Acta Scientific Orthopaedics (ISSN: 2581-8635)

Volume 3 Issue 7 July 2020

Research Article

Reamed Intramedullary Exchange Nailing for Aseptic Non-Union of Isthmus and Enhanced Distal Fixation Exchange Nailing for Non- Union of Distal Third Shaft Femur Fractures

Govind S Kulkarni[1], Supreet N Bajwa[2]*, Siddharth S Vakil[3], Deepak Garg[4], Umesh S Shelke[4] and Yash S Parikh[2]

[1]Director, MS Orthopaedics, Department of Orthopaedics, Post Graduate Institute of Swasthiyog Prathisthan, Miraj, Maharashtra, India

[2]Resident, D. Orthopaedics, Department of Orthopaedics, Post Graduate Institute of Swasthiyog Prathisthan, Miraj, Maharashtra, India

[3]Resident, MS Orthopaedics, Department of Orthopaedics, Post Graduate Institute of Swasthiyog Prathisthan, Miraj, Maharashtra, India

[4]Resident, DNB Orthopaedics, Department of Orthopaedics, Post Graduate Institute of Swasthiyog Prathisthan, Miraj, Maharashtra, India

***Corresponding Author:** Supreet Bajwa, D Resident, D. Orthopaedics, Department of Orthopaedics, Post Graduate Institute of Swasthiyog Prathisthan, Miraj, Maharashtra, India.

Received: May 08, 2020

Published: June 12, 2020

Abstract

Background: The aim of this study was to evaluate the role of exchange nailing in isthmus and exchange nailing with poller screw fixation and multiplanar interlocking screws for Distal Third shaft femur aseptic non-union.

The evaluation was addressed by measuring the clinical, functional and radiological outcome of our treatment methods in both non-union groups.

Design: Retrospective study

Methods: Between 2006 to 2014, 55 patients with Non-union of shaft femur were operated using a standardised protocol at our institute and followed up for functional and radiological outcome.

5 patients were lost to follow up and thus were excluded from this study.

Out of 50 patients, 29 were cases of Isthmus Non-union and remaining 21 were cases of Distal Third Non-union. Our approach in Isthmus group was closed Exchange nailing with 2 mm larger nail with medullary reaming. Some needed isthmus when radiological signs of healing were delayed.

In Distal Third group, poller screws were used in conjugation with reamed exchange nailing with a 2 mm larger diameter nail and interlocking screws in different planes.

Out of the 50 patients, 48 were men and 2 women. Their mean post-surgical procedure period at presentation of non-union was 11.60 months.

Results: Out of a total 55, 5 were lost to follow up- all from isthmus group. In isthmus group, healing was observed in 25 out of 29 patients with union achieved in a mean of 7.60 months. Delayed union was seen in 3 patients and addressed with dynamisation of distal screws leading to union in all cases in a mean of 13 months without further intervention.1 patient had superficial infection which resolved with debridement at 4 months. 1 patient required additional bone grafting for persistent non-union and healed at 18 months. Non-union was encountered in 3 patients who refused further treatment and accepted functional limitations. Harris Hip Score for this group was 87.40.

In Distal Third group, all 21 patients achieved union in a mean time of 10.30 months.

No patients required further revisions however 4 patients had superficial infection which was treated with antibiotics and debridement. No further complications were encountered in this group of patients and bony union was uneventful otherwise. Harris Hip Score of this group was 92.40.

Conclusion: Using exchange nailing for isthmus and poller screw augmentation for Distal Third Shaft Femur Non-union yields excellent clinical, functional and radiological outcome. Exchange nailing with or without poller screw augmentation is a less invasive method to treat aseptic non-union of shaft femur fractures without additional complications.

Keywords: Nonunion; Exchange Nailing; Poller Screw; Femoral Non-Union; Aseptic Non-Union

Introduction

The current standard of treatment for shaft femur fractures in adults is Closed Intramedullary Nailing [1,2]. Although union rates are reported to be 85 - 100%, recent studies have shown high rate of Non-Union after Intramedullary Nailing [3]. The management of such cases still represents a challenge to the operating surgeon. Many risk factors for Aseptic Non-union of shaft femur have been identified viz. smaller undreamed nail, open fractures, tobacco consumption [1]. However, the rate of non-union of Distal Third fractures is higher due to inability to provide stable fixation in the distal fragment. This is due to the comparatively larger medullary cavity in the Distal Third fragment as compared to the isthmus thereby invariably using a smaller than warranted nail diameter [4,5].

