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Extracapsular hip fractures: fixation with a twin hook or a lag screw?

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Abstract The twin hook, which has 2 oppositely directed apical hooks, is an alternative to the lag screw for use with a ‘dynamic plate’ in the fixation of trochanteric hip fractures. In this prospective study lasting 1 year, 102 consecutive patients with trochanteric hip fractures were treated by 19 surgeons with either a twin hook or a lag screw combined with a conventional sliding hip screw plate or a Medoff sliding plate. Seven intraoperative errors were made with the twin hook but postoperative migration did not differ significantly between the 2 groups. Postoperative fixation failures were equally distributed between the 2 groups. The twin hook provides adequate fixation, which is comparable to that produced by a lag screw.

Résumé Le “Twin-hook” avec deux crochets est une alternative à la vis plaque dynamisée dans le traitement des fractures intertrochantériennes. Dans cette étude prospective, 102 cas de fractures intertrochantériennes ont été stabilisés avec le double crochet ou avec la vis plaque dynamisée. Les malades ont été suivis pendant un an. Dans 7 cas on a constaté une mauvaise position du double crochet. La migration postopératoire n’a pas été différente entre les groupes. Dans 8 cas de fracture multifragmentaire réparti égalent entre les 2 groupes la fixation post-opératoire n’a pu être maintenue. La stabilité de fixation obtenue par le double crochet est comparable avec celle de la vis plaque dynamisée.

Introduction

The internal fixation of unstable intertrochanteric fractures still challenges orthopaedic surgeons. Sliding hip screw

(SHS) devices allow fracture compression in the axis of the femoral neck and this facilitates inter-fragmentary stress transfer [8,9]. However, fixation failures, mainly superior cut-out or screw penetration of the femoral head, still occur in 3–20% of unstable intertrochanteric fractures [17,24]. A low rate of fixation failure in unstable fractures can be achieved with the Medoff sliding plate (MSP), which allows movement to occur along the femoral shaft in addition to sliding along the femoral neck [12,13,15]. With SHS plates as well as with the MSP, proximal fragment fixation is produced by the insertion of a threaded lag screw into the femoral neck and head.

Hansson pins have been used for the treatment of femoral neck fractures since the early 1980s [20]. These hook pins are placed close to the subchondral bone of the femoral head and this supports the smooth convex surface of the hook at the apex of the pin. Cut-out or penetration of the head is extremely uncommon with this implant in spite of a high rate of early fracture displacement and non-union [20].

A new nail for fixation of trochanteric fractures, the twin hook has been developed as an alternative to the lag screw for use with a dynamic plate. The twin hook is designed with the object of incorporating the simplicity of the Hansson pin construction while improving purchase in the femoral head and thus increasing resistance to cutout or femoral head penetration and lessening rotational displacement. The present prospective study was performed with a consecutive controlled series of trochanteric and low cervical fractures fixed with a twin hook used in combination with the MSP or the side-plate of a standard SHS.

Patients and methods

Operative technique

The twin hook (Swemac Orthopaedics, Linköping, Sweden) resembles the Hansson implant in that it is based on a cannulated nail, but it has 2 apical apertures for the hooks that are situated on opposite sides of the nail (Fig. 1). The nail as well as the hooks are thicker than those of the Hansson. The nail shaft dimensions

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Fig. 1 The twin hook and the lag screw used in the study. The shaft dimensions are identical. With the rotational maneuver that completes the insertion of the twin hook, the internal stem of the nail is driven in and its 2 apical hooks are forced out in opposite directions through the apertures of the nail

Fig. 2 A saw-bone model of the twin hook used in combination with a 4-hole MSP. Distal enlarging of the plate barrel entry hole has been performed in order to prevent impingement of the sliding function of the plate

(6.8×7.9 mm) are identical to those of the shaft of the lag screw, which was inserted in the control group, and the same reamer was also used. After reaming a 7.9 mm diameter channel the nail is inserted and by rotating the handle of the introducer the hooks are forced out through the apertures and into the subchondral bone of the femoral head in the anteroposterior plane. The shape of the apertures bends the hooks into arches with their convexity facing the periphery of the femoral head (Fig. 2). The flat long sides of the oval nail body are keyed by the plate barrel in order to prevent rotation occurring between the 2 parts of the device. The plate may be placed in its correct position in the femoral cortex before the nail is inserted through the plate barrel and into the reamed channel.

