

Is augmentation plating an effective treatment for non-union of femoral shaft fractures with nail in situ?

H. R. Jhunjhunwala¹ · A. A. Dhawale¹

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Abstract

Purpose There are few reports of non-union femur shaft fractures treated with plate fixation with the nail in situ. This study reports our results in 40 cases.

Methods Retrospective series of non-union and delayed union of femoral shaft after intramedullary nailing treated with plate fixation. Patients were serially followed-up till 12 months. Fracture union, time to union, knee range of motion, deformity, shortening and complications were recorded. Descriptive statistics were performed as applicable.

Results There were 40 patients with mean age of 35 years (18–65). There were 14 cases of hypertrophic non-union, 24 cases of atrophic non-union and 2 cases of delayed union. The average time of surgery was 1 ½ h and average blood loss was 300 ml. Exchange nailing was done in 9 cases. Union was achieved in 39 patients. The mean time to fracture union was 4 months. Post-operative knee range of motion was >120° in 35 patients. One patient developed deep infection which was treated with removal of implants and exchange nailing with a vancomycin coated nail and union was achieved.

Conclusion Plating is an effective treatment for non-union of diaphyseal femur fractures after intramedullary fixation with the nail in situ.

Keywords Femur · Fracture · Nonunion · Nail · Plate · Osteosynthesis

✉ A. A. Dhawale
arjundhawale@hotmail.com

H. R. Jhunjhunwala
drhrj2@gmail.com

¹ Department of Orthopaedics, Bombay Hospital Postgraduate Institute of Medical Sciences, Marine Lines, Mumbai, India

Introduction

Interlocking intramedullary nailing currently is considered the treatment of choice for femoral shaft fractures. Although most femur fractures heal with intramedullary fixation, non-union does sometimes occur. Webb et al. [1] reported a 4 % non-union rate in 101 patients with intramedullary nails. Brumback et al. [2] reported a 2 % non-union rate with locked intramedullary nails. The options for treatment of non-union of femoral shaft fractures are dynamization, bone grafting, exchange nailing, compression plating and circular ring fixation; however, there is no single standard technique [3]. Instability is thought to be a cause of non-union and hence increasing stability may promote union [4].

There are few reports of femur shaft non-unions treated with plate fixation with the nail in situ [4–6]. This study reports our results of treating femoral shaft non-union subsequent to primary intramedullary nailing with augmentation plating in 40 consecutive cases.

Methods

This is a retrospective case series of 40 patients with non-union and delayed union of shaft of femur after intramedullary nailing treated with plate fixation. Inclusion criteria were cases of non-union or delayed union of the femoral shaft after intramedullary nailing as primary treatment. Exclusion criteria were pathological fractures and infected non-unions. Demographic data, mode of injury, and the presence of any associated injuries at the time of fracture were recorded. Details of the femoral shaft fracture; classification of the primary fracture pattern by the Winquist Hansen system [7], primary operative intervention and

the duration of the fracture (in months) before secondary operative intervention were recorded. The presence of pain, limping, shortening or rotational deformity and knee joint range of motion was recorded.

Evaluation of anteroposterior and lateral radiographs of the femur for the presence of a radiolucent line or radiolucent defect at the fracture site was considered as diagnostic of a non-union or delayed union. The presence of non-union was diagnosed by the following radiological criteria: sclerosis of the bone ends at the fracture site, failure to show any progressive change in roentgenographic appearance over a 6 month interval, a lucent interval through the callus itself, and/or bone atrophy above and below the fracture site [8]. Fracture which showed no evidence of union for more than 3 months was considered as delayed union. Fracture which showed no evidence of union for more than 6 months was considered as non-union. The type of non-union was evaluated on a radiograph, which is hypertrophic or atrophic type and confirmed intra-operatively.

