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Mini-Open Intra-Medullary Interlocking Nailing of Fracture Femur in a Tertiary Care Center; Our Experience.

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ABSTRACT

The number of studies confirmed the advantages of closed intramedullary nailing; however in certain situations, a mini-open technique may be alternative and advantageous. To evaluate the efficacy, convenience and outcomes of mini-open intramedullary nailing for fracture femur patients and to compare with the previously published reports. Thirty patients who had undergone mini-open interlocking nailing for femur fracture were evaluated for their outcomes. Evaluation included different aspects on range of movement at hip, knee, limb length discrepancy, delayed union, mal-union, non union, infection, implant failure and other complications like pain etc following surgery. The functional evaluation of the patients were done and graded accordingly which involved criteria like mal-alignment, rotation, shortening. Knee flexion and extensions too were evaluated, post-operatively. Results were graded as Excellent in 23 patients, Good in 3 patients and Fair in 4 patients. Three patients had restriction of flexion of the knee beyond 90 ° at 16 weeks of follow up. Union occurred in 80% of the individuals in less than 19 weeks period. Infection was seen in our series in two patients (6.66%). Delayed union (defined as the presence of inadequate callus at 16 weeks post operatively) was seen in our series in four patients (13.33%). Sixteen percent patients had complications like implant failure or quadriceps wasting. A secondary procedure like dynamisation was required in 13% of the individuals. The mini-open reamed interlocking intramedullary nailing for fractures of the femoral shaft is an excellent modality of treatment. It appears that all fractures from the lesser trochanter to the femoral condyles such as transverse, comminuted, spiral, segmental, oblique fracture can be treated successfully by this technique. Moreover the fractures of the upper third and lower third which is difficult to reduce by closed technique can be treated better with open technique with lesser complications.

INTRODUCTION

Fractures of shaft of femur are commonly encountered in orthopedic practice[1]. The spectrum of femoral shaft fractures is wide and ranges from non-displaced stress fractures to fracture with severe comminution and soft tissue injury. Femoral shaft fractures are usually the result of high-energy forces sufficient to fracture the strongest bone in the body [1]. Femoral shaft fractures are the result of motor vehicle accidents, pedestrian/auto accidents, sports related trauma, gun shots wounds, fall from a height and primary bone or metastatic disease. Femoral fracture patterns vary according to the direction of force applied and quantity of force absorbed. The art of treatment of fractures shaft of femur is delicate and requires normal alignment and early functional rehabilitation of the limb.

Treatment of femoral shaft fractures has undergone significant evolution over the past century. Until recently splinting, traction was used as a definitive method of treatment. Traction as a treatment method has many drawbacks due to poor control of length, alignment, rotation, development of pulmonary insufficiency and joint stiffness due to supine position. Surgical treatment with plates and screws has many disadvantages. It is a load-bearing device and due to stress shielding effect osteopenia occurs at the implant bone interface leading to re-fracture following plate removal. Intramedullary is procedure of choice for virtually all

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diaphysial fractures [2]. The goals of treatment are reliable anatomic stabilization allowing mobilization primarily out of supine position. It is also helpful for early extremity function, allowing both hip and knee motion and muscle strengthening. The choice of intramedullary may be open and closed method.

Closed femoral nailing usually requires a fracture table and continuous traction for fracture reduction, is time consuming and is associated with complications such as peroneal and pudental nerve palsy, compartment syndrome, excessive exposure to radiation and inadequate reduction and mal-rotation of fragments. In obese patients and in patients with multiple injuries it is time consuming to use a fracture table. Although traditional open Intramedullary has the advantage of being easily learned, producing good reduction and having short operative time .According to studies open nailing has complications such as high infection rate and delayed union and nonunion. These complications can be avoided if minimal soft tissue stripping is done during reduction of fracture.

The present study attempts to highlight the management of fracture shaft femur in adults by mini-open IM interlocking nailing. Our study compares the results of treatment of fracture shaft of the femur in adults treated with mini-open IM interlocking nailing with previously published literature of results of treatment of fracture shaft of femur in adults with closed IM interlocking nailing. We aimed to study the management of fracture shaft of femur in adults with IM interlocking nailing, to compare the end result of open methods with standard published literatures, also, to emphasize on the advantages and disadvantages of open techniques. We made an attempt to make a prospective study of fracture shaft of femur treated in adults with mini-open method of IM interlocking nailing and evaluated the functional and anatomical end results.

