Dynamic hip screw in the treatment of intertrochanteric fractures: a comparison of two fixation methods

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Abstract The study is a prospective evaluation and comparison. A minimally invasive Dynamic Hip Screw (MIDHS) technique is presented. One hundred and two patients with intertrochanteric fractures were treated with either a MIDHS or a conventional dynamic hip screw (CDHS). We used the Singh index as a measure of osteoporosis and also classified the fractures according to three different systems (OTA, Boyd-Griffin, and Evans). All patients were followed up for 12 months with a hip score evaluation. The patients were divided into two groups, based on the method of treatment. The MIDHS group includes 42 patients with an average age of 72.6 years. The CDHS group includes 60 patients, with an average age of 71.3 years. Both groups were similar in injury mechanism, fracture types, mean Singh index and confounding medical condition (all p values >0.05). The CDHS group had significantly larger wound incision, greater haemoglobin level drop, higher pain level, more total analgaesic use and longer hospital stay than the MIDHS group (all p values <0.05). The hip score, union rate, healing time, adequate reduction and adequate screw position rate was not significantly different between the two groups (all p values >0.05). In conclusion, either a MIDHS or a CDHS in the treatment of intertrochanteric fractures is an effective, simple and safe method. The mini-invasive technique as opposed to the conventional technique has smaller wound size, lower pain level, and lower blood loss. Hospital stay and total analgaesic use were decreased, benefitting the patient and reducing hospital cost.

Résumé Etude prospective de 102 patients avec une fracture intertrochantérienne traitée par une vis-plaque dynamique soit avec une technique mini-invasive (MIDHS) soit avec une technique conventionnelle (CDHS). L'index de Singh était utilisé pour la mesure de l'ostéoporose et les fractures étaient classées selon trois systèmes : OTA, Boyd-Griffin et Evans. Tous les patients étaient suivis 1 an. Le groupe MIDHS comprenait 42 patients d'âge moyen 72,6 ans et le groupe CDHS comprenait 60 patients d'âge moyen 71,3 ans. Les 2 groupes étaient similaires pour le mécanisme du traumatisme, le type de la fracture, l'index de Singh et les conditions médicales générales (toujours $p<0,05$). Le groupe CDHS avait une plus longue incision cutanée, une plus grande chute du taux d'hémoglobine, un plus haut niveau de douleurs, et un séjour hospitalier plus long que l'autre groupe ($p<0,05$). En conclusion les 2 méthodes de traitement étaient efficaces et sûres. La technique mini-invasive permettait une incision plus courte, un niveau de douleurs et une perte sanguine plus faibles. La durée de séjour et la consommation d'analgésiques étaient diminuées au profit du patient et du coût hospitalier.

Introduction

Femoral intertrochanteric fractures have been estimated to occur in more than 2,000,000 patients each year in the United States [14, 19]. The cost of treating these fractures is estimated to be US \$16 billion per year [19]. Closed methods of treating intertrochanteric fractures have been abandoned. Rigid fixation with early mobilisation of patients should be considered as the standard treatment [8, 12, 13]. Although many devices can achieve rigid fixation, the dynamic hip screw (DHS) is the most commonly used device for intertrochanteric fractures [1, 5, 15]. However, the disadvantages of conventional DHS (CDHS) techniques

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are a large skin incision and more soft tissue dissection with greater blood loss.

Recently, we have used a minimally invasive DHS (MIDHS) technique to reduce soft tissue stripping and blood loss. It is the purpose of our study to present our minimally invasive technique and to compare the clinical outcomes of intertrochanteric fractures that were treated with MIDHS or CDHS.

