Comparative Study between Submuscular Biological and Open Anatomic Dynamic Condylar Screw Plating for Comminuted Subtrochanteric Fracture Femur in Adults

[1] Mohamed Gamal, [2]Ahmed Hashem Amin and [2]Omar Kelany

[1]Orthopedic Department, Faculty of Medicine, Al-Azhar University, Egypt
[2]Orthopedic Department, Faculty of Medicine, Zagazig University, Egypt
hashmdr@yahoo.com

Abstract: Objectives: The aim of this study was to compare the long-term results of two groups of patients with comminuted subtrochanteric fractures of the femur treated with dynamic condylar screw by two different techniques either submuscular biological technique or open surgical technique. **Patients and methods:** Between January 2007 to March 2011, thirty patients with comminuted subtrochanteric fractures of the femur were treated with dynamic condylar screw by two different techniques either submuscular biological or open surgical technique. Group I included 14 patients operated with biological submuscular internal fixation with dynamic condylar screw. Group II consisted of 16 patients operated with open reduction internal fixation with dynamic condylar screw. There were 27 men and 3 women with the average age thirty seven and half years (range: 17-58 years) for group I and forty one years (range: 20-62 years) for group II. The mean follow-up period was 2.5 years (range: 1.2 - 5 years) for both groups. **Results:** The average operating time was 84 minutes (range: 55-120 minutes) for group I and 135 minutes (range: 90-180 minutes) for group II. The average blood loss was 250 ml (range: 100 - 500 ml) for group I and 525 ml (range: 250 - 800 ml) for group II. The average hospital stay was 8.5 days (range: 5 to 14 days) for group I and 14 days (range: 7 to 21 days) for group II. Implant failure was not observed and union was achieved in all patients, except one female patient from group I needed bone graft after 9 months from the first operation. Leg shortening was the commonest complication encountered, occurring in 3 (21.4%) patients in group I, average 1 cm and none in group II. Superficial wound infection occurred in 3 patients (18.8%) in group II and was rapidly controlled by repeated dressings and broad spectrum antibiotics and none in group I. No deep infection was observed in both groups. No deep vein thrombosis occurred in our patients. There was no significant varus/valgus malunion and no patient had significant rotational mal-alignment as determined by clinical examination. **Conclusion:** According to our results, no superiority of either technique was demonstrated with respect to fracture union time and functional results. Submuscular biological plating had superiority regarding the hospital stay, average operative time and intraoperative blood loss.

[Mohamed Gamal, Ahmed Hashem Amin and Omar Kelany **Comparative Study between Submuscular Biological and Open Anatomic Dynamic Condylar Screw Plating for Comminuted Subtrochanteric Fracture Femur in Adults***J Am Sci* 2012;8(11):421-429]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 65

Keywords: Subtrochanteric fracture, biologic fixation, dynamic condylar screw.

1. Introduction

Subtrochanteric femoral fractures, between the lower limit of the lesser trochanter to about 5 cm distal to it**,** pose certain anatomical, biological and biomechanical challenges and typically give high complication rates. Subtrochanteric femoral fractures represent 7 to 34% of proximal femoral fractures **(1).** In young individuals they usually result from high-energy trauma and often show significant comminution **(1-3).** Major compressive stresses in the femur are greatest in the medial cortex 2.5 to 7.5 cm below the lesser trochanter, exceeding 84 kg/cm^2 **(4, 5).** Slightly less tensile forces of 63 kg/cm^2 occur at the proximal lateral femoral cortex **(4,5).** The treatment of comminuted fracture of the subtrochanteric region is problematic. Biomechanical studies have shown that the femoral cortex in the postero-medial subtrochanteric region is subjected to the highest stresses in the body **(6).** Restoration of the integrity of the postero-medial column then allows the dynamic condylar screw to act as a tension band along the lateral femoral cortex **(1,6).** However, if the column's integrity is not restored, all implants are subjected to high bending stresses **(6,7).** Only a durable and long implant that is firmly anchored above and below the fracture region will allow early weight bearing **(8).** The best treatment for such kind of fractures is biological indirect reduction and splinting by a new generation of intramedullary nails, and these include the gamma nail and the Russel-Taylor reconstruction nail, yet it is technically demanding. Plate devices include the angled blade-plate, the dynamic hip screw and the dynamic condylar screw. The dynamic condylar screw is technically easier to insert than the condylar blade plate. The dynamic condylar screw act as a lateral tension band if the medial cortex is intact. The dynamic codylar screw plate has a 95° barrel angle, allowing it to enter the femur more proximally than the dynamic hip screw Plate and allowing insertion of two or more screws into the calcar. Further, its two round proximal plate holes

permit insertion of 6.5 mm cancellous screws, for stable proximal fixation [8-13].