MATERIALS AND METHODS

Thirty-two adult patients with diaphyseal fracture of the femur (closed fracture) were treated with mini-open reamed IM interlocking nailing at our institute between January 2008 to June 2012 .Of the thirty-two patients two patients did not had follow up. Thirty patients were available for the study. Patients included were with age more than 20 years, closed fractures, transverse, short oblique, fracture shaft of femur with a butterfly fragment, spiral fractures, patients with fresh fractures less than 3 weeks old and fractures extending from 5 cm below lesser trochanter to 5 cm above the adductor tubercle. Patients with age less than 20 years, open fractures, pre-existing deformity of femur or with pathological fractures were excluded. Fractures with severe comminution (Winquist Type III & IV) and fracture greater than 3 weeks old were too excluded.

As soon as the patient was brought to the casualty, each patient's airway, breathing and circulation were assessed. Any other co existing injuries were ruled out and if found in shock, resuscitative measures were given. On admission to ward, detailed history was taken about age, sex, occupation, mode of injury, present and past associated medical illness. Associated orthopaedic and other systemic injuries were assessed and managed accordingly. Since our aim was to operate at the earliest, fracture femoral shaft was splinted with fixed traction on a Thomas splint. Whenever the delay in surgery was anticipated, skeletal traction was considered. All fractures were classified according to AO classification. Analgesics, antibiotics, tetanus toxoid, and blood transfusions were administered whenever necessary. Routine investigations were done for all patients and were operated as early as possible once the general condition of the patient was stable. Radiograph of whole length of both the femurs with knee and hip joint in anterior – posterior view and lateral view was taken. Preoperatively the length of the nail was calculated clinically and radiographically. Clinically, the length of the nail was measured from the tip of the trochanter to the joint line of the unaffected leg and 20-30mm was deducted. Radiographically, on AP (anterio-posterior) view from tip of greater trochanter to upper border of patella of the unaffected leg and 15% of radiographical magnification is deducted.

Preoperative Preparation included patients were having fasted for 8hours, with adequate amounts of blood bottles were kept ready after crossmatching. Each patient had whole of extremity below the umbilicus including the private parts were prepared and scrubbed with betascrub, systemic antibiotic, a third generation cephalosporin was given intravenously 30 minutes before surgery administered. Operative technique included patient in a lateral decubitus position, the affected side hip was flexed about 40- 50° and the knee flexed about 90° , the unaffected limb was extended with the knee flexed about 20-25° to give unobstructed C arm image. Adequate padding was given to the bony prominences. A 6 cm skin incision was made from the tip of the trochanter upwards in line with the femoral shaft.The gluteus maximus muscle was incised in line with its fibres and the piriformis fossa was palpated. The entry point was made with a straight pointed awl. The medullary canal was perforated at the piriformis fossa slightly medial to the tip of the trochanter. A ball tipped guide wire was passed through the entry point into the proximal fragment upto the fracture site. Closed reduction was attempted by manual traction and if, unsuccessful in achieving, the reduction, the fracture site was exposed through the lateral approach after confirming the site under c arm image and after incising the vastus lateralis and reflecting it anteriorly and posteriorly with minimal soft tissue dissection through a 2-3 cm incision. No periosteal elevation was done. The fracture was reduced and the guide wire was passed into the distal fragment after freshening the fracture edges with a scoop. The position of the guide wire was confirmed under image intensifier in both AP and lateral view and the tip of the guide wire was hammered into the subchondral bone. After checking the fracture reduction, direct measurement of the nail was done by subtracting the exposed length of the guide wire from its overall length. Thorough wash of the exposed wound was done with normal saline and muscle was allowed tofall back over the fracture site to prevent the loss of reamed material which has osteogenic potential from the fracture site. Reaming was done with flexible reamers. Reaming was done in 0.5 mm increments up to 1 mm larger than the chosen nail to make nail passage easier. Teflon sleeve was inserted over the ball tipped guide wire and was exchanged for the nail guide wire. The teflon sleeve was removed after confirming satisfactory placement of nail guide wire. The chosen nail was then mounted on the jig and the

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nail was mounted over the guide wire and inserted using a hammer. The position of the nail was then checked both in AP lateral views with image intensifier and the guide wire was removed. Rotational alignment was checked clinically intraoperatively.

