Results of biological fixation for subtrochanteric femoral fractures with a beveled dynamic condylar screw

Shazly S. Mousa

Sohag University Hospital

Correspondence to Shazly S. Mousa, Sohag University Hospital
Tel: 00201223856260;
e-mail: shazly1saleh@yahoo.com

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Background

Subtrochanteric femoral fractures are fraught with certain anatomic, biologic, and biomechanical challenges. Surgical treatment is the preferred method for management of such fractures; however, comminuted subtrochanteric femoral fractures may be associated with a high incidence of nonunion and implant failure. The types of extramedullary and intramedullary implant techniques continue to evolve. Intramedullary nailing is the mainstay in the surgical treatment of subtrochanteric femoral fractures, but nailing is often unsuitable for difficult fracture patterns with comminution or when the medullary canal is narrow. Biological fixation decreases the complication rate while preserving soft tissue vascularity by encouraging rapid callus formation, which buttresses the medial cortex.

Objective

The aim of the study was to assess the benefits and effectiveness of a beveled dynamic condylar screw (DCS) using biological fixation the treatment of comminuted subtrochanteric fractures in terms of radiological and functional outcome, operative time, operative blood loss volume, and intraoperative and postoperative complications.

Patients and methods

From 2006 to 2010, 24 patients (16 male and 8 female patients) with a mean age of 33 years (range 17–66 years) presented with comminuted subtrochanteric femoral fractures and were treated with indirect reduction and biological plate fixation using a beveled DCS at Sohag University Hospital. An overall 83% of the fractures were caused by traffic accidents and falls from a height, whereas 17% were due to simple falls.

Results

The average follow-up period was 3 years. The average operation time was 45 min. The average blood loss was 250 ml. Partial and full weight bearing was recommended at an average postoperative period of 3.3 and 4.8 months, respectively. The fractures united at a mean of 4.6 months postoperatively in 23 patients (96%), whereas one patient (4%) encountered complications with nonunion but achieved union after undergoing an open graft technique. One patient with a prominent lag screw required removal of the DCS after healing. One patient had loosening of the compression screw, which required removal. Two patients had a lower limb shortening of 1 and 2 cm. There was no significant statistical difference between the injured and noninjured femoral neck–shaft angle. According to the criteria of Radford and Howell, 18 patients showed excellent results, four patients showed good results, one patient showed fair results, and one patient encountered failure.

Conclusion

Use of a beveled DCS and biological bridge plating offers the significant advantage of being less technically demanding with a high percentage of subtrochanteric fracture union without major complications.

Keywords:

beveled dynamic condylar screw, biological fixation, subtrochanteric femoral fractures

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Introduction

Subtrochanteric fractures of the femur account for 10–34% of hip fractures [1]. High compressive and tensil stress across this region are associated with nonunion [2] and could cause failure of internal fixation of inadequate strength [3,4].

Surgical treatment is the preferred method for subtrochanteric fractures, and a variety of intramedullary and extramedullary implant techniques have been introduced, which continue to evolve [5].

Comminution in subtrochanteric fractures renders anatomic reconstruction difficult, prolongs operative time, increases blood loss, and contributes to avascularity of fracture fragments [6].

Comparison between the conventional technique and the indirect reduction technique in the literature revealed high incidences of delayed/nonunion of up to 16% and a high infection rate in the former [7].

No single implant technique is universally recommended for internal fixation of this fracture, and hence periodically new fixation devices are introduced [8].

Dynamic condylar screw (DCS) was advised for the distal femur but Schatzker *et al.* [9] and Regazzoni [10] initially described its use for subtrochanteric fractures.

The introduction of DCS simplified fixation because of its less exacting nature compared with the condylar blade plate technique. It requires only two-plane alignment, whereas the condylar blade plate requires three-plane alignment [10,11]. The indirect reduction technique allows correct axial and transitional alignment of the fractured extremity without damaging vascularity of the comminuted fracture fragments [12–14].

Minimally invasive surgery provides relative stability and less surgical trauma, which results in rapid healing of the fracture [15,16]. Practically, there is a technical difficulty in the step of plate sliding. This study attempted to overcome this difficulty by using beveled DCS.

Patients and methods

From August 2006 to March 2010, 24 patients (16 male and 8 female patients) with a mean age of 33 (range, 17–66) years presented with comminuted subtrochanteric femoral fractures and were treated with indirect reduction and biological plate fixation with beveled DCS (range from 9 to 14 holes in length) (Fig. 1) at the Orthopedic and Traumatology Department at Sohag University Hospital.

