

The patient underwent further rehabilitation and upon discharge after six weeks, was able to ambulate with walking frame. Plain radiographs done subsequently at ten months follow up are shown in Fig 5.

Fig 5: X-ray of pelvis antero-posterior view ten months post total hip arthroplasty

Case 2

An 80-year old lady with poor pre-morbid status (home ambulant - furniture cruiser, wheelchair user in community) presented to the Emergency Department with left hip pain after an episode of non-vertiginous giddiness led to a low energy fall. She had a history of multiple co-morbidities including hypertension, hyperlipidemia, diabetes mellitus, chronic kidney disease and osteoarthritis of her bilateral knees.

On examination, her left hip was shortened and externally rotated, with intact distal neurovascular status. Plain radiographs of the pelvis and left hip and computed tomography of the left hip revealed a comminuted left hip intertrochanteric fracture (Fig 6).

Fig 6: Pre-operative X-ray of left hip

Additional CT images of the left hip were done, which showed an involvement of the left neck of femur (Fig 7).

Fig 7: Coronal cut of CT image of the left hip pre-operatively

The patient underwent surgical fixation with a short PFNA nail and was allowed full weight-bearing as tolerated post-operatively. Post-operative radiographs are in Fig 8.

Fig 8: X-ray of the left hip antero-posterior view post PFNA insertion

The patient was re-admitted 1 month post-operatively with a fall while transferring and complained of left hip pain after. X-rays showed non-union of the previous left hip fracture, with PFNA blade migration (Fig 9).

Fig 9: X-ray of the left hip antero-posterior view one month post-operatively showing non-union of the hip fracture and PFNA blade migration

The patient then underwent left hip removal of PFNA implants, and left hip cemented hemiarthroplasty, with a greater trochanteric plate fixation (Fig 10).

Fig 10: X-ray of left hip post revision cemented hemiarthroplasty with greater trochanteric plate

She was allowed toe-touch weight bearing post-operatively and was discharged to a community hospital for rehabilitation.

Discussion

Discussion of literature: A literature review was done, and 15 case reports were noted describing 17 segmental neck of femur fractures. The cases were noted between 1989 to 2017 (Table 1). Patients' age, mechanism of injury (showing a likely high or low energy mechanism), fracture pattern (including methods of diagnosis) and management were included. Outcomes of management – fixation or replacement were recorded.

Table 1: 17 cases described in literature of segmental neck of femur fractures

Author	Sex/Age	Mechanism	Fracture configuration	Pre-operative imaging	Additional diagnosis	Management	Follow up	Outcome	Revision
An *et al*. 1989 [4]	97/M	Twisting fall	Subcapital and 4-part intertrochanteric fracture	Radiograph	Subcapital fracture noted after imaging in traction	Hemiarthroplasty – long porous coated stem with bipolar head. Cerclage wiring	8 months	No complications	No
Pemberton *et al*. 1989 [3]	73/F	Fall getting out of bed	Subcapital Garden IV and basi-cervical fracture	Radiograph Isotope bone scan	Nil	Five hole DHS	30 months	No complications. No AVN on bone scan	No
Cohen *et al*.1999 [6]	79/F	Fall at home	Comminuted pertrochanteric and subcapital fracture	Radiograph	Intra-operative fluoroscopy noted subcapital fracture	Four hole DHS	24 months	Mobilising with stick	No
Isaacs *et al*. 1993 [9]	72/F	Run over by car	Intertrochanteric & subcapital Garden II fracture	Radiographs and CT	Additional CT	Four hole DHS	1 month	Radiograph acceptable. Died afterwards of cancer.	No
Kumar *et al*. 2001 [10]	83/F	Slid down couch	Comminuted intertrochanteric & subcapital Garden II fracture	Radiographs	Nil	Derotation screw, five hole DHS, trochanteric grip plate	12 months	FWB, no hip pai. Radiographs satisfactory	No
Lakshmanan *et al*. 2005 [16]	91/F	Fell from bed	Intracapsular fracture, extends to lesser trochanter	Radiographs	Nil	Cemented hemiarthroplasty	6 months	Satisfactory clinically and radiographically	No
Sayegh *et al*. 2005 [11]	54/M	Crush injury	Pertrochanteric and subcapital fracture with nondisplaced greater trochanter	Radiographs	Nil	Open reduction. Five hole DHS and cerclage wire	58 months	Satisfactory radiographs	No
Butt *et al*. 2007 [12]	30/M	RTA	Intra-capsular and reverse oblique intertrochanteric fracture	Radiographs	Nil	DHS with derotation screw	12 months	Pain free. No AVN	No
Poulter *et al*. 2007 [13]	76/F	NA	Minimally displaced intertrochanteric fracture. Subcapital fracture	Radiographs	Nil	Percutaneous compression plate	4 months	No pain. Satisfactory radiographs	No
Dhar *et al*. 2008 [14]	30/M	RTA	Femoral neck and trochanteric reverse oblique fracture	Radiographs	Nil	Two intertrochanteric lag screws, a DCP, 2 cannulated neck screws	12 months	No pain. No AVN	No
Perry *et al*. 2008 [8]	86/F	Fall at home	Undisplaced intra-capsular fracture. Displaced trochanteric fracture.	Radiographs	Intracapsular fracture noted only 10 weeks post-mobilisation.	Four hole DHS	3 months	Fixation failed even with protected weightbearing.	Refused revision surgery
Loupasis *et al*. 2010 [15]	36/M	Motorcyclist collision with car	Garden II subcapital fracture. Displaced intertrochanteric fracture	Radiographs	Nil	Three hole DHS. Derotation screw	24 months	Asymptomatic. Radiographs satisfactory	No

