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Augmentation Plate Fixation for Treating Subtrochanteric Fracture Nonunion

Dr. Vimal Singh[1] (Asst. Prof.), Dr. Vanchhit Singh[2] (Senior Resident), Dr. P K Verma[3] (Assoc. Prof.), Dr. V B Singh[4] (Assoc. Prof.), Dr. Shubham Mishra[5] (Asst. Prof.), Dr. A. K. Chaurasia[6] (Prof.) & Dr. P K Lakhtakiya[7] (Prof. and HOD)

Shyam Shah Medical College, Rewa[1,2,3,4,5,6&7]

Corresponding Author: **Dr. Vanchhit Singh**

Abstract
Background:
The treatment of subtrochanteric fracture nonunion is challenging. Although revision with either an intramedullary or extramedullary device had been advocated with acceptable results, complications that require secondary procedures still arise. The use of an intramedullary device with augmentation plate fixation is a well-known approach for femoral or tibial diaphyseal nonunion. However, this approach has not previously been reported for subtrochanteric fracture nonunion.
Materials and Methods:
A series of 10 cases of subtrochanteric fracture nonunion treated with an intramedullary device in combination with augmentation side plating followed for18 months. All patients underwent revision nailing in addition to side plating and bone grafting.
Results:
All fractures united well without major complication. The average time to union was 6 months.
Conclusion:
The use of an intramedullary device with augmentation plate fixation is a reliable and decisive procedure for treating subtrochanteric fracture nonunion that produces satisfactory results with a low complication rate.

Keywords: Intramedullary nail, nonunion, side plating, subtrochanteric fracture

1. INTRODUCTION

Subtrochanteric fractures account for 10% to 30% of all hip fractures.1 This area of hip possesses unique mechanical and biological characteristics that render fracture union problematic. Mechanically, the proximal femur bears tremendous varus stress. Biologically, the proximal femur is largely composed of cortical bone, which achieves bony incorporation relatively slowly.2,3 Thus, subtrochanteric fractures are more prone to nonunion than fractures in neighboring areas, such as the intertrochanteric region. Even when contemporary methods are used, the complication of nonunion nonetheless occurs in approximately 7%–20% of cases.4,5,6,7 Studies have shown that intramedullary devices can achieve higher union rates and fewer complications than extramedullary devices such as a blade plate.8,9 This phenomenon could be attributed to the closed nailing technique, which produces less soft tissue disruption and more favorable mechanical properties, including load sharing and a shorter lever arm, than the use of extramedullary devices. The management of subtrochanteric fracture nonunion is more challenging than the treatment of a fresh fracture because of bone loss, retained broken implants, loss of reduction, and the compromised osteogenic potential of local tissue.10,11,12 Over the past several years, the "diamond concept," a comprehensive strategy of evaluation and management of fracture nonunion, has been introduced. This concept emphasizes the importance of an optimized mechanical environment and enhanced biological conditions for refractory or atrophic nonunion.13,14,15 Accordingly, the authors believe that rigid and durable fixation is required to create a stable environment for the healing of subtrochanteric fracture nonunion. Although an intramedullary device serves as a load-sharing fixator and provides higher resistance to failure, it can only provide relative stability at the metaphyseal-diaphyseal junction area. Lateral side plating at this location acts as a tension band device that provides compressive force and adds resistance to the varus load. The use of an intramedullary device with augmentation plate fixation is a well-known method for treating nonunion for diaphysis fractures of the femur and tibia.However, to our knowledge, this approach has not been discussed for the treatment of subtrochanteric fracture nonunion. This study presents clinical results for a series of cases of subtrochanteric fracture nonunion treated with an intramedullary device with augmentation plate fixation and autogenous bone grafting.

