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Segmental Fractures of the Neck of Femur: Fix or Replace?

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A B S T R A C T

Combined intracapsular and extracapsular fractures of the proximal femur—segmental fractures of neck of femur (SFNOF)—are rare and complex injuries. Literature regarding SFNOF is very limited; only one small retrospective study and 19 unique case reports have been described. We report the case of a 42-year-old man who suffered a compound subcapital femur fracture type Garden IV and an ipsilateral multifragmentary greater trochanter fracture from severe crush trauma. Neither the precise fracture constellation nor our management strategy, primary cemented total hip arthroplasty combined with tension band cerclage and triple K-wire trochanteric fixation, has been described in contemporary literature. We conclude that SFNOF needs clear categorization and derivative treatment principles. Prosthesis longevity, risk of nonunion, and avascular necrosis should be considered.

Introduction

Concomitant ipsilateral intracapsular and extracapsular fractures of the femur—SFNOF—occur very rarely. Clear classification of all fracture components is necessary, and the corresponding state of the blood supply to the femoral head will dictate appropriate treatment selection.

Prevalence of SFNOF is divided over 2 demographic groups. First, there is the geriatric patient population, that suffer SFNOF from low-energy trauma such as simple falls. However, the underlying osteoporosis or even pathological encroachment of the bone needs to be considered. Second, the younger patient population suffer SFNOF from high-impact trauma such as crush injuries or road traffic accidents [1].

SFNOFs are associated with significant complication risks, such as avascular necrosis of the femoral head (AVN), malfunction of the hip abductor apparatus, malunion, and nonunion. Owing to the rarity of SFNOF, limited research has been conducted regarding prevalence of these complications. However, given that SFNOF are in essence a complex mixture of intracapsular and extracapsular fractures, it is important to be aware of the complications of each respective fracture type and select the most appropriate treatment plan accordingly [1].

Case history

Informed consent

Before gathering all data, informed consent was acquired from the involved patient.

Patient information and clinical findings

A 42-year-old man was admitted to the emergency department after suffering a crush injury when he was ran over by a heavy crane at a construction site. Upon arrival, the patient had a Glasgow Coma Scale (GCS) of 15/15 and experienced dyspnoea. The right lower extremity was in an externally rotated and shortened position. Upon clinical examination, the patient reported pain at the right hip and left knee. When briefing the exact patient situation, the emergency physician described a patellar luxation of the left knee, which he had already reduced on site. Analgesics were administered according to the emergency room traumatology protocol. No evidence of nerve or vascular injury to the lower or upper limbs was noted. No previous injuries or illness were mentioned in the patient's medical records.

Further diagnostic assessment

Computed tomography imaging of the thorax and abdomen showed bilateral lung contusion. Radiographs (Figs. 1 and 2) show a

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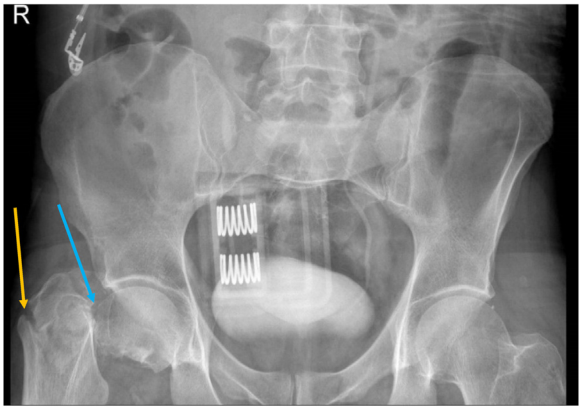

Figure 1. Anteroposterior radiographic view of the patient's pelvis. Blue arrows point to subcapital (intracapsular) fracture. Yellow arrows point to trochanteric (extracapsular) fracture.

compound subcapital femur fracture type Garden IV (complete displacement), Pauwels III (vertical orientation), and an ipsilateral multifragmentary trochanteric avulsion fracture. Advanced imaging using CT scan and 3D reconstruction was performed for precise assessment of subcapital displacement and extent of the trochanteric fracture (Fig. 3).