The Medoff sliding plate and operative technique

The MSP can 'slide' along both the axis of the femoral neck and of the femoral shaft. Sliding of the twin hook or of the lag screw can be prevented by the use of a locking set screw; thus, only allowing uni-axial sliding along the femoral shaft. The entry hole of the barrel of the MSP must be enlarged distally so as not to impede the sliding movement of the plate (Fig. 2).

The twin hook was combined with either a 4-hole or a 6-hole 135° MSP (Medpac, Valencia, Calif, USA) or a 4-hole 135° standard side plate of an SHS (Osteo AG, Selzach, Switzerland).

The study was designed originally as a 1-year consecutive case series using the twin hook. However, since a number of intraoperative errors, of which the clinical consequences were uncertain, occurred with the twin hook, the 'pure' series was interrupted and a control group of equal size was established in which a standard lag screw was used (Osteo AG). The twin hook or the lag screw was inserted into the femoral head to a depth of 5–10 mm from the articular surface.

During 1996, a total of 102 consecutive patients (median age 83 years) with either a basi-cervical, intertrochanteric or high subtrochanteric fracture were included in the study. Patients with pathological fractures or patients with previous surgery on the ipsilateral

proximal femur were excluded. Prior to the injury 51 patients were able to walk without any support and 72 patients were living in their own homes. Seven patients had sustained other concomitant fractures. The intertrochanteric fractures were classified according to Jensen and Michaelsen [6], and subtrochanteric fractures were classified according to Seinsheimer [19]. For basi-cervical and stable intertrochanteric fractures (Jensen and Michaelsen types 1 and 2) the SHS was used. The MSP is designed for use in unstable trochanteric fractures, and a 4-hole MSP or a 6-hole MSP (to allow the insertion of at least 4 bone screws in the femoral shaft) was used with bi-axial dynamization for unstable intertrochanteric fractures (Jensen and Michaelsen types 3, 4 and 5), and a 6-hole MSP with uni-axial dynamization for subtrochanteric fractures. The type of plate and the dynamization mode of the MSP that were used were based on previous studies of uni-axial and bi-axial dynamization of the MSP in trochanteric fractures [2,12,13,15]. During the first half of the study the MSP and the SHS were combined with the twin hook (twin hook group, 50 patients), and during the second half of the study the MSP and the SHS were combined with the Osteo lag screw (lag screw group, 52 patients). The types of fracture and the fixation methods are shown in Table 1. As final classification of the fractures was made using the complete series of radiographs, the fixation methods (chosen according to the fracture classification made on the primary radiographs) are not strictly in accordance with the treatment protocol. Nineteen orthopaedic surgeons with varying degrees of experience performed the operations (a median of 6 operations each). Additional cerclage wiring was used in 2 patients, and an additional cancellous bone screw was used in 1 patient. As a result of threatening or manifest femoral head penetration, staged bi-axial dynamisation was performed in 2 patients (secondary release of the locking screw to allow sliding of the twin hook or the lag screw within the barrel as described by Ceder et al. [2]). In one of these the twin hook, which had penetrated the femoral head, was removed and replaced with a new twin hook, the hooks being placed distal to the previous position of insertion.

Prophylactic anticoagulant therapy (subcutaneous Enoxaparin 40 mg daily) was started preoperatively and continued until the patient was mobilized. Intravenous prophylactic antibiotic therapy (cefuroxime 1500 mg) was started during the operation with a second dose after 24 h. Eighty-eight patients were allowed to be weight-bearing as tolerated immediately after their operation. The remaining 14 patients who had subtrochanteric or multi-fragmentary intertrochanteric fractures (4 had Jensen and Michaelsen type 5, 1 had Seinsheimer type 3A, and 9 had Seinsheimer type 5) were not allowed unrestricted weight-bearing until 4–8 weeks after surgery.

The incidence of deep venous thrombosis (verified by phlebography), pulmonary embolus (verified by pulmonary scintigraphy) and wound infection was recorded.

