Intramedullary Fixation of Failed Plated Femoral Diaphyseal Fractures: Are Bone Grafts Necessary?

Khaled M. Emara, MSc, MD, and Mohamed Farouk Allam, MPH, PhD

Background: Nonunited fracture shaft femur after plate fixation is a common problem in third world countries because of economic reasons. Management of such a problem is still controversial and is associated with many surgical details, due not only to the nonunited fracture itself, but also to the broken implant which is not easy to remove.

Methods: This study is a randomized prospective study presenting 40 patients with aseptic nonunited fracture shaft femur associated with failed plating managed by the removal of hardware, and intramedullary fixation using an interlocking nail with or without autogenous iliac bone graft.

Results: There was no statistically significant difference between patients with and without iliac autogenous bone graft regarding the demographic data, the preoperative condition, and the postoperative course including time needed for bone union and return to work. The statistically significant difference was in the intraoperative blood loss and the duration of surgery with less blood loss and shorter duration of surgery occurring in the group treated by reamed intramedullary nail without iliac bone graft.

Conclusion: In cases with aseptic nonunited fracture shaft femur after failed plating, intramedullary reamed nailing without autogenous bone graft produced similar results as with bone graft, but with less operating time and blood loss.

Key Words: Fracture, Femur, Nonunion, Intramedullary nail, Plate, Shortening, Bone graft, Ilizarov, Deformity.

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shortening of more than 2 cm, history of infection or external fixation, or a patient who was unwilling to participate in the trial. All patients were required to sign an informed-consent form.

Between October 2000 and March 2003, 47 adult patients with femoral shaft aseptic nonunion after plating, were treated in our university hospitals. Of the 47 patients fulfilling the criteria for inclusion in the study, 7 patients were lost

**Table 1**  No Statistically Significant Difference Between Both Groups Regarding Union Time and Return to Work on the Other Hand a Significant Difference was in the Duration of Surgery and the Intraoperative Blood Loss

<table>
<thead>
<tr>
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<th>Group A (Bone Graft)</th>
<th>Group B (No Bone Graft)</th>
<th>If the Difference is Statistically Significant (p)</th>
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<tr>
<td>Number of patients</td>
<td>20</td>
<td>20</td>
<td></td>
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<tr>
<td>Duration of nonunion (mo), mean (SD)</td>
<td>21 (7.55)</td>
<td>21.8 (6.58)</td>
<td>0.756*</td>
</tr>
<tr>
<td>Diameter of the intramedullary nail used for treatment of nonunion (mm), mean (SD)</td>
<td>11.7 (0.801)</td>
<td>11.6 (0.820)</td>
<td>0.699*</td>
</tr>
<tr>
<td>Operative time (min), mean (SD)</td>
<td>210.0 (42.9)</td>
<td>166.0 (29.6)</td>
<td>0.001†</td>
</tr>
<tr>
<td>Amount of blood loss during surgery (mL), mean (SD)</td>
<td>760.0 (125.2)</td>
<td>552.5 (125.1)</td>
<td>0.000†</td>
</tr>
<tr>
<td>Duration needed for union after surgical fixation by intramedullary nail (mo), mean (SD)</td>
<td>4.8 (1.15)</td>
<td>4.9 (1.33)</td>
<td>0.801*</td>
</tr>
<tr>
<td>Duration needed to return to original job after the index operation (mo), mean (SD)</td>
<td>11.3 (1.80)</td>
<td>11.3 (1.75)</td>
<td>0.930*</td>
</tr>
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* p > 0.05, not significant.
† p < 0.05, highly significant.
SD indicates standard deviation.