Therapeutic intervention

Conscientious determination of the appropriate surgical management plan was necessary; the 2 primary options were osteosynthesis or arthroplasty. Concerning the femoral neck fracture: 3D-CT imaging showed extensive comminution and vertical orientation. These findings and the additional marked displacement of the femoral head would render an osteosynthesis procedure technically demanding and the risk of AVN or loss of fixation substantial. After taking these considerations into account, a cemented Pinnacle C-stem THA (total hip arthroplasty) using a posterior approach to the hip joint was performed. Opting for a cemented stem, we deemed the risk that cement could possibly interfere with osseous healing less impendent than the risk of propagating the fracture further down the trochanteric and subtrochanteric region when reaming the medullary canal in preparation of inserting an uncemented stem.

Concerning the trochanteric fracture, the 3D-CT showed marked fragmentation. With the aim of not injuring the precarious gluteal muscles any further, a minimally invasive approach to the greater trochanter was executed. Protecting the abductor apparatus additionally, we performed a tension band (and triple K-wire) osteosynthesis. This open reduction internal fixation method is superior to hook-plate systems regarding preservation of the gluteal musculature and thus preventing a limping gait outcome.

No complications occurred during admittance; postoperative radiographs (Fig. 4) showed anatomical and maintained position of both the trochanteric osteosynthesis and the THA. The patient remained at our department of orthopedics and traumatology so that an optimized postoperative analgesia protocol could be administered and the initial rehabilitation could be supervised. At 7 days postoperatively, the patient was discharged, respecting plantar touch-weight-bearing with 2 crutches for 6 weeks.

Follow-up

The first postoperative follow-up consultation took place after 2 weeks. Upon clinical anamnestic examination, the patient reported activity-related pain in the right hip joint. Furthermore, the passive range of motion of the hip was still confined: hip flexion of 90°, extension of 10°, abduction of 30°, and adduction of 15°. The patient followed an outpatient modified THA rehabilitation program at the specialized department of our hospital. No wound infection signs were present, and the sutures were removed successfully. At 4 months after surgery, no wound healing problems had occurred, and the patient did not report any complaints of pain.

Figure 2. Anteroposterior radiographic view of the patient's right femur. Blue arrows point to subcapital (intracapsular) fracture. Yellow arrows point to trochanteric (extracapsular) fracture.