2. Patients and methods

Thirty patients with comminuted subtrochanteric fractures were treated by Dynamic Condylar Screw (DCS) using two different techniques, either submuscular biological or open surgical technique at Zagazig University Hospitals, Egypt and Al Hayat Hospital, KSA, between January 2007 and March 2011, and were retrospectively analyzed. The average age was 37.5 years (rang: 17- 58 years) for group I and 41 years (rang: 20-62 years) for group II. There were 12 males (40%) and 2 females (6.7%) for group I and 15 males (50%) and one female (3.3%) for group II. There were no bilateral fractures; the right femur was fractured in 10 cases (33.3%) and the left in 4 cases (13.3%) in group I and the right femur was fractured in 7 cases (23.3%) and the left in 9 cases (30%) in group II. According to the mechanism of injury, 6 patients (20%) felt from a height and 8 patients (26.7%) sustained motor vehicle accidents in group I and 9 patients (30%) felt from a height and 7 patients (23.3%) sustained motor vehicle accidents in group II. Associated injuries included only fracture both bones contralateral leg in one case in group I and fracture olecranon in one case in group II. On admission, priority was given to correction of any haemodynamic instability especially in the high- energy trauma patients. All fractures in group I and II were closed. Operations were performed within a mean of 2 days (range: 1–4 days) for group I and a mean of 3 days (range: 2–6 days) for group II. A universally accepted fracture classification does not exist for subtrochanteric femur fractures. In 1978, Seinsheimer[28] presented an important classification with 8 subgroups that identified fractures with loss of medical cortical stability [20] (Table I). Distribution of fracture type in both groups listed in (Table 2). Union was defined as callus formation at the fracture site, with the fracture line visible for less than a quarter of the circumference. The activities of daily living and level of pain were assessed 12 months after fractures. Walking ability was evaluated according to the criteria of Parker [14] (Table 3). Pain was scored as absent when no painkiller was used, mild when only occasional oral painkiller was used, moderate when painkiller was used regularly, or severe when the pain was difficult to treat with oral painkillers or when narcotic analgesics were used regularly.

Table 1: Seinsheimer's classification. [28]

Type I	Non-displaced or minimally displaced fractures.
Type II	Two – part fractures:
Type IIA	A two – part transverse femoral fracture.
Type IIB	A two – part spiral fracture with the lesser trochanter attached to the proximal fragment.
Type IIC	A two – part spiral fracture with the lesser trochanter attached to the distal fragment.
Type III	Three – part fractures:
Type IIIA	A three – part spiral fracture in which the lesser trochanter is part of the third fragment.
Type IIIB	A three – part spiral fracture where the third part is a butterfly fragment.
Type IV	Comminuted fractures with four or more fragments.
Type V	Combined subtrochanteric – intertrochanteric fractures.

Table 2: Distribution of fracture type.

	Group I	**Group II**
Type I	**0**	**0**
Type IIA	**1**	**2**
Type IIB	**3**	**4**
Type IIC	**2**	**3**
Type IIIA	**3**	**3**
Type IIIB	**2**	**2**
Type IV	**2**	**2**
TypeV	**1**	**0**

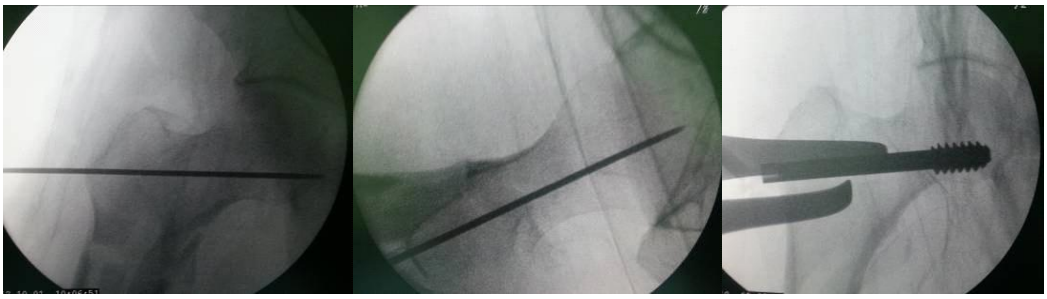
Table 3: Mobility Score of Parker and Palmer*[14]