Distal locking was done with a free hand technique and using C-arm. Similarly, proximal locking was done with the help of proximal jig. The second screw was placed in the similar manner. And finally, the whole length of the nail, reduction, proximal, and distal locking screws were checked under image intensifier. The incised wound was washed with betadine and normal saline and the skin sutured. Sterile pads were put and compression bandage was applied.

Routine postoperative care was advised for our patients with analgesics and antibiotics. Quadriceps strengthening and active assisted range of motion exercises and straight leg rising were started on the 2nd day depending on the pain status. The patients were mobilized with crutches or walker as soon as pain and local condition permit with partial toe touch weight bearing. Physiotherapists were asked to teach them static exercises. Sutures were removed on 10-12th postoperative day and patients were discharged. They were advised to bear weight according to their fracture pattern and signs of union on follow up radiographs. Follow ups were done at 6th, 12th, 18th and 24th weeks and follow up ranged up to a period of 18 months and were assessed clinically and radiographically.

The data obtained were analyzed using the 'Z' tests of significance.

OBSERVATIONS AND RESULTS

Table 1: Demographic data

1. Age (years)	33.3±13.65	
2.Sex [m][f]	[26][4]	
3. Affected side [R][L]	[16][4]	
4. Mode of injury		
RTA	25	
Fall from Height (FH)	2	
Assault	3	
5.Gustilo Type		
Closed fracture	30	100%
Open fracture	0	0%
6. Pattern of Fracture		
Short oblique	10	33.33%
Spiral	6	20.00%
Segmental	2	6.66%
Transverse	8	26.66%
Comminuted(winquist type I & II)	4	13.33%
7. Level of Fractures		
Upper Third	5	16.66%
Middle Third	16	53.33%
Lower Third	9	30.00%
8. AO Classification of Fracture		
32 A3	8	26.66%
32 A2	11	36.66%
32 C1	4	13.33%
32 A1	5	16.66%
32 C2	2	6.66%
9. Associated injuries		
# Left Humerus	1	3.33%
# Right Tibia	1	3.33%
# Right Tibia & Fibula	1	3.33%
Poly Trauma	1	3.33%
Head Injury	1	3.33%
# Ribs with hemothorax	1	3.33%
10. Duration between hospitalization trauma and operation		
0 – 4 days	15	15%
5 – 9 days	13	43.33%
10 – 14 days	2	6.66%

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The demographic data, type, pattern and level of fractures were detailed in table 1. AO classification of fractures, associated injuries and duration to operate after trauma too are shown in table 1. Surgical and anaesthetic factors are described in table 2. Surgical details regarding type of nail (implant), diameter, type of locking, difficulties encountered, and duration of surgery, estimated blood loss are shown in table 2. Post operative quadriceps exercises, weight bearing, secondary procedures like dynamisation and implant removal are detailed in table 3. Duration of stay and durations of union of fractures are shown in table 3. Complications and functional outcome are shown in table 4 and 5 respectively. The associated injuries including polytrauma was in 6 patients and has been described in table 1. One patient had associated humerus fracture; crutches' walking was not possible till the fracture union (radiological). Two patients had associated lower limb fracture, the non-weight barring mobilization was started in the first week after the surgery, however, the partial weight bearing was started from 4-5 weeks surgery. Hemothorax, head injury and splenic injuries were co-existed in each single patient, thus weight bearing was delayed (2-4 weeks).

Table 2: Surgical factors.