2. Materials and Methods

10 consecutive cases of subtrochanteric fracture nonunion treated with intramedullary nailing and side plating at a single tertiary referral center between 2019 to 2022 were included in this prospective study [Table]

In this study Patient informed consents were obtained. Skeletally mature patients with nonunion of a surgically treated subtrochanteric fracture were enrolled and reviewed. The subtrochanteric region was defined as the area 5 cm distal to the lower border of the lesser trochanter. Initial fracture patterns were classified with the AO/OTA classification. In accordance with the Food and Drug Administration's definition, nonunion was defined as a fracture that had not completely healed within 9 months or showed no progression toward healing on serial radiographs over 3 consecutive months. Implant failure or loss of reduction at any time point was also regarded as nonunion. Cases involving a pathologic fracture, an atypical fracture, and/or septic nonunion were excluded from the study. In addition, cases of nonunion treated with an extramedullary device or solely with exchanging nailing were excluded from the study.

These cases involved 6 males and 4 females. According to AO/OTA classification, there were 8 cases of AO/OTA 32A, 1 cases of 32B, and 1 cases of 32C for the initial fracture pattern. The mechanism of the initial injury was either low energy trauma, such as a simple fall, or high energy trauma, such as a motor vehicle collision. Patients' average age at presentation was 47.9 years (range 19–79 years). The average time that had elapsed from initial surgery to the relevant revision surgery was 11months (range 9–31 months). The average followup time was 15months (range 6–32 months). There were 4 cases of oligotrophic nonunion and 6 cases of atrophic nonunion according to the Weber and Cech classification. There was no evidence of infection at the time of the index operation. All patients treated with antegrade interlocking nails with piriformis fossa starting point, all had an appropriate starting point. The initial surgeries were performed by different surgeons.

Implant failure was present in all 10 patients, and failed implants were removed during revision surgery and revised with an intramedullary device and extramedullary plate.

The revision surgery involved the following steps.

Patients were placed in the lateral decubitus position on a radiolucent table that allowed for fluoroscopic examination. An incision was made as a direct lateral approach to the proximal femur. If necessary, this incision was incorporated into a previous incision.The original implants were completely removed. The nonunion site was debrided thoroughly and recanalized through both ends using a flexible reamer or drill. Intramedullary nailing was performed. A 3.5-mm dynamic compression plate (DCP) was then contoured and placed on the lateral side, and distal locking screws were inserted using a free-hand technique.
Debridement and decortication were performed around the nonunion site as extensively as possible. A 3.5 mm DCP was then applied directly on the lateral side. To facilitate compression at the nonunion site, the static distal locking screw of the nail was removed before the side plate was attached. At least one distal static locking screw was then inserted.

A copious autogenous bone graft harvested from the iliac crest was applied to the nonunion site at the end of surgery. Postoperatively, patients were encouraged to ambulate with partial weight bearing on the repaired hip for the first 4 weeks. All patients were regularly followed, and union was judged based on painless ambulation and the presence of a bridging callus on both anteroposterior and lateral radiography.