Indications of this study were subtrochanteric femoral fractures in which intramedullary nailing was viewed as being difficult in terms of accurate fixation and/or in which the intramedullary nailing reaming procedure might provoke fat embolism or additional damage. Patients with open fractures and pathological fractures were excluded. The right lower limb was injured in 19 patients and the left lower limb in five patients; 19 fractures (83%) were caused by traffic accidents and falls from a height, whereas five fractures (17%) were due to simple falls. Ten patients had sustained multiple fractures: humeral, pelvic, and tibial fractures (Table 1).

All patients underwent an initial assessment and a Thomas splint was applied to the injured limb. Radiological examination of injured and noninjured limbs in all patients was carried out, and according to the AO/OTA classification [17] eight patients were classified as having type B fracture and 16 patients as having type C fracture.

The final functional assessment was made on the basis of the criteria laid down by Radford and Howell [18] (Table 2).

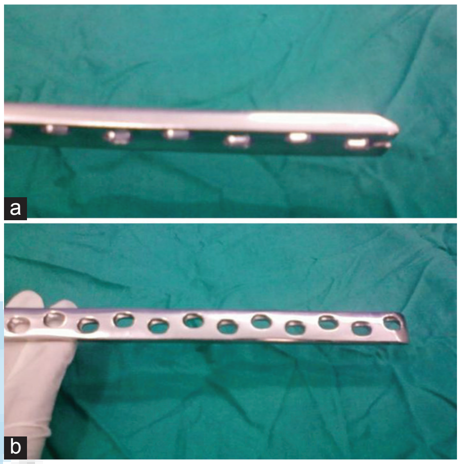
Implant characteristics

The distal end of the plate was beveled to the thickness of the periosteal elevator without violation of the distal screw hole (Fig. 1).

Operative technique

The patient was anesthetized and placed in supine position on a radiolucent operative table to allow

Figure 1



Beveled dynamic condylar screw: (a) lateral view and (b) outer surface view.

Table 1 Patient's basic clinical data

Number of patients	24 patients (16 male and eight female patients)
Mean patient age (years)	33
AO/OTA fracture classification	Eight patients: type B16 patients: type C
Injured side	
Right	19
Left	5
Cause of injury	
High-energy trauma	19
Low-energy trauma	5
Associated injuries	10

Table 2 Criteria used for final assessment of the results [18]

Excellent	Flexion loss of less than 10° no varus, valgus, or rotatory deformity perfect joint congruity no pain
Good	Not more than one of the following: Loss of length not more than 1–2 cm less than 10° varus or valgus deformity flexion loss not more than 20° minimal pain
Fair	Any of the two criteria in the good category
Failure	Flexion less than 90° varus or valgus exceeding 15° joint incongruency disabling pain

excellent fracture visualization. Correct alignment and rotation was checked under an image intensifier. A traction table was not used for all patients. After draping, two separate incisions were made above and below the fracture site (Fig. 2) in the proximal trochanteric incision. The entry point for the lag screw was determined by the use of a guidewire under fluoroscopic control. A submuscular tunnel under the vastus lateralis was delivered and the plate was slid from proximal to distal in a regular manner. The beveled edge of the plate facilitated this step. The barrel of the beveled DCS was positioned toward the surgeon and advanced extraperiosteally distal to the fracture line and rotated 180°, thus facing the bone. The plate was engaged to the lag screw. Distal incision was carried out, followed by reduction. Frontal alignment was assessed using the cable technique described by Krettek *et al.* [19] and rotational alignment was determined by the shape of the lesser trochanter as described by Krettek *et al.* [20] Distal and proximal screw insertion was completed. Plate length was checked preoperatively and intraoperatively for at least four screws distal to the fracture extent and then the wound was closed. No bone grafting was performed.

Postoperative follow-up

Postoperative radiography was performed. Intravenous injection of antibiotics and subcutaneous low-molecular-weight heparin was administered for 3 days, followed by oral antibiotics for 12 days. Sutures were removed 15 days postoperatively. Patients were made to perform quadriceps and hamstring muscle exercises, and full weight bearing was not allowed until the fracture had healed. Fracture healing was considered when callus formation and fading of the fracture line were observed on follow-up radiographs at 1.5, 3, 6, and 12 months postoperatively.

Figure 2

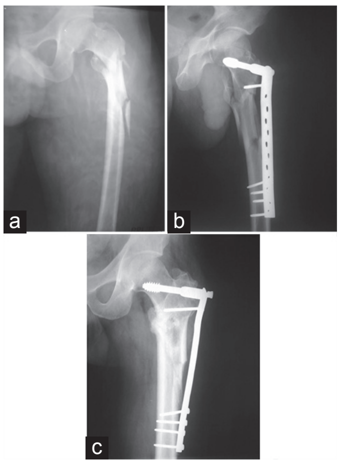
Intraoperative proximal and distal incisions.

