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CASE REPORT

A novel feasible technique for rapid removal of broken proximal femoral nails: A case series

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ABSTRACT

Proximal femoral nail (PFN) fixation is a technique widely used to treat various femoral fractures, but femoral re-injury may occur, leading to PFN breakage. Broken nail removal, particularly removal of the distal broken nails, is usually challenging. Herein, we describe a feasible approach to successfully remove broken femoral intramedullary nails in three sites (proximal, middle, and distal section) of the PFN. Three patients required surgery for PFN breakage. We performed a novel technique using minimal exposure and a cerclage wire to remove the PFN fragment, which a distal knot on the wire was applied to hold the PFN fragment, and the removal trajectory was completed through the minimal exposure, a distal femoral bone window, and the marrow cavity. We successfully operated these three patients and removed the PFN fragments rapidly and effectively. In conclusion, this novel technique is rapid, feasible, and cost-effective, and can also be promising in removing intramedullary nail breakages in other long bones.

Keywords: Antegrade, broken nail removal, cerclage wire, proximal femoral intramedullary nail, proximal femoral nail.

Proximal femoral nail (PFN) fixation is the gold standard for unstable intertrochanteric fractures.[1] However, dangerous sports, traffic accidents, and falls may lead to femoral re-injuries. Although rare, re-injury may occur after surgery, which may result in pain, dyskinesia, and even PFN breakage. In a study, the prevalence of PFN breakage was reported as <3.3%.[2]

Removal of broken PFNs is quite challenging for many orthopedists. To date, surgeons have described many methods to remove broken intramedullary nails.[3-6] However, these methods have certain limitations, making the removal of broken nails difficult. Moreover, many devices have been developed, but none of them can be conveniently used at different sites of nail breakage.

In this article, we describe an easy, inexpensive, and rapid technique to remove broken femoral intramedullary nails in three cases using a medical grade cerclage wire with no other extraction device. Briefly, a minimal exposure and a cerclage wire were applied to remove the PFN fragment, which a distal knot on the wire was tied to hold the distal PFN fragment, and the removal trajectory was completed through the minimal exposure, a bone window located superiorly to the medial femoral condyle, and the femoral marrow cavity.

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CASE REPORT

Surgical technique

A sterilized medical grade cerclage wire (2.0 mm in diameter, Baoji Langtai Titanium, BLTi, China) was used with other regular orthopedic instruments.

The 10 steps of the surgical technique applied are as follows:

1. The apex of the femoral tuberosity is exposed.
2. The wire is inserted through the proximal opening of the PFN (Figure 1a).
3. The wire is continually inserted via the C-arm, until it crosses the broken section of the nail and reach the distal opening of the PFN (Figure 1b).
4. A very small longitudinal incision crossing the adductor tubercle is made (Figure 2a).
5. The incision is extended deeper into the periosteum, which is located superior and medial to the patella surface of the femur and superiorly to the adductor tubercle (Figure 2b).
6. A small bone window (Figure 2b) is made, and a curved forceps is used to hold the distal portion of the wire or to directly penetrate the marrow and hold the wire (Figure 1c).
7. The wire is, then, pulled out from the bone window (Figure 1d).
8. A knot is made at the distal portion of the wire.
9. The proximal portion of the wire is pulled out and the knot is prevented from entering the marrow cavity (Figure 1e, f).
10. Finally, the broken nail is removed (Figure 1g).

