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Case Series

"Cut-In" Phenomenon – the Rare and Secret Complication of Proximal Femoral Nails – 2 Case Reports and Review of Literature

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Abstract

The use of intramedullary devices to fix intertrochanteric Neck of Femur fractures is an internationally well-established fixation method which demonstrated mechanical and biological advantages, especially in the treatment of unstable fractures patterns. Despite the biomechanically proved advantages of the proximal femoral nails, some complications had occurred over the years. A very rare type of complication was sporadically reported over the last few years, and was termed "Cut-in" or "medial migration" of the blade. We will present our experience of 2 cases with the "cut-in" complication and review the latest literature.

INTRODUCTION

Proximal femoral intertrochanteric fractures are among the most common fracture types within the elderly population [1]. These fractures are usually the result of low energy traumatic falls and require surgical treatment in most cases. The use of intramedullary devices to fix these fractures is an internationally well-established fixation method which demonstrated mechanical and biological advantages, especially in the treatment of unstable fractures such as the reverse-oblique and subtrochanteric fracture patterns [2-8].

The Proximal Femoral Nail Antirotation (PFNA; Synthes, Oberdorf, Switzerland) is a recently developed intramedullary fixation device which utilizes a helical blade rather than a conventional screw [9]. The blade is claimed to be biomechanically more resistant to the conventional "cut-out" phenomena, because it achieves bony purchase through bone compaction as it is being advanced into the femoral neck [10-12].

Despite the biomechanically proved advantages of the PFNA in the treatment of unstable pertrochanteric fractures, some complications had occurred over the years, the most common being cut-out of the blade and periprosthetic diaphyseal femur fractures at the distal tip of the nail [9,10,13-15]. A very rare type of complication which represents a different type of mechanical failure of the nail was sporadically reported over the last few years, and was termed "Cut-in" or "medial migration" of the blade [9,16-21]. The reported incidence of this complication is between 0.6-6.3% in different reports [16,22].

We have been using the PFNA for the treatment of pertrochanteric fractures in our institution since 2009, and currently encountered two cases of cut-in of the blade into the acetabulum. We will present these two cases and review the current literature and data regarding this rare complication, with the aim of increasing the awareness amongst orthopaedic trauma surgeons to this rare and troubling complication.

CASE

A 68 years old man, with a history of type 2 Diabetes Mellitus, end stage kidney disease with chronic hemodialysis treatment, hypertension and atrial fibrillation, was admitted to our orthopaedic surgery department after a fall during the night, which resulted in an AO 31- A2.2 neck of femur fracture on his right hip (Figure 1). The next morning he was taken to theatre, where closed reduction and internal fixation were done, using a 12mm wide, 200mm long and 130 degrees PFNA. A 105mm blade was used without predrilling of the neck and head. Intraoperative fluoroscopy revealed satisfactory outcome, with a tip-apex distance of 22mm, and a center-center location of the blade within the femoral head.

The patient started full weight bearing exercises on the second post-operative day, without restrictions, according to our usual protocol, and was discharged to a rehabilitation center after 7 days, when he was able to walk a few meters, for further training.

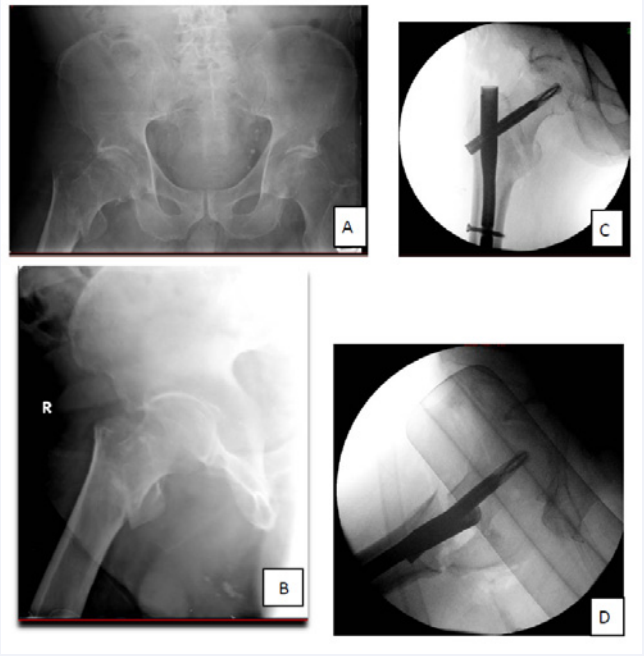

Figure 1 A+B: AP and Axial views demonstrating a Right sided pertrochanteric fracture of the hip. C+D: intra-operative final fluoroscopy after PFNA fixation.

