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Nail breakage in patients with hypertrophic pseudoarthrosis after subtrochanteric femur fracture: treatment with exchanging nail and decortication

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In this study, we aimed to show the results of exchange nail and decortication in patients whose subtrochanteric femur fractures were treated with intramedullary nails and subsequently developed fracture nonunion and nail breakage complications. This study consisted of patients presenting with subtrochanteric femur fractures between January 2013 and April 2019 who underwent surgery and later experienced nail breakage due to hypertrophic nonunion. There were a total of 10 patients aged 26-62 years (Avg 40,30, SD: 9,989). Nine patients were smokers, and 1 patient had diabetes and hypertension. Three patients were admitted to the trauma center due to a car accident and 7 patients were admitted because of a fall. The infection parameters of all patients were normal. All patients had pathological movement complications and pain at the fracture site. Preoperatively, medulla diameter was measured with standard radiography in all patients. The diameters of the old nails applied to the patients ranged from 10 to 12 mm, and the diameters of the newly applied nails ranged from 14 to 16 mm. The fracture lines of all patients were opened to remove the broken nails, and decortication was performed. No additional autograft or allograft was applied to any patient. Union was achieved in all patients. We conclude that the use of larger diameter nails in conjunction with decortication will prevent nail breakage, improve healing and provide early union in patients with subtrochanteric femur fractures with hypertrophic pseudoarthrosis.

Keywords: subtrochanteric femur fracture, implant failure, hypertrophic nonunion, intramedullary nailing, decortication, early union.

INTRODUCTION

The subtrochanteric region is defined as the 5 cm region distal to the trochanter minor[1]. It is a load-bearing region and is exposed to very high mechanical stresses during walking. The blood supply of the subtrochanteric femoral region is supplied by primary nutrients and periosteal vessels. Blood flow is mainly circumferential. The subtrochanteric femoral region has poor vascularity and is composed mainly of cortical bone, which is a reason for its poor ability to achieve union. Subtrochanteric fractures have a high complication rate of 10-34% among all hip fractures. These fractures are subject to severe deforming muscle forces; therefore, fracture reduction during operation is challenging. For these reasons, the recovery period for those with subtrochanteric fractures is relatively long, with a high risk of nonunion or implant failure[2,3,4,5]. Therefore, any internal fixation device will be subject to significant concentrated bending stress, leading to implant fatigue and fixation failure if the fracture does not unite in a timely manner. This situation prolongs the time to return to work and may cause additional morbidity in patients with subtrochanteric femoral fractures[1,2,5,6]. Several surgical techniques have been described for subtrochanteric nonunion and metalworking failure (broken cephalomedullary nail). These techniques comprise surgical procedures such as exchange nailing, augmentation plating, bone grafting, decortication techniques, adjuvant therapies (electrical or ultrasound stimulation) and recombinant human bone morphogenetic protein treatment[5,6,7,8].

Osteoperiosteal decortication is a surgical method that was described by Judet et al. in 1972[9]. This technique has been in use for a long time, is inexpensive, and does not cause donor site morbidity. It is indispensable in emerging countries as a strict technique used to create pedicle grafts at the nonunion site. Judet's technique of osteoperiosteal decortication combined with the internal fixation of plates and

screws remains a highly effective, reproducible surgical technique in the management of failed fracture union. This technique is most suitable for the treatment of hypertrophic nonunion following intramedullary nailing in short oblique and transverse diaphyseal fractures[9,10].

In our study, we evaluated patients who underwent surgery with intramedullary nailing in subtrochanteric femur fractures and subsequently experienced complications of nail breakage and hypertrophic non-union. These patients were treated by adding osteoperiosteal decortication to the exchanged nail, and treatment success was determined by recovery and an early return to social life.

PATİENTS AND METHODS

This study was approved by the institutional review board and performed under the ethical standards laid down in the Declaration of Helsinki. Approval for this retrospective study was granted by the Institutional Review Board (decision no: 694).