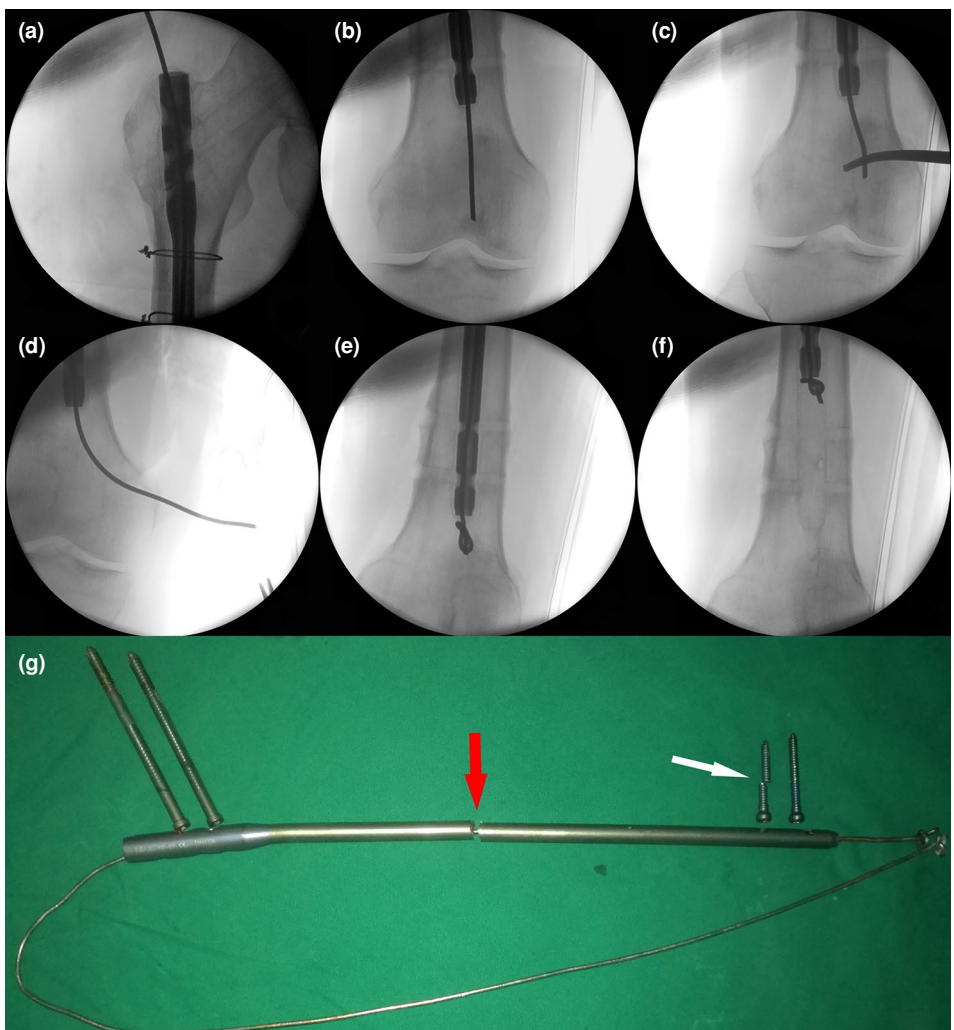


FIGURE 1. Intraoperative procedure of the removal of the broken PFN in Case 1. **(a-f)** The sequential procedures of the whole extraction; **(g)** Postoperative image of the whole extraction with the cerclage wire in the broken PFN. The white arrow indicates a breakage in one of the distal locking screws, and the red arrow shows a broken site of the main PFN.
PFN: Proximal femoral nail.

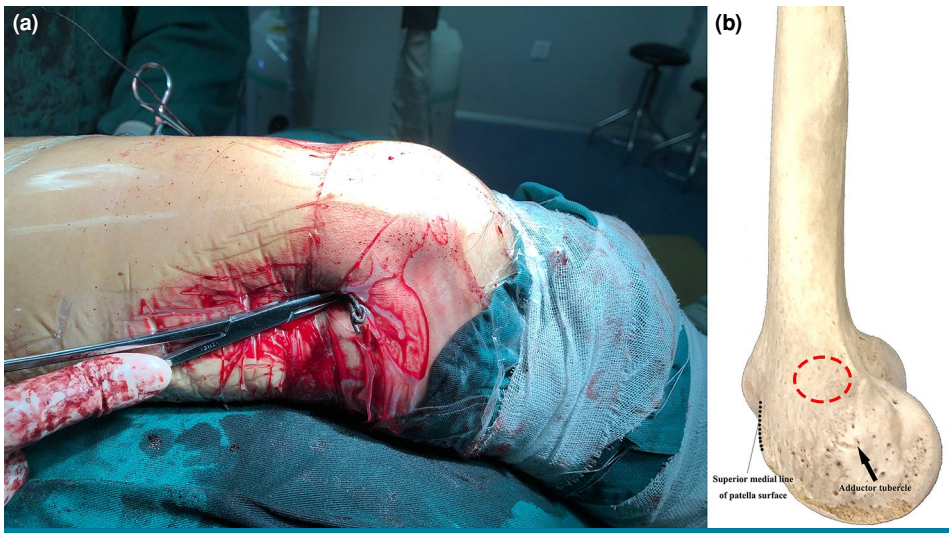


FIGURE 2. The minimal exposure in our study. **(a)** Intraoperative view of the wire knot passed through the incision in the medial portion of femoral condyle; **(b)** the red dotted oval is the site where the cerclage wire would pass through; the black dotted line is the superior medial line of patella surface of the femur, and the black line is pointing at the adductor tubercle).

