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Treatment of the femoral shaft nonunion with double plate fixation and bone grafting: A case series of 14 patients

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ABSTRACT

Introduction: The management of femoral shaft nonunion still remains a challenge in orthopaedic surgery. It represents a serious postoperative problem for the patient, associated with plate breakage and loosening, bone defect, shortening deformity and infection. A double plate fixation combined with bone grafting may become a promising therapeutic strategy for the treatment of patients with femoral shaft nonunion. In this study, our goal was to evaluate the clinical outcome of a novel approach for 14 consecutive patients with femoral shaft nonunion using double plate fixation with bone grafting.
Methods: Retrospective data from June 2010 to August 2012 were obtained from records for 14 consecutive femoral shaft aseptic nonunion patients treated with double plate fixation combined with bone grafting. Nine patients were men and five patients were woman and average age of the patients was 26 years (range from 22 to 32 years). The mean time since injury was 26.2 months. The nonunion had resulted from repeated internal fixation failure (including plate or intramedullary nail fixation) in nine cases and primary internal fixation in five cases.
Results: All the 14 patients were followed up for an average of 14.8 (10–25) months. All cases achieved bony union without wound infection or fixation failure and the mean time to union was 5.2 months (range 4–7 months).
Conclusion: Double plate fixation and bone grafting are a promising method for femoral shaft nonunion. In addition, this strategy is useful for such a nonunion caused by a repeated plate or intramedullary nail fixation failure with bone defect due to its strong stability with three-dimensional fixation and fully bone graft availability.

Introduction

Femoral shaft fractures are a common injury that occurs most frequently in young men after high-impact trauma and in elderly women after a low energy fall. Intramedullary nailing or open reduction with plate fixation can achieve a high union rate of almost 99% [1,2]. However, there was a high complication rate of 24%, including implant failures such as plate and screw breakage, internal fixator loosening, refracture after plate removal, non-union, and infection [3]. Femoral nonunion is a functional and economical challenge for the patient, as well as a treatment dilemma for the surgeon, since the causes of the nonunion are complex and multiple factors are involved.

There are several different surgical modalities for treating femoral shaft nonunion, including nail dynamization [4,5], nail exchange [6], plate osteosynthesis [7,8], Ilizarov external fixation with or without electrical or ultrasound stimulation [9–12], autogenous or allogenic bone grafting [13,14], mono-lateral external fixator [15], vascularized bone transfer and distraction osteogenesis [16,17], and other treatment modalities, such as bone morphogenetic proteins (BMPs) [18–20].

Plate fixation is listed as valid principles, especially when there is a medial bony defect; a standard plate is subjected to a local concentration of bending forces which may induce failure [21,22]. In addition, it is difficult to achieve a rigid, stable and three-dimensional fixation when only using a single plate fixation in some nonunion with large bone defect.

Closed reamed intramedullary nailing combined with or without open bone grafting has been preferred by many authors as the optimal strategy for femoral shaft nonunion [23–25], and the

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nonunion rate of these procedures ranges between 1% and 20% depending on the fracture type and treatment methods [22]. However, it is difficult to ensure the stability of the grafted bones when leaving the intramedullary nail in situ.

The Ilizarov ring fixator has been used in the management of infected nonunions. However, its application in aseptic nonunion is limited since it is cumbersome, time consuming, a steep learning curve and it may not be widely applicable in general practice [9]. Furthermore, the extensive soft-tissue envelope around the femur, the neurovascular structures, the pain caused by tensioned wires, and the difficulty in clothing are the main drawbacks of this device [26]. In a word, the currently available methods are not ideal and effective in dealing the problems of deformity correction, rigid fixation, and achieving completely bony union.

To the best of our knowledge, this is the first report describing the use of double plate fixation and bone grafting for femoral shaft nonunion.

Patients and methods

A total of 14 patients of nonunion of the femurs were treated with double plate fixation and bone grafting at our hospital from June 2010 to August 2012. This study was approved by the institutional review board. Informed consent was obtained from each patient. In general, a delayed union is defined as no fracture healing after 6 months and nonunion is defined a no fracture healing after 9 months with no radiological progression for 3 consecutive months. All primary and delayed nonunion and nonunion cases were included. The diagnosis of delayed or nonunion was made with history, physical examination, and radiographs or CT-scanning. Bone defects due to excision of tumours, congenital defect and limb with vascular insufficiency were excluded from the study. The average age of the patients was 26 years (range 22–32 years), and nine cases were men, five patients were women. The most common fracture site was the middle third of the femur and were aseptic nonunion. The nonunion cases were classified into atrophic and hypertrophic nonunions, according to [27,28]. There were six atrophic nonunions and eight hypertrophic nonunions.