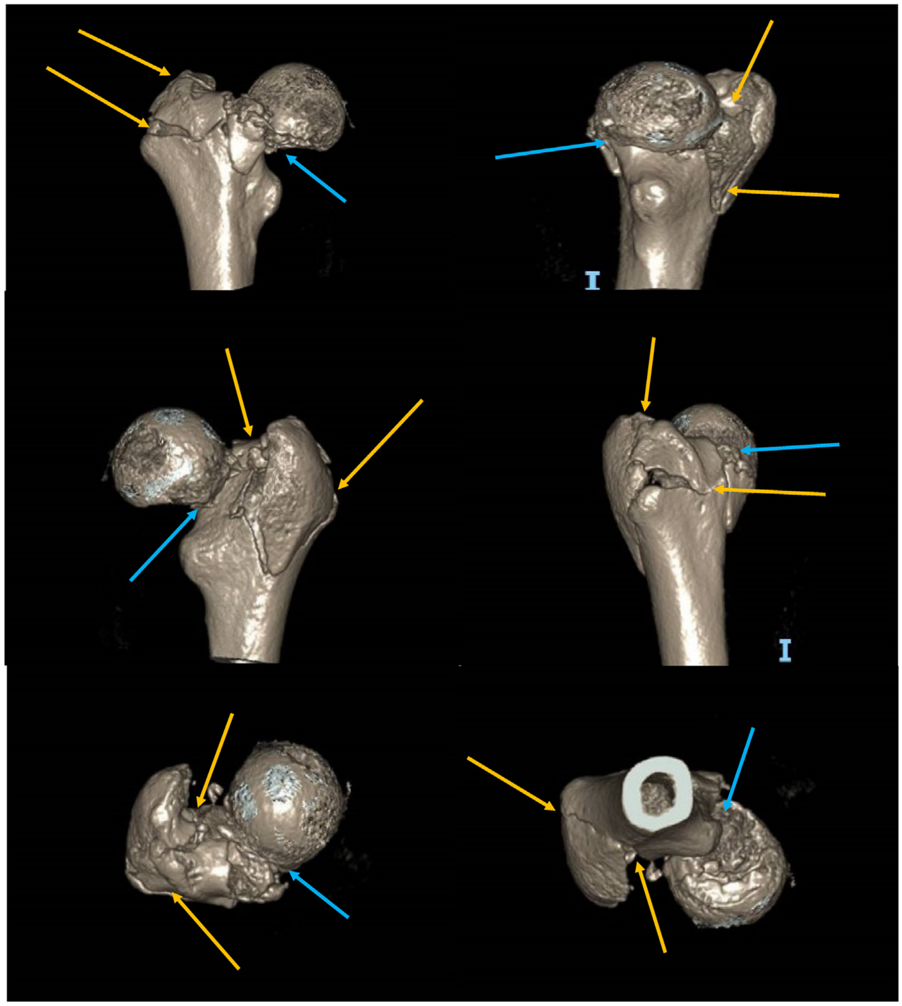

Figure 3. Three-dimensional CT proximal femur. Blue arrows point to subcapital (intracapsular) fracture. Yellow arrows point to trochanteric (extracapsular) fracture.

Nonetheless, he still needed one crutch for walking. Upon clinical examination, Trendelenburg gait was diagnosed, and pain could be provoked when applying pressure to the greater trochanter.

Taking into account that the K-wire osteosynthesis of the greater trochanter might cause irritation of the medial and minimal gluteal muscle and friction on the iliotibial tract, the aforementioned clinical findings could have been expected. After explaining the cause of the limping gait and local pain to the patient, informed consent was acquired to perform a surgical removal of the K-wire osteosynthesis material.

Postoperative radiograph (Fig. 5) showed maintained and anatomical position of the osteosynthesis and the total hip prosthesis and osseous healing of the greater trochanter. At 6 weeks after the surgical hardware removal, the patient no longer exhibited Trendelenburg gait and did not report any pain in the greater trochanter region whatsoever.

Outcome

These radiographic findings, the anatomical and clinical outcome of the surgical procedures, render this SFNOF successfully treated. Additional follow-up appointments were conducted at 4 and 8 months after the second surgical procedure, respectively. The aforementioned rehabilitation scheme was successfully completed and full functionality was achieved eventually.

Discussion

We performed a literature review and found 19 unique case reports and one small retrospective study. Treatment strategy has not been standardized in the 19 cases reported in literature (Table 1 [1–17]). Yoo et al. performed a retrospective study reporting the efficacy of cephalomedullary nailing (CMN) as treatment for SFNOF in a geriatric population, injured by simple fall. Twenty-eight of 33 patients obtained osseous union. Three patients experienced implant penetration through the femoral head (cut-through and cut-out). One case of CMN-breakage and one case of nonunion due to implant loosening was observed. BHA was performed as revision surgery in 4 cases; one patient refused revision [18].

As only limited data are available regarding treatment of SFNOF fractures, we advise the provisional management algorithm to be based on 3 major criteria. First, the precise classification of the intracapsular and extracapsular fracture components. Second, the corresponding and most appropriate treatment option of each fracture component. Finally, the risks and (dis)advantages of each respective treatment strategy.

Intracapsular fractures consist of femoral head, subcapital, midcervical, and basicervical fractures. Extracapsular fractures are divided into trochanteric avulsion, pertrochanteric, intertrochanteric, and subtrochanteric fracture types. Clear classification of these fractures is essential, as intracapsular fractures exhibit only