Walking ability	**No difficulty**	**Alone with an assistive device**	**With help from another person**	**Not at all**
Able to walk inside house	**3**	**2**	**1**	**0**
Able to walk outside house	**3**	**2**	**1**	**0**
Able to go shopping, to a restaurant, or to visit family	**3**	**2**	**1**	**0**

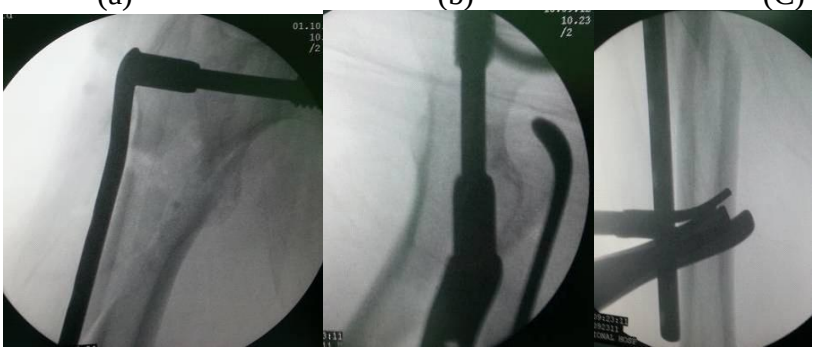
*The values are given as the number of points assigned for that answer. The maximum possible score is 9 points.

Operative procedure:

For group I patients, under general or spinal anesthesia, the patient were placed on the fracture table in a supine position. The unaffected limb was placed in hip abduction and knee flexion to enable fluoroscopy use. Closed reduction was performed under fluoroscopic guide. After observing satisfactory reduction the plate size was reconfirmed by fluoroscopy. A minimal incision on the lateral aspect of the thigh at the level of greater trochanter was performed with minimal soft-tissue dissection to expose the greater trochanter. It is frequently helpful to position a guidewire anteriorly on the femoral neck, approximating the axis of the femoral neck, to assist in proper orientation of the starting point in the proximal femoral fragment. The tip of the guide pin engaged the subchondral bone of the lower quadrant of the femoral head. In the lateral view (frog leg) the guide pin was either centrally or slightly posteriorly positioned in relation to both the femoral neck and head. Anterior or posterior placement was unacceptable. A condylar lag screw was then inserted after reaming over the guide pin with a triple reamer. A distal incision was then made. A track for plate advancement was made extra-periosteally beneath the muscle with a blunt instrument, without stripping the periosteum. The plate was introduced through the proximal incision, keeping the barrel towards the surgeon. The plate was rotated 180º to face the bone and guided over the condylar screw. After proper placement of the plate, frontal and rotational alignments were checked. In the proximal segment cancellous or cortical screw must be inserted as an antirotational screw without exposing the fracture site. On the distal fragment the plate fixed with 4 to 5 screws. Separate drains were used for each wound. For group II patients, similar technique was done except that the incision was straight with open reduction for the fragments with aid of interfragmentary screws and then application of the plate. Regardless of the severity of comminution, no initial bone graft was used in any patient. Operations were performed within a mean of 2 days (range: 1–4 days) for group I and a mean of 3 days (range: 2–6 days) for group II. The average duration of the operation was 84 minutes (range: 55 to 120 minutes) for group I and 135 minutes (range: 90 to 180 minutes) for group II.The average intra-operative blood loss for group I patients was 250 ml (range: 100 to 500 ml) and it was 525 ml (range: 250 - 800 ml) for group II patients . All fractures were fixed with a standard dynamic condylar screw with the lag screw length varied from 65 mm to 95 mm with the most commonly used being the 80 mm size. The wound is checked for proper healing 7-14 days postoperatively. Partial weight bearing (20-30 kg) was allowed as soon as the patient could tolerate it, and full weight bearing was begun after 3 to 6 months based on the degree of comminution of the fracture and the radiological findings for each patient. Patients were evaluated at 4-8 week intervals until fracture union and at 3 - 6 month intervals thereafter.