The patient did not return to our follow-up clinic as requested, most likely due to general deterioration and a CVA he had sustained which unfortunately left him wheelchair bound and hemiparetic a few weeks after the operation, and we first saw him again in clinic 15 months after the operation. The x-rays (Figure 2) demonstrate backing out of the PFNA blade with compression at the fracture site and callus formation, however, without complete union of the fracture at that stage. The patient was not walking at that stage anymore and was only standing passively on the leg for transfers. He was pain free and a-symptomatic.

The next clinic visit was 10 months later, about two years after the original surgery, after the patient started to complain of hip pain. The X-rays (Figure 3) shows cutting-in of the blade into the acetabulum and through the quadrilateral plate, with full union of the hip fracture. The patient was immediately admitted and taken into theatre again, where the blade was removed without any complications (Figure 4). The patient was discharged two days later and did not return again for further follow-up.

CASE

A 77 year old man with medical history of hypertension, presented with an AO 31-A2.2 neck of femur fracture to his Right hip after a fall at home (Figure 5). He was operated the next morning and had a closed reduction and internal fixation using a 200/10mm, 130 degrees PFNA, with a 105mm blade. No predrilling of the femoral neck or head was performed. Intraoperative fluoroscopy demonstrated satisfactory results, with Tip-Apex Distance of 20mm and a center-center position of the blade within the femoral head.

The patient began weight bearing on the 2nd post-operative day and was discharged to a rehabilitation center 4 days after surgery, to continue his recovery. The first follow-up visit to our clinic was 1 month after surgery, when the patient came in walking with his cane, as per his condition before the injury. He had full range of motion of the right hip and was pain free. X-rays shows good position of the blade with some degree of compression and callus formation around the calcar area (Figure 6).

The second clinic visit was 2 months later. The patient began complaining of mild hip pain but was walking with his cane without any obvious clinical limitations. The X-rays demonstrated further compression of the fracture with backing-out of the blade but without any displacement at the fracture site (Figure 7). The next visit was 3 months later, now reaching 6 months from the operation. The patient was still walking, now with apparent limping, and complained of intense pain in his Right hip that had appeared 2 weeks prior to the current visit. X-rays showed cutting-in of the blade into the acetabulum (Figure 8). The patient was admitted immediately and was taken to theatre the next morning.

During the operation, the blade was removed and a new shorter blade was inserted (Figure 9). Unfortunately, the next clinic visit, 1 month after the operation demonstrated, again, cutting in of the new blade, and a second operation had to be done where the blade was completely removed (Figure 10). The last follow-up visit was 1 month after the 2nd removal. The patient demonstrated great clinical improvement and effectively returned to his pre-fracture function. X-rays demonstrated full healing of the fracture (Figure 9).

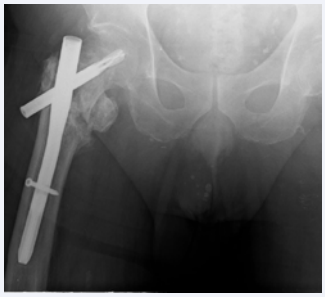

Figure 2 Backing out of the PFNA blade with compression at the fracture site.

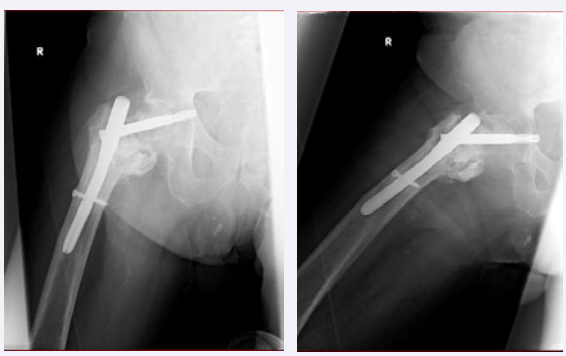

Figure 3 Cut-In of the blade into the acetabulum.

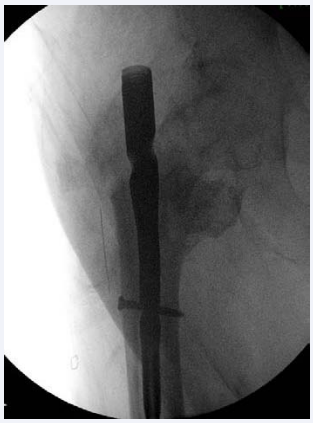

Figure 4 Intraoperative fluoroscopy after PFNA removal.

Figure 5 X-ray on arrival demonstrating a neck of femur fracture to the Right hip.