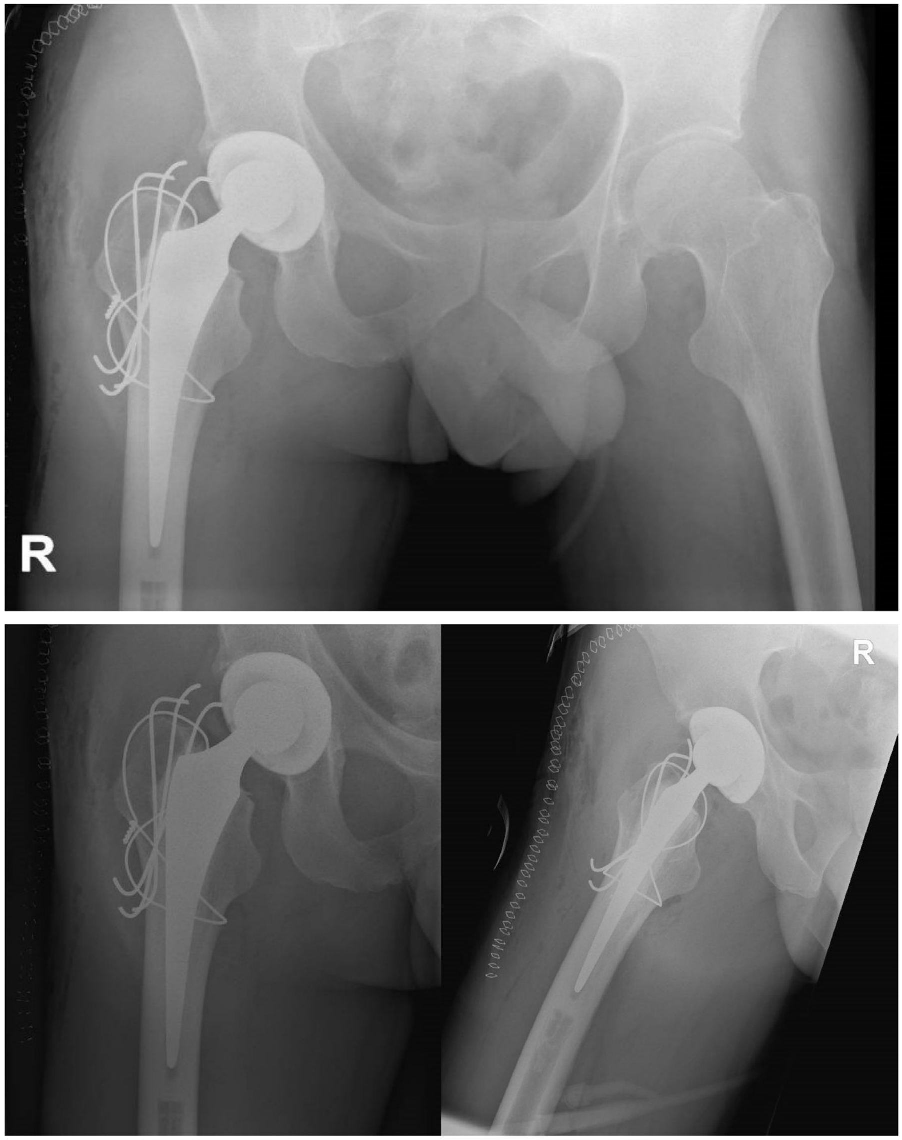

Figure 4. Postoperative radiographic imaging of pelvis and femur.