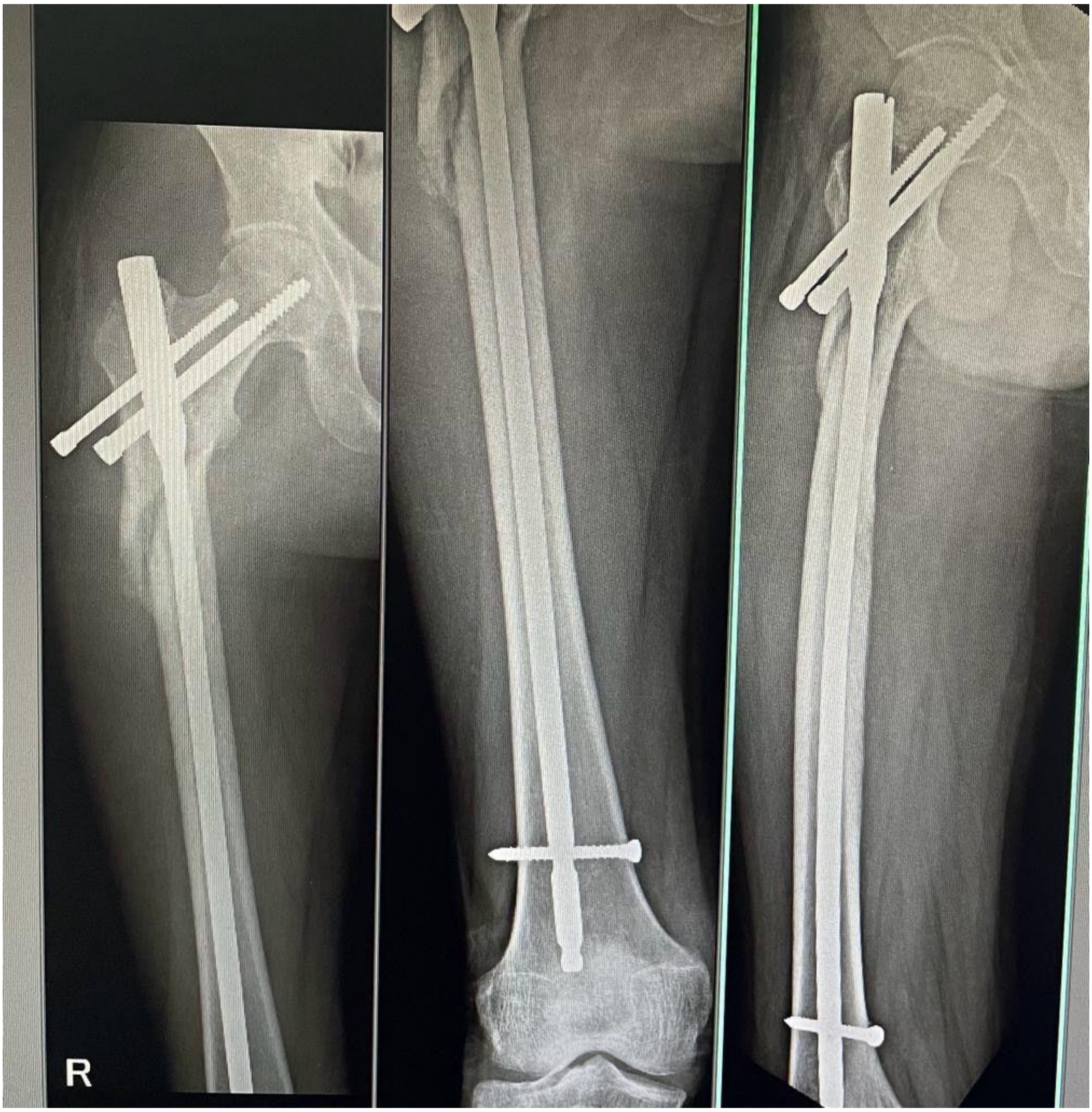
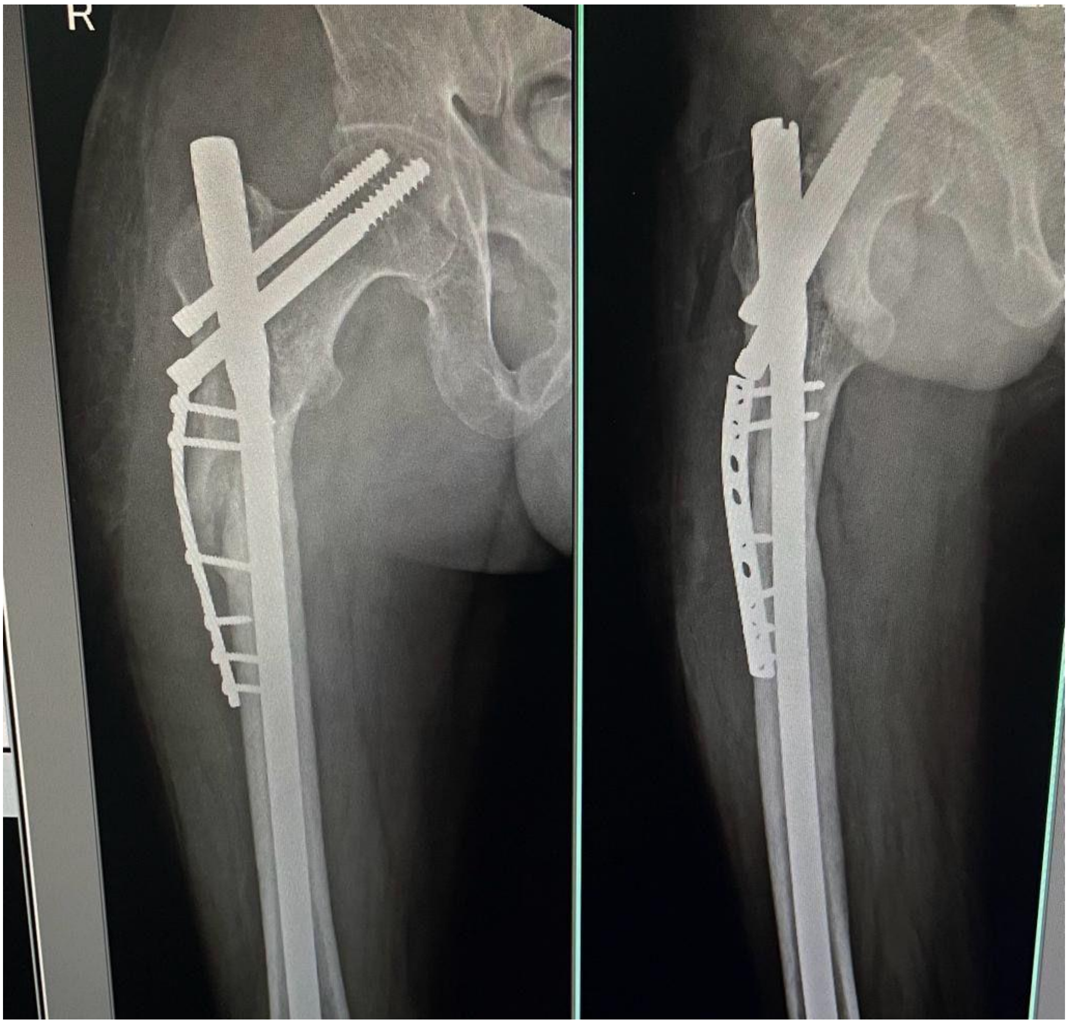