Case 1- A 54-year-old male patient had an accident 18 months after PFN implantation. He was admitted to our hospital on December 12th, 2017 by emergency transportation and was transferred to our department. He was diagnosed with PFN breakage and femoral nonunion following a femur fracture on digital radiography. This was our first attempt at using the cerclage wire to remove the broken nail. In this case, we used the novel surgical method.

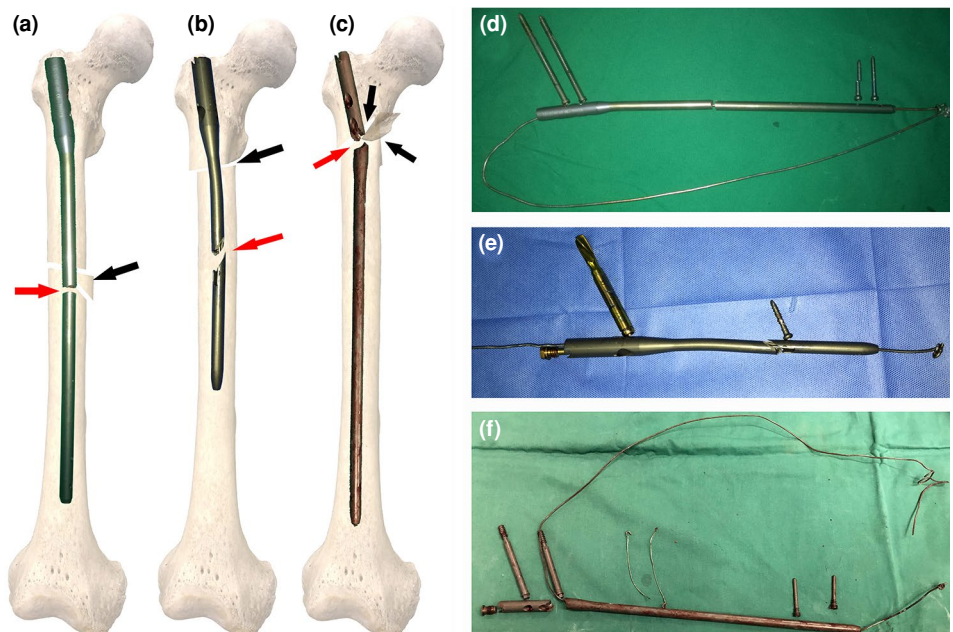


FIGURE 3. Diagram of three broken PFNs in three different patients; a, b, and c are for Case 1, Case 2, and Case 3, respectively; d, e, and f show the extracted implants from Case 1, Case 2, and Case 3, respectively. The black arrow points the fractural region, and the red arrow points the broken section of the nail.
PFNs: Proximal femoral nails.



FIGURE 4. Postoperative diagram of a new PFN implanted in Case 2 after the broken PFN was removed. The hollow white arrow points at the site where we made the bone window, which is approximately 1.0×1.5 cm in size.
PFN: Proximal femoral nail.



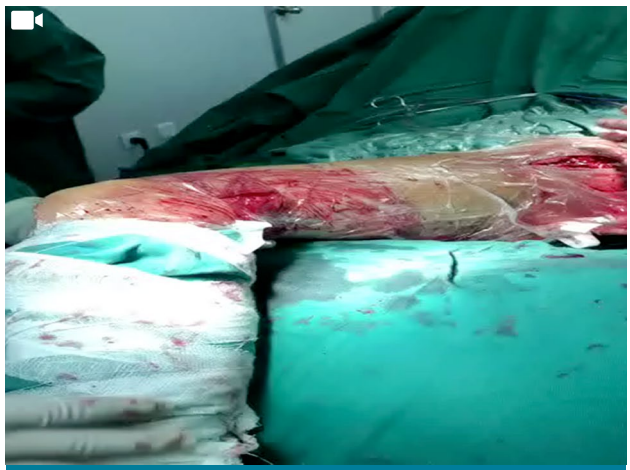
VIDEO 1. Proximal femoral nail removal from Case 1.

After physical evaluation and laboratory tests, an emergency surgery was performed, as described above. As seen in Figure 1g (white arrow), there was an extra broken breakage in one of the distal locking screws. Thus, the distal femoral opening was enlarged, and more time was required to extract the two fragments. The required bone window was successfully made at the junction between the cortex and cancellous bone, as seen in Figure 2b. Moreover, we successfully caught the tail of the wire after several attempts. The whole procedure took approximately 30 min, and postoperative images of the broken intramedullary nail were taken. Figure 3a shows a diagram of the broken nail in this patient.