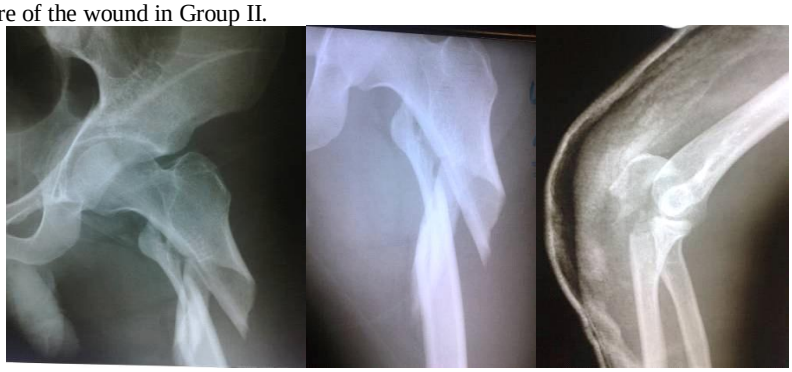
(a) (b) (C) •



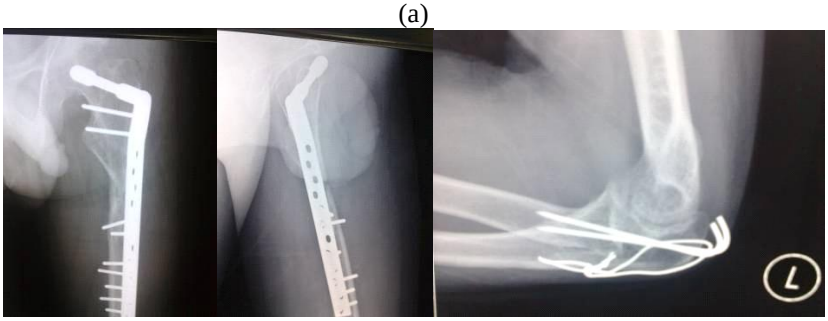
(d) (e) (f)

(g) (h) (i)

Fig. (1)
Steps of the operation
(a) In the AP view the guide pin was placed at an angle of 95°.
(b) In the lateral view the guide pin was centrally placed in relation to both the femoral neck and head.
(c) Insertion of the condylar screw after reaming over the guide pin with a triple reamer.
(d) Insertion of the side plate in the AP view.
(e) Assessmentnt of the screw and side plate in the lateral view.
(f) Fixation of the plate on the distal fragment with plate holding forceps.
(g) Insertion of cancellous or cortical screw as an antirotational screw.
(h) Patient after closure of the wounds in Group I.
(i) Patient after closure of the wound in Group II.



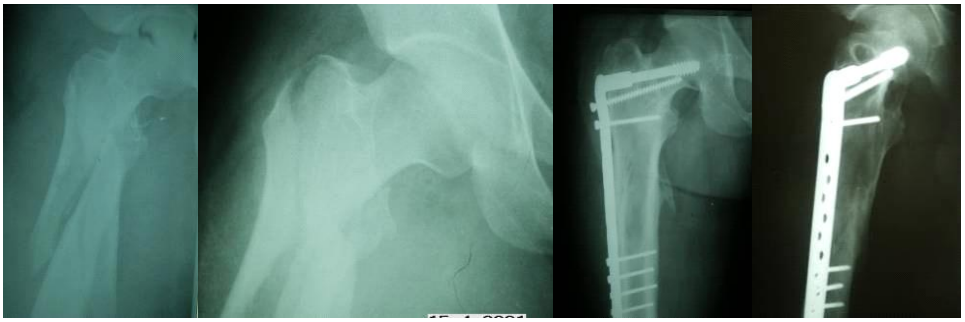
(a)



(b)

(c)

(Fig.2)
(a) Preoperative views showing Seinsheimer's type IIIB, in a 29 years old patient from group II associated with fracture olecranon.
(b) Postoperative x-ray after 8 months with complete union.
(c) Follow - up photos, 8 months with excellent results.



(a) (b)

(c)

Fig. (3)
(A) Preoperative view showing Seinsheimer's type IIB, in 35 years old patient from group I.
(B) Radiographs, 9 months postoperatively showing complete union.
(C) Follow - up photos, 9 months with excellent results.

(a) (b)

(c) (d)

Fig.(4)
(a) Preoperative views showing Seinsheimer's type IIC in 42 years old male patient from group II.
(b) Immediate postoperative x-rays.
(c) Follow up x-rays after 11 months with complete union.
(d) Follow up photos after 11 months with excellent results.