Neogi *et al*. 2011 [7]	28/M	Front seat passenger in RTA	Reverse oblique trochanteric fracture. Minimally displaced intracapsular fracture.	Radiographs. CT scan.	Intra-capsular fracture noted on contralateral hip CT	DCS and derotation screw	28 months	Functionally good. No AVN.	No
Tahir *et al*. 2014 [5]	87/F	Fall at nursing home	Minimally displaced intertrochanteric and subcapital fracture	Radiographs. CT scan	Nil	Cemented bipolar hemiarthroplasty and trochanteric plate	3 months	Improving mobility. Satisfactory radiographs.	No
Khan *et al*. 2017 [17]	66/M	Fall	Displaced intracapsular and intertrochanteric fracture	Radiographs	Nil	Total hip replacement with trochanteric grip plate	18 months	Mobilising unaided. Radiographs satisfactory.	No
	82/M	Fall	Intracapsular fracture, subtrochanteric fracture	Radiographs. CT scan.	Nil	Total hip replacement with plate stabilisation	12 months	Mobiliizing with walking stick. Satisfactory radiographs	No
	80/F	Fall	Intracapsular fracture and subtrochanteric fracture	Radiographs	Nil	Hemiarthroplasty – uncemented modular, taper-fluted titanium stem	24 months	Mobile with Zimmer frame	No

Investigations done

Of the 17 patients diagnosed with SFNOF, the fractures were not initially noted in 4 of the cases. Cohen *et al*. [6] noted the additional fracture on intra-operative fluoroscopy. Repeat radiographs on traction showed the additional fracture in the case of An *et al*. [4] For Neogi *et al*. [7], computed tomography of the contralateral hip revealed the extent of the fracture, while for Perry *et al*. [8], the neck of femur fracture was only noted after dynamic hip screw fixation failed and displaced after 10 weeks of mobilization.
2 other cases also underwent a computed tomography scan pre-operatively [5, 9] for better fracture delineation.

Management and outcomes

A mixture of fixation methods and hip replacement has been reported in literature.
Of the 17 cases, 11 cases underwent fixation with dynamic hip screws, compression plating, dynamic condylar screws and similar fixation constructs [3, 6, 7, 9-15]. Only 1 of these 11 cases had a failure of fixation with avascular necrosis [8] despite protected weight bearing. The patients had an age range of 28-86 years. It must be noted that a large number of these cases that underwent fixation were patients of a younger age group, and the oldest patient in these 11 cases (86 years old) had a failure of fixation.
6 cases [4, 5, 16, 17] underwent a hip replacement, either primary hemiarthroplasty or total hip replacement. Fixation devices such as cerclage wiring, and greater trochanteric plates were used. These patients were generally noted to be older, with an age range of 66-97 years old. All cases that underwent a primary hip arthroplasty had good outcomes post-operatively.