Operative intervention was done in the form of compression plate fixation using 4.5 mm AO DCP using a lateral approach. The patient was placed in supine position with or without use of fracture table depending on the individual case. Removal of the locking screws was done in cases where dynamization was not previously performed at either the proximal or distal end depending on the fracture location to achieve dynamic compression at non-union. In all cases, rotational instability of the fracture site was demonstrated intra-operatively. After raising osteoperiosteal flaps, a dynamic compression plate—4.5 mm broad AO DCP obtaining six cortices above and below the fracture were applied to the lateral surface of the femur. The length of the plate depended on the degree of comminution of the fracture. In more comminuted fractures, a longer DCP was used which would span the fracture site and give an adequate fixation with the screws above and below the fracture site. While placing the screws, ‘missing the nail technique’ was used, that is the screws had to be placed in an antero-medial or posteromedial direction avoiding the nail [4–6]. Some screws had a unicortical hold. In cases of hypertrophic non-union, the hypertrophic callus was chiseled and the bone chips were placed around the fracture, while in cases of atrophic non-union, autogenous iliac crest corticocancellous bone graft was placed at the fracture site. Physiotherapy was started from the first post-operative day with static quadriceps exercises followed by dynamic quadriceps exercises. Continuous passive motion (CPM) was started in cases when patients had difficulty in active knee flexion because of pain and apprehension. Partial weight bearing with a walker or axillary crutches was begun from the second post-operative day. The average period of hospital stay was 7 (range 5–10) days.

All patients were serially followed-up until union at fixed time intervals, and subsequently till 12 months post-operative. The presence of bridging callus across at least three cortices on assessment of anteroposterior and lateral radiograph was interpreted as evidence of union along with the absence of pain and tenderness at the fracture site. Patients were allowed full weight bearing 2 weeks after operative pain had decreased. Knee range of motion, shortening and deformities were assessed at the time of union and compared to the pre-operative findings. Complications if any were recorded. Descriptive statistics were performed as applicable.

Results

There were 40 patients with 31 males and 9 females. The mean age was 35 years (18–65). There were 14 cases of hypertrophic non-union, 24 cases of atrophic non-union and 2 cases of delayed union. 39 cases had primary closed fractures and 1 an open fracture. The primary fracture was Winquist Hansen type 1 in 18 and type 3 in 22 cases. The mean time interval since the primary nailing was 6 months (range 3.5–12 months). All patients complained of pain at the non-union site. Four patients with broken nail had an external rotational deformity of the lower extremity. The fracture site was upper third in 3 cases; middle third in 32 and lower third in 5. Primary intervention was performed with a locked intramedullary nail in 33 cases, Kuntscher nail in 4 cases and locked supracondylar nail in 3. Pre-operative knee range of motion was $\geq 90^\circ$ in 36 patients and $\leq 90^\circ$ in 4 patients. Mean shortening of 1.5 cm was present in 4 patients.

The average time of surgery was 1 ½ hours and average blood loss was 300 ml (range 200–500). Plating was done with 4.5 mm DCP (Synthes) with 6 cortices fixation on either side. Exchange nailing was done in 9 cases, 4 with broken nails, 3 cases with thin nails and 2 with short nails. Supplementary autogenous bone grafting was done in 24 patients with atrophic non-union.

Union was achieved in 39 patients after plating. The mean time to fracture union was 4 months (range 3–6 months). Post-operative knee range of motion was $>120^\circ$ in 36 patients and $\geq 90^\circ$ in 4 patients. Mean shortening of 1.5 cm was present in four patients.

One patient developed an infection which was treated with removal of the implants and exchange nailing with a vancomycin coated nail, and union was achieved after 1 year.

Case illustrations of hypertrophic non-union are shown in Fig. 1a–d and atrophic non-union are shown in Fig. 2a–d. Summary of results is shown in Table 1.