3. Results

For group I, 14 Patients had been followed for an average of 2.5 years (range: 1.2 - 5 years). The average age was 37.5 years (range: 17- 58 years). There were 12 males (40%) and 2 females (6.7%). The average duration of the operation was 84

minutes (range 55 to 120 minutes). The right femur was fractured in 10 cases (33.3%) and the left in 4 cases (13.3%). According to the mechanism of injury, 6 patients (20%) felt from a height and 8 patients (26.7%) sustained motor vehicle accidents. Associated injuries included only fracture both bones contralateral leg in one case. Operations were performed within a mean of 2 days (range: 1–4 days). Average hospitalization was 8.5 days (range: 5 to 14 days). The average intraoperative blood loss was 250 ml (range: 100 to 500 ml). Distribution of fracture type listed in (Table 2) with more prevalence to type IIB and type IIIA. All fractures united after a mean of 6 months (range: 4 – 8 months) without additional procedures except one female patient with non-union and needed bone graft after 9 months from the first operation. At final follow- up, 11 patients (78.6%) returned to their preinjury pattern of walking, the other three (21.4%) had a mild limp. Eleven patients (78.6%) were totally free from pain related to their fracture. The other 3 patients (21.4%) presented with variable grades of pain as shown in (Table 4).

For group II, 16 patients had been followed for an average of 2.5 years (range: 1.2 - 5 years) as in group I. The average age was 41 years (range: 20-62 years). There were 15 males (50%) and one female (3.3%). The average duration of the operation was 135 minutes (range: 90 to 180 minutes). The right femur was fractured in 7 cases (23.3%) and the left in 9 cases (30%). According to the mechanism of injury, 9 patients (30%) felt from a height and 7 patients (23.3%) sustained motor vehicle accidents. Associated injuries included fracture olecranon in one case. Operations were performed within a mean of 3 days (range: 2–6 days). Average hospitalization was 14 days (range: 7 to 21days). Distribution of fracture type listed in (Table 2) with more prevalence to types IIB, IIC and IIIA. All fractures united after a mean of 7 months (range: 4 – 9 months) without additional procedures. At final follow- up, 13 patients (81.2%) returned to their preinjury pattern of walking, the other three (18.8%)had superficial infection without limping. Thirteen patients (81.3%) were totally free from pain related to their fracture. The other 3(18.7%) patients presented with variable grades of pain as shown in (Table 5).

Although many complications occurred, they did not materially affect the end result, leg shortening was the commonest complication encountered, occurring in 3 (21.4%) patients in group I, average 1 cm and none in group II. Superficial wound infection occurred in 3 patients (18.8%) in group II and was rapidly controlled by repeated dressings and broad spectrum antibiotics and none in group I. No deep infection was observed in both groups. No deep vein thrombosis occurred in our patients because of good coverage with thrombolytic treatment and early intervention for the fractures. There was no significant varus/valgus malunion and no patient had significant rotational mal-alignment as determined by clinical examination. Implant failure was not observed and union was achieved in patients except one female patient with non-union in group I and treated with bone graft after 9 months from the first operation.

Table 4: Demographic Data of group 1

Case	Gender	Age	Etiology	Type b	M.T. C	Time d	Union e	Score f	Pain	Complication
1	M	34	MVA	IIA	_	1	4	9	Absent	_
2	F	25	Fall	IIIA	_	2	8	8	Mild	Non-union
3	M	17	MVA	IIB	_	2	5	9	Absent	_
4	M	30	Fall	IIIA	_	2	4	9	Absent	_
5	M	32	MVA	IIC	_	3	6	9	Absent	LLD
6	M	35	MVA	IIB	_	2	4	9	Absent	_
7	M	28	Fall	IIIA	_	1	5	9	Absent	_
8	M	58	Fall	IV	_	4	5	9	Mild	LLD
9	M	38	MVA	IIC	_	3	7	9	Absent	_
10	F	42	Fall	IIB	_	1	4	9	Absent	_
11	M	44	MVA	IIIB	+	1	6	9	Mild	_
12	M	27	MVA	IIIB	_	3	7	8	Absent	LLD
13	M	20	MVA	IV	_	3	6	9	Absent	_
14	M	31	Fall	V	_	2	6	9	Absent	_