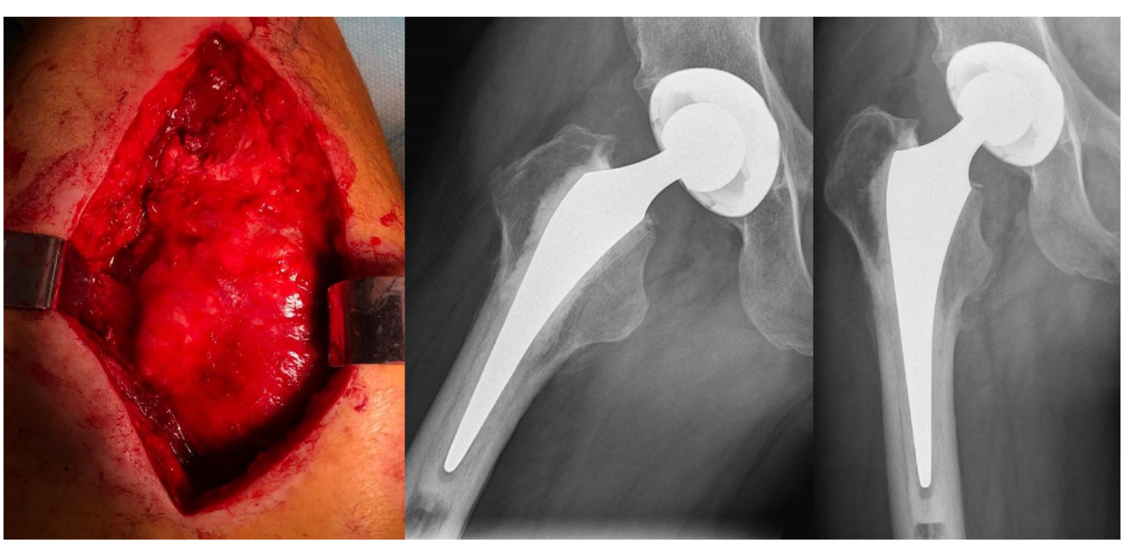

Figure 5. Preoperative view of the medial and minimal gluteal muscles insertion. Postoperative imaging of femur after removal of cerclage and K-wires.

Table 1
Overview of all unique case reports of SFNOF.

Author/y	Age	Sex	Mechanism	Fracture type	Preoperative imaging	Implant used	Follow-up (mo)	Outcome
Pemberton, 1989 [2]	73	F	Fall	Basocervical + subcapital	X-ray + isotope bone scan	DHS	30	Good
An, 1989 [3]	97	M	Fall	Intertrochanteric + subcapital	X-ray	Hemiarthroplasty + cerclage	8	Good
Lawrence, 1993 [4]	72	F	Fall	Intertrochanteric + subcapital	X-ray	Pinning	2	Death-unrelated
Cohen, 1999 [5]	79	F	Fall	Peritrochanteric + subcapital	X-ray	DHS	24	Good
Oda, 2001 [6]	89	F	Fall	Peritrochanteric + subcapital	X-ray, CT, MRI	BHP	NA	Good
Kumar, 2001 [7]	83	F	Fall	Intertrochanteric + subcapital	X-ray	DHS + TSP + ARS	12	AVN
Lakshmanan, 2005 [8]	91	F	Fall	Subcapital with extracapsular extension	X-ray	Hemiarthroplasty	6	Good
Sayegh, 2005 [9]	54	M	Crush injury (olive press)	Intertrochanteric + subcapital	X-ray	DHS + cerclage	58	Good
Poulter, 2007 [10]	76	F	Fall	Intertrochanteric + subcapital	X-ray	PCCP	4	Good
Butt, 2007 [11]	30	M	RTA	Intertrochanteric reverse oblique + intracapsular	X-ray	DHS + ARS	12	Good
Perry, 2008 [12]	86	F	Fall	Intertrochanteric + intracapsular	X-ray	DHS	3	AVN
Dhar, 2008 [13]	30	M	RTA	Intertrochanteric reverse oblique + intracapsular	X-ray	DCP + lag screws	12	Good
Loupasis, 2010 [14]	36	M	RTA	Intertrochanteric + subcapital	X-ray	DHS + ARS	24	Good
Neogi, 2011 [15]	38	M	RTA	Intertrochanteric reverse oblique + intracapsular	X-ray, CT	DCS + ARS	28	Good
Tahir, 2014 [16]	87	F	Fall	Intertrochanteric + subcapital + greater trochanter	X-ray, CT	BHP and proximal femur ORIF	3	Good
Saleeb, 2017 [17]	88	F	Fall	Intertrochanteric + subcapital	X-ray, CT	THP cementless	NA	Good
Khan, 2017 [1]	66	M	Fall	Intertrochanteric + subcapital	X-ray	THP with constrained liner + trochanteric grip plate	18	Good
Khan, 2017 [1]	82	M	Fall	Subtrochanteric + subcapital	X-ray, CT	THP with plate stabilization for the fracture extension	12	Good
Khan, 2017 [1]	80	F	Fall	Subtrochanteric + subcapital	X-ray	BHP long stem	24	Good