According to current literature, exchange nailing remains the treatment of choice for aseptic non-union of femoral shaft [6]. This includes removal of previously inserted nail, over-reaming of medullary cavity by 2 mm and replacing with a larger diameter nail. Bone grafting is not required due to increased vascularity of non-union site due to changes in the vascular dynamics at the fracture site [7]. Reaming increases the periosteal blood flow in response to endosteal circulation [8-10] thus stimulating bone formation at non-union site. In addition, there is mechanical stability offered by larger diameter nail and increased cortical contact due to reaming [11,12].

However, conflicting data has emerged in the recent past for the management of Distal Third non-union of shaft femur. Exchange nailing alone has resulted in higher failure rate [5]. Furthermore, 2 studies questioned the effectiveness and outcomes of exchange nailing of isthmus non-union and demonstrated failure rate of 27% [13] and 42% [14] respectively.

To obtain a clear consensus, this study was conducted: (1) To determine the functional and radiological outcome of reamed exchange nailing of isthmus aseptic non-union of shaft femur. (2) To determine if enhanced stability of distal fragment attained by placing blocking screws (poller) and distal interlocking screws in multiple planes gave acceptable union rates, radiological and functional outcomes.

Materials and Methods

Between 2006 and 2014, 55 patients with Aseptic Femoral Shaft Non-Union were analysed and treated at our institute. 5 patients were excluded from the study due to loss of patient follow up. Out of the remaining 50 patients included in our study, 29 were cases of Non-union of Isthmus and 21 were cases of Non-union of Distal Third region. All the patients included were cases previously operated with an intramedullary nail for a femoral shaft fracture and subsequently developed Non-union. All patients on presentation had a retained intramedullary nail. Nonunion for these patients was defined according to literature as missing union in treated fractures without progression towards healing. These patients in opinion of the treating surgeon had very little possibility of clinical and radiological union without any surgical intervention [15]. All patients presented with persistent pain, inability to bear weight and loss of function. Radiologically, lack of cortical bridging in 3 out of 4 cortices assessed in Antero-Posterior and Lateral conventional radiographs was considered confirmatory. None of the patients presenting in our OPD had any clinical or laboratory signs of infection nor any previous history during earlier treatment.

All patients with infected Non-unions of shaft femur, segmental defects more than 50% of cortical contact area, periprosthetic fractures, insufficiency fractures or pathological fractures were excluded from this study.

Out of the 50 patients included in this study, 48 were men and 2 women with a mean age of 32.70 (range 16 - 64 years) on presentation. Anatomically, 29 were non-union of Isthmus region and 21 were Non-union of Infra isthmus region. The mean duration of Non-union (Interval between first surgery and subsequent exchange nailing) was 11.60 months (range 7 - 25 months).

All patients were tested for infection preoperatively with complete blood count, ESR and CRP. No patient had any clinical or laboratory evidence of infection. Pre-operative templating was done with true size X-rays for all patients in standard AP and Lateral views. All surgeries were performed by the senior author at an Orthopaedic Trauma Centre. All patients were followed up till union was achieved or until patients refused further management.

Healing was determined by the presence of bone bridging in 3 out of 4 cortices [16] on serially taken post-operative x-rays (Figure 1).

The surgical strategy adopted for isthmus nonunion was: (a) Removal of previous nail. (b) Over reaming by at least 2mm followed by Exchange nailing. For Distal Third Nonunion, additionally, (c) Multiple distal interlocking screws in different planes in distal fragment were added to conform additional stability. (d) Blocking screws.

By definition, isthmus of femur was defined as the narrowest region between the cortices of femur shaft on AP view. Distal Third region was defined as region between the isthmus and the upper border of trans-epicondylar width in knee joint [5].