1. Type of anaesthesia		
Spinal/Epidural Anaesth.	28	93.33%
General Anaesth.	2	6.66%
2. Length of nail (mm)		
360	2	6.66%
380	8	26.66%
400	11	36.66%
420	9	30.00%
3. Nail diameter		
9 mm	6	20%
10 mm	15	50%
11 mm	9	30%
4. Types of locking		
Static	30	100%
Dynamic	--	--
5. Difficulties durng surgery		
Difficulties in reduction	2	6.66%
Broken drill bit	1	3.33%
Difficulty in locking distal screw hole	1	3.33%
6. Duration of surgery		
40-69 min	17	56.66%
70-99 min	10	33.33%
100-130 min	3	10%
7. Estimated blood loss (ml)		
400 – 599	17	56.66%
600 – 799	11	36.66%
800 – 1000	2	6.66%

Our criteria for consolidation were a clinically solid, painless callus; full motion of the hip and knee; walking with full weight-bearing without crutches: and as a minimum, radiographic evidence of a large continuous external callus that bridged the site of fracture. Patients were assessed both functionally and anatomically. Evaluation of the functional results of this study was done on the basis of classification system , the result by Bjorn O Thoresen et al [9].

At follow up results in thirty fractures were graded as excellent in 23, good 3, fair in 4. In the result graded as excellent mal-alignment was nil to minimum, shortening was minimum, knee range of movements was full and there was no pain or swelling. In the patient graded as good result one patient had valgus mal-alignment of 10° and shortening of about 2 cm and fracture was located in the distal third and of comminuted type and the nail was off centre and was medially placed distally. This was treated by removal of the distal screws at 2 weeks postoperatively, manipulation of the femur into correct position and reinsertion of the screws. The same patient also had hip pain for which nail removal had to be done after one year. The second patient graded as good result had valgus mal-alignment of 5° which was tolerated well by the patient but the knee range of motion was less than 120° because the patient did not cooperate for physiotherapy. The third patient graded as good result had shortening of about 1.5 cm and the fracture was of comminuted variety.

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Table 3: Post operative events.

1. Static quadriceps exercises (SQE)		
0 to 2 days	28	93.33%
> 2 days	2	6.66%
2. Commencement of non weight bearing (NWB)		
0 to 1	24	80%
2 to 4	5	16.66%
> 5	1	3.33%
3. Commencement of partial weight bearing (PWB)		
0 to 2	24	80%
3 to 5	5	16.66%
> 6	1	3.33%
4. Commencement of full weight bearing (FWB)		
10 to 14	16	53.33%
15 to 19	13	43.33%
20 to 24	1	3.33%
5. Secondary procedures		
Dynamization	4	13.33%
Nail removal after fracture union	1	3.33%
6. Stay in the hospital (Days)		
0 to 10	4	13.33%
11 to 20	25	83.33%
> 20	1	3.33%
7. Union in weeks		
10 to 14	5	16.66%
15 to 19	19	63.33%
20 to 24	5	16.66%
25 to 29	1	3.33%

Table 4: Complications (N= number pf patients)

1. Range of motion/stiffness					
Joints	N	<90°	~120 °	> 120°	%
Knee	3	3	0	0	10%
Hip	Nil	Full	Full	Full	
			1 – 2		
2. Limb length discrepancy	N	<1 cm	cm	> 2 cm	%
	3	1	1	1	10%
3. Delayed union	N	%			
	4	13.33%			
4. Infection	N	%			
Superficial Infection	1	3.33%			
Deep Infection	1	3.33%			
Total	2	6.66 5			
5. Malunion					
Types	<5°	5 to 15°	>15 °	N	%
Valgus	1	1	0	2	6.66%
External Rotation	0	0	1	1	3.33%
6. Implant failure					
TYPES	N	%			
Broken Nail	0	0			
Broken Distal Locking Screw	2	6.66%			
7. Other complications					
a. Pain	N	%			
Hip	1	3.33%			
Knee	2	6.66%			
b. Quadriceps wasting	3	10%			
c. Pulmonary embolism	3	10%			

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Table 5: Functional results, data in number of patients.