Results

A total of 24 patients were included in this study. The mean follow-up period was 12 months (range 14–42) postoperatively. The mean operation time was 45 min (range 35–90). The mean blood loss was 250 ml (range 125–325 ml). Partial and full weight bearing was recommended at an average postoperative period of 3.3 and 4.8 months, respectively.

Fracture union was achieved in 23 patients (96%), with an average 4.6 months (range 3–6 months) postoperatively. In one patient (4%) the fracture failed to unite primarily and the patient achieved fracture union at 9 months after undergoing open bone grafting. One patient had superficial wound infection treated by repeated dressing and intensive antibiotics. One patient had deep venous thrombosis. One patient had a prominent lag screw and required removal of the DCS at 1 year postoperatively. Another patient with loosening of the compression screw required its removal. Two patients had lower limb shortening of 1 and 2 cm. Three patients had malunion in terms of anterior angulation and varus deformity. Postoperative knee stiffness was seen in one patient, who was subjected to physiotherapy. At the final follow-up according to the criteria of Radford and Howell, 18 patients (75%) showed excellent results, four patients (17%) showed good results, one patient (4%) showed fair results, and one patient (4%) encountered failure (Fig. 3).

Figure 3



Male patient, aged 37 years: (a) preoperative radiograph showing type C subtrochanteric fracture; (b) postoperative radiograph; (c) united fracture at 12 months' follow-up.

In this study, no major intraoperative complications, implant failure, or hip complaint were experienced (Table 3).

Discussion

To our knowledge, this is the first article that focuses on the minimally invasive plate osteosynthesis technique and the use of beveled DCS for fixation of subtrochanteric femoral fractures. No experimental biomechanical studies had been reported that beveled DCS altered the mechanical construction of the DCS.

DCS was designed for distal femoral fractures as well and is now widely used in proximal femoral fractures.

Subtrochanteric femoral fractures constitute 7–34% of proximal femoral fractures [1,21] and usually result from high-energy trauma and essentially occur in young patients, with significant comminution.

Subtrochanteric femoral fractures present a challenge to orthopedic surgeons because of the high rate of nonunion and implant failure [2,22].

The proximal bone fragments of the subtrochanteric area are relatively small and provide a limited area for fixation and high tensil and compressive stress across this region [23]. Classification of subtrochanteric fractures based on therapeutic criteria has undergone modifications through the years [24].

The goals of subtrochanteric fracture fixation are restoration of the normal neck–shaft angle, re-establishment of the leg length, rotation, union, and avoidance of abductor weakness [25]. Options for surgical treatment of subtrochanteric femoral fractures include conventional open reduction with rigid internal fixation, intramedullary fixation, external fixation, and biological internal fixation [26].

Table 3 Patients' results and complications

Mean follow-up (range) (months)	12 patients (14–42)
Mean union (range) (months)	4.6 (3–6)
Mean operative time (range) (min)	45 (35–90)
Mean blood loss (range) (ml)	250 (150–325)
Functional assessment [*n* (%)]	
Excellent	18 (75)
Good	4 (17)
Fair	1 (4)
Failure	1 (4)
Complications (*n*)	
Nonunion	1
Prominent lag screw	1
Loosening lag screw	1
Lower limb shortening	2
Anterior angulation	2
Varus deformity	1
Superficial wound infection	1
DVT	1
Knee stiffness	1

DVT, deep vein thrombosis.

Twenty percent of 33 cases reported by Velebi *et al.* [26] presented with comminuted subtrochanteric fractures that were treated with indirect reduction technique and internal fixation by DCS. Full-length incision was performed because of difficulty in gliding and rotation of the plate. In this study it was found that it was easier to glide or rotate the plate without the use of a traction table; hence, no full-length incision was performed. In this study, no traction table was used.

Use of a conventional plate and rigid internal fixation usually necessitates extensive surgical exposure of the bone; thus, the risk of delayed union, infection, refracture, nonunion, and implant failure is as high as 26%, particularly in comminuted fractures [27,28].

Asher *et al.* [27] reported 20% varus malalignment and 10% implant failure and nonunion with conventional open reduction and blade plate fixation. Siebenrock *et al.* [29] reported using conventional DCS plate fixation and recorded a 20% failure rate.

