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Comparison Between Non-Union Fractured Femur Shaft By Double Plate and Intra Medullary Screw

A Research Project Submitted to the College of Medicine, to partially fulfill the Requirements for MBChB Degree.

By

AHMED JUM'AA RADHI

SARAH RASOOL KAREEM

FATIMA MOHAMMED NEAMA

ANWAR ABD-ALWAHAB ABD-ALWAHID

BALSAM FADHIL MWAZI

Supervised by

Prof. Dr. Khalid Ali Zaiyr

MBChB F.I.C.M.S (Orthop)

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Contents

Abstract

Introduction

For many years, conservative treatment with traction and/or casting has been the gold standard for all femoral fractures, with relatively good results. The disadvantages are that the patient is tied to the bed with traction or to a wheelchair with spica cast, that there is pain during nursing, that there is a risk of skin problems, and that repeated radiographs are required because of difficulties in maintaining the alignment. For parents, the treatment may result in a long period away from work and for the child there may be a long absence from school. It has become more common for patient not to want a prolonged treatment time in traction. In many societies, the economic pressure to reduce health care costs also favors treatments that reduce hospitalization time.

As the treatments way have developed, the trend has been moving away from non-operative methods such as traction and Spica casting towards methods such as open/minimally invasive plating and intramedullary nailing. Each way has its set of advantages and disadvantages. Several studies advocated different lines of treatment ranging from immediate conservative treatment to delayed surgical intervention.

Despite advances in surgical technique, fracture fixation alternatives, and adjuncts to healing, femoral nonunion continues to be a significant clinical problem. Femoral fractures may fail to unite because of the severity of the injury, damage to the surrounding soft tissues, inadequate initial fixation, and demographic characteristics of the patient, including nicotine use, advanced age, and medical comorbidities. Femoral

nonunion is a functional and economical challenge for the patient, as well as a treatment dilemma for the surgeon. Surgeons should understand the various treatment alternatives and their role in achieving the goals of deformity correction, infection management, and optimization of muscle strength and rehabilitation. Used appropriately, nail dynamization, exchange nailing, and plate osteosynthesis can help minimize pain and disability by promoting osseous union. A review of the potential risk factors and treatment alternatives should provide insight into the etiology and required treatment of femoral nonunion.

Aim

To study the method of treatment of femoral shaft fracture, and to compare and select the proper modality that is always present and easy to get in our city. Also, to check the efficacy of double-plating compared to intra-medullary screws. And to determine the management outcome and which procedure achieved better anatomical reduction and holding this reduction until the fracture is completely united with minimal complications, without interfering with the growth epiphysis. And to prove this surgical procedure is simple, technically less demanding, and suitable in peripheral hospitals in developing countries.

Materials and Methods

A comparative analytical study performed in Al-Husain teaching hospital of Nasiriyah city in Orthopedic department. With average follow-up duration of 10 months, ranged from 3-36 months. Including all patients exposed to femoral shaft fracture, where the divided into 2 groups, 1st group composed 16 patient who underwent Double-Plating, while the 2nd group (16 patient) underwent intra-medullary screws. Patients with inadequate follow-up, incomplete medical records, or death as a result of associated injuries all were excluded. The socio-demographic characters chosen to be nearly was of no significant difference. The outcome was the targeted subjects in form of risk of infection, time of walking, time of healing, amount of callus formation, time of stay in hospital, joint stiffness and type and number of screws. A well prepared questionnaire had been filled by each patient enrolled in this study , where age, gender, mechanism of injury [sport accident (SA), motor cycle accident (MCA), fall from height (FFH), vehicle hit a pedestrian (VHP), Passenger in vehicle accident (PVA)], fracture configuration, time from injury till operation and complications as listed below:

1- Pin tract infection
2- Pin loosening
3- Leg length discrepancy
4- Re-fracture
5- General complications
6- Mal-union and non-union
7- Need for bone graft
8- Knee joint stiffness
9- Osteomyelitis

Follow-up period until the fracture healed. A written consent had been taken from the parents of children who were recruited for this study.

Review of Literature

A fracture of the femoral diaphysis occurring between 5 cm distal to the lesser trochanter and 5 cm proximal to the adductor tubercle is termed a shaft fracture. Femoral shaft fractures occur most frequently in young men after high-energy trauma and elderly women after a low-energy fall. Pathological fractures commonly occur at the relatively weak metaphyseal–diaphyseal junction. A fracture that is inconsistent with the degree of trauma should arouse suspicion for pathological fracture.

The difference between delayed union and nonunion is of degree. In delayed union healing has not advanced at the average rate for location and type of fractures but healing can still take place if the limb is immobilized for a longer period. In nonunion, there is evidence to show clinically and radiologically that healing has ceased and union is improbable and needs surgery. Final status of nonunion is pseudarthrosis.