Technique

All patients were positioned in supine position on the radiolucent fracture table. All nails were exchanged in anterograde man-

Figure 1: 16-year-old Male with AP and Lateral X-rays presenting 9 months after primary surgery. Post-operative X-rays show an over-reamed nail with 2mm larger diameter showing complete union.

ner. After nail removal, the intramedullary canal was sequentially over-reamed until strong resistance was felt or bony debris were seen within the reamer flutes. The increased nail diameter was exchanged in an anterograde manner with nail diameter at least 2 mm larger than the previous nail. The mean nail diameter of nail inserted in primary procedure was 9.45 mm (range 8 - 12) whereas the mean exchanged nail diameter was 11.20 mm (range 10 - 14). Furthermore, poller screws were inserted in the distal fragment of Distal Third non-union in all cases of exchange nailing. Additional Interlocking screws were added in distal fragment in multiplanar directions. The poller screw was positioned in the sagittal plane of the distal fragment closest to the nail. All the screws were self-tapping, predrilled screws inserted using drill guides. Additionally, all the nails were reimpacted ("backslapped") after distal locking to improve contact at non-union site.

All patients received physiotherapy postoperatively. Weight bearing was allowed as tolerated and follow up X-rays were taken serially at 6-week intervals. Clinical assessment of weight bearing, wound healing and functionality were assessed at 3 months postoperatively (Figure 2).

Figure 2: 27-year-old male presenting with an Distal Third non-union of shaft femur at 13 months post primary nailing. Subsequent X-rays show exchange nailing and full union at 9 months post exchange nailing.

Non continuous variables were tested using Fisher Exact Test. Main outcome measures (radiological union and clinical union) were evaluated using multiple logistic regression analysis. One way analysis of variance was used to determine time to healing and nail diameter. Criteria for significance was $p < 0.05$.

Results

Out of 55 patients, 5 were lost to follow up. Remaining 50 were analysed and 47 (94%) patients went on to heal radiologically at a mean of 8.52 (range 3 - 18 months). Remaining 3 patients refused further treatment (Table 1).

Parameters	Values
Age (years), Mean	32.70 (16 - 64)
Male/Female	48/2
Anatomical Classification	
Isthmus	29
Distal Third	21
AO Classification	
Type A	43 (86%)
Type B	7 (14%)
Type C	0
Non-union type	
Hypertrophic	33 (66%)
Oligotrophic	9 (18%)
Atrophic	8 (16%)

Table 1: Summary of characteristics of 50 patients with aseptic non-union of femur shaft.

25 isthmus nonunion healed out of total 29 (86.2%) at a mean duration of 7.60 months. Of the remaining 4, 3 refused further surgery and 1 was treated surgically with bone grafting and went on to heal at 18 months postoperatively. of the 25 isthmus non-union that healed successfully, 3 required dynamisation and went on to heal at a mean of 13 months. 1 patient had superficial infection which resolved with debridement at 4 months. Harris Hip Score for this group was 87.40.

In 21 patients with Distal Third non-unions, all healed (100%) with radiological union seen at a mean of 10.30 months. 4 patients had superficial infection which were debrided and went on to heal uneventfully. All patients in addition to exchange nailing were stabilised with multiple distal inter locking screws and poller screws in this group. Harris Hip Score of this group was 92.40.

The mean nail diameter of nail inserted in primary procedure was 9.45mm (range 8 - 12) whereas the mean exchanged nail diameter was 11.20 mm (range 10 - 13).

In both groups, no clinical limb length discrepancy, axial or rotational malalignment was seen.

All 47 patients resumed their physical activity while 3 accepted their functional limitations and refused further management.

Discussion

Femur shaft Non-union constitute for about 0.5 - 3% of all non-unions [17,18]. However, there has been an increase in the number due to use of closed intramedullary nailing technique. The pitfalls of closed intramedullary nailing are poor surgical technique, soft tissue interposition at the fracture site, distraction at the fracture site on nail insertion [1].

In cases with hypertrophic non-union, union may not be achieved due to excessive fracture site mobility and can be addressed with stable fixation. In case of atrophic non-union, biological environment as well as the overall mechanical stability has to improve along the fracture site.

Most common method of treating non-union of shaft femur is closed exchange nailing [19]. Some authors recommend 2 mm or more over-reaming [20]. Therefore, periosteal damage is minimal and chances of infection are reduced. Axial, rotational and length are maintained using interlocking screws. Medullary reaming increases vascularity to the periosteum due to an inflammatory response and release of growth factors thereby autograft effect at the non-union site [21,22]. The insertion of an oversized nail increases the stability of the construct and also increases the medullary contact area between the bone and the nail. Therefore, our 86.2% of healing rate of isthmus non-union can be attributed to use of a substantially larger reamed intramedullary nail than original. The disadvantage of this closed technique is splaying (distraction) of the fracture fragments during nail insertion, radiation exposure, necrosis of bone due to excessive reaming. Getting a stable fixation for Distal Third non-union is difficult due to difference in nail diameter and non-union site diameter.