Materials and methods

Between Feb. 2002 and Mar. 2005, 146 consecutive patients were surgically treated in our orthopaedic department for femoral intertrochanteric fractures. The fractures were classified according to three different systems (OTA [16], Boyd–Griffin [6], and Evans [11]). Inclusion criteria for this study were: (a) OTA 31-A1, -A2 and Boyd-I, -II fractures; (b) fractures that can be reduced adequately by closed manipulation (anatomical to 10° of valgus on anteroposterior radiograph and posterior angulation less than 5° on lateral radiograph); (c) internal fixation with either a 3-hole MIDHS or a 3-hole CDHS; (d) patients able to walk without any assistance before injury. Exclusion criteria for this study were: (a) bilateral hip fractures; (b) nonunion or pathological fractures; (c) patients who required intensive care or treatment in other departments; (d) previous ipsilateral hip fracture or surgery. There were 112 patients (MIDHS, n=46; CDHS, n=66) who met the inclusion criteria. However, ten patients could not be followed up due to death (four cases) or relocation (six cases), and they were excluded. Therefore, 102 patients with an average age of 71.8 years were followed up 12 months after discharge from the hospital and were included in this study. There were five surgeons involved in our study. Three surgeons used CDHS and the remaining two surgeons used MIDHS to treat femoral intertrochanteric fractures. Owing to our orthopaedic surgeons' assigned shift according to schedule, the patient distribution was regarded as randomised.

The 102 patients were divided into two groups, based on the method of treatment. The MIDHS group included 42 patients with an average age of 72.6 years. Thirty-five patients (83.3%) suffered from simple falls. The fracture classification was: OTA A1: 20; A2: 22, Boyd type I: 20; type II: 22, and Evans' stable fracture: 27; unstable: 15. The CDHS group included 60 patients with an average age of 71.3 years. Fifty-one patients (85%) suffered from simple falls. The fracture classification was: OTA A1: 27; A2: 33, Boyd type I: 27; type II: 33, and Evans' stable fracture: 40; unstable: 20 (Table 1).

We reviewed the preoperative X-ray films of all the patients to record their bone quality, as defined by the

Table 1 The injury mechanism, fracture type, Singh index, preoperative demographics and compounding medical conditions in the two groups

	MIDHS	CDHS	<i>p</i> value
Simple fall (*N)	35	51	1.0
Vehicular trauma (*N)	5	7	1.0
Fall from a height (*N)	2	2	1.0
Boyd-I (*N)	20	27	0.84
Boyd-II (*N)	22	33	0.84
OTA 31-A1 (*N)	20	27	0.84
OTA 31-A2 (*N)	22	33	0.84
Evans' stable fracture (*N)	27	40	0.83
Evans' unstable fracture (*N)	15	20	0.83
Mean Singh Index	3.48	3.52	0.45
Osteoporosis (*N)	20	25	0.69
Gender (F/M)	23/17	36/24	1.0
Mean Age (years)	72.6	71.3	0.32
Mean body weight (Kg)	68.2	69.3	0.36
Average stature (cm)	165.2	168.4	0.26
Mean preoperative ⁺ Hb (g/L)	122.1	119.8	0.38
Hypertension (*N)	4	6	1.0
Diabetes (*N)	3	4	1.0
Renal diseases (*N)	2	3	1.0
Respiratory (*N)	2	2	1.0
Heavy smoker (*N)	3	3	0.69

*N=number of patients ⁺Hb= haemoglobin

Singh index [17]. The injury mechanism and preoperative demographics of each patient are recorded in detail (Table 1).

Surgical techniques

All the patients were on a radiolucent fracture table and their fractures were reduced by closed manipulation. In some cases, skin traction with internal rotation force was necessary. The patients in the study had closed reducible fractures before starting the surgery under a fluoroscopic control. The CDHS operative procedure has been clearly described in the literature or previous studies [8, 14]. The MIDHS technique is described below.

The vastus lateralis ridge was regarded as a landmark in MIDHS. An adequate point for skin incision was located approximately 4 cm below this landmark. A 3-cm incision was made directly through the fascia to the bone (Fig. 1a). In addition, a guide wire was inserted approximately 2 cm below the vastus lateralis ridge and a 135° guide plate was placed close to the femoral shaft in a parallel position. As the guide wire was inserted, fluoroscopy was used to confirm satisfactory alignment, as judged on anteroposterior and lateral views (Fig. 1b).