Nonunion is said to be established when a minimum of nine months has elapsed since the injury and the fracture shows no radiologically visible progressive signs of healing continuously for three months. (FDA Panel)

Clinical Evaluation

The diagnosis is usually obvious with a swollen thigh and a shortened and rotated limb. These patients may be haemodynamically unstable as, often, more than 1000 mL blood loss may occur into the thigh. These fractures are the result of high-energy trauma, and associated musculo-skeletal and major organ injury is seen in 5–15% of cases. About half of these patients also have ipsilateral knee ligamentous and meniscal injuries, and hence stability of the knee should be evaluated with the patient under anaesthesia immediately after bony stabilization.

Radiological Evaluation

Anteroposterior and lateral radiographs including the joint above and below are evaluated to determine the fracture pattern and comminution, bone quality, presence of bone loss and the presence of air in the soft tissues. Associated hip dislocations and femoral neck and intertrochanteric fractures should be ruled out. Associated femoral neck fractures, although found in only 2.5–6% of patients, are missed in 30% of patients. The proximal segment of the femur is normally in abduction and the appearance of the femoral shaft in adduction should alert the surgeon to the possibility of an associated posteriorly dislocated hip.

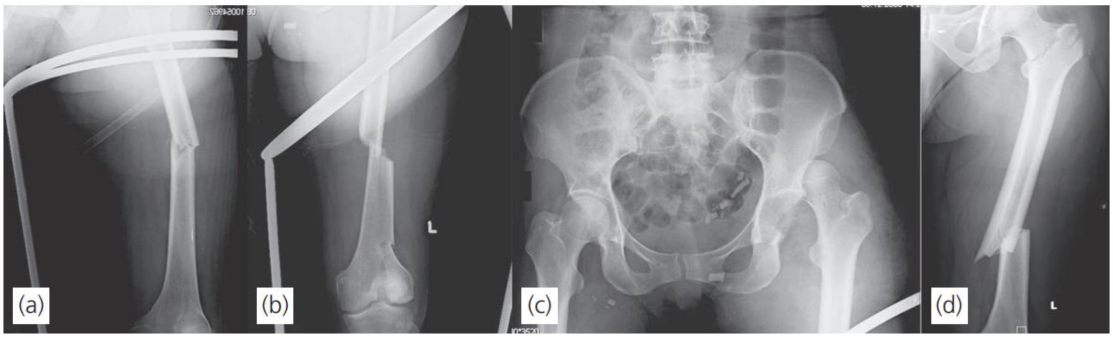


Fig 1(a) Isolated fracture of the shaft of femur showing abduction of the proximal fragment owing to the muscular forces acting on it.

Classification

Femoral shaft fractures may be classified descriptively based on the location (proximal, middle or distal one-third), pattern of the fracture geometry (spiral, oblique or transverse), amount of displacement (shortening, translation, angulation or rotational deformity), extent of comminution (comminuted, segmental or butterfly fragment) and status of soft-tissue envelope (open or closed).

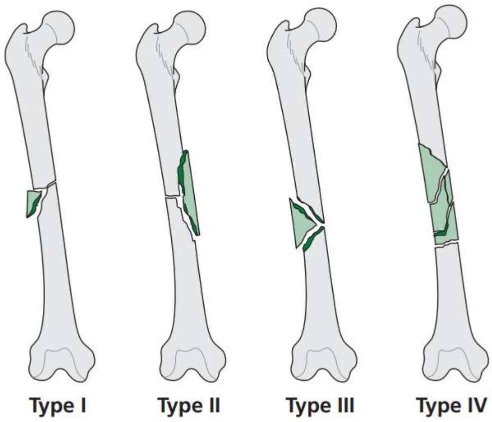


Fig2 Winquist and Hansen Classification

Type I Minimal or no comminution

Type II Cortices of both fragments at least 50% intact

Type III 50–100% cortical comminution

Type VI Circumferential comminution with no cortical contact

The Winquist and Hansen classification based on the diameter of bone that is comminuted was commonly used prior to the introduction of statically locked intramedullary nails1 (Fig. 2).

Type I and II fractures are axially stable, whereas type III and IV fractures are both axially and rotationally unstable. Rotational stability for less comminuted fractures is determined by the amount of comminution and obliquity of the fracture, with more transverse fracture patterns being less rotationally stable. Axially stable fractures are more amenable to earlier weight bearing after intramedullary nailing.

Classification of Femoral Non-Union

Femoral nonunions can be classified according to the criteria described by Weber and Cech. This classification is based on the principle of osseous viability, with fractures divided into viable and nonviable subtypes.

A viable nonunion has an intact blood supply and is capable of mounting a healing response to injury. Subtypes within this classification include hypertrophic nonunion and oligotrophic nonunion. A hypertrophic nonunion displays exuberant callus on anteroposterior (AP) and lateral radiographs, demonstrates increased uptake on radionuclide scans, and represents inadequate stability in the setting of an adequate blood supply and healing response.

In contrast, oligotrophic nonunion, which also has an intact blood supply and demonstrates radiotracer uptake on radionuclide scans, differs in that it possesses an inadequate healing response characterized by evidence of little or no callus on AP and lateral radiographs.