AVN, avascular necrosis; CT, computed tomography; MRI, magnetic resonance imaging; NA, not available; ORIF, open reduction internal fixation; SFNOF, segmental fractures of neck of femur; DHS, dynamic hip screw; BHP, bipolar hip prosthesis; TSP, trochanteric stabilisation plate; ARS, anti-rotation screw; PCCP, percutaneous compression plating; RTA, road traffic accident; DCP, dynamic compression plating; THP, total hip prosthesis.

limited healing capabilities [19]. Regarding blood supply to the femoral head, the deep femoral artery serves as the main provider by its 2 major branches: the medial and lateral circumflex femoral arteries. Bhandari and Swiontkowski provide a visual representation of the underlying anatomical rationale as well as an evidence-based management algorithm regarding the standardized treatment of acute hip fractures, when divided into separate types [20]. Guidelines and recent (systematic) reviews of contemporary literature provide a clear treatment overview [19,21].

Preoperatively, we have considered the option of a dynamic fixation device supplemented with an antirotation screw [22]. When using CMN in a younger population, the risk of damaging the medial gluteal tendon insertion needs to be taken into account. Especially when the greater trochanter region is already fragmented. Even when opting for CMN, this complex fracture would require an open and technically demanding reduction [19,21].

According to Panteli et al., the vertically oriented (Pauwels III) intracapsular fracture component in our case should be treated with dynamic hip screw [23].

Nonetheless, considering the high degree of displacement of the femoral head, the overall risk of AVN and nonunion in Pauwels III fractures despite appropriate management, the comminution of both intracapsular and extracapsular fracture sites and the additional complication risks of osteosynthesis, we preferred THA.

In 2017, Khan et al. reported 3 cases of SFNOF treatment using hip arthroplasty, one of which regarded a 66-year-old patient [1]. Similar to our case, this patient was treated with THA and a secondary fixation device [1]. Owing to the course and extent of comminution of the fracture in our case, and considering the personal experience of the senior orthopedic surgeon treating this case, we decided not to use a trochanteric hook plate or cable-grip device. Two years earlier, a patient suffering a similar trochanteric fracture was treated with a trochanteric hook plate system and had developed an extensive medial and minimal gluteal muscle necrosis with subsequent invalidating abductor weakness and limping gait.

Consequently, in order to treat the extracapsular fracture component in our case, a tension band fixation was executed. Nonetheless, we were conscious that this method could lead to some irritation of the abductor apparatus and iliotibial band.

In 2018, Mei et al. performed a systematic review, comparing different fixation methods for trochanteric fractures [24]. Cerclage and K-wire osteosynthesis demonstrated lower rates of bursitis when compared to trochanteric bolts and cable-plate devices. Notwithstanding the theoretical mechanical superiority, postoperative clinical outcomes, particularly in compound fractures or revision cases, remain suboptimal for cable-plate devices [24].

Devising a standardized treatment algorithm for SFNOF, we advise that the following concepts should be conscientiously considered in future research: clear fracture component classification, prosthesis longevity, functionality of the abductor apparatus, risk of nonunion, AVN, and general complications of each surgical procedure.

Concerning the complication risk of AVN, a systematic review by Duckworth et al. reported an incidence of 11.5% after fixation of intracapsular fractures of the femoral neck in young patients [25]. A recent retrospective cohort study by Stockton et al. described an incidence of AVN and subsequent reoperation rate and conversion to THA of 14% after internal fixation of femoral neck fractures in a young patient population [26]. Papakostidis et al. conducted a systematic review investigating the importance of osteosynthesis surgery timing on development of AVN [27]. Before and after 6 hours, they reported 12.5% vs 25.1%. Before and after 12 hours, they reported 7.9% vs 8.1%. Before and after 24 hours, they reported 21.7% vs 24.7%. In this same review, nonunion rates before and after 6 hours of 1.5% vs 17.1%; before and after 12 hours of 0-25% vs 27%; before and after 24 hours of 6.4% vs 17.3% were reported [27]. In 2014, another systematic review was performed by Slobogean et al., reporting an AVN incidence of 14.3% and nonunion incidence of 9.3% in femoral neck fractures in a young patient population [28].

The additional fracture complexity and disruption of soft tissue in SFNOF renders obtaining good long-term results even more difficult and increases AVN risk.