1. Grade	Excellent	Good	Fair	Poor
Malalingnment of femur (degrees) Varus & Valgus	5	5	10	>10
Antecurvatum & Recurvatum	5	10	15	>15
Internal rotation	5	10	15	>15
External Rotation	10	15	20	>20
Shortening (cm)	1	2	3	>3
2. Knee Motion	>120	min of 120°	min of 90°	<90
Flexion/ Extension deficit	5	10	15	>15
3. Pain or Swelling	None	Sporadic	Significant	Severe

Table 6: Comparision of various previous studies with the present study.

study	n	hospital stay days(mean)	surgical duration(minutes)	Blood loss(ml)	Time To Partial weight barring (Days)	Time To Full weight barring (Weeks)	Union (Weeks)	non union(%)	malunion(%)	Delayed Union(%)	Infection(%)	Range of movement Knee	Knee Pain	Shortening (> 1cm) %
Rothwell et al	32	–	--	--	–	–	–	6%	6%	–	–	–	–	44%
Winquist et al	245	–	--	--	–	–	–	0.80%	2%	–	0.40%	128°	–	7.30%
Johnston et al	24	19.5	161*	485¥	–	11.7¥	13.8*	–	–	16.6%¥	–	Full	–	13%¥
Winquist RA et al	442	26.9	60	750*	–	–	12*	0.90%	–	–	0.9%¥	--	–	2%¥
Johnston et al	27	16	160*	890*	–	–	34	22%	–	22%	13%¥	120°	–	48%
Kempf et al	52	21	--	--	3	–	18	7.69%	15%¥	3.8%¥	–	No ROM 1.92%	–	21.5%¥
Thoresen BO et al	46	–	65¥	--	–	–	16¥	–	21.79%¥	–	–	–	–	15.2%¥
Jen – Chung Liao et al	76	21	75¥	250¥	--	--	26	2.63%	2.63%¥	--	2.63%¥	--	--	2.63%¥
Present study	30	13.6*	66.66	428	12.2	14.4	17.6	–	10%	13.33%	6%	No/stiff ROM 3%	6.66%	10%

*p < 0.05, ¥p > 0.05, n= number of patients

Of the four patients graded as fair result one patient had restriction of right knee flexion beyond 90°, the same patient had ipsilateral fracture of the tibia which was treated with interlocking nailing and because of knee pain post operatively did not follow physiotherapy instructions as advised. The second patient graded as fair result also had restriction of right knee flexion beyond 90° and the same patient had ipsilateral fracture of tibia and fibula which was treated by interlocking IM of the right tibia and semitubular plating of fibula and because of pain post operatively the physiotherapy could not be carried to our satisfaction. The third patient graded as fair result had a external rotation deformity of 15° and shortening of about 1 cm and the same patient had comminuted fracture of the femur located in the lower third. The deformity was tolerated well by the patient and the shortening was treated by shoe raise .The fourth patient graded as fair result had decreased knee flexion beyond 90°, the same patient had developed deep infection with discharging chronic sinus and the patient had developed extensive wasting and fibrosis of the quadriceps muscle. All

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the patients who had rotational mal-alignment or angulation deformity and shortening had either comminuted variety of fracture or the fracture was located in the upper or lower third of the femur.

COMPLICATIONS

Complications are shown in table 4. In our series there were no major intra operative complications. In two patients there was difficulty in reduction ,one of these patient had comminuted fracture located in the lower third and the other had spiral fracture located in the lower third. In one patient the drill bit was broken while drilling distal locking hole in which the fracture was transverse located in the lower third. In another patient there was difficulty in locking distal screw hole in a patient with spiral fracture located in the middle third. Post operative complications with respect to range of movements of the knee and hip, all the patients had full range of movements at the hip joint. Three patients had restriction of flexion of the knee beyond 90° at 16 weeks of follow up. In two of these patients the patient had sustained ipsilateral fracture of the tibia which was treated with interlocking nailing and so because of the pain status post operatively the patient did not fully cooperate with the physiotherapy regimes. One patient with knee stiffness had developed deep infection and had fibrosis of the muscles of the thigh and quadriceps wasting. In our series three patients (10%) had shortening of the effected limb. One patient had shortening of about 2 cm in whom the fracture was located in the lower third and was of comminuted type. The same patient had associated complication of 10° of valgus mal-alignment for which the patient was taken to operation theatre at 2 weeks postoperatively after suture removal ,the distal screw was removed and reinserted after manipulation and correction of valgus mal-alignment and subsequently the shortening was also corrected. The second patient had shortening of about 1cm in whom the fracture was comminuted type and located in the lower third of femur. This patient tolerated the shortening well after shoe raise. The third patient had shortening of 1.5 cm and had comminuted fracture in the middle third and he tolerated the shortening well after shoe raise.