A nonviable femoral nonunion is often called an atrophic or avascular nonunion. These nonunions demonstrate ischemic or cold radionuclide scans, indicating a complete lack of the normal biologic response to injury. Radiographically, atrophic nonunions demonstrate eburnated, osteopenic, and/or sclerotic bone ends. (Fig 3)

Fig3 Anteroposterior radiograph of a nonviable nonunion of the femoral diaphysis demonstrating an atrophic and osteopenic fracture with no callus formation, indicating a lack of an appropriate healing response to the original injury. A technetium bone scan would show decreased uptake in a case such as this

Choice of implant

1- Intramedullary Nailing

Reamed locked antegrade intramedullary nailing through the piriformis fossa is the gold standard for treatment of femoral shaft fractures.

Healing rates as high as 99%, with low complication rates, have been achieved with this treatment. Intramedullary location of the implant results in lower tensile and shear stresses on the implant than plate fixation. Other benefits of intramedullary nailing over plate fixation include less extensive exposure and dissection, lower infection rate and less quadriceps scarring.

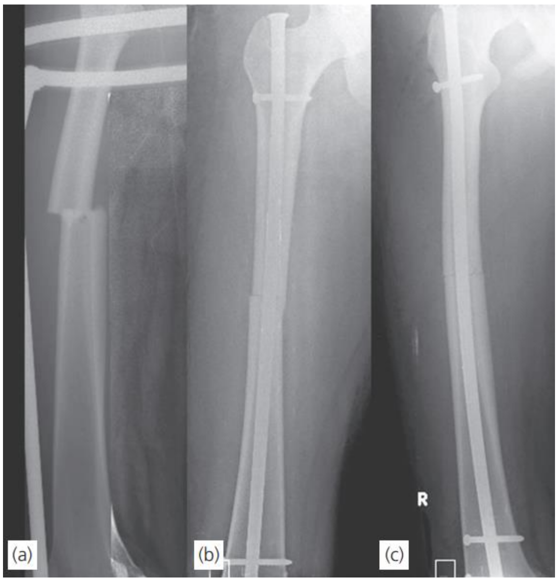


Fig4 (a) Transverse femoral shaft fracture managed by dynamic intramedullary interlocked nailing (b,c).

Closed intramedullary nailing in closed fractures has the advantage of maintaining both the fracture haematoma and the attached periosteum. If reaming is performed, the reamed products provide a combination of osteoinductive and osteoconductive materials to the site of the fracture. Locking of the nail also allows restoration of length and alignment with comminuted fractures, early functional use of the extremity, rapid and high union rates of more than 95% and low re-fracture rates.

Increased Nail Diameter

Insertion of an increased diameter nail has several mechanical advantages. Augat et al. have demonstrated that with larger nail diameters, the axial and rotational stability and resistance against shear forces increased. Comparing to normal torsion of 7 Nm/degree of the intact bone, torsional stability increased by 10% and by 21 % when utilizing a 9 or 11 mm diameter nail respectively.

The resistance to shear forces increased from 1,300 N/mm for the intact bone by 10 and 17 % for the 9 and 11 mm nails. For bending forces, the resistance increased by 18 and 29 % when utilizing 9 or 11 mm diameter nails.

Surgical Technique

The patient is placed in a lateral position on a radiolucent operation table. Alternatively, a fracture table can be utilized with the patient in supine position. Perioperative antibiotic prophylaxis is administered only after bacterial swaps from the extracted nail and reaming material have been taken.

As a first step, the extraction device is inserted into the nail tip and interlocking screws are removed. Nail extraction is done cautiously to prevent contact of the extracted nail with the skin in order to avoid secondary contamination. Following nail removal, a guide wire is gently bent at the tip and is inserted into the intramedullary canal. Care is taken to precisely position the guide wire into the center of the femoral intercondylar region assessed by anteroposterior and lateral radiologic views.

By this cautious procedure, perfect axis alignment of the femoral shaft can be expected after successful femoral nailing.

Obviously, a correct insertion point of the nail is also very important. A new insertion point has to be chosen in case the previous one was mal-positioned. A poller screw which is placed in the entry path of the previous nail prevents the new nail to slip back into the old wrong nail path.

Sequential reaming is performed using incremental increase of drill bits with the goal of inserting a nail which has a diameter of 2 mm more than the initial nail diameter, or at least 12 mm. Therefore, in the isthmal region the intramedullary canal is over-reamed with 2 mm more than the determined, final nail diameter. It is ensured that the new nail has good cortical contact and a snug fit and that any fracture gap or dehiscence is avoided.

For exchange nailing, we utilize a compression nail offering the possibility of interfragmentary compression. Distal interlocking screws are inserted first. Consecutively, the proximal interlocking, placed in the dynamic hole, is put under compression by tightening the compression screw, which is inserted proximally in the nail.

Before proximal interlocking and compression are performed, we assess femoral torsion radiologically. The femoral condyles are assessed in the lateral view where both condyles project precisely over each other. The C-arm is fixed in all directions and then moved horizontally and centered over the region of the femoral head. Torsion of the femur is considered acceptable if the femoral head projects anterior to the axis of the femoral shaft with two thirds of its circumference.