Fig: Non union with implant failure



02 and half months follow up

Fig 02: 05 months follow up

Fig 03: 08 months follow up

3. Results

All patients achieved clinical and radiographic union. The mean union time was 7.1 months (range 4–18 months). One patients achieved union after 1 year without implant failure. Minor complications occurred in two patients; one patient experienced superficial wound infection that was managed successfully with local wound treatment alone and one patient experienced trochanteric bursitis that was managed conservatively. All patients ambulated independently at their most recent followup.

Table 1: Patient demographics

Case	Age (years)/gender	Prior fixations	Nonunion type	Time elapsed (months)	Treatment	Time to union (months)	Complications
1	35/male	Gamma nail	Atrophic	10	DCP nail	10	
2	60/male	ILN	Oligotrophic	12	DCP nail	6	
3	60/male	Gamma nail	Oligotrophic	12	DCP, nail	4.5	
4	65/female	Gamma nail	Atrophic	9	DCP nail	9.5	Superficial infection
5	27/female	PFN	Atrophic	10	DCP nail	5	
6	64/male	PFN	Atrophic	10	DCP nail	10	
7	45/male	PFN	Atrophic	7	DCP, nail	8	
8	69/male	Gamma nail	Atrophic	11	DCP nail	10	
9	68/female	PFN	Oligotrophic	9	DCP, nail	6	Trochanteric bursitis
10	62/female	Gamma nail	Oligotrophic	9	DCP nail	7	