This study included patients with subtrochanteric femur fractures between January 2013 and April 2019 who had undergone a number of previous surgeries[1-3] and subsequently presented with the complication of nail breakage due to hypertrophic nonunion. Ethics committee approval was obtained. There were a total of 10 patients, 9 male and 1 female, in the study. The age of the patients was between 26 and 62 years (Avg 40,30, SD: 9,989). Nine patients were smokers, and 1 patient had diabetes and hypertension. Three patients were admitted to the trauma center due to a car accident and 7 patients were admitted after falling. (Table I) The subtrochanteric region fracture of the patients upon their first admittance to the trauma center was type 2 according to the Seinsheimer classification. Sedimentation and CRP values were normal in the laboratory values of the patients. During the previous operations, 8 patients had incision scars that indicated open reductions, while 2 patients had closed reductions and intramedullary nailing. No graft was used for any of the patients' operations. The diameters of the old nails applied to the patients ranged from 10 mm to 12 mm. (Fig. 1) All of the new nails applied after the removal of the broken nails were locked with at least 4 screws, and the new nail diameters ranged from 14 mm to 16 mm. (Fig. 2) (Tasarımmed®, Istanbul) (Table II) Fracture lines were opened, and decortication was applied to all patients during the removal of the broken nails to induce a restorative process. (Fig. 3) Postoperative blood transfusion was not required in

Table I. — Demonstrative Data of the Study Group.

		Male	Female	Total
Gender		9	1	10
Smoking Status	Smokers	8	1	9
	Non smokers	1	0	1
AdditionalDisease	Non	8	1	9
	1 or More	1	0	1
Trauma Type	Fall from High	7	0	7
	Car Accident	2	1	3
Harris Hip Score	Excellent	8	1	9
	Good	1	0	1
Past Surgery Type	Closed Reduction	7	1	8
	Open Surgery	2	0	2

Figure 1. — a: *shows the AP view of the implant failure with the broken nail and a broken proximal interlocking screw. b: shows the lateral view of the implant failure. c: shows the AP view of the implant failure with the broken nail and 2 broken distal interlocking screws. d: shows the AP view of the new larger diameter nail in the femur with 2 proximal and distal interlocking screws at early postoperatively. e: shows the lateral view of the new larger diameter nail at early postoperatively. f: shows the AP view of final x-ray film at 3 years postoperatively with full recovery and without any complaint.*

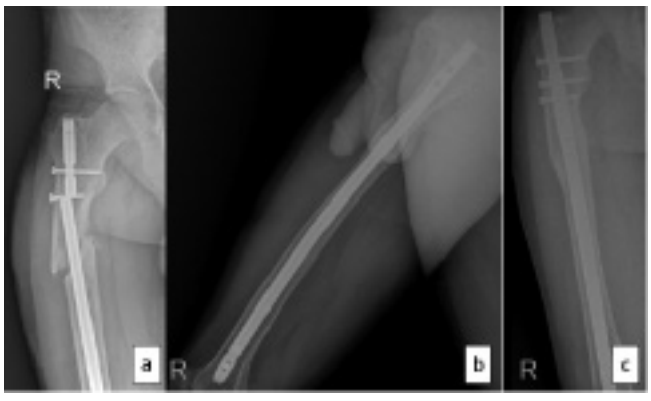

Figure 2. — a: shows the AP view of the implant failure with the broken nail at the point of the second proximal interlocking screw. b: shows the lateral view of the femur with the complete union at 3 months postoperatively. c: shows the AP view of the femur with the complete union at 3 months postoperatively.

Table II. — Descriptive Statistics.