Intraoperative radiological assessment of torsion with the above described method is easier in the lateral than in the supine position. The operative procedure ends with anteroposterior and lateral views of the femur including the adjacent knee and hip joint. (Fig 5, 6)

Postoperatively, patients receive physiotherapy and are mobilized out of bed immediately. Weight bearing as tolerated is permitted. Sequential radiologic follow-up studies are done at regular intervals at 6 and 12 weeks as well as 6 months postoperatively.

Fig 5 (a – d) Atrophic nonunion of the femoral shaft and plate breakage 7 months after plate osteosynthesis. Anteroposterior (a , b) and lateral (c , d) views of the proximal and distal left femur. (e , f) Revision surgery with plate removal, debridement of nonunion, antegrade intramedullary nailing using a T2 femur compression nail with a diameter of 11 mm. Proximal single dynamic and distal double static interlocking. Anteroposterior view of both lower extremities (e) and lateral view of the left femur (f). (g , h) Anteroposterior (g) and lateral (h) view of the left femur 4 months after revision showing progressive bone healing

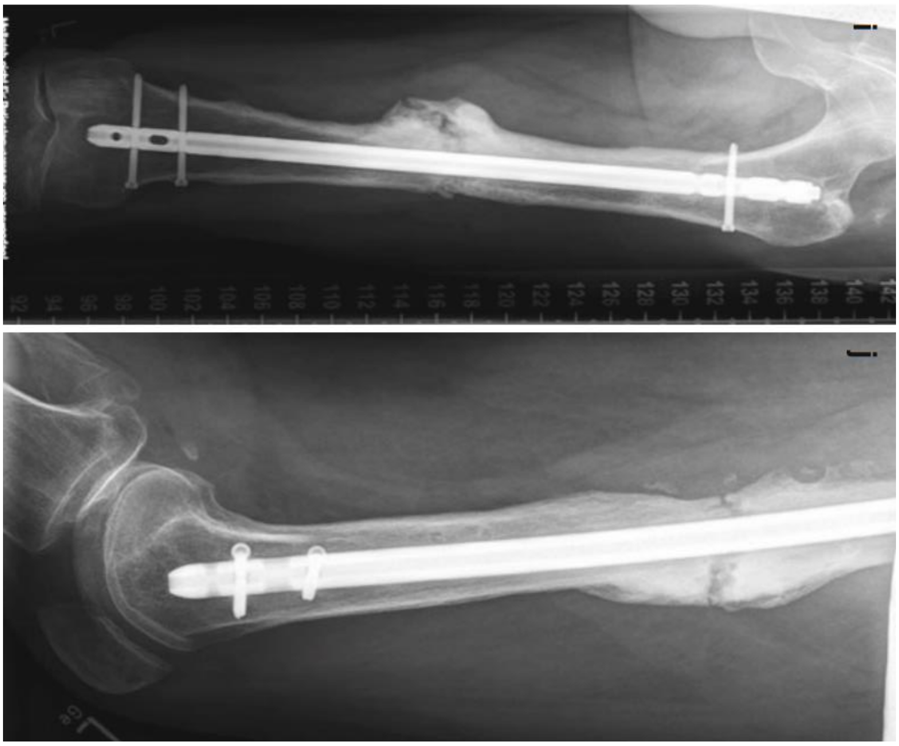


Fig 6 (i , j) Anteroposterior (i) and lateral (j) view of the left femur 12 months after revision showing abundant callus formation.

Duration of The Operation

In a study (Randomized Controlled Trial) by Im and Tae, 64 patients with fractured femur shaft was treated by intra medullary nailing (34 patients) and internal fixation by double plating (30 patients).

Duration of operation – 72 min (Group I)

and 89 min (Group II)

Time to union −18 weeks in Group I

and 20 weeks in Group II

Complications were: one superficial infection in Group I

and six superficial infections and one deep infection in Group II

Postoperative Care

Phase 1 (Protect Repair, Optimize mobility, Minimize Deconditioning):

• Foot flat weight bearing (Weight of leg on ground or 20#) o If patient unable to adhere to/ comprehend limitations, then bed-chair transfers only.

• Isometric quadricep strengthening, VMO emphasis.

• Up with assistance only. Progress to independent mobility as tolerated. Bedside commode.

• Fall prevention and gait training with assistive device.

• AROM/ PROM of knee while sitting on side of bed.

• ADLs

Antibiotics: Standard perioperative antibiotic therapy x 24 hours.

Anticoagulation:

• 4 weeks of prophylactic anticoagulation with Lovenox

• Start Lovenox 40mg sq daily 14 hours after close of surgery.
Pain Control (Multimodal Approach)

• Geriatric Protocol (>70 yo) :

-Scheduled Tylenol 1000mg po q8hours.

- Oxycodone 5-10mg po q 4 hours prn pain

- Morphine 2mg iv q 2 hours prn breakthrough pain.

• Younger patient (<65 yo)

-Ketorolac 30mg iv q6 hours x 3, postop

- Norco (7.5 or 10) 1-2 tabs po q4 hours prn pain

- Morphine 4mg iv q 2 hours prn breakthrough pain

- Tramadol 50mg po q6 hours scheduled if not taking SSRI or MAOI (Cymbaltacounts)

1st follow-up POD 10-14:

• XR of hip: Ap/ Lat hip. Confirm that fixation is stable, no evidence of loss of reduction or new injury.