Table 5: Demographic Data of group 2

Case	Gender	Age	Etiology	Type b	M.T. c	Time d	Union e	Score f	Pain	Complication
1	M	26	MVA	IIA	_	2	6	9	Absent	_
2	M	28	Fall	IIC	_	3	5	9	Absent	_
3	M	20	Fall	IIB	_	2	6	9	Absent	_
4	M	34	MVA	IIIA	_	2	7	9	Absent	Infection
5	M	42	Fall	IIC	_	2	5	9	Absent	_
6	M	29	MVA	IIB	+	4	5	9	Absent	_
7	M	62	Fall	IIIB	_	6	9	8	Moderate	_
8	M	46	MVA	IIIA	_	3	5	9	Absent	_
9	M	38	MVA	IIB	_	4	4	9	Absent	_
10	F	27	MVA	IV	_	2	6	9	Absent	_
11	M	33	Fall	IV	_	2	6	9	Absent	_
12	M	37	Fall	IIA	_	2	7	9	Absent	_
13	M	23	MVA	IIIA	_	2	4	9	Absent	_
14	M	52	Fall	IIC	_	4	6	8	Mild	Infection
15	M	49	Fall	IIB	_	3	5	9	Mild	_
16	M	40	Fall	IIIB	_	2	4	9	Absent	Infection

Abbreviations: M: male; **F**: female **MVA:** Motor vehicle accident; **b:** Seinsheimer's classification.
c: Multiple trauma; **d:** Time to operation in days;
e: Time to bone union in months; **f:** Mobility score of Park and Palmer; **LLD:** Leg length discrepancy.

4. Discussion

Subtrochanteric femoral fractures are difficult to treat and account for 7 to 15% of all hip fractures [7,15,16]. Anatomically, the area consists of hard cortical bones with a slower healing rate than metaphyseal bones[17-19].

Biomechanically, the proximal femoral shaft is under high stress. There are high compressive and tensile forces in the medial cortex distal and lateral to the lesser trochanter, respectively. Internal fixation is difficult and risks a high failure rate [16]. Biologically, extensive comminution and fragment devitalization compromises bone healing [20]. The goals of subtrochanteric fracture fixation are restoration of the normal neck-shaft angle, reestablishment of leg length, rotation, union and avoidance of abductor weakness [21]. These fractures are known to be difficult to treat and various intra- and extramedullary devices have been advocated for this purpose in the past. Intramedullary devices have been shown to have a minimal failure rate due to its rigid axial and rotational stability [22-24]. The central position of the intramedullary nail prevents excessive collapse with immediate weight bearing [21,25,26]. However, complications such as intraoperative nail protrusion, cephalic screw cutting-out, delayed union, malunion and fractures at the tip of the nail have been reported [3,21]. Reconstruction nailing is technically demanding; plate and screw fixation is probably the best option [24]. Indirect reduction and condylar blade plate fixation achieved excellent results in comminuted subtrochanteric fractures, [27] despite being technically demanding [3,26]. The dynamic condylar screw was introduced as an alternative to the condylar blade plate with the screw replacing the blade portion of the plate. The introduction of the dynamic condylar screw, simplified the fixation, due to its less exacting technique compared to the condylar blade plate. It requires only two-plane alignment, while the condylar blade plate requires three-plane alignment [29]. Indirect reduction techniques with the condylar blade plate are reported but are technically demanding especially during rotation of the implant after sliding under the vastus lateralis. The dynamic condylar screw facilitates this rotation with ease and even allows sagittal plane alignment by rotation of the plate screw construct after insertion of the condylar screw [29].

Indirect reduction enables faster healing, lower nonunion and infection rates, earlier full weight bearing, and avoids bone grafting [17,20].

Vaidya et al,[3] in their series had thirty-one consecutive patients with a mean age of 32.6 years old who sustained subtrochanteric femoral fracture were treated with biologic fixation using dynamic condylar screw. Patients assessed clinically and radiographically with regards to fracture classification, operating time, blood loss, time of union, malunion and other complications. Union was achieved in all cases (100%) with full-weight bearing after an average of 4.9 months. There was only one case of superficial infection, malunion was seen in 2 cases out of 31 without the need for further surgery [3]. Chrisotirsinos et al, [32] in their study on 20 comminuted femoral fracture include

11 subtrochantric fracture treated in accordance with the principles of indirect reduction and biological osteosynthesis technique had union in all fractures on at average of 5 months irrespective of use of bone grafts[32]. Kinsat et al, [17] reported use of the AO condylar blade – plate and reported a 32% non – union rate. Mulji and Thomas [12] reported a 9% non – union rate and Ruff and Lubbers [29] reported a 5% non – union rate in subtrochanteric fractures treated with the sliding compression hip screw.