Infection was seen in our series in two patients (6.66%). The first infection was seen in a patient on the 7th post operative day when the patient started getting fever with chills and had tenderness at the sutured area over the fracture site persisted. Prophylactic antibiotics were started, sutures were removed, the wound was left open thorough wash given and swab sent for culture and sensitivity. The infection was superficial and the organism grown on culture was staphylococcus aureus. A definite intravenous antibiotic were started after culture and sensitivity reports and was followed by serial dressings. Delayed secondary closure of the wound was done at fourth post op week after we were sure that the infection had subsided but the antibiotic was continued for another two weeks.

In the second patient with infection had associated diabetes mellitus. On the third post operative week the patient developed fever and had pain and swelling with discharge of pus from the sutured scar over the affected thigh. Prophylactic antibiotic was started immediately covering both gram positive and gram negative organisms. The patient was taken to operation theatre, the wound was drained at the fracture site and at the entry point for the nail and aggressive debridement was done and antibiotic laden beads applied and the blood sugar levels controlled medically. Pus swab was sent for culture and sensitivity. The wound was left open for drainage of pus. Definitive intravenous antibiotics were started depending on the culture report after which the infection subsided to a considerable extent but persisted. The antibiotic laden beads were removed after 3 months post operatively. The fracture went to achieve delayed union at 22 weeks. The patient developed chronic osteomyelitis and the nail was removed after one year after sufficient involucrum had formed after one year. Sequestrectomy and debridement of the sinus tract done at the time of nail removal and the infection subsided. This patient had severe restriction of knee flexion beyond 90 ° and could not return to his pre-fracture occupation because of increased morbidity.

Delayed union (defined as the presence of inadequate callus at 16 weeks post operatively) was seen in our series in four patients (13.33%). Of this four patients three fractures was transverse type and the fourth one was Winquist type I comminuted fracture. Three patients achieved union at 20 to 24 weeks interval after dynamization at 16 to 18 weeks. One patient who had deep infection with delayed union achieved union at 22 weeks after the infection was controlled adequately. However, we observe there was no nonunion. Mal-union was observed in 3 patients (10%) in our series. One patient had 5° of valgus mal-alignment in whom the fracture was transverse and located in the lower third. It was tolerated well by the patient. The second patient had valgus mal-alignment of 10° in which the fracture was comminuted and located in the lower third. This patient had a associated shortening of 2cm. The patient was treated after second postoperative week with manipulation with correction of valgus after removal of the distal locking screw followed by reinsertion of the distal locking screw after adequate correction was achieved. The shortening disappeared after mal-alignment was corrected. The third patient had external rotational deformity of 15° which was associated with shortening of 1 cm. This patient tolerated the deformity well and no correction was required. In two patients (6.66%) the distal locking screw was broken at 12 weeks postoperatively but the fracture went on to achieve union and the broken screw was removed at the time of nail removal at 18 months post-operatively.

In our series one patient had hip pain (3.33%), two patients (6.66%) had knee pain, two patients (6.66%) had quadriceps wasting at follow up at 4 weeks postoperatively .All the patient with hip and knee pain had pain of mild degree and was tolerated well without specific treatment .Out of the two patients with quadriceps wasting one had deep infection at the fracture site and the wasting persisted. The other patient with wasting of the quadriceps achieved normal bulk of the quadriceps with aggressive physiotherapy.

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All the patients in our series could attain their pre-fracture level of activities after fracture union except in one patient with deep infection who had to change his occupation because of increased morbidity.

DISCUSSION

Open reduction and plate osteosynthesis, while restoring length and alignment, requires an extensive surgical dissection with considerable blood loss and a small but definitive risk of infection, delayed union and nonunion, and implant failure [3]. Standard closed or open Intramedullary followed by traction for three to six weeks is an another treatment alternative, but it compromises the full benefit of Intramedullary as it does not completely eliminate the possibility of shortening at the fracture site and further rotation is not well controlled. Open Intramedullary with adjunctive cerclage wiring provides a good mechanical solution for certain comminuted fractures, but it increases the risk of infection and delayed union [4].