• Wound check. Stitches out, steri-strips applied.

• Pain assessment. Refill pain medications as needed.

• Confirm that anti-coagulation regimen is effective and that appropriate communicationhas been maintained with nursing home/ home health.

2nd follow-up at 8 weeks after surgery.

• XR of hip: AP/ Lat views. Confirm that fixation is stable and fracture has healed radiographically.

-Advance to Phase 2 therapy when 3+ cortices are bridged with callus on plainfilms.

- If< 3 cortices bridged, then continue with Phase 1 therapy and have patient follow-up in one month.

• Wound check. • Pain assessment. Refill prescriptions as needed.

• Repeat osteoporosis counseling.

Otherwise uncomplicated patients: follow-up at 3 months after surgery.

3rd follow-up at 3 months:

• XR of femur: AP/Lat. Confirm union of fracture. –

If still <3 cortices bridged, then start with External Bone Stimulator.

- If united, then this is the last x-ray.

- If not united, then patients next follow up is in 4 weeks

Final Follow-up at 4-4 ½ months

• Harris Hip Score when united. Pain assessment/ refill medications if needed.

• Work Note: Based on patient performance. No expected limitations.

• Work conditioning for manual laborers as needed. Follow-up in 4-6 weeks for Heavy Manual Laborers.

• Expected Return to Work:

- Cognitive/ Sedentary: 9-10 weeks.

- Medium Labor: 3 months

- Heavy Labor: 4-6 months

Use of Graft

Each patient received the same surgical protocol for treatment of the nonunion. The protocol consisted of lateral approach of the fracture site, retaining the previous implant, decortication, refreshing the fracture site (removal of interposed tissues), reduction of the fracture with appropriate cortical contact (in cases with broken nails or loose nails), internal fixation with 1 broad 4.5-mm dynamic compression plate, and application of cancellous bone graft (harvested from ipsilateral anterior iliac crest) around the medial, posterior, and anterior aspects of the non-union site.

The fixation stability in each patient was rigid enough; therefore, full weight bearing of the operated limb as tolerated and range of motion (ROM) exercise of the hip and knee started immediately postoperatively. No other supplemental fixation, such as cast or brace, was used postoperatively. The functional result was supervised throughout the follow-up period.

Callus Formation

A study by Tetsuo Yamaji et al. used radiographs to compare callus formation with two types of intramedullary nailing for femoral shaft fractures: reamed interlocking (IL) nails and Ender nails. Femoral shaft type A fractures (AO classification) were studied. Twenty-seven fractures were treated with reamed IL nailing, and 81 fractures were treated with Ender nailing.

The callus area was calculated from the maximum cross-sectional area on the anteroposterior and lateral radiographs. The callus appeared at a mean of 3.9 weeks after surgery in the IL group, and at a mean of 2.8 weeks in the Ender group ($P < 0.05$). In the IL and Ender groups, fracture healing was noted at a mean of 3.4 and 2.0 months, respectively.

The mean area of callus formation in the IL and Ender nailing groups was 439.5mm2 and 699.4 mm2, respectively ($P < 0.02$). Ender nailing results in abundant callus, which forms at an earlier stage after the procedure than in patients treated with IL nailing. Dynamization at the fracture site is reported to increase external callus formation.

2- Double Plating

Although surgical stabilization of femoral shaft fractures has become very successful with current treatment modalities, nonunions can result and can lead to pain, loss of function, deformity, and other complications.

Various treatment modalities exist to address femoral shaft nonunions, which include nail dynamization, exchange nailing, plate fixation, bone grafting, Ilizarov technique, and combinations thereof.

Despite the success rates reported in the literature for these revision techniques, each methodology has its own set of complications and failures. Although reported failure rates of Ilizarov external fixation for long bone nonunions are less than 6%, they often require prolonged use (which can lead to pin tract infections, subjective inconvenience, and discomfort).

While most surgeons are more familiar and comfortable with revision intramedullary nailing, complication rates are higher, as reported in the literature. Some studies have reported a 27 % complication rate of failure for intramedullary nailing (range 0–67 %) as compared to 18 % for plate fixation (range 0–30 %). (Fig 7) Reported union rates also favor plate fixation, with union rates of 96 % for plate fixation (range 91–100 %) as compared to 75 % for IM nailing (range 56–100 %).

Fig7 a Femoral shaft nonunion with intramedullary nail fixation at 9 month. b 12 month after double locking plate revision showed bone union.

Surgical Technique

The patients were placed in the supine position on a radiolucent flat table and administered general anesthesia. A longitudinal incision (6–10 cm) was made at the anterior aspect of the fracture zone.

The vastus intermedius muscle was separated from the vastus lateralis in the direction of the fibers and retracted medially.

The fracture site was exposed, and the periosteum and blood supply to the bone fragments were preserved. The fracture was directly reduced through manual traction and clamp-assisted reduction. The limb length, fracture rotation, and angulation were then adjusted.