For group I in our study, 92.9 % union rate was achieved without bone grafting in all cases except one female patient need bone grafting after 9 months with radiological evidence of non-union which is similar to other series with union rates of 93.7 to 100%.[3,6,20,31].

In our study, in group I patients, short duration of the operation was achieved, average 84 minutes (range: 55 to 120 minutes), with minimal intraoperative blood loss average was 250 ml (range: 100 to 500 ml), leg shortening was the commonest complication encountered in group I patients, occurring in 3 (21.4%) patients average 1cm without infection or deep venous thrombosis. There was no significant varus/valgus malunion and no patient had significant rotational mal-alignment as determined by clinical examination.

Anatomic reconstruction of comminuted fractures is difficult and results in increased operating times, blood loss, and avascularity of fragments [3]. Although open reduction and internal fixation achieves anatomic reduction and rigid fixation, extensive surgical exposure increases the risk of delayed union, infection, non-union, refracture, and implant failure [17, 20, 28, 34].

Open reduction of subtrochanteric fractures is associated with 17 to 23% of non-unions, with 29% of patients needing bone grafting [15,17,30].

For group II in our study, 100 % union rate was achieved without bone grafting in all cases.

In our study, in group II patients, long duration of the operation was achieved, average 135 minutes (range: 90 to 180 minutes), with moderate intraoperative blood loss average was 525 ml (range: 250 to 800 ml). Superficial wound infection was the commonest complication encountered in group II patients, occurred in 3 patients (18.8%) and was rapidly controlled by repeated dressings and broad spectrum antibiotics. Neither deep infection nor deep vein thrombosis was observed. There was no significant varus/valgus malunion and no patient had significant rotational mal-alignment as determined by clinical examination. No implant failure was encountered in our series.

In conclusion, our findings indicate that dynamic condylar screw fixation using either submuscular biological fixation technique or open reduction technique leads to union of all comminuted subtrochanteric fractures without major complication. According to our results, no superiority of either technique was demonstrated with respect to fractue union time and functional results. Submuscular biological plating had superiority regarding the hospital stay, average operative time and intraoperative blood loss. Appropriate placement of the guide wire and slipping of the plate over the lag screw are important steps with one or two cortical screws should be used through proximal plate holes so as to fix it to the calcar to improve rotational stability.

Corresponding author
Ahmed Hashem Amin
Orthopedic Department, Faculty of Medicine, Zagazig University, Egypt
hashmdr@yahoo.com

References

1. **Bedi A, Le TT.** Subtrochanteric femur fractures. *Orthop Clin North Am.* 2004; 35: 473-483.
2. **Kayali C, Agus H, Zincircioglu G.** The role of biological fixation with bridge plating for comminuted subtrochanteric fractures of the femur. *Ulus Travma Acil Cerrahi Derg.* 2008; 14: 53-58.
3. **Vaidya SV, Dholakia DB, Chatterjee A.** The use of a dynamic condylar screw and biological reduction techniques for subtrochanteric femur fracture. Injury. 2003;34(2):123-8.
4. **Koch JC.** The laws of bone architecture. *Am J Anat.* 1917; 21: 177-298.
5. **Tordis TG.** Stress analysis of the femur. *J Biomech.* 1969; 2: 163-174.
6. **Celebi L, Can M, Muratli HH *et al.*** Indirect reduction and biological internal fixation of comminuted subtro - chanteric fractures of the femur. *Injury*. 2006; 37: 740- 750.
7. **Fielding JW, Cochran GV, Zickel RE.** Biomechanical characteristics and surgical management of subtrochanteric fractures. *Orthop Clin North Am.* 1974; 5: 629-650.
8. **Browner BD, Cole JD.**: Current status of locked intramedullary nailing: a review. *J Orthop Trauma*. 1989; 1:183-195.
9. **Collinge CA., sanders RW.** Percutaneous plating in the lower extremity , *J Am Acad Orthop Surg*. 2000; 8(4): 211-216.
10. **Johnson E.**: Combined direct and indirect reduction of comminuted four-part intra-articular T-type fractures of the distal femur. *Clin Orthop*. 1988; 231: 154-162.
11. **Krettek C, Schandelmaier P, Miclau T, Tscherne H.:** Minimally invasive percutaneous plate osteosynthesis (MIPPO) using the DCS in proximal and distal femoral fractures. *Injury*. 1997; 28: 20-30.