**Fig. 1.** (A) Fracture shaft femur fixed by a plate that has begun to fail in the form of bending and screw breakage 10 months after surgery. At this stage, the treating doctor performed a bone graft, and exchanged the plate with another plate. (B) The same patient had broken plate with displaced fracture associated with aseptic nonunion 16 months after the fracture. (C, D) AP and lateral early postoperative radiographs show fixation by interlocking nail after the removal of plate and screws and fracture reduction without iliac bone graft. (E, F) AP and lateral radiographs 1-year postoperative showing the healed fracture.
during the early follow-up, resulting in 40 patients being included in the study, 30 men and 10 women, ranging in age from 18 to 40 years old (mean age 30.1-years old) (Table 2). Two cases had fracture of the femoral shaft due to a fall from height, whereas the other 38 patients were victims of motor vehicle crashes. All cases were treated initially by open reduction and internal fixation using AO broad dynamic compression plate. Some patients had more than one operation before presentation; these operations included revision of plate fixation after failure of the first one, autogenous bone graft, and/or percutaneous bone marrow injection (Fig 1, A and B).

![Fig. 2](image-url) (A, B) AP and lateral view of a nonunited fracture shaft femur with broken screws after 14-months postfixation. (C, D) Early postoperative radiographs following an implant removal and replacement using an interlocking nail with autogenous iliac bone graft. (E, F) follow-up radiographs 4 months after interlocking nail insertion. (G) Follow-up X-ray film after 8 months.

<table>
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<th>Table 2</th>
<th>The Age and Sex Distribution in the Two Groups and Number of Smokers</th>
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<tr>
<td></td>
<td>Group A (bone graft)</td>
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<tr>
<td>Sex, n (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (75)</td>
</tr>
<tr>
<td>Female</td>
<td>5 (25)</td>
</tr>
<tr>
<td>Number of smokers, n (%)</td>
<td>6 (30)</td>
</tr>
<tr>
<td>Age (yr), mean (SD)</td>
<td>31 (6.66)</td>
</tr>
</tbody>
</table>

* $p > 0.05$, not significant.
Limb length discrepancy was assessed clinically and radiologically using a CT scanogram. Cases with more than 2 cm shortening were excluded and a limb reconstruction procedure was performed using the Ilizarov technique. To exclude deep infection, preoperative assessment including clinical and laboratory evaluation was performed. A detailed history of wound healing course, along with hematological laboratory studies were, including ESR and C reactive protein. Of the 40 patients, 11 were cigarette smokers and one intravenous drug abuser as well as a cigarette smoker (Table 2). The plate used for fixation was a broad DCP in all cases ranging between 9 and 12 holes plates. Twenty-one patients had a broken implant at the time of presentation (either broken screws or a broken plate) (Figs 1, A, B and 2, A). Ten patients had an intact plate and screws, but the implant had come loose, its screws pulled out. The remaining nine patients had stiff hypertrophic nonunion with intact and stable plate fixation.

All patients were randomly divided into two groups according to the sequence of treatment. An iliac bone graft was not used, as in the case presented in (Fig. 1) or used, as in the case presented in (Fig. 2) alternately.

Technique

Under spinal or general anesthesia, surgery was performed with the patient in the lateral decubitus position. The site of nonunion and plate were exposed using the same previous incision, which was the posterolateral approach to the femur. The hardware was removed along with any broken plate or screws. In many cases with broken screws, the shaft is deep inside the bone with no available head to allow a screw driver to be used to remove the screw using the classic technique (Fig. 2, A). In such cases, drilling multiple holes around the screw shank using a 2.0-mm diameter drill bit, allowed the fragment to be removed, with as minimal amount of bone damage as possible. The multiple drill holes around the screw made the screw shaft loose enough that the screw could be held and removed by artery forceps or arthroscopic grasper. This technique may require more time but is less invasive, which improve the nail fitting and decrease the need for bone graft to reconstruct the defect, than removing the lateral femoral cortex as described by Wu.18

An Incision was made over the greater trochanter for antegrade nail insertion. Usually the medullary canal is obliterated at the site of nonunion, and this sclerotic bone needs to be penetrated using sharp front cutting rigid reamers. Care must be taken during this step to avoid cortical penetration or malalignment. This step requires very close radiologic monitoring using the C arm image intensifier. The use of front cutting rigid medullary reamer to cross the nonunion site is followed by passing a flexible guide wire into the distal bony segment under direct vision along with radiologic guidance. Cases of nonunion of the femoral shaft with many operations and a long period of immobilization are usually associated with knee stiffness. Any adhesions between the quadriceps and the fracture site were released during this step, without trying to bend the stiff knee. Adhesions between the quadriceps and anterior femur were released using a periosteal elevator during removal of the plate.