	Min	Max	Mean	St. Deviation
Age	26	62	40,30	9,989
Number of Past Surgery	1	3	1,5	0,707
Pseudoarthrosis Duration (Months)	9	18	11,5	2,799
Recovery Time (Months)	2	6	3,8	1,135
Old Nail Diameter	10	12	10,8	0,789
New Nail Diameter	14	16	14,2	0,632

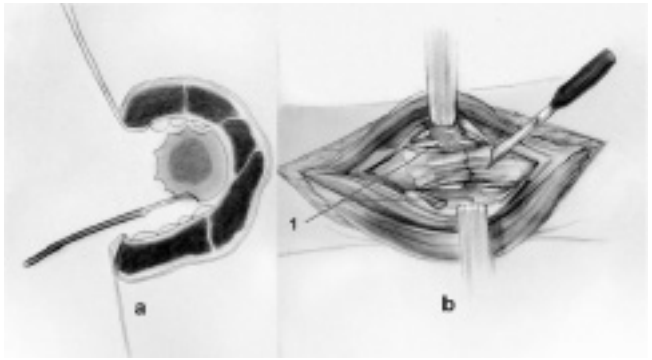

Figure 3. — a: Cross-sectional view of osteoperiosteal flap lifting from the proximal and distal 2-4 cm part of the nonunion area about more than half the circumference of the femur. b: Nonunion area exposed by chisel and osteoperiosteal flaps left attached to the periosteum (shown with arrows).

any of the patients. One patient was 1.5 cm shorter after the operation. The patients were mobilized with partial weight bearing at the postoperative 3rd week and immediately included in the physical therapy program for hip and knee ROMs. Superficial skin infection at the proximal incision line was encountered in 1 patient and treated with oral antibiotics without any problems. All patients were followed up for 3 years.

All patients were placed in the lateral decubitus position under general anesthesia, and the original incision site was used as a proximal entry site for our incision. First, the proximal part of the nail was identified, the end cap was removed if placed, and the universal extractor was placed on the proximal part of the nail. Afterwards, the distal and proximal locking screws were removed. The proximal broken nail was removed with the help of a universal extractor. Then, the fracture line was opened over the old incision, and the broken part of the nail was removed in a controlled manner. Old nail lengths and diameters were measured (10-12 mm), and then the nail guide wire was sent through the old entrance hole.

The medulla was then reamed with a thicker reamer. Then, the medulla was enlarged with the reamer, which was thicker than the old broken nail; the reamer was not included in the standard sets. (Tasarımmed®, Istanbul) A thicker nail, 1 mm smaller than the last reamer, was placed anterograde. (Fig. 1)

Proximal and distal locking were performed with at least 2 screws each. Decortication was applied by raising a small osteoperiosteal flap from the opened fracture line in each patient. No autograft or allograft was placed. A haemovac drain was placed, and the layers were closed anatomically.

SPSS for Windows version 15.0 software (SPSS Inc., Chicago, Ill., USA) was used for statistical analysis. Descriptive statistics of the data are stated as the mean ± standard deviation, median minimum and maximum values, frequency (n) and percentage (%).

RESULTS

Complete union was achieved in all patients. (Fig. 2) After an average of 4 months (3,8, SD: 1,135), it was observed that there was no pain in the fracture area. The mean operation time was 75 minutes, and the mean amount of bleeding was 180 ml. The Harris hip score was excellent in 9 patients and good in one patient whose reduction of 1.5 cm in height persisted from his previous surgery. (Table I) Nail removal and dynamization were not performed in any of the patients. The total follow-up period was 38 (36-44) months. Partial loading was allowed in the 3rd week with two crutches. Full extremity load was achieved in 6 weeks, and physical therapy exercises were recommended for hip and knee joint ROMs. Superficial skin infection at the proximal incision line was encountered in 1 patient at the first week and was treated with oral antibiotics without any problems. All the patients returned to their normal activities and social lives after approximately 4 months (3,8, SD:1,135) without any problems. (Table II)

DİSCUSSİON

Management of nonunion problems in subtrochanteric femur fractures becomes complicated due to reasons such as implant failure and peri-implant bone defects. The treatment of these complications requires a

comprehensive approach, such as the removal of the implant, extensive debridement of the nonunion, bone grafting and reosteosynthesis[11]. In the literature, the use of bone grafts has been frequently shown to aid in bone healing in cases of nonunion. Alternative methods for the treatment of nonunion include extracorporeal shock wave therapy, osteoinductive molecules such as bone morphogenetic protein (BMP) or platelet-derived growth factor (PDGF) and ultrasound stimulation, and stimulation by electric/electromagnetic fields[12]. However, these methods are relatively expensive and are not currently recommended as the primary treatment option for nonunion.