Other technique for such non-union is nail removal and fixation with a compression plate. Bone grafting is usually required if the bone defect is extensive or when associated with a rotational, angular malalignment or LLD is present [23]. This is however an invasive technique and limits mobility post operatively with an added risk of stress fractures after implant removal.

Retrograde nailing is another alternative technique but establishing a new entry point in the knee may cause damage to the articular surface and PCL insertion [24]. It may also lead to impingement during knee flexion if left proud during insertion.

Another available method is augmentative plating [25] with nail *in situ*. The drawback of this method is longer surgical time, difficult plate fixation as screw insertion has to be between the nail and medullary cavity.

Poller screws are blocking screws that prevent coronal shift of ILN within a relatively wide medullary cavity thereby preventing toggling [26]. They also strengthen the construct in sagittal plane by increasing the interlock strength between bone and ILN if inserted close to the nail. The routine role of these blocking screws is to prevent the nail reentry in wrong channel if previously created by preventing the shift of bone fragments. Poller screws were used in all cases of Distal Third Nonunion. Along with larger exchanged nails, additional distal locking screws were inserted where the implant design allowed such addition. Local bone grafting was obtained by over-reaming which deposited bone fragments at the fracture site. Gap at fracture site was reduced using a backstroke technique after locking the screws in distal fragment. Bone union was achieved in patients irrespective of type of non-union after nail exchange. The author tried using poller screw for stabilisation of fracture and prevent translation in a minimally invasive method after nail exchange. The advantages of this technique are faster postoperative mobilisation, minimal surgical trauma and reduced chances of infection by virtue of smaller incision and minimal soft tissue damage. However, radiation exposure, poor surgical technique for free hand distal locking, vascular damage are potential pitfalls for this technique (Figure 3).

Figure 3 40-year-old male presenting with Distal Third non-union with intramedullary nail in situ at 12 months. Exchange nailing with poller screw was done and union was achieved at 12 months post exchange nailing.

The limitations of this study are: Factors leading to non-union are not addressed and there is no comparison between isthmus and Distal Third non-union groups; Confounding factors could not be evaluated; Primary nail- whether reamed or unreamed could not be assessed; No difference in outcome of Hypertrophic, Oligotrophic and atrophic non-union was analysed; Due to a limited case load, Distal Third group treated with exchange nailing and a comparative with exchange nailing with augmentation could not be drawn. These questions can be addressed by a future RCT study with a larger case load.

However, this study does succeed in demonstrating that exchange nailing has a definite role in treating isthmus non-union with good functional and radiological outcome. It is a straightforward solution to a potentially worrisome complication to closed intramedullary nailing.

Addition of poller screws and distal interlocking screws in various planes is a minimally invasive approach to Distal Third non-union. This is particularly useful for unstable non-union that occur due to larger medullary cavity in relation to the nail diameter.

Conclusion

Using exchange nailing for isthmus and poller screw augmentation for Distal Third Shaft Femur Non-union yields excellent clinical, functional and radiological outcome. Exchange nailing with or

without poller screw augmentation is a less invasive method to treat aseptic non-union of shaft femur fractures without additional complications.

Conflict of Interest

None.

Study Funding

None.

Bibliography

1. Taitsman LA., *et al*. "Risk factors for femoral nonunion after femoral shaft fracture". *The Journal of Trauma* 67.6 (2009): 1389-1392.

2. Canadian Orthopaedic Trauma Society. "Nonunion following intramedullary nailing of the femur with and without reaming. Results of a multicenter randomized clinical trial". *The Journal of Bone and Joint Surgery American Volume* 85.11 (2003): 2093-2096.

3. Wolinsky PR., *et al*. "Reamed intramedullary nailing of the femur: 551 cases". *The Journal of Trauma* 46.3 (1999): 392-399.

4. Zickel RE. "Nonunions of fractures of the proximal and distal thirds of the shaft of the femur". *Instructional Course Lectures* 37 (1988): 173-179.

5. Yang KH., *et al*. "Nonisthmus femoral shaft nonunion as a risk factor for exchange nailing failure". *The Journal of Trauma and Acute Care Surgery* 72.2 (2012): E60-E64.

6. Pihlajamaki HK., *et al*. "The treatment of nonunions following intramedullary nailing of femoral shaft fractures". *Journal of Orthopaedic Trauma* 16.6 (2002): 394-402.