After implant removal and the passing of the guide wire, before complete reaming of the medulla with larger diameter reamers, the incision site of the plate removal is closed without draining, with or without cancellous iliac crest bone graft, according to the plan made before surgery. In cases where iliac crest graft was planned, the graft was harvested and placed at the site of nonunion and the lateral and medial cortex, along the area of previous plating. The area of nonunion was prepared for the bone graft by freshening bone ends and shingling the cortex using an osteotome. After closing the incision at the level of fracture site, we began canal preparation with flexible reamers over guide wire from the same manufacturer as that of the nailing system until cortical chatter could be heard and felt, implying filling of the canal and endosteal contact at the isthmus of the diaphysis with the reamer. Closure of the plate removal incision before finishing reaming was aimed at gaining the advantage of closed reaming, the bone graft resulting from reaming, and avoiding its loss with blood suction. A nail measuring 1.0 mm less than the final reaming was then inserted. The implants that were used included the Russell-Taylor femoral nail (Smith and Nephew Richards, Memphis, TN), Grosse-Kempf nail (Howmedica, Rutherford, NJ), and ZMS (Zimmer, Warsaw, IN). Static locking was performed in most cases. Closed manipulation of the knee to improve range of movement was performed after nail insertion (Figs. 1, C, D and 2, C, D).

Bone Graft Technique

The trapdoor technique was used for harvesting the graft. Cancellous bone is harvested from the iliac tubercle which lies 3 cm posterior to the anterior superior iliac spine. The attachments of the fascia and abdominal muscles to the iliac crest are kept intact. A horizontal cut extending from 3 cm posterior to the anterior superior iliac spine to a point 6 to 8 cm posterior is made through the iliac crest, allowing the crest to be reflected medially. Cancellous bone is harvested from between the inner and outer cortices of the ilium. The reflected iliac crest is then hinged back and secured by sutures.20

Postoperative Program

Patients were permitted to walk with protected weight bearing 2 weeks after surgery. Gradual increases in knee exercises for range of movement and muscle strength were performed in the outpatient clinic, under the supervision of a physical therapist. Progressive increase in weight bearing and gait training was in accordance with the progress in radiologic bone healing. Patients were followed up at the outpatient clinic in 4 to 6 weeks intervals. Clinical and radiographic bony healing process was recorded (Figs. 1, E, F and 2, E–G). Crutches were discontinued when the fracture showed evidence of healing.
Bone union was defined clinically when no pain was present, no tenderness, and the patient was able to walk with out the assistance of any aids. Radiologic union was defined as solid callus with cortical density, bridging the bone fragments is seen in both anteroposterior and lateral views (Figs 1, E, F and 2, G).

The data were analyzed statistically, using SPSS statistical package version 12 and the following tests were performed: Mean, SD, t test for independent sample means, Man-Whitney U test, and χ² test.

The courses during the operation were approximately evaluated, and the operating time and blood loss were compared. For comparison Fisher’s exact test or Student’s t test was used; p < 0.05 was considered statistically significant.

RESULTS

Forty patients received follow-up care for mean period of 24 months (ranging between 18 and 48 months). All nonunions healed. The union period ranged between 4 and 8 months. The mean union period in cases managed with iliac bone graft was 4.8 months (SD, 1.15 months), whereas the union period for the cases managed without iliac bone graft was 4.9 months (SD, 1.33 months) with no statistically significant difference [(p = 0.801) p > 0.05] (Table 1).

The early complications included superficial infection at the incision site of plate removal in one of the cases treated without iliac bone graft. The infection responded to intravenous antibiotics according to culture and sensitivity for 2 weeks with no residual problem. One case had a hematoma at the site of harvested iliac graft wound that required drainage in the operating room 5 days postoperatively.