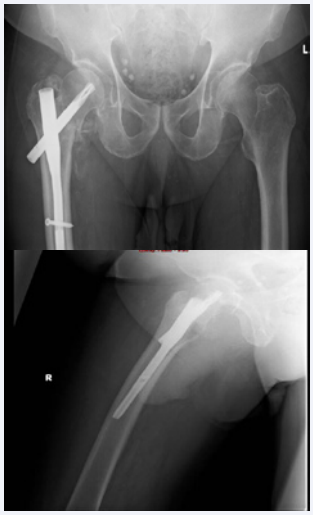

Figure 6 AP and Lateral x-rays of the Right hip, 1 month after PFNA fixation.

DISCUSSION

The "cut-in" or medial migration of the femoral neck component through the femoral head and into the acetabulum has been reported in several case series and case reports during the last decade. We have conducted a web based search to try and find all these case series and case reports in the English literature and summarized their cumulative data (Table 1).

The true incidence of the cut-in complication is actually quite hard to estimate, since all the case reports and case series in the literature are retrospective in nature, and it is not unlikely to assume that some cases remained undetected. On top of that, since this is still a rather "new" complication, it is probable that some cases were diagnosed under the general term of "cut-out" instead of cut-in. With that in mind, the actual reported incidence of this complication is between 25% in the early reports and down to 0.7% in the largest series reported so far by Brunner, et al. [23].

We have retrospectively looked at all our PFNA cases operated between the years 2009-2015 and found an incidence of 0.25% (2/785). This percentage is lower than reported in most other case-series although there is a single report of zero cases of cut-in or cut-out in a series of 500 cases form a single Chinese institution [24]. It is worth mentioning that their post-operative

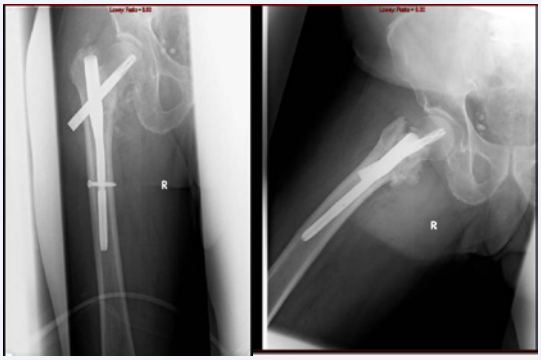

Figure 7 AP and Lateral x-rays 2 months after the PFNA fixation demonstrating compression of the fracture and backing out of the blade with callus formation at the medial clacar area.

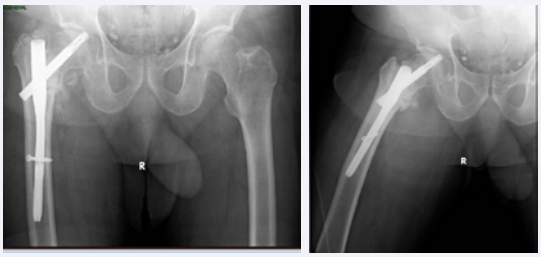

Figure 8 AP and Lateral x-rays 6 months after the PFNA fixation demonstrating cut-in of the blade into the acetabulum.

Figure 9 Intraoperative fluoroscopy after the blade exchange.

Figure 10 Final x-ray of the right hip after removal of the blade. The fracture healed completely.

weight bearing protocol commenced only 1 month after the operation, a period of time that may have enabled the fracture to consolidate, which might explain their good results.

Biomechanically, the helical blade of the PFNA was designed to compact the bone of the femoral head and neck during its insertion and by doing so to resist their rotation and prevent cut-out from occurring [12,13]. While this design proved to be biomechanically superior to regular lag screw in preventing rotation, it failed to demonstrate the same results regarding axial loads, especially in osteoporotic bones [23].

Several theories were suggested in order to try and explain the cut-in phenomena. Most authors claim that the main reason for this mode of failure is the inability of the helical blade to lateralize and slide through its hole at the nail, as impaction at the fracture site progresses, thus causing the blade to perforate the femoral head [16,19,20]. As described by Frei et al. [16], the PFNA blade acts within the nail similar to the "short barrel" side plate device and may very well jam in the same manner.

A second explanation, offered by some of the authors, is blaming the failure on the "z-effect" phenomena [16,18, 20], which is characterized by central migration of the neck-head component due to changing support at the craniolateral and caudomedial nail-blade interface [16]. In fact, the z-effect phenomena was originally described for older versions of PFN which had two neck head components, and referred to the medial migration of the proximal component and lateral migration of the distal component – thus creating a "z" like shape between them [25]. Despite the theoretical possible explanation of the cut-in phenomena by the "Z-effect" theory – to date there is no actual biomechanical or other date to support it as such.