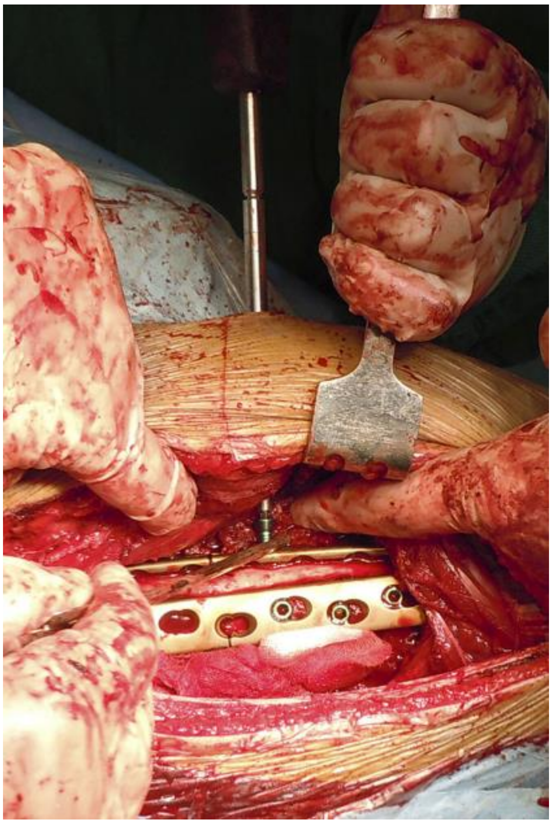


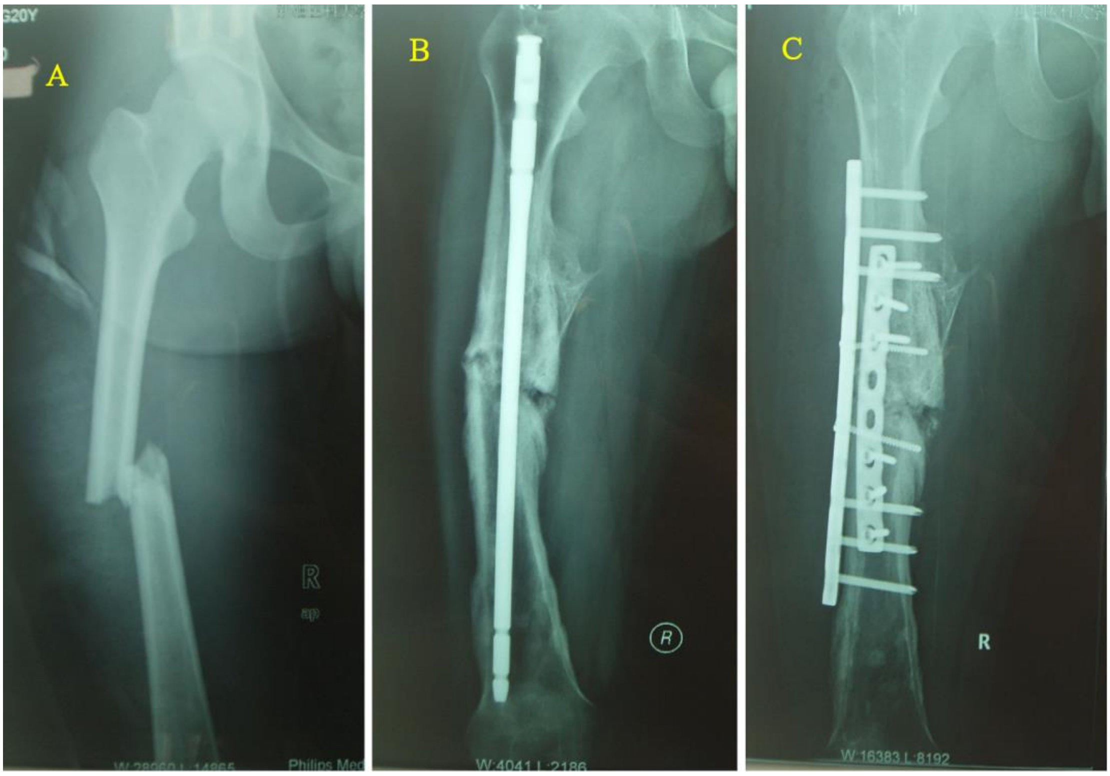
Fig8 Biologically preserving techniques for medial side locking plate.

A locking compression plate with a 3.5-mm hole was positioned on the anterior surface of the femoral shaft and fixed with a minimum of three screws (six cortices) placed in the major proximal and distal fracture fragments.

If necessary, a lag screw was used to achieve absolute stability of the large wedge fragment. Small (4- to 5-cm) distal incisions were then made over the lateral aspect of the femur with deep dissection through the iliotibial tract and vastus lateralis muscle.

A second locking compression plate (4.5-mm hole) was placed perpendicular to the first plate through a minimally invasive submuscular technique. The plate was then locked with locking screws over the proximal percutaneous small incisions, thereby omitting one or two holes.