Late complications included persistent pain at the graft site more than 12 months in two cases. Hypoesthesia and numbness at the site of iliac graft wound was present in one case. One case had a breakage of the two distal locking screws, which occurred 4 months postoperatively. This patient was in the group managed by iliac bone graft. The patient was taken back to the operating room and the nail was changed using the closed technique, with a new statically locked nail, and eventually healed with no residual problems.

There was no statistically significant difference between both groups of patients regarding the demographic data, the preoperative condition, and the postoperative course including time needed for bone union and return to work. The only statistically significant difference was in the intraoperative blood loss and the duration of surgery with less blood loss and shorter duration of surgery occurring in the group treated by reamed intermedullary nail without iliac bone graft (Table 1).

DISCUSSION

Nails are effective in reconstructing femoral diaphyseal nonunions after plating. Bone grafts are not necessary to achieve union, and add to the rate of potential complications.

In developing countries, the use of a dynamic compression plate for treatment of fracture shaft femur in adults is more common despite the lower success rate than that of the interlocking nail.

The economic factor in the use of plate fixation in poor countries is due not only to the less expensive price of the implant (AO dynamic compression plate and screws in relation to interlocking nail), but also due to the surgical equipments needed in the operating theater including a C arm (image intensifier), and an orthopedic traction table, as well as trained personnel for each system of the interlocking nail. Another factor is the type of training and clinical experience that regular orthopedic surgeons have. The AO basic principals for fracture fixation using plates and screws is well known by most orthopedic surgeons, as this has been part of basic orthopedic training over the last 20 years throughout most of the world.

Intramedullary fixation has biological and biomechanical advantages over other techniques in managing nonunited fracture shaft femur and can result in a good clinical and radiologic outcome.2,3,12

The problem of a broken implant in association with a nonunited fracture was addressed in the literature. There are different methods recommending how to deal with such a problem.16,18 The treatment plan can be leveraging the broken implant and trying to improve the mechanical stability and healing biology at the fracture site by the using external fixation13 or internal fixation in association with bone graft.11 This method is technically easier based on the short-term assessment but is associated with many risks. The risks and problems of external fixation include joint stiffness, and pin infection which could turn into a deep infection in the presence of a broken metal implant at the fracture site.13,14 On the other hand, internal fixation by plating does have less mechanical strength than with intramedullary nailing. The aim of broken screws removal is mainly to allow for insertion of intramedullary nail. Also leaving a failed implant at the fracture site if the fracture has already healed, might be a problem the treating doctors could face, if this patient should need another surgery that requires an open medulla in the same bone (for example arthroplasty or refracture at the same or different level of the same bone). Because of these drawbacks, the method we prefer in such a problem is to remove the failed hardware and then fix the fracture properly.16,18 Although this method is more technically demanding, the advantage of this technique is that it provides the opportunity to correct any local problem at the fracture site, including deformity, without leaving any lost hardware inside that might cause future problems in healing or in any other procedure that might be needed for patient management in the future.

Wu18 described a technique to remove broken screws from the bone. This technique was based on the removal of a bony window made on the lateral femoral cortex, making possible, the removal of the ends of broken screws. The technique we used in this study is different and the advantage of our technique is that it is less invasive and is associated.
with less bone loss and a lesser need for a bone graft. Our technique keeps most of the bony cortex, with better intramedullary nail fitting which can give better fracture stability and earlier rehabilitation.

The use of iliac bone graft in treatment of nonunited shaft femur is recommended by some authors, whereas some authors recommend autogenous bone graft from closed reaming of the femur without exposing the patient to another surgical wound with the risk of more complications. In this study, there was no statistically significant difference between both groups of patients—with or without iliac bone graft—regarding age, sex, smoking, duration of nonunion, the type of broken implant, union time, return to work, knee range of movement on final follow-up, or the diameter of the nail used for fixation. The statistically significant difference was in the operating time itself and the intraoperative blood loss.

We think that there is no need to use iliac bone graft in such cases, as it exposes the patient to a longer operating time, more blood loss, and a greater risk for complications, while it brings about the same results as reamed intramedullary nail with out bone graft.

REFERENCES

AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES

AQ1— Kindly check whether the short title is OK as given.
AQ2— Kindly check whether the edit made to Table 1 is appropriate.