A third explanation for the cut-in phenomena was offered by Weil et al. [21]. They created a biomechanical testing model with the purpose of identifying the variables that cause medial migration of the head-neck component. They postulated that the main reason for the medial migration was the result of an unstable fracture pattern, and incorporated this into their model, creating an unstable medial cortex together with lateral buttress deficiency. They tested five different nail implant designs (TFN, PFN, PFNA, Gamma 3, and IMHS), and found that all of them eventually demonstrated medial migration. They concluded that the medial migration phenomenon is an inherent property of these devices, especially when used to treat unstable fracture patterns. This claim was clinically demonstrated with the publication of several case reports describing medial migration with the Gamma 3 nail as well [18,26,27].

A different explanation was actually provided, in the form of a secondary trauma. Seven such cases were reported by Brunner

Table 1: Summery of 51 cases of PFNA Cut-In in the literature.

Author	Year	Journal	No.	Age / Gender	Type of Fracture	Incidence	Time to Weight Bearing	Time to Failure	Salvage Technique
Brunner et al.	2008	JOT	3	F / 89	unstable	25%	immediate	6 weeks (trauma)	revision
				F / 88	unstable 31-A2		immediate	6 weeks	Revision
				F / 67	unstable		immediate	6 weeks (infection)	THR
simmermacher et al.	2008	INJURY	4	NA	31-A2/3	1.20%	immediate	6 months (trauma)	NA
Mereddy et al.	2009	INJURY	2	NA	31-A2/3	NA	NA	4-6 w	THR
Takigami et al.	2010	JOT	1	F/79	unstable 31-A2	NA	immediate	11 months	THR
Cheung et al.	2011	JOT	1	M / 81	unstable 31-A2	NA	partial weight bearing	2 months	THR
Frei et al.	2011	JOT	7			6.30%	NA	NA	NA
frank et al.	2011	JOT	1	F / 87	31-A2	NA	immediate	3 w	THR
Nikolski et al.	2013	JOSR	2	NA	unstable	NA		-	-
kun-chow	2014	JoTR	1	M / 80	unstable 31-A2	NA	NA	13 months	Nail removal
Gomes et al.	2016	RBO	1	F / 88	31-A1	NA	immediate	2m	Nail removal
Brunner et al.	2016	INJURY	28		31-A1/2/3	0.70%	NA	1.8m (mean)	Revision/ THR

THR: Total Hip Replacement; NA: Not available

et al. [19], and by Simmermacher et al. [9]. Although they possibly constitute a very reasonable explanation for the cut in phenomenon – these 7 are the only reported cases related to this complication.

The recommendations on how to try and prevent this devastating complication from happening are almost unanimous amongst the authors of the case reports and case series published. Brunner et al. [19], was one of the first surgeons to report the cut-in complications and he was the first to recommend using shorter blades and not to pre-drill the femoral neck and head before the introduction of the blade in osteoporotic patients. Frei et al. [16], emphasized the quality of reduction and the caudal placement of the blade as major prevention steps. Nikolski et al. [28], checked and demonstrated that the Tip-Apex distance (TAD) should be altered when using the PFNA and that it should be between 20-30mm, and not under 25mm as classically described.

Many suggestions were made over the last years regarding treatment options for these patients. A multicenter study by Brunner et al. [23], was recently published, and summarized the latest outcomes and recommendations for treatment. The authors collected retrospective data from twenty hospitals in Western Europe, and reached a total of 4109 patients treated with PFNA or TFN between the years 2003-2010. All fractures were classified as AO type 31-A1/2/3. A total of 28 patients were identified as suffering from the cut-in complications, which represents an incidence level of 0.7%. 3 main types of revision surgery were identified – blade exchange, blade exchange with cement augmentation and total hip arthroplasty (THA).

The authors demonstrated that blade exchange alone had a 50% failure rate, which mandated a second revision. Blade exchange with cement augmentation demonstrated 33% failure rate, and THA demonstrated zero failure rate. According to their results, Brunner et al. recommend a THA as the revision surgery of choices for these cases. Both our patients had their blades removed, even though a failed blade replacement attempt was done with the second case before the final removal, and both our patients did well. It is worth mentioning that our 2 cases had a very late presentation of their cut-in, so we were able to safely remove the blade without any actual need for reinforcement of the femoral head and neck.

In conclusion, the cut-in complication should be well recognized by all surgeons who perform these surgeries and use the proximal femoral nails. Even though the actual incidence of this complication is quite low in high volume centers, less than 1%, it may possibly have a devastating outcome, and in most cases a revision surgery will have to take place. Steps should be taken by the surgeons to try and avoid this complication by following the published recommendations, and more research should be done in an attempt to find better ways of preventing it from happening at all.

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