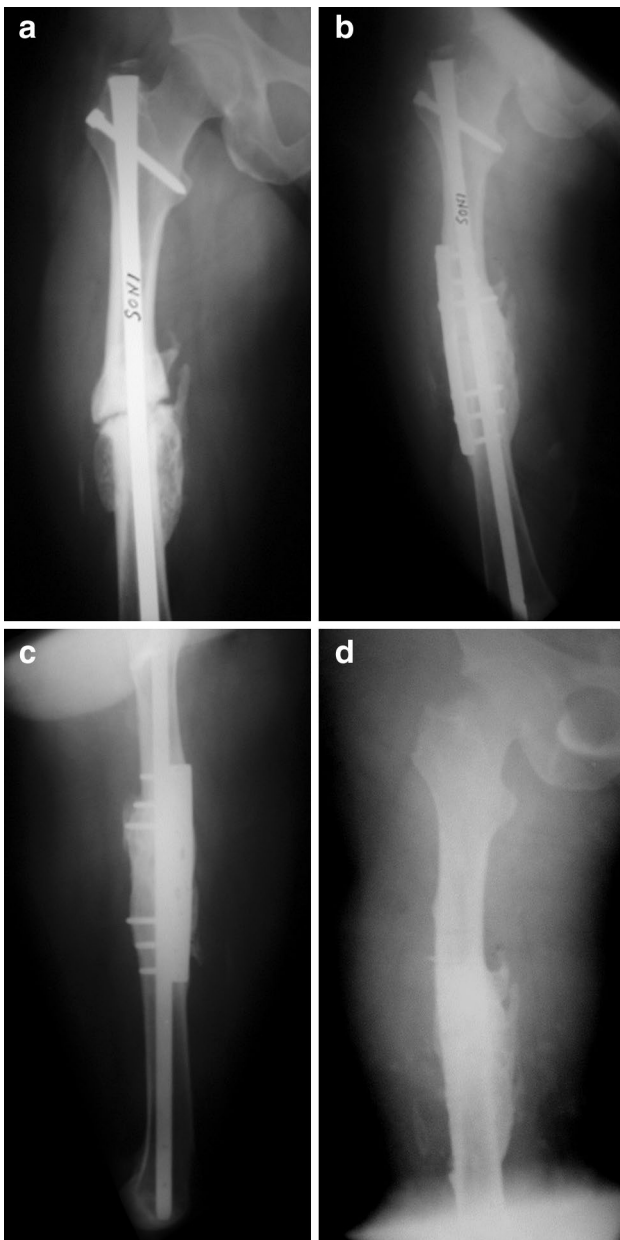


Fig. 1 **a** Hypertrophic non-union with intramedullary interlocking nail. **b** AP radiograph showing union. **c** Lateral radiograph showing union. **d** After implant removal

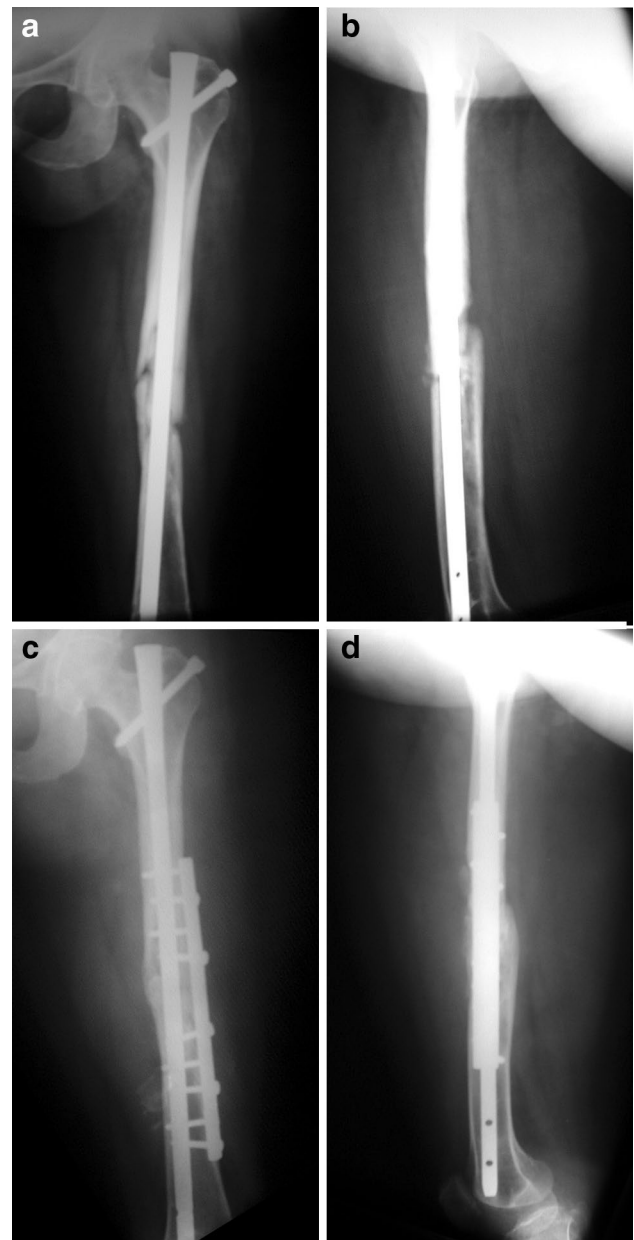


Fig. 2 **a** AP radiograph of atrophic non-union with intramedullary interlocking nail. **b** Lateral radiograph of atrophic non-union. **c** AP radiograph showing union. **d** Lateral radiograph showing union