In 2017, Noda et al. reported a postoperative decline of 25-30% of muscular strength in abductor function when comparing CMN to bipolar hip prosthesis for treatment of extracapsular intertrochanteric fractures [29]. Ozsoy et al. reported superior gluteal nerve injury in 2.8% of patients and myogenic damage of medial and minimal gluteal muscles in 20% after CMN treatment of extracapsular proximal femur fractures [30].

Prosthesis longevity should be considered when deciding to perform THA in a 42-year-old patient. Halvorsen et al. reviewed the data from the Nordic Arthroplasty Register Association from 1995 to 2016 regarding the outcome of 881 THAs in 747 patients of age 21 years or younger [31]. They found that at 10 years, the overall prosthesis survival rate was 86%. Schmitz et al. reviewed the long-term results of cemented THA in patients aged less than 30 years and the outcome of subsequent revisions [32]. They defined the need for revision surgery for aseptic loosening as endpoint. Subsequently, they found a 90% survival rate at 10 years and an 82% survival rate at 15 years after surgery. At 10 years after revision reimplantation surgery, none of the 13 cases required rerevision. In 2018, Kiran et al. performed a prospective study including 104 patients younger than 55 years who underwent cemented THA [33]. They described a mean Harris Hip Score of 88 at a mean follow-up of 25 years in 89% of the cases. With the need for revision as endpoint, survivorship was 97% at a minimum 22-year follow-up [31–33].

Summary

We found that SFNOF are rare and complex injuries that need clear categorization and derivative treatment principles. They demonstrate a bimodal distribution in patient age and respective injury mechanisms. We advise meticulous preoperative planning considering exact patient/fracture configuration. In SFNOF treatment, orthopedic surgeons should take all complication risks and (dis)advantages of the treatment options (arthroplasty and osteosynthesis) into consideration.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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The patient acknowledged informed consent regarding the publication of this case report, as his personal data, except for age and medical imaging, were not included. No funding sources are applicable for publication of this case report.