Intramedullary nail fixation allows proximal fixation into the femoral head. This technique has shown minimal failure and has biological and biomechanical advantages [30,31]. However, under certain circumstances the results are not satisfactory [32], such as when the fracture extends to the pyriform fossa or greater trochanter, or in patients with a narrow medullary canal and in polytrauma patients or in patients with associated chest injury. The reaming procedure during nailing results in additional damage to the patient [30].

Intramedullary nailing has been considered the technique of choice for addressing simple type A subtrochanteric fractures throughout the literature [33]. However, several problems have been encountered, especially in AO-classified type C fractures after intramedullary nailing, such as nonunion, delayed union, varus deformity, perineal nerve paralysis, shaft fracture during surgery, fracture of the greater trochanter, perforation in the femoral neck or knee joint, and fixation device breakage [34].

The reported average operation time for the intramedullary device was 1.5 h [35], that for the DCS (open technique) was 2 h [36], for the fixed angle plate was 1.7 h [6], and for biological fixation using DCS was 2 h [6]. In the current study, it was 45 min. This can be explained by the facilitation of the sliding of the plate from proximal to distal because of the beveled edge of the plate.

The estimated blood loss for the intramedullary device was about 500 ml, [35] compared with about 740 ml for the extramedullary device and 430 ml in the study by Vaidya *et al.* [6] using biological fixation with DCS. In this study the average blood loss was 250 ml.

A DCS has been used to treat subtrochanteric fractures [10], but implant failure and nonunion have been reported in up to 17% of cases [6,37]. This high rate may be due to the traditional open reduction technique, which causes damage to the periosteal blood supply. Thus, focus has shifted from the mechanical aspects of absolute anatomic reduction and stability toward the biological aspect of preserving tissue vascularity [12]. DCS with the indirect reduction technique has been used to treat subtrochanteric fractures [19] but implant failure continues to be reported [38].

The DCS and plate provides strong fixation in the cancellous bone of the neck and head with considerable rotational stability [6]. After indirect reconstruction of the medial cortex, the DCS acts as a tension band device on the lateral side [39].

With insufficient reconstruction of the medial cortex, the implant is loaded with substantial bending forces and strict partial weight bearing has to be observed [29].

Biological fixation does not damage the medullary blood supply as in intramedullary nailing, nor the vascularity of the medial fragments [6]

Many authors published their results concerning biological fixation in comminuted subtrochanteric femoral fractures after the 1980s. All of them reported that union was achieved in 4–5 months in general and there were no complications regarding fracture union and infection [16,24,29]. In this study, the average fracture union was 4.6 months without major complications.

Some authors observed that even the use of a bone graft had no effect on the consequences [40]. In this study, no bone graft was used except in the patient with nonunion who reported union at 9 months.

In Wenda's *et al.* study [41], it was proposed that a long plate biologically applied through the lateral side gives better strength to the lateral cortex against tensil forces and decreases the deficiency risk of the fixation device. For comminuted fractures affecting a large part of the femur, insertion of the plate using mini skin incisions minimizes surgical trauma [34].

Perren [42] stated that in comminuted subtrochanteric fractures the lack of so-called medial support is compatible with safe healing under conditions of adequately maintained or restored blood supply.

In this study eight patients had type B and 16 patients had type C fractures according to the AO classification; 23 patients united at an average of 4.6 months.

In biological plating, reduction is achieved by means of the indirect method. The fracture site is not opened and use of a compression apparatus and interfragmental screw fixation is avoided [29].

The indirect reduction technique maintains the integrity of the perforating and nutrient arteries and is associated with superior periosteal and medullary perfusion.

This improved the blood supply, which translated into improved rate of union, decreased rate of grafting, and decreased incidence of nonunion, refracture, and infection, as stated by De Lee and Farouk *et al.* [43,44]. In this study one patient (4%) had nonunion and one patient had superficial wound infection, which was treated with repeated dressing and an intensive course of antibiotics.

In biological fixation, callus is a welcome sign of vitality in the area of fracture comminution [42]. With biological fixation techniques, the operation time is shorter and the blood loss is lesser than that in conventional plating. Also, infection is minimal, union is faster without any need for bone grafting, and complications are minimal [6]. This study supported all of the above-mentioned advantages.

Conclusion

It is difficult to establish a treatment approach for biological plating of unstable comminuted subtrochanteric femoral fractures.

Subtrochanteric femoral fractures with beveled DCS allows easy insertion, provides stable fixation, and allows preservation of vascularity of the fracture site with high union rate and minimal complications when intramedullary nailing is inappropriate. The biological fixation technique using beveled DCS is an alternative method for treatment of comminuted subtrochanteric fractures.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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