ILN=Antegrade interlocking nail, PFN=Proximal femoral nail

4. Discussion

The management of subtrochanteric fracture nonunion is difficult because of malalignment, bone loss, broken implants, and poor vascularity. Since Charnley and Zickel described successful management with revision nailing for subtrochanteric fracture nonunion, various methods to treat this complication have been advocated. However, there remains a lack of consensus regarding the best approach for this task.10,22

Barquet et al. treated 26 patients with a long Gamma nail (Howmedica/Osteonics, Mahwah, NJ, USA) and the selective use of bone grafts; healing was ultimately observed for 25 of these patients, with a mean healing time of 7 months.23 These authors claimed that a long period of protected weight bearing is necessary following fixation with an extramedullary device; this requirement would be difficult or even impossible for elderly patients. In contrast, intramedullary devices have biomechanical advantages relative to plates, including a short lever arm, a lower bending moment, and load-sharing characteristics. These advantages allow for early full weight bearing, which is beneficial for elderly patients. However, in the series examined by Barquet et al., five patients received secondary interventions, including dynamization, bone grafting, and/or nail exchange, and three patients developed broken implants, which include two broken distal bolts and one broken nail. In contrast, no broken implants were observed in our study. No implant breakage or loosening occurred despite the fact that >1 year was required to achieve union.

de Vries et al. treated 33 cases of subtrochanteric nonunion in 32 patients with blade plates and the selective use of bone grafts; eventual union was observed in 32 cases, with an average time to union of 5 months.24 These researchers suggested that alignment correction and fracture site compression are more feasible with plating than nailing. Nine of the 32 patients experienced a complication after the index operation; the observed complications included blade tip protrusion and implant breakage. Due to these complications, five patients required reintervention. In contrast, in our study, no patient underwent a secondary intervention, and no major complications were observed. Haidukewych and Berry reported a similar union rate between extramedullary plating and intramedullary nailing.25 In their series, 21 subtrochanteric fracture nonunions were treated with open reduction and internal fixation with a cephalomedullary nail, a standard antegrade interlocking nail, 95° blade plate, or sliding hip screws. Twenty of the 21 cases of nonunion healed and there was no difference between using intramedullary or extramedullary device. No details regarding union time or secondary interventions were discussed.

Exchanging nail alone has been shown to be a successful method for treating nonunion of the femur. However, the location of nonunion has been shown to be related to the success rate of exchanging nail. Yang et al. performed a retrospective review of 41 patients with aseptic femoral nonunion that was treated by exchanging nail.26 Union was achieved in 87% of patients with isthmus nonunion compared with 50% only with nonisthmus nonunion.

Park et al. compared the augmentation plating with exchange nailing for nonisthmus femoral nonunion.27 Five of the seven cases of nonunion who were treated by exchange nailing failed to achieve union. In contrast, all 11 cases of nonunions who were treated with augmentation plating achieved union. The enlargement of the medullary canal at the metaphyseal and meta-diaphyseal areas resulted in a size mismatch between the diameter of the medullary canal and the nail. A lack of a secure fit can result in instability, particularly rotational instability, which

is strongly related to failed intramedullary nailing. The authors believed that nonunion of the subtrochanteric area bears similar characteristic of the nonisthmus femoral nonunion. Isolated exchange nailing might not be sufficient enough despite better refixation.
The virtues of side plating could not be differentiated from routine autogenous bone grafting based on this study design. However, they both delivered positive result to the successful union from the point of view of the authors. The ideal treatment for subtrochanteric fracture nonunion has not yet been determined. Individualized treatment is advised, and various fixation methods have been proposed. Our study suggests that the use of a combination of an intramedullary device, augmentation side plating, and autogenous bone grafting is a reliable approach for treating subtrochanteric fracture nonunion without major complication

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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