After reaming, the lag screw was inserted (Fig. 2a). Then, the side plate was introduced through the small incision. The placement of a 7-cm side plate (3-hole

Fig. 1 The mini-invasive technique: a 3-cm long incision and guide wire use. **a:** An adequate point for skin incision is located 4 cm below the vastus lateralis ridge. A=vastus lateralis ridge (landmark); B=upper incision point; C=lower incision point. **b:** A guide wire was inserted approximately 2 cm below the vastus lateralis ridge. GW=guide wire; S=skin

Zimmer) into a 3-cm incision may require a special technique. We suggest that the guide wire first be removed and then the plate placed under the soft tissue in an oblique and 180° rotation position (Fig. 2b). When the plate is completely inserted into the wound, return the plate to a normal position. The guide wire should then be re-inserted through the side plate barrel and the lag screw (Fig. 3a). However, this procedure is difficult to perform in obese patients with thick soft tissue. In these patients, fluoroscopy is generally necessary for guide wire re-insertion. The three screw holes of side plate were viewed clearly and the screws were placed in the usual manner by retracting the skin and soft tissue using a retractor (Fig. 3b). Particularly, if the initial skin incision was made correctly, the second screw hole of side plate will be located in the middle of the incision (Fig. 4). Deep layer closure can be performed in most cases. The skin was then closed with two stitches using 3–0 nylon. No wound drainage was used. One day after surgery, haemoglobin levels were checked; if haemoglobin was lower than 85 g/L in association with increased heart rate or decreased blood pressure, blood transfusion was considered.

Plain films in the immediate postoperative period were reviewed for adequacy of fracture reduction and screw position for each patient. Reduction was considered adequate when (a) anatomical to 10° of valgus on anteroposterior radiograph, (b) posterior angulation was less than 5° on lateral view and (c) the proximal fragment was not inferior to the distal fragment on the AP view.

Fig. 2 The mini-invasive technique: lag screw insertion and side plate placement. **a:** A lag screw is inserted. GW=guide wire; S=skin. **b:** After lag screw insertion, the guide wire is removed. A 7-cm long side plate (3 holes) is placed into a 3-cm incision wound in an oblique and 180° rotation position. When the plate is completely inserted to the incision wound, return the plate to a normal position. P=side plate; S=skin

Lag screw position of DHS was considered adequate when (a) the screw was inserted over the inferior calcar and in the lower half of the femoral head on the AP view, (b) the screw was inserted in the center, or slightly in the dorsal part, of the femoral head and through the central part of the femoral neck on the lateral view and (c) screw tip was within 5 mm from the subchondral bone, but did not penetrate the joint on either the AP or the lateral view.

Partial weight bearing with crutches or walker assistance was routine for all patients for at least four weeks after discharge, and full weight bearing was permitted after four weeks, depending on individual clinical condition. Patients were reviewed at one, two, three, four, six, and 12 months after fracture. AP and lateral roentgenograms were taken for all patients at each follow-up appointment for evaluations of fracture healing and implant position. Radiographic healing was interpreted by the attending surgeon at each follow-up and was verified by the all authors of the present study. Radiographic healing was defined as evidence of bridging callus across the fracture sites or the obliteration of the fracture lines on both AP and lateral views.

Postoperative pain was assessed from postoperative day one. The visual analogue pain scale (scale: 1–10) was used. For the initial three days, total analgaesic use was recorded. Twelve months postoperatively, we evaluated the results using the Harris hip scoring system. In this system, both subjective and objective clinical data are included, with a maximum score of 100 points.

Fig. 3 The mini-invasive technique: Insertion of the guide wire and retractor use. **a:** The guide wire is inserted through the side plate and the lag screw. GW=guide wire; S=skin. **b:** A retractor is used and the 3 screw holes are viewed clearly. R=retractor; S=skin

Statistics

The Chi-Square test with Yates' correction, Fisher's exact test and t-test were used to compare the two groups. SPSS 10.0 statistical software was used to analyse the data: *p* values below 0.05 were considered significant.

Results

Forty-two of the original 46 (91.3%) treated with MIDHS and 60 of the original 66 (90.9%) treated with CDHS had complete follow-up. The final follow-up rate was not

significantly different ($p=1.0$) between the groups. Two out of 46 (4.3%) patients treated with MIDHS and two out of 66 (3.0%) patients treated with CDHS died before the final follow-up. The mortality rate was not significantly different ($p=1.0$) between the groups. The causes of death were not directly related to their hip fractures. Both the groups were similar in respect to injury mechanisms, fracture types, mean Singh index, gender, age, and compounding medical conditions (all *p* values ≥ 0.26) (Table 1). Furthermore, if the Singh index ≤ 3 was defined as osteoporosis, the osteoporotic rate was 20/42 (47.6%) in the MIDHS group and 25/60 (41.7%) in the CDHS group. The osteoporotic rate showed no significant difference ($p=0.69$) between the groups.