Decortication with rigid fixation is the simplest and least expensive way to achieve union without causing significant vascular impairment. The decortication technique is used to increase the healing response and create a well-vascularized bed, as in bone grafting. This technique is based on the principle of enhancing union when the fracture zone is surrounded by vascularized bone chips from the bone itself. It has also been reported that the decortication technique is easier to perform when there are adhesions between soft tissues and bone[9,13].

Many authors recommend treating hypertrophic nonunions by exchanging nails and rigid fixation with thicker nail[14]. It has been stated that a successful union is achieved in this way. In our study, in accordance with the literature, we exchanged nails with thicker nails and applied decortication, which we consider to have enhanced union.

It has been reported that in subtrochanteric femur fractures, nail breakage complications may occur after 6 months[4,15]. Removing the broken nail after the complication of nail breakage is a difficult surgical procedure that has many complications[17]. The biology of fracture healing may be impaired by opening the fracture zone; therefore, osteogenic stimulating grafts or decortication may be needed[9,18,19]. In our study, we believe that when the fracture site is opened to remove the broken nail, performing the decortication procedure to increase the blood supply of the area and soft tissue stimulates bone healing.

Fracture nonunion affects patients' quality of life and their ability to return to work. These patients experienced difficulties in their social lives and daily activities due to the delayed union or nonunion of their fractures and are psychologically affected by the prolongation of their recovery period[19]. In our study, we provided early union and early return to social life, daily activities and work by applying decortication; we think the application of decortication increases union, after opening the fracture line, removing the broken nail and exchanging it with a large diameter nail.

Although autogenous bone grafts are the gold standard in fracture union, decortication has a great effect on healing fractures. Although there are publications suggesting treatment methods that do not open the fracture site in hypertrophic nonunions[20], it may be necessary to open the fracture site when nail breakage is encountered. We opened the fracture area and applied decortication to the proximal and distal parts to easily remove the broken nail, to prevent additional complications and to shorten the operation time.

In subtrochanteric fractures, failure of intramedullary nailing may be caused by the use of fine nails, which makes stability insufficient[3,21,22,23]. In hypertrophic nonunions, if the biology is normal but the stability is insufficient, the aim of treatment should be to increase the stability[24]. These implants could be intramedullary nails for long bones. We measured the diameter of the medulla before the surgery and applied a nail large enough in diameter to fill the medulla with the distal and proximal screws to provide rigid fixation.

Ramoutar et al. recommend the application of autogenous or allografts to the nonunion area on nonunion of the long bones[25]. These fractures are mostly atrophic-type fractures that result in nonunion. There are a number of donor-site morbidities after graft application. Since the nonunion type of our patients was of the hypertrophic type, an additional graft was not needed.

Some authors stated that intracanal osteoblasts that travel to the fracture site after the exchanging of nails provide a multipotent grafting effect and increase union[26,27]. In our study, we speculate that the maximal height reaming of the medulla diameter already regenerates the region and meets the needs of autogenous grafting with a high rate of medulla content.

There are various treatment alternatives for the nonunion of long bone fractures that have undergone multiple surgeries. These treatment options include plate augmentation, blade plate, and graft placement on nails. However, angled blade plate applications are high in cost, and autogenous grafts can lead to infections rather than donor site morbidity[28,29].

In our study, we aimed to replace the nail to fill the medulla. In addition, we added osteoperiosteal decortication close to the areas of distal and proximal nonunions to avoid donor site morbidity.