This procedure increased the fracture span and allowed for micromovement of the fragments to enhance callus formation. A drain is used for 48 h to prevent postoperative hematoma. All patients are given antibiotics after surgery.



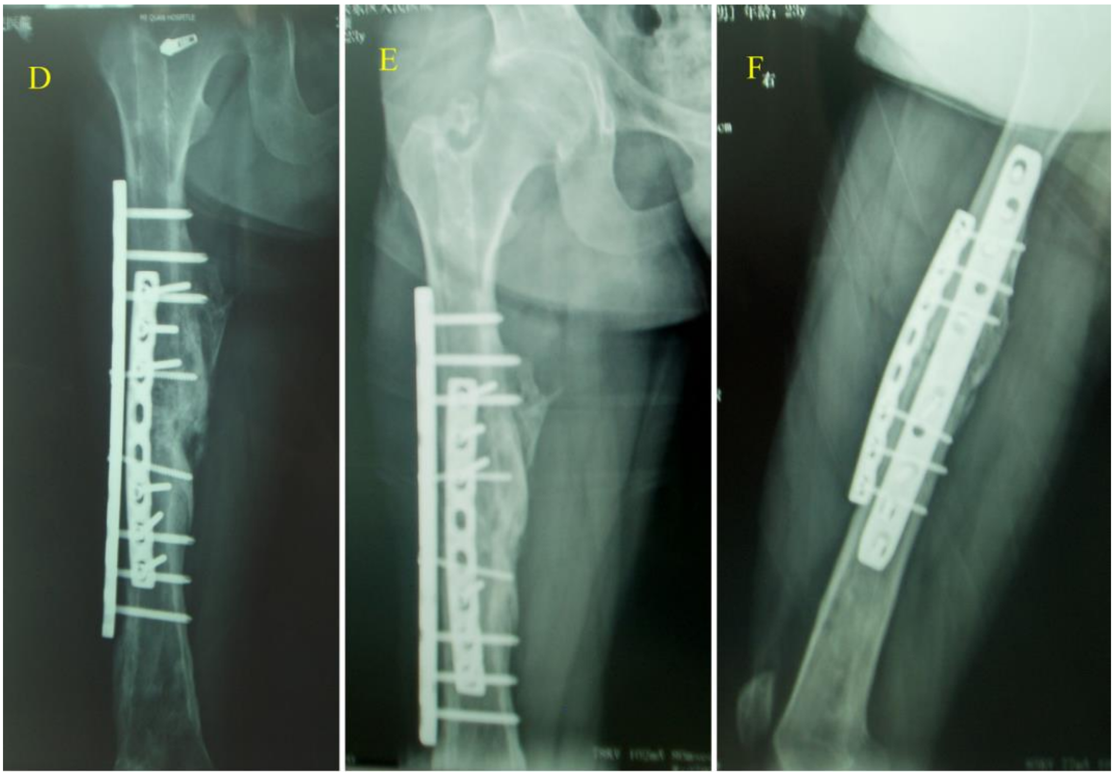


Fig 9 . 24 years old male patient who had a femoral shaft fracture in 2008 (A). Initially treated by open reduction and intramedullary nailing (B). Intramedulary nail (N) removed, deformity correction was done and double plate fixation and bone grafting applied after the initial operation of intramedullary nailing and dynamization (C). 4 month follow up patient was allowed to walk with weight bearing (D). Consolidation of newly formed bone occurred at 8 months postoperatively (E and F).

Duration of The Operation and Intra-Operative Outcome

The mean operative time was 92.7 ±14.2 minutes (range, 70–190 min). The estimated blood loss was 302.9 ± 41.2 mL (range, 168– 432 mL), with an average perioperative transfusion requirement of 3.8 ±0.4 units (range, 2–5 units).

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.

In a study by Maimaitiyiming et al. A total of 14 patients of nonunion of the femurs were treated with double plate fixation.

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. (Fig 10)

Clinical detail of 14 patients who were treated with double plate fixation and bone grafting.

Sr. No.	Age	Sex	Initial operation numbers (procedure)	Time since injury (months)	Classification	Follow-up (months)	Union time (months)
1	48	M	1 (P)	15	Atrophic	13	4
2	46	F	1 (N)	20	Atrophic	22	5
3	22	M	2 (ND)	33	Hypertrophic	7	4
4	38	F	1 (P)	11	Atrophic	11	4
5	39	M	1 (P)	40	Hypertrophic	16	6
6	35	M	2 (P+ND)	26	Hypertrophic	14	6
7	47	M	2 (P)	20	Hypertrophic	22	9
8	28	F	2 (N+ND)	27	Hypertrophic	12	5
9	23	M	1 (P)	6	Atrophic	14	6
10	20	M	1 (P)	6	Atrophic	14	8
11	44	F	3 (P+N+ND)	27	Hypertrophic	27	8
12	62	M	4 (N+ND+P+P)	72	Atrophic	8	6
13	24	F	2 (N+ND)	22	Atrophic	20	6
14	44	F	1 (P)	9	Hypertrophic	15	5

P, plate; N, intramedulary nail; ND, nails dynamization.