12. **Mulji B and Thomas T.:** Low energy subtrochanteric fractures in elderly patients; Results of fixation with the sliding screw plate. *J Trauma.* 1993; 34; 5661.
13. **Parker MJ, Dutta BK, Sivaji C, Pryor GA**.: Subtrochanteric fractures of the femur. *Injury*. 1997; 28:91-5.
14. **Parker MJ, Palmer CR.** A new mobility score for predicting mortality after hip fracture. J Bone Joint Surg Br. 1993; 75:797-8.
15. **Nungu KS, Olerud C, Rehnberg L.** Treatment of subtrochanteric fractures with the AO dynamic condylar screw. Injury. 1993; 24: 90–2.
16. **Kyle RF, Cabanela ME, Russell TA, Swiontkowski MF, Winquist RA, Zuckerman JD, *et al.*** Fractures of the proximal part of the femur. Instr Course Lect. 1995; 44: 227–53.
17. **Kinast C, Bolhofner BR, Mast JW, Ganz R.** Subtrochanteric fractures of the femur. Results of treatment with the 95 degrees condylar blade-plate. Clin Orthop Relat Res. 1989; 238: 122–30.
18. **Asher MA, Tippett JW, Rockwood CA, Zilber S**. Compression fixation of subtrochanteric fractures. Clin Orthop Relat Res. 1976; 117: 202–8.
19. **Trafton PG.** Subtrochanteric-intertrochanteric femoral fractures. Orthop Clin North Am. 1987; 18:59–71.
20. **Siebenrock KA, Muller U, Ganz R.** Indirect reduction with a condylar blade plate for osteosynthesis of subtrochanteric femoral fractures. Injury. 1998; 29(Suppl 3): 7–15.
21. **Tornetta P 3rd**. Subtrochanteric femur fracture. J Orthop Trauma. 2002; 16(4):280-3.
22. **Borens O, Wettstein M, Kombot C, Chevalley F, Mouhsine E, Garofalo R.** Long gamma nail in the treatment of subtrochanteric fractures. Arch Orthop Trauma Surg. 2004; 124(7): 443-7.
23. **Roberts CS, Nawab A, Wang M, Voor MJ, Seligson D.** Second generation intramedullary nailing of subtrochanteric femur fractures: a biomechanical study of fracture site motion. J Orthop Trauma. 2002; 16(4):231-8.
24. **Grosse A, Favreul E, Taglang G.** The long gamma nail experience: 79 cases. Orthopedics. 1994; 2(1):3-5.
25. **Hotz TK, Zellweger R, Kach KP.** Minimal invasive treatment of proximal femur fractures with the long gamma nail: indication, technique, results. J Trauma. 1999; 47(5):942-5.
26. **Hoover GK, Browner BD, Cole JD, Comstock CP, Cotler HB.** Initial experience with a second generation locking femoral nail: the Russell-Taylor reconstruction nail. Contemp Orthop. 1991;23(3):199-208.
27. **Blatter G, Janssen M.** Treatment of subtrochanteric fractures of the femur: reduction on the traction table and fixation with dynamic condylar screw. Arch Orthop Trauma Surg. 1994; 113(3):138-41.
28. **Seinsheimer, F.:** Subtrochanteric fractures of the femur. *J Bone Joint Surg* Am. 1978; 60: 3006.
29. **Ruff, M.E. and Lubbers, LM:** Treatment of subtrochanteric fractures with a sliding screw plate device. *J Trauma. 1986;* 26; 7580.
30. **Kulkarni SS, Moran CG.** Results of dynamic condylar screw for subtrochanteric fractures. Injury. 2003; 34:117–22.
31. **Pai CH.** Dynamic condylar screw for subtrochanteric femur fractures with greater trochanteric extension. J Orthop Trauma. 1996; 10: 317–22.
32. **Chrisoritsinos JP, Xenakis T., Papakostides KG., Skaltsoyannis N., Grestas A., Soucacos PN.:** Bridge plating osteosynthesis of 20 comminuted fractures of the femur , Acta orthop scaned suppl. 1997; 275: 72-6.
34. **Perren SM.** Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br. 2002; 84: 1093–110.