Risk of failure of fixation

The adult femoral head is supplied by the lateral group of the ascending cervical branches of the extra-capsular ring. This is formed by the medial and lateral circumflex arteries [18]. There is also an intra-articular arterial ring, where epiphyseal arterial branches enter the femoral head [19].
There is a risk of avascular necrosis (AVN) in sub capital fractures in view of the disruption to these vessels. Age plays a factor in the AVN rate, as reported by Ravikumar *et al*. [20]. An additional fracture at the trochanteric region increases the instability of the fracture, causing bony and soft tissue injury, and thus, can lead to a higher risk of AVN. In SFNOF, the risk of AVN is quoted by Tahir *et al*. [5] to be 20% risk, an even higher risk of 33% in those aged above 65.
Osteoporosis has also been shown to contribute to increased risks of surgical complications after fracture fixation. Fixation failure rates in elderly with osteoporotic neck of femur (NOF) fractures have been quoted to be as high as 15% in undisplaced NOF fractures and 41% in displaced NOF fractures [21].

Consideration for further imaging

For patients where there is a high index of suspicion of additional fractures, or poor visualization of the fracture extent with plain radiographs, additional pre-operative imaging such as a computed tomography (CT) scan can be done. This also helps with surgical planning.
As seen in Case 2, our patient had undergone a pre-operative CT scan of the left hip prior to surgery, which could have suggested to the surgeons to do a primary hemi-arthroplasty instead of a short PFNA fixation.

Management algorithm

In our case series, the fracture configuration of the patient in Case 1 was a displaced sub-capital fracture with concomitant 4-part inter-trochanteric fracture, while that in Case 2 was a comminuted inter-trochanteric fracture with involvement of the femoral neck.
While other cases have been managed well with percutaneous compression plates and dynamic hip screws, anti-rotation screws [10, 13, 15], these patients had an un-displaced subcapital fracture.
The risk of AVN in a displaced subcapital fracture is higher due to disruption of the blood supply. The cases in our series appears to be similar to that managed by Tahir *et al*. [5]. Tahir *et al*. [5] describes a fracture configuration of a displaced subcapital element and concomitant intertrochanteric and greater trochanteric fracture. As per

their algorithm for the management of segmental neck of femur fractures [5], for patients above 65 years old with a displaced intra-capsular component, a hip arthroplasty should be considered. In Tahir *et al*. [5], the greater trochanteric fracture was fixed with a cable grip device, before a hemiarthroplasty was performed.

Khan *et al*. [17] also described 3 cases (66, 80 and 82 years of age) of an intra-capsular femoral neck fracture with concomitant trochanteric fractures or extension. All three had undergone primary arthroplasty, in order to reduce the chances of revision surgery from the high risk of fixation failure.

As the patients in our case series had a displaced subcapital fracture, advanced age (80 and 90 years old), with an additional unstable intertrochanteric fracture, consideration for primary arthroplasty with fixation of the medial buttress with either a trochanteric plate or cables could have been considered.

Repeated surgeries from fixation failure increases the risk of morbidity and mortality. In addition, a single primary arthroplasty has the benefit of earlier mobilization, decreasing the complications associated with immobility in the elderly. Literature has shown that better outcomes have been reported with total hip arthroplasty, including return to baseline or near baseline functional ambulation status upon recovery [22].

If fixation is considered in patients with SFNOF, a consideration could be internal fixation with a long nail and cement augmentation for example a long cemented TFNA. These may reduce the risk of complications, implant failure and cut out [23].

Conclusion

Ipsilateral segmental fractures of the neck of femur (SFNOF) are rare injuries that pose challenging problems. Considerations such as fracture pattern, patient's age, co-morbidities should be taken into account. Primary arthroplasty instead of fixation should be considered for older patients with SFNOF involving displaced intra-capsular fractures. For fracture patterns that are not clearly defined, pre-operative CT scans are recommended.

Declarations

There are no conflicts of interest to declare. This case series has no funding.

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