All the fractures healed within six months. Differences in healing time between the two groups were not significant ($p=0.38$). All the fractures in the MIDHS group and the CDHS group had adequate reduction. The adequate reduction rates showed no difference ($p=1.0$) between the two groups. Thirty-nine of 42 (92.9%) MIDHS and 57 of 60 (95%) CDHS had adequate screw positions. Differences in the rate of adequate screw position between the two groups were not significant ($p=0.69$). Differences in surgery time between the two groups were not significant ($p=0.26$). However, the average incision length showed significantly smaller ($p<0.001$) in the MIDHS group (3.0 ± 0.21 cm) when compared to the CDHS group (9.5 ± 2.61 cm). The average haemoglobin level drop showed significantly less ($P<0.001$) in the MIDHS group (13.8 ± 1.9 g/L) when compared to the CDHS group (24.2 ± 3.6 g/L). The blood transfusion rate was significantly higher ($p<0.001$) in the CDHS group (24/60, 40%) than those in MCS group (3/42, 7.1%). The average hospital stay was longer ($p<0.001$) in the CDHS group (8.8 ± 1.92 ; range: five to eleven days) when compared to the MIDHS group (5.4 ± 1.42 ; range: four to eight days) (Table 2).

All patients were placed on the standard protocol at our institution for analgesia that consisted of patient-controlled meperidine (pethidine), acetaminophen, and non-steroidal anti-inflammatory drugs (NSAID) (either tiaprofenic acid, celecoxib or ketoprofen). For the initial three days, total values for analgesic was recorded. Total meperidine use

Fig. 4 An intra-operative MIDHS picture. The second screw hole (arrow) is just located at the middle of the incisive wound

Table 2 Clinical results and hospital data in the two groups

	MIDHS (*M±SD)	CDHS (*M±SD)	<i>p</i>
Union within six months	42/42	60/60	1.0
Healing time (days)	85.1±10.8	90.2±12.5	0.38
Adequate reduction	42/42	60/60	1.0
Adequate screw position	39/42	57/60	0.69
Surgery time (min)	46±9.4	51±10.8	0.26
Wound size (cm)	3.0±0.21	9.5±2.61	<0.001
Haemoglobin drop (g/L)	13.8±1.9	24.2±3.6	<0.001
Blood transfusion	3/42	24/60	<0.001
Hospital stay (days)	5.4±1.42	8.8±1.92	<0.001

*M=Mean; SD=Standard Deviation

was significantly less ($p<0.001$) in the MIDHS group (mean: 47.6, range: 0–200) when compared to the CDHS group (mean: 158.3, range: 0–450). Tiaprofenic acid use was 214.3 mg for the MIDHS group (range: 0–1000) and 283.3 mg for the CDHS group (range: 0–1400) ($p<0.001$). Celecoxib use was 402.4 mg for the MIDHS group (range: 0–600) and 450.0 mg for the CDHS group B (range: 0–800) ($p<0.001$). Ketoprofen use was 35.7 mg for the MIDHS group (range: 0–150) and 66.7 mg for the CDHS group (range: 0–250) ($p<0.001$). Total acetaminophen use averaged 535.7 mg for the MIDHS group (range 0–2000) and 1625.2 mg for the CDHS group (range: 0–4500) ($p<0.001$) (Table 3).

The visual analogue pain scores did not significantly differ between the two groups on the first two postoperative days ($p=0.25$, $p=0.21$, respectively). However, patients in the MIDHS group had lower pain scores on days three and four when compared to the CDHS group ($p=0.02$, $p=0.01$, respectively).