7. Shroeder JE., *et al*. "The outcome of closed, intramedullary exchange nailing with reamed insertion in the treatment of femoral shaft nonunions". *Journal of Orthopaedic Trauma* 23.9 (2009): 653-657.

8. Danckwardt-Lilliestrom G. "Reaming of the medullary cavity and its effect on diaphyseal bone. A fluorochromic, microangiographic and histologic study on the rabbit tibia and dog femur". *Acta Orthopaedica Scandinavica Supplementum* 128 (1969): 1-153.

9. Grundnes O and Reikeras O. "Acute effects of intramedullary reaming on bone blood flow in rats". *Acta Orthopaedica Scandinavica* 64.2 (1993): 203-206.

10. Reichert IL., *et al*. "The acute vascular response to intramedullary reaming. Microsphere estimation of blood flow in the intact ovine tibia". *The Journal of Bone and Joint Surgery British Volume* 77.3 (1995): 490-493.

11. Russell TA., *et al*. "Mechanical characterization of femoral interlocking intramedullary nailing systems". *Journal of Orthopaedic Trauma* 5.3 (1991): 332-340.

12. Utvag SE., *et al*. "Graded exchange reaming and nailing of nonunions. Strength and mineralisation in rat femoral bone". *Archives of Orthopaedic and Trauma Surgery* 118.1-2 (1998): 1-6.

13. Weresh MJ., *et al*. "Failure of exchange reamed intramedullary nails for ununited femoral shaft fractures". *Journal of Orthopaedic Trauma* 14.5 (2000): 335-338.

14. Banaszkiewicz PA., *et al*. "Femoral exchange nailing for aseptic non-union: not the end to all problems". *Injury* 34.5 (2003): 349-356.

15. Cleveland KB. "Delayed union and nonunion of fractures". In Canale and Beaty: Campbell's Operative Orthopaedics, Volume III. 12th edition. Edited by Canale ST, Beaty JH. Philadelphia: Mosby, Chapter 59 (2013).

16. Heckman JD., *et al*. "Acceleration of tibial fracture-healing by non-invasive, low-intensity pulsed ultrasound". *The Journal of Bone and Joint Surgery American Volume* 76.1 (1994): 26-34.

17. Kessler SB., *et al*. "The effects of reaming and intramedullary nailing on fracture healing". *Clinical Orthopaedics and Related Research* 212 (1986): 18-25.

18. Brumback RJ. "The rationales of interlocking nailing of the femur, tibia, and humerus". *Clinical Orthopaedics and Related Research* 324 (1996): 292-320.

19. Niedzwiedzki T., *et al*. "Treatment of femoral shaft union disturbances with intramedullary nailing. Treatment failure". *Ortopedia, Traumatologia, Rehabilitacja* 9.4 (2007): 377-383.

20. Brinker MR and O'Connor DP. "Nonunions: evaluation and treatment". In: Browner BD, Jupiter JB, Levine AM., *et al*. eds. Skeletal Trauma: Basic Science, Management, and Reconstruction. Philadelphia, PA: W.B. Saunders (2009): 615-707.

21. Frolke JP., *et al*. "Viable osteoblastic potential of cortical reamings from intramedullary nailing". *Journal of Orthopaedic Research* 22.6 (2004): 1271-1275.

22. Wenisch S., *et al*. "Human reaming debris: a source of multipotent stem cells". *Bone* 36.1 (2005): 74-83.

23. Gelalis ID., *et al*. "Diagnostic and treatment modalities in non-unions of the femoral shaft: a review". *Injury* 43.7 (2012): 980-988.

24. Zhang X., *et al*. "Treatment of distal femoral nonunion and delayed union by using a retrograde intramedullary interlocking nail". *Chinese Journal of Traumatology = Zhonghua Chuang Shang Za Zhi* 4.3 (2001): 180-184.

25. Ueng SW., *et al*. "Augmentative plate fixation for the management of femoral nonunion after intramedullary nailing". *The Journal of Trauma* 43.4 (1997): 640-644.

26. Krettek C., *et al*. "The mechanical effect of blocking screws ("Poller screws") in stabilizing tibia fractures with short proximal or distal fragments after insertion of small-diameter intramedullary nails". *Journal of Orthopaedic Trauma* 13.8 (1999): 550-553.