Case 2- A 78-year-old male patient was involved in a road traffic accident and was referred from



VIDEO 2. Proximal femoral nail removal from Case 2.



VIDEO 3. Proximal femoral nail removal from Case 3.

a nearby hospital to one of our allied hospitals; the surgeons referred him due to lack of necessary expertise. He was diagnosed with a simple PFN breakage. Surgery was performed on April 23rd, 2018, three days after the accident. Based on the experience gained from Case 1, we decided to use curved forceps to directly open the bone window, since the patient was aged (almost 80 years) and had osteoporosis, as assessed by digital radiography. The procedure lasted approximately 20 min, and the broken nail is shown in Figure 3b.

The procedure was the same as that in Case 1. In this case, we made a very small opening, less than 4 cm, and the bone window was very small, approximately 1×1.5 cm (Figure 4).

Case 3- A 55-year-old male patient had a road accident that led to a fracture of the nail. A minimally invasive surgery was successfully performed to remove the nail (Figure 2a), and the extraction time decreased to less than 20 min, although we used a drill to open the bone window.

The recorded operative videos for each patient are presented in supplementary materials marked as Case 1, Case 2a, Case 2b, and Case 3. Case 2a shows the knot and Case 2b shows the nail removal.

DISCUSSION

The PFN implantation is very effective in intertrochanteric femoral fractures, as the implant is stable and the method is standard.[7,8] The implant does not easily break, but if it does, removal can be very challenging for many surgeons. Although many studies have described numerous methods to treat nail fractures, there is no consensus on the most optimal method to be used.[9,10] Whalley et al.[2] presented a review showing 11 different methods to remove broken nails, with different devices used, including sigmoidoscopy grasper or Petelin laparoscopic forceps. Moreover, the authors described the use of a larger diameter nail and a reamer in the extraction of the fractured nail.

Our technique can be considered a combination of Marwan and Ibrahim's[11] and Gosling et al.'s[12] techniques, but with some modifications; further, it was performed in real patients. Marwan and Ibrahim[11] used a cerclage wire; the looped wire was inserted in the distal screw hole and an appropriate bone window was made. The distal hole might be impacted; therefore, they suggested that the bone window be enlarged, and the procedure would fail, if the looped wire unfolded or slipped out. Gosling et al.[12] extracted the broken nail via an enlarged osseous channel in the lateral femoral condyle and used a curette to enlarge the channel and to get the distal fragment. However, this method is not suitable for passing a large or long distal fragment through the osseous channel.[12]

Several promising ideas can be found in our method and are worth promoting. First, the tool used is very easy to obtain, which makes the method feasible. Second, the cortical bone is not injured severely and the existing bone window in the distal metaphysis is used, which makes our method faster (less than 20 min). The bone window in the present study can be seen in Figure 2b (Case 2). Three performable points could be seen here. The first one is that the bone window is located at the posterosuperior aspect of the adductor tubercle, which is a suitable landmark. Second, the tendons of the adductor muscles and gracilis pass behind the bone window and attach to the adductor tubercle on the medial condyle of the femur. It is easier to create a bone window in the medial condyle than in the lateral condyle owing to the iliotibial tract, which may obstruct the lateral condyle of the femur. Moreover, the medial condyle is larger than the lateral.

An additional incision, comparing to other surgical techniques, was required in the present technique, which was applied to open the bone window. Moreover, the wire knot could be allowed to pass through the bone window, which the knot was made to provide a firm hold for the wire to pull out the broken nail. One other lesson learnt from our method is that the knot on the wire should not be too sharp, to avoid additional damage to surrounding tissues while leaving the skin to the femoral bone marrow.

In conclusion, our novel technique is rapid, feasible, and cost-effective to remove PFNs via inserting a cerclage wire. This technique requires further promotion. Of note, the present method should not be limited to the removal of PFNs, but can be also used to remove intramedullary nails that are difficult to extract in the femur and in other long bones. Further studies should be performed to promote and investigate this method in a higher number of patients with broken intramedullary nails.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Manuscript drafting: J.H., F.W., W.C., P.W.; Data collection: J.H., F.W., W.C.; Data analysis: W.P., F.W.; Study design: J.H., F.W., P.W.

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