Table 3 Overall analgaesic use on the first three postoperative days

Analgesic	MIDHS (*M±SD)	CDHS (*M±SD)	<i>p</i> value
Meperidine	47.6±10.5 mg ⁺ i.m.	158.3±18.8 mg ⁺ i.m.	<0.001
Tiaprofenic acid	214.3±178.2 mg ⁺⁺ p.o.	283.30±167.4 mg ⁺⁺ p.o.	<0.001
Celecoxib	402.4±84.1 mg ⁺⁺ p.o.	450.0±120.6 mg ⁺⁺ p.o.	0.03
Ketoprofen	35.7±10.4 mg ⁺ i.m.	66.7±12.2 mg ⁺ i.m.	<0.001
Acetaminophen	535.7±120.4 mg ⁺⁺ p.o.	1625.2±412.3 mg ⁺⁺ p.o.	<0.001

*M=Mean; SD=Standard Deviation

⁺ i.m.=intramuscularly⁺⁺ p.o.=oral

The implant was deemed to have failed mechanically if the lag screw migrated within or cut out of the femoral head, the side plate was bent or broken, or the cortical screws loosened. Two of 42 MIDHS (4.8%) and three of 60 CDHS (5%) showed evidence of mechanical failure. Difference in the implant failure rate between the two groups was not significant ($p=1.0$). Particularly, there was no loosening of 3-screw fixation in this study.

Twelve months postoperatively, the patients' Harris hip scores were evaluated. Differences in mean hip score between the two groups were not significant ($P=0.35$). The mean hip score was 87.2±5.1 points for MIDHS group and 86.6±5.6 points for CDHS group.

Discussion

For a femoral intertrochanteric fracture, many devices can result in stable fixation and achieve union [2–4, 7, 9, 18]. The advantage of the DHS was interfragmental compression effect with a high union rate [5, 15]. In this study, all the fractures treated with DHS achieved bone healing within six months. Furthermore, in either the MIDHS or the CDHS group, the mean surgery time was not more than 60 minutes. All the fractures treated with DHS had adequate reduction. In both the MIDHS and the CDHS group, the implant failure rate was low (4.8%, 5%, respectively). Therefore, either a MIDHS or a CDHS in the treatment of intertrochanteric fractures was an effective, simple and safe method.

The question of side plate length has recently been addressed. Previous biomechanical studies have shown no advantage of four screws over three [10]. Yian et al. [20] have attempted to quantitatively determine the minimal screw number needed for stable side plate fixation to the femoral shaft in treating intertrochanteric fractures. They concluded that three bone screws provide an optimal distribution of tensile force. In our study, all the patients were treated with three-hole DHS without loosening of three-screw fixation. Several authors have reported the use of two-hole side plate and produce satisfactory healing [1, 5]. However, to date the two-hole DHS has not been widely used in our hospital.

With regard to surgical blood loss, a previous angiographic study revealed that the average distance from the vastus lateralis ridge to the first significant branch was 9.3 cm [1]. However, this area is a safe vascular zone. In the MIDHS technique, a 3-cm long incision was made and the incision point was approximately 4 cm below the vastus lateralis ridge. We determined that the lower amount of blood loss was due to less soft tissue dissection and an incision within the safe vascular zone. Although the CDHS allowed easy visualisation and haemostatic control of the

first perforator, blood loss may be larger due to greater exposure of the fracture and bone surfaces as well as muscle dissection.

A minimally invasive technique can offer many advantages. Intertrochanteric fractures usually occur in elderly patients who may have some cognitive deficit from age or some medical conditions where less meperidine use is important. Lower blood loss can decrease the need for blood transfusion. In general, total analgaesic use in the first three postoperative days was less in the mini-invasive group. Decreased drug use and costs may make the technique beneficial to both the patient and the hospital. There was no significant difference in the visual analogue pain level between the two groups in the first two days ($p=0.25$, $p=0.21$, respectively). This is a period when most CDHS patients are on meperidine with or without NSAID as analgaesia. However, on days three and four, there was a significantly higher pain score in the conventional group ($p=0.02$, $p=0.01$, respectively). This is a period when most patients are on NSAID (or acetaminophen) without meperidine as analgaesia.

In conclusion, either a MIDHS or a CDHS in the treatment of OTA A1 and A2 intertrochanteric fractures is an effective, simple and safe method. The mini-invasive technique as opposed to conventional technique has smaller wound size, lower pain level, and lower blood loss. Hospital stay and total analgaesic use are decreased with a benefit to the patient and reduction in hospital cost.

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