To overcome these difficulties several investigators have developed and implemented a locking nail. Locking the nail into the bone is achieved by the addition of self tapping screws inserted through holes located in the ends of the nail with the aid of image intensifier [5]. Interlocking nailing provides immediate length and rotational stability to the fracture and allows the patient to be mobilized without risk of shortening. Early mobilization following fracture of the femoral shaft has been shown to have significant advantage in terms of joint mobility and economic impact. Interlocking nailing can be done by open and closed technique. Closed nailing has been advocated by many authors.

The advantage of closed nailing is preservation of the fracture hematoma and in addition reaming during closed nailing deposits bone graft material at the fracture site [6]. In closed nailing the soft tissue envelope around the fracture fragments remain intact. Disadvantages of closed nailing is that it requires special equipment, causes excessive radiation exposure, causes difficulty in shifting the patient to the fracture table in obese patients and in multiple injured patients, surgery is prolonged and the technique is difficult for young orthopedic surgeons. Also there are increased chances of mal-rotation. The chances of infection after closed nailing are minimal.

Advantages of open IM interlocking nailing is that it requires no special equipment, radiation exposure is less, accurate inter-digitation of the fracture fragments can be done at the time of reduction and the technique is easy to learn. Disadvantage of the open technique is blood loss, skin scar, fracture hematoma is theoretically lost, bone graft from reaming is lost, and chances of non-union and delayed union are high. The disadvantage of open IM interlocking nailing can be minimized if the soft tissue dissection is kept to minimum as done in our series thus getting the benefit of both open and closed technique of IM interlocking nailing.

In our present series of 30 patients we attempted to compare our study with published data of other series of both closed IM interlocking nailing and open Intramedullary. We also attempted to compare our technique with the one which was similar to our study as proposed by Jen -Chung Liao et al [7]. Comparison was also made with a published series of open Intramedullary with cerclage wiring as proposed by Johnston et al [4]. Since the data available was very much variable only a rough comparison could be made.

The average stay in hospital in our study was less than all the other studies and was statistically significant ($p<0.05$).The duration of surgery in our study was comparable to the study of closed IM interlocking nailing by Thoresen BO et al[9] ($p>0.05$) and open IM interlocking nailing of Jen-Chung Liao et al [7] ($p\geq0.05$). However in series of Johnston et al[4] of both open nailing and cerclage wiring and closed IM interlocking nailing the duration of surgery is more and the difference is statistically significant ($p<0.05$). Average blood loss in our series was much less since only minimal soft tissue stripping was done and the incision was only 2-3 cm. Blood loss during surgery was comparable to the study of Jen-Chung Liao et al[7] ($p\geq0.05$) and Johnston et al[4] series ($p\geq0.05$) of closed IM interlocking nailing but there was a statistically significant difference to the study of Winquist RA et al [8] ($p<0.05$) study of closed nailing and Johnston et al ($p<0.05$) series of open nailing in which blood loss is more. Thus the disadvantage of open technique is minimized by our new technique (Table 6).

There was a significant difference ($p<0.05$) in the time to union in our series compared to the study of closed IM interlocking nailing by Johnston et al [4] and Winquist RA et al in which union was early but our union time was comparable to the study of closed IM interlocking nailing by Thoresen BO et al [9] ($p\geq0.05$).The four cases (13.33%) of delayed union observed in our series was comparable to the series of closed IM interlocking nailing of Johnston et al ($p\geq0.05$) and Kempf et al [10] ($p\geq0.05$).

The primary advantage of closed fixation method is that bony structure can be restored with an intact soft tissue envelope .Many published studies have demonstrated superior results of closed interlocking intramedullary, such as reliable fracture healing and a low infection rate. To obtain a closed reduction, fracture tables are currently used, although they may cause complications and the need to transfer patients seriously limits the care of patients with polytrauma. Although they were effective in achieving a closed reduction the technique seems to be cumbersome and are unfamiliar to most orthopaedic surgeons.

Faced with polytrauma patients when rapid fixation is essential, these techniques may prolong the procedure and put the patient at additional risk. Several studies demonstrated that in a multiple injured patients chance of survival was increased by

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immediate fixation of long bone fracture [11]. Jen-Chung Liao et al [7] demonstrated the usefulness of mini-open IM interlocking nailing in his series and found it useful in multiple injured patients. We in our series applied the technique of open IM interlocking nailing not only in multiple injured patients but also to all fractures of the femoral shaft and had satisfactory results compared to closed technique. We excluded winquist type III & IV and open fractures from our study.