In subtrochanteric femur fractures, although there is a high incidence of nonunion in the fracture site, nail breakage is not a frequent complication. In a study by Franklin et al., 60 broken nails of 56 patients were

investigated. As a result of this study, it was determined that the most common location for nail breakage was the nonunion area where implant deformation was the highest due to movement and the areas where the metal deteriorated, such as the joints and screw holes of the nails[21]. In our study, broken nails were mostly found in areas with pseudoarthrosis. The extracted nails were thin and did not fill the medulla. We assume that the nails were broken because they did not fill the thin medulla. Preoperatively, we measured the appropriate diameter needed for the nails to fill the medulla and ensured stability by using nails of the appropriate size and diameter, which are not included in the standard nail set. (Tasarımmed®, Istanbul)

In the literature, union has been reported up to 5-6 months following the nail changes applied after nonunion[23,24,30]. Unlike the literature, our addition of decortication when exchanging nails is beneficial because it reduces the time of union. If the fracture area is opened, decortication should be added to the treatment.

Among the limitations of our study are the low number of patients and the lack of long-term follow-up since nonunion and nail breakage after isolated subtrochanteric region fractures are rare. Multicentre studies may be more useful in investigating this rare complication.

CONCLUSİON

We conclude that in subtrochanteric region fractures, when nonunion and subsequent nail breakage are encountered, in addition to exchanging with larger diameter nails, applying decortication is more effective in achieving unions in this region. When the nonunion area is opened, decortication must be added to the treatment so patients can benefit from its healing-enhancing effect.

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REFERENCES

1. Yli-Kyyny TT, Sund R, Juntunen M, Salo JJ, Kröger HP. Extra- and intramedullary implants for the treatment of pertrochanteric fractures – results from a Finnish National Database Study of 14,915 patients. Injury. 2012;43(12):2156-2160.
2. Panteli M, Mauffrey C, Giannoudis PV. Subtrochanteric fractures: Issues and challenges. Injury. 2017;48(10):2023-2026.
3. Krappinger D, Wolf B, Dammerer D, Thaler M, Schwendinger P, Lindtner RA. Risk factors for nonunion after intramedullary nailing of subtrochanteric femoral fractures. Arch Orthop Trauma Surg. 2019;139(6):769-777.
4. Loizou CL, McNamara I, Ahmed K, Pryor GA, Parker MJ. Classification of subtrochanteric femoral fractures. Injury. 2010;41(7):739-745.
5. Kim JW, Park KC, Oh JK, Oh CW, Yoon YC, Chang HW. Percutaneous cerclage wiring followed by intramedullary nailing for subtrochanteric femoral fractures: a technical note with clinical results. Arch Orthop Trauma Surg. 2014;134(9):1227-1235.
6. Panteli M, Vun JSH, West RM, Howard AJ, Pountos I, Giannoudis PV. Management of subtrochanteric femur fractures: is open reduction associated with poor outcomes? Eur J Trauma Emerg Surg. 2022;48(3):1759-1768.
7. Walter N, Kerschbaum M, Pfeifer C, et al. Long-term patient-related quality of life after successfully treated aseptic non-unions of the long bones. Injury. 2021;52(7):1880-1885.
8. Rupp M, Biehl C, Budak M, Thormann U, Heiss C, Alt V. Diaphyseal long bone nonunions - types, aetiology, economics, and treatment recommendations. Int Orthop. 2018;42(2):247-258.
9. Judet PR, Patel A. Muscle pedicle bone grafting of long bones by osteoperiosteal decortication. Clin Orthop Relat Res. 1972; 87:74-80.
10. René KM, Kloen P. Concepts and Cases in Nonunion Treatment. AO Trauma. 2011;1:98-100.
11. Lotzien S, Rausch V, Schildhauer TA, Gessmann J. "Revision of subtrochanteric femoral nonunions after intramedullary nailing with dynamic condylar screw". BMC Musculoskelet Disord. 2018;19(1):448.
12. Finkemeier CG, Chapman MW. Treatment of femoral diaphyseal nonunions. Clin Orthop Relat Res.2002;(398):223-234.
13. Zhang Q, Zhang W, Zhang Z, Tang P, Zhang L, Chen H. Accordion technique combined with minimally invasive percutaneous decortication for the treatment of bone non-union. Injury. 2017;48(10):2270-2275.
14. Crowley DJ, Kanakaris NK, Giannoudis PV. Femoral diaphyseal aseptic non-unions: is there an ideal method of treatment? [published correction appears in Injury. 2007 Oct; 38(10):1224]. Injury. 2007;38 Suppl 2:S55-S63.
15. Kennedy MT, Mitra A, Hierlihy TG, Harty JA, Reidy D, Dolan M. Subtrochanteric hip fractures treated with cerclage cables and long cephalomedullary nails: a review of 17 consecutive cases over 2 years. Injury. 2011;42(11):1317-1321.
16. Brien WW, Wiss DA, Becker V Jr, Lehman T. Subtrochanteric femur fractures: a comparison of the Zickel nail, 95 degrees blade plate, and interlocking nail. J Orthop Trauma. 1991;5(4):458-464.
17. Sims SH. Subtrochanteric femur fractures. Orthop Clin North Am. 2002;33(1):113-viii.
18. Guyver P, Wakeling C, Naik K, Norton M. Judet osteoperiosteal decortication for treatment of non-union: the Cornwall experience. Injury. 2012;43(7):1187-1192.
19. Giannoudis PV, Ahmad MA, Mineo GV, Tosounidis TI, Calori GM, Kanakaris NK. Subtrochanteric fracture non-unions with implant failure managed with the "Diamond" concept. Injury. 2013;44 Suppl 1:S76-S81.
20. Nicholson JA, Makaram N, Simpson A, Keating JF. Fracture nonunion in long bones: A literature review of risk factors and surgical management. Injury. 2021;52 Suppl 2:S3-S11.
21. Franklin JL, Winquist RA, Benirschke SK, Hansen ST Jr. Broken intramedullary nails. J Bone Joint Surg Am. 1988;70(10):1463-1471.