References

[1] Khan W, Williams R, Hopwood S, Agarwal S. Combined intracapsular and extracapsular neck of femur fractures case series, literature review and management recommendations. Open Orthop J 2017;11:600.
[2] Pemberton DJ, Kriebich DN, Moran CG. Segmental fracture of the neck of the femur. Injury 1989;20(5):306.
[3] An HS, Wojcieszek JM, Cooke RF, Limbird R, Jackson WT. Simultaneous ipsilateral intertrochanteric and subcapital fracture of the hip. A case report. Orthopedics 1989;12(5):721.
[4] Lawrence B, Isaacs C. Concomitant ipsilateral intertrochanteric and subcapital fracture of the hip. J Orthop Trauma 1993;7(2):146.
[5] Cohen I, Rzetelny V. Simultaneous ipsilateral pertrochanteric and subcapital fractures. Orthopedics 1999;22(5):535.
[6] Oda Y, Yamanaka M, Tada H, Isaka N. A case of femoral neck and trochanteric fracture in ipsilateral femur. Orthop Traumatol 2001;50(4):1072.
[7] Kumar R, Khan R, Moholkar K, Smyth H, Borton D. A rare combination fracture of the neck of femur. Eur J Orthop Surg Traumatol 2001;11(1):59.
[8] Lakshmanan P, Peehal JP. Management of an unusual intra- and extra-capsular subcapital femoral neck fracture. Acta Orthop Belg 2005;71(5):622.
[9] Sayegh FE, Karataglis D, Trapotsis SJ, Christoforides JE, Pournaras JD. Concomitant ipsilateral pertrochanteric and subcapital fracture of the proximal femur. Eur J Trauma 2005;31(1):64.
[10] Poulter R, Ashworth M. Concomitant ipsilateral subcapital and intertrochanteric fractures of the femur. Inj Extra 2007;38:88.
[11] Butt MF DS, Hussain A, Gani NU, Kangoo KA, Farooq M. Femoral neck fracture with ipsilateral trochanteric fracture: Is there room for osteosynthesis? Internet J Orthop Surg 2007;5.
[12] Perry DC, Scott SJ. Concomitant ipsilateral intracapsular and extracapsular femoral neck fracture: a case report. J Med Case Rep 2008;2:68.
[13] Dhar S, Mir MR, Butt MF, Farooq M, Ali MF. Osteosynthesis for a T-shaped fracture of the femoral neck and trochanter: a case report. J Orthop Surg 2008;16(2):257.
[14] Loupasis G, Ntagiopoulos PG, Asimakopoulos A. Concomitant ipsilateral subcapital and intertrochanteric fractures of the femur: a case report. J Med Case Rep 2010;4:363.
[15] Neogi DS, Ajay Kumar KV, Trikha V, Yadav CS. Ipsilateral femoral neck and trochanter fracture. Indian J Orthop 2011;45(1):82.
[16] Tahir M, Lakkol S, Naique S. Segmental neck of femur fractures: a unique case report of an ipsilateral subcapital, greater trochanteric and intertrochanteric fracture and proposed management algorithm. Int J Surg Case Rep 2014;5(5):277.
[17] Saleeb H, Kanvinde R, Rahman T. Literature review and case report: current concepts for concomitant intra and extracapsular fractures of neck of femur in elderly patients. Trauma Case Rep 2017;8:24.
[18] Yoo H, Cho Y, Hwang S. Outcomes of combined neck and trochanter fractures of the femur treated with cephallomedullary nail in elderly. Hip Pelvis 2019;31(4):200.
[19] Hayat Z, Varacallo M. Surgical management of femoral neck fractures. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2020.
[20] Bhandari M, Swiontkowski M. Management of acute hip fracture. N Engl J Med 2017;377(21):2053.
[21] Emmerson BR, Varacallo M, Inman D. Hip Fracture Overview. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.
[22] Shen M, Wang C, Chen H, Rui YF, Zhao S. An update on the Pauwels classification. J Orthop Surg Res 2016;11(1):161.
[23] Panteli M, Rodham P, Giannoudis PV. Biomechanical rationale for implant choices in femoral neck fracture fixation in the non-elderly. Injury 2015;46(3):445.
[24] Mei XY, Gong YJ, Safir OA, Gross AE, Kuzyk PR. Fixation options following greater trochanteric osteotomies and fractures in total hip arthroplasty: a systematic review. JBJS Rev 2018;6(6):e4.
[25] Duckworth AD, Bennet SJ, Aderinto J, Keating JF. Fixation of intracapsular fractures of the femoral neck in young patients: risk factors for failure. J Bone Joint Surg Br 2011;93(6):811.
[26] Stockton DJ, O'Hara LM, O'Hara NN, et al. High rate of reoperation and conversion to total hip arthroplasty after internal fixation of young femoral neck fractures: a population-based study of 796 patients. Acta Orthop 2019;90(1):21.
[27] Papakostidis C, Panagiotopoulos A, Piccioli A, Giannoudis PV. Timing of internal fixation of femoral neck fractures. A systematic review and meta-analysis of the final outcome. Injury 2015;46(3):459.
[28] Slobogean GP, Sprague SA, Scott T, Bhandari M. Complications following young femoral neck fractures. Injury 2015;46(3):484.
[29] Noda M, Saegusa Y, Takahashi M, et al. Comparison of post-operative muscular strength between gamma nailing and hemiarthroplasty system in femoral intertrochanteric fractures. Open Orthop J 2017;11:255.
[30] Ozsoy MH, Basarir K, Bayramoglu A, et al. Risk of superior gluteal nerve and gluteus medius muscle injury during femoral nail insertion. J Bone Joint Surg Am 2007;89(4):829.
[31] Halvorsen V, Fenstad AM, Engesæter LB, et al. Outcome of 881 total hip arthroplasties in 747 patients 21 years or younger: data from the Nordic Arthroplasty Register Association (NARA) 1995-2016. Acta Orthop 2019;90(4):331.
[32] Schmitz MW, Busch VJ, Gardeniers JW, et al. Long-term results of cemented total hip arthroplasty in patients younger than 30 years and the outcome of subsequent revisions. BMC Musculoskelet Disord 2013;14:37.
[33] Kiran M, Johnston LR, Sripada S, Mcleod GG, Jariwala AC. Cemented total hip replacement in patients under 55 years. Acta Orthop 2018;89(2):152.