Fig 10 Clinical details of 14 patients who were treated with double plate fixation

Use of Graft

Bone grafting combined with nailing or plating has been used as adjuncts strategy in the treatment of femoral nonunion.

Open reduction and internal fixation supplemented with deep frozen allograft struts and autogenous iliac bone grafts is considered an effective treatment method for nonunion of the femur.

However, it is difficult to ensure that the grafted bones are stable when using only a single plate for fixation, so double plating is more preferred.

Double plating providing adequate biological conditions including eradication of infection and has been described as the biomechanically ideal option for treating long bone fracture nonunion with many advantages. El Haj et al. treated 22 cases of nonunion of long bone fractures (three clavicles, six humeri, three femora, seven ulnae, two tibiae and one radius) with an orthogonal double plate combination of autologous bone graft or bone graft substitute. Union was achieved in all patients, with an average time to union of 5.8 months, which was similar to the findings of our present study.

It provides excellent rigidity and stable fixation in three planes. Implants were placed in the femoral lateral and anterior sides, to make 90 angle with each other, and which enable the fixator to generate a rigid, three-dimensional fixing environment and to provide a strong resistance ability to counter shear effect.

On the other hand, it is convenient and less invasive to place another plate through the one incision where the primary implant being and may be adjusted.

Besides, double plate fixation ensures that the grafted bones do not displace. In our study, patients achieved a complete union after receiving the double plate fixation combined with autogenous iliac grafting with the average follow-up of 14.8 (10– 25) months.

Callus Formation

In a study by L. Sedel et al. a comparison has been made between callus formation of plating fixation and intramedullary nailing.

All the values of ultimate bending strength, stiffness, moment of inertia, energy to failure and tangential stress were higher in the case of nail fixation. (Fig 11)

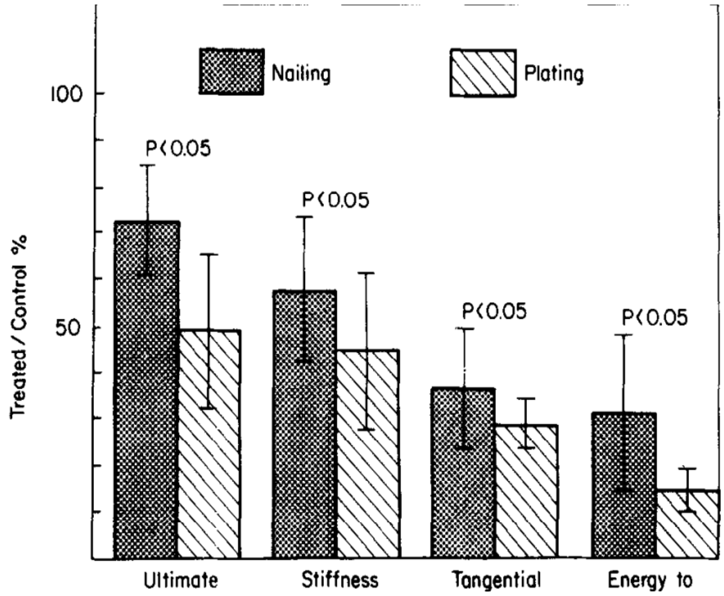


Fig11 Histograms showing comparativcl mean values for four parameters. All the mean values are higher in the cast of nailing (vertical bars represent plus or minus one standard deviation).

Comparative Data

Outcome	EN group (*n* = 14)	DP group (*n* = 16)	*p* value
Number of unions	14	15	0.341
Time to union (months)	5.7 ± 1.7	8.4 ± 4.1	0.024
Return to work (months)	8.2 ± 2.9	18.4 ± 10.3	< 0.01
Number of complications	6	10	0.153
Superficial infection	0	1	
Bone infection	0	0	
Knee stiffness	2	4	
Refracture	0	1	
Non-union	0	1	
Malunion	4	2	
Reoperation	0	1	

Fig 12

This table compare post operative outcome of EN (Exchange Nailing -intramedullary screws-) and DP (Double Plating).

Note that the joint stiffness is more probable in the DP group.

Variable	EN group	DP group	*p* value
Length of the incision (cm)	19.3 ± 5.8	30.4 ± 5.9	0.000
Operative time (min)	194.0 ± 33.0	182.0 ± 42.0	0.407
Deformities (*n*)			
LLD	1	0	0.277
Angulation	1	0	0.277
Rotation	4	2	0.272

Fig 13

LLD = Leg Length Discrepancy

Conclusion

Reamed intramedullary screws can be considered as the treatment of choice for nonunion of femoral shaft fractures. A single and closed operative procedure leads to bone healing in most cases. Limited correction of axis deviation is possible without opening the nonunion site.

Additional surgical damage to the soft tissues is avoided and there is a lower operative morbidity. The increased stability of a thicker nail results in high postoperative patient comfort and a low pain sensation and allows for early unrestricted weight bearing and active rehabilitation.

Deformity correction is the main surgical technical difficulty in femoral non-union cases. Double Plating has been the main method of deformity correction.

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