Surgical technique

The operations in this study were performed by the senior author (SSS). Under general or spinal anaesthesia, the patient was positioned supine on a radiolucent table with a sandbag beneath the pelvis of the involved side. A lateral 15 cm long anterolateral incision was made at the middle third of the femur centre on the nonunion, followed by further incision of subcutaneous tissue was made dividing the iliotibial band (tract) in line with the skin incision. Split the fascia lata femoris to explore the original fixation and fracture site without excessive peeling of soft tissue and periosteum. The scar tissue and sclerotic bone were resected adequately. In cases where hardware from previous surgery was present, it was removed using a minimally invasive technique. Tissues were obtained for aerobic and anaerobic cultures and biopsy. A locking compression plate (10–11 holes, 4.5/5.0 mm broad) was placed in the lateral proximal part of the femur, and it was stabilized with a suitable number of locked screws and unlocked screws. Autologous bone grafts were harvested from the iliac crest and cut into small pieces before use, and were placed in the bone defect. Finally, another appropriate size locking plate (8–9 holes, 4.5/5.0 mm broad), which would make a right angle (90°) with the first plate, was placed in the anterior site of the femur through the same incision, and was fixed with at least four screws.

Postoperative care

Postoperative analgesia was given and conventional antibiotics were modified 30 min before surgery to postoperative 24 h, and active or passive ankle flexion, dorsiflexion was started after the surgery in order to contract the lower limb muscles. One day after the surgery can start to move the hip and the knee range of motion 24–48 h after ambulation without weight-bearing activities with the help of two crutches. From 6 weeks after surgery, partial weight bearing was started as the patient was comfortable to walk with the help of two crutches based on the X-ray results. Full weight-bearing walking was done until achieving the complete bone union.

Outcome measures

Postoperative evaluation was divided into bone union and functional results [29]. Bone results were evaluated based on four criteria: union, infection, deformity and limb length discrepancy (LLD). An excellent bone result was one with union, no infection, deformity $<7^{\circ}$ and LLD <2.5 cm; a good result was union with any two of the above criteria. A fair result was obtained when union was present with any one of the above criteria. A poor result was obtained when the bone remained ununited with none of the criteria fulfilled. As to the rest, functional results, five criteria were evaluated: observable limp, stiffness of the adjacent joint, soft tissue dystrophy, severe pain and inactivity (unemployment or inability to return to daily activities). The functional outcome was considered excellent if the patient was active and the other four criteria were absent, good when one or two of the other criteria were present, fair when three or four of the other criteria were present and poor when the patient was inactive, regardless of the other criteria. In view of the small number of patients treated, the data were not subjected to any form of statistical analysis.

Results

All the patients underwent double plate fixation and bone grafting. Mean follow-up was 14.8 months (range 10–25 months). Union was achieved in all the patients in a mean of 5 months and 2 weeks (range, 4–7 months). No patients had plate and screw breakage, internal fixator loosening, deformity, additional surgery, and infection (Table 1).

Discussion

The management of femoral shaft fracture nonunion still remains a challenge to trauma and orthopaedic surgeons. When an associated bone defect, shortening, deformity, infection and poor soft tissue condition do occur, it is hard deal with such complicated matters [8]. Most orthopaedic surgeons and scholars are presenting variety of treatment recommendations for nonunion of long bones, including semi-invasive surgical modalities such as internal fixation applying an interlocking nail [4,5], plate–screw fixation [21,22] and mono-lateral [15], Ilizarov ring external fixation [9–12], bone marrow aspirate infiltration [30], autogenous or allogenic bone grafting [13,14], and other non-invasive management options such as an electric stimulation, low-intensity pulsed ultrasound and extracorporeal shock wave therapy [11,12].

Intramedullary nailing has been recommended for the majority of femoral nonunions by many authors, since it is a minimally invasive method without disturbing the periosteal blood supply and has a high union rate [31,32]. However, there is an ongoing debate on the effect of exchange nailing in the treatment of femoral