Discussion

The limitations of this study are the retrospective design and absence of a control group. Notwithstanding, this is a fairly large series with encouraging results. In cases where exchange nailing was performed, rotational instability at the fracture site was observed even after exchange locked nailing with a larger diameter nail necessitating the use of a plate. In the cases where the

nail was in situ, rotational instability was noted intraoperatively and plating resulted in additional rotational stability which was important for union. Locking screws were removed to achieve compression at non-union at the time of plating. The decision for plating with the nail in situ was based on the technical accuracy of the primary nailing. When the nail working length and diameter was adequate, and proximal and distal locking screws were present, then plating was performed with the nail in situ

Table 1 Details of treatment

Patients	31 Males 9 Females
Age	35 years (18–65)
Type of non-union	Hypertrophic non-union 14 Atrophic non-union 24 Delayed union 2
Primary fracture type	Closed 39 Open 1
Winquist Hansen fracture classification	Type 1–18 Type 3–22
Fracture site	Upper third—13 Middle third—32 Lower third—5
Primary intervention	Locked intramedullary nail—33 Kuntscher nail—4 Locked supracondylar nail—3
Prior dynamization	21
Dynamization at time of surgery	11
Mean interval since primary surgery	6 months (3.5–12)
Exchange nailing	Broken nails—4 Thin nails—3 Short nails—2
Plating	With supplementary autogenous bone grafting—24 No bone grafting—16
Rotational instability demonstrated intra-operatively	40
Fracture healing	Union—39 Infective non-union—1
Mean time to fracture union	4 months (3–6 months)

after removal of the locking screws. When the nail was broken, thin or short, exchange nailing was performed along with the augmentation plating. The DCP plate achieves compression at the fracture site which facilitates union and early weight bearing.

Factors responsible for non-union include the severity of trauma, degree of comminution and technical problems in primary intramedullary nailing [3]. Kessler et al. [9] have studied the effects of reaming and intramedullary nailing on fracture healing and found that revascularization of the medulla occurs in the space between the nail and the cortex within a period of 4 weeks, hence, when plating is done secondarily, the medullary canal blood supply is already revascularised. Although plating causes damage to the periosteal blood supply, this can be minimized by gentle soft tissue handling and avoiding excessive periosteal stripping. In our series, autogenous bone grafting was also done in atrophic non-union to improve the biology for healing, the rationale was to ensure union as the fracture site was opened; and the morbidity of persistence of the non-union was thought to be greater than the donor site morbidity. We did not use bone graft substitutes or bone morphogenic protein.

In comparison with intramedullary exchange nailing, plate fixation for femoral non-unions with the nail in situ

has been reported in few case series [4–6]. Weresh et al. [10] in a series of 19 patients reported a high failure rate of 47 % for exchange reamed intramedullary nailing of femoral non-unions with one or more additional procedures needed to achieve union. In 17 cases of femoral non-union, Ueng et al. [4] reported union in all cases within 7 months with augmentation plating with the nail in situ without bone grafting. Choi et al. [5] reported 100 % union within 7.2 months after plating and bone grafting with the nail in situ in 15 cases of femoral non-union. Although this technique provides the advantage of early weight bearing, it does not allow for correction of unacceptable deformity unless exchange nailing is performed. Park et al. [11] performed a biomechanical study in 13 matched cadaveric femur fracture models to compare the mechanical rigidity between plate fixation with the nail in situ and interlocking nail, and found a 2.6-fold increase in bending stiffness and a 3.3-fold increase in torsional stiffness in plate augmentation compared to interlocking nailing.

Plating with the nail in situ is an effective treatment for non-union of diaphyseal femur fractures after intramedullary fixation. The technique is simple and does not require any special instrumentation. It facilitates early weight bearing as with the nail in situ, axial loading is achieved and the plate gives additional rotational stability.

Conflict of interest A. A. Dhawale and H. R. Jhunjhunwala declare that they have no conflict of interest.

Compliance with ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

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