In the largest study of closed reamed Intramedullary Wolinsky et al reported a union rate of 93.6% after initial nailing and an overall union rate of 98.9% after an additional procedure [12]. We demonstrated a union rate of 100%.In our series we encountered four delayed union at 16 weeks follow up. In three of these patients the fracture healed between 20 to 24 weeks after dynamisation in three patients and in the other patient it eventually achieved union without dynamisation. The average time to union of 17.6 weeks was almost similar or better than all the other series of both open and closed nailing as indicated by the table below.

The observed malunion incidence is of low in our series but the ultimate functional result was satisfactory and no patient needed operative intervention. Other published series of closed IM interlocking nailing by Thoresen [9] et al, Kempf [10] et al showed higher mal-union rate but it was not statistically significant ($p \geq 0.05$). All the patients in which mal-alignment occurred, the fracture was in the lower third. Thoresen [9] BO et al in their series observed that fractures in the distal end of the femur was more prone to mal-alignment and reported in his series a mal-union rate of 21.79%.

In our series the percentage of patients seen with shortening was less and all the patient could be managed conservatively because shortening was not more than 2 cm. This is in contrast to other published series of closed nailing where shortening due to mal-union rate is high compared to our series. This can be explained by the good anatomical reduction we achieved during open nailing thus lowering the mal-union and shortening rate in our series. All the fractures in our series in which shortening was observed were comminuted fractures (Winquist Type II). Shortening rarely occurs in patient with patients with Type I comminution, a segmental fracture, or a fracture with stable pattern [13] (short oblique or transverse fractures).

The two observed infection rate in our series of which one was superficial and did not eventually affect the outcome, the other infection was deep and the patient had associated uncontrolled diabetes mellitus and the functional result was affected in this patient. This patient went on to achieve delayed union. In comparison to other series of closed IM interlocking nailing our infection rate is considered high but it did affect the ultimate result only in one patient (3.33%) with deep infection. Even in this patient the patient had associated diabetes mellitus which increased the susceptibility to infection. The infection percentage observed in our study was not statistically significant compared to the series of closed IM interlocking nailing of Winquist RA[8] et al ($p \geq 0.05$) and open IM interlocking nailing of Jen- Chung Liao [7] et al ($p \geq 0.05$).

Majority of the patient in our series were operated within the first four days. Early operative fixation in long bone fractures and in polytrauma patients is life saving and significantly decreases pulmonary complications, mortality, multiple organ failure and length of stay in intensive care unit [14, 15]. Early fixation of fractures helps avoid soft tissue stiffness that makes reduction difficult. One advantage of our technique is that the time required to complete the entire procedure is very short since no time is wasted in reducing the fracture after attempting 2 to 3 times, the closed reduction.

One important limitation of our technique is extent of comminution. In severely comminuted fracture (Winquist type III & IV), there is no abutment of cortices at the fracture level, and the rotational alignment and length stability may we hard to control. Under such conditions use of our technique is not feasible.

CONCLUSION

It is clear that the mini-open reamed interlocking intra-medullary nailing for fractures of the femoral shaft is an excellent modality of treatment. The results are comparable if not better than closed interlocking intramedullary nailing if certain steps are followed meticulously. By and large all fractures from the lesser trochanter to the femoral condyles such as transverse, comminuted, spiral, segmental, oblique fracture can be treated successfully by this technique. Moreover the fractures of the upper third and lower third which is difficult to reduce by closed technique can be treated better with open technique.

Mini-open intramedullary interlocking nailing allows for good inter-digitation of the fragments and decreases the incidence of mal-union and malrotation and it is especially important in segmental and fractures of the upper and lower third of femur. To conclude, closed intramedullary nailing will continue to be the gold standard treatment for acute femoral fractures, but in cases where closed reduction is not possible the mini open intramedullary nailing with small incision and minimal soft tissue stripping has results comparable to the closed reduction nailing of fracture shaft femur. However with careful patient selection and a proper surgical technique our technique of open nailing can be as safe and effective as the closed method.

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