22. Pan K, Chan W. Symptoms indicating imminent breakage of a femoral interlocking nail: a case report. Malays Orthop J. 2013;7(3):21-23.
23. Mittal KK, Gupta H, Kaushik N. Reunion of post nail aseptic non-union of diaphyseal femoral fractures by augmentation plating, decortication and bone grafting - Replacement for exchange nailing. Injury. 2021;52(6):1529-1533.
24. Hak DJ, Lee SS, Goulet JA. Success of exchange reamed intramedullary nailing for femoral shaft nonunion or delayed union. J Orthop Trauma. 2000;14(3):178-182.
25. Ramoutar DN, Rodrigues J, Quah C, Boulton C, Moran CG. Judet decortication and compression plate fixation of long bone non-union: Is bone graft necessary?. Injury. 2011;42(12):1430-1434.
26. Nauth A, Lee M, Gardner MJ, et al. Principles of Nonunion Management: State of the Art. J Orthop Trauma. 2018;32 Suppl 1:S52-S57.
27. Cho Y, Byun YS, Suh JD, Yoo J. Osteoperiosteal Decortication and Autogenous Cancellous Bone Graft Combined with Bridge Plating for Non-hypertrophic Diaphyseal Nonunion. Clin Orthop Surg. 2021;13(3):301-306.
28. Haidukewych GJ, Berry DJ. Nonunion of fractures of the subtrochanteric region of the femur. Clin Orthop Relat Res. 2004;(419):185-188.
29. Rollo G, Tartaglia N, Falzarano G, et al. The challenge of non-union in subtrochanteric fractures with breakage of intramedullary nail: evaluation of outcomes in surgery revision with angled blade plate and allograft bone strut. Eur J Trauma Emerg Surg. 2017;43(6):853-861.
30. Jackson C, Tanios M, Ebraheim N. Management of Subtrochanteric Proximal Femur Fractures: A Review of Recent Literature. Adv Orthop. 2018;2018:1326701.