Radiographic examinations were performed on days 1 and 7 after operation, and clinical and radiographic examinations were repeated 4 and 12 months later. The initial postoperative position of the implant was assessed radiographically. Migration of the twin hook or of the lag screw within the femoral head was estimated by dividing the femoral head into 4 sectors by 2 perpendicular lines in both the antero-posterior and lateral films. The position of the tip of the implant was then compared between the initial postoperative radiographs and the final follow-up radiographs. Movement of 3 mm or more was considered to indicate migration. Twin hook and lag screw migration was measured on all patients with a minimum radiographic follow-up of 4 months. The degree of sliding of the device along the femoral shaft and neck was assessed on antero-posterior radiographs. Postoperative fixation failures defined as twin hook or lag screw cut-out or penetration, breakage or loosening of the implant, or non-union were also recorded.

Analysis of data

The Mann-Whitney U-test was used for making comparisons between the 2 groups, and the 2-tailed Fisher exact test was used for proportions. A *P*-value of less than 0.05 was considered significant. For measurements on radiographs a correction of 15% was made for estimated magnification.

Table 1 Distribution of fracture types and fixation methods used (*SHS* Sliding hip screw, *MSP* Medoff sliding plate)

Fracture type	Type of plate				
		SHS	4-hole biaxial MSP	6-hole biaxial MSP	6-hole uniaxial MSP
Basicervical fracture		Twin hook	1	–	–
		Lag screw	1	–	–
Intertrochanteric fracture Jensen-Michaelsen	Type 1	Twin hook	2	–	–
		Lag screw	1	–	–
	Type 2	Twin hook	2	–	–
		Lag screw	1	–	–
	Type 3	Twin hook	–	8	–
		Lag screw	1 ^a	6	–
	Type 4	Twin hook	–	–	–
		Lag screw	–	3	–
	Type 5	Twin hook	–	28	1 ^a
		Lag screw	1 ^a	28	–
Subtrochanteric fracture Seinsheimer	Type 1	Twin hook	–	–	–
		Lag screw	–	–	1
	Type 3A	Twin hook	–	–	2
		Lag screw	–	–	–
	Type 4	Twin hook	–	–	–
		Lag screw	–	–	1
	Type 5	Twin hook	–	–	3 ^b
		Lag screw	–	1 ^b	5

^a Divergence from the treatment protocol due to different primary and final classification of the fracture; ^blocking of the twin hook or lag screw forgotten by the surgeon

Results

Eighty-six of the 88 patients who were alive after 4 months attended for follow-up, and information was obtained by telephone regarding the other 2. After 1 year 60 of the 76 patients who were alive attended for follow-up examination. Of the remaining 16 patients only the immediate post-operative radiographs were available for 1 patient, but telephone information was obtained at 4 and 12 months. The other 15 patients were all X-rayed at between 4 and 6 months after surgery. There were no clinical or radiological signs of threatening fixation failure at the last follow-up and for all but 2 patients telephone information was obtained at 1 year. No significant hip pain or loss of function attributable to the hip fracture was found in these patients.

There were no differences between the twin hook and the lag screw groups concerning age and sex, pre- and post-injury walking capacity and residential status or general postoperative complications (Table 2). Intraoperative bleeding was significantly greater ($P<0.001$) and operating time was longer ($P<0.001$) when a 6-hole rather than a 4-hole plate was used, but there were no differences between the twin hook and lag screw groups.

The surgeon primarily placed a hook through the subchondral bone of the femoral head in 7 patients operated

on using the twin hook. Similar mal-positioning of a lag screw occurred in only 1 case ($P<0.05$). In one of the twin hook patients the hook had protruded into the acetabulum and had become bent, which necessitated replacement of the twin hook. One patient suffered slight pain on hip rotation that appeared to be caused by 1 hook of the twin hook protruding into the hip joint, but a further operation was not considered necessary. In the remaining 5 patients with a twin hook and in 1 patient with a lag screw the device appeared to be covered by cartilage and no adverse symptoms were observed.

Sixty patients were operated on using a 4-hole MSP and had a minimum radiological follow-up of 4 months. Migration was noted in 2 of the 30 patients with a twin hook, and in 5 of the 30 patients treated with a lag screw ($P=0.42$). In subtrochanteric fractures migration was noted in 3 of 8 patients in the twin hook group and in 3 of 7 in the lag screw group. The plate 'slide' of the 4-hole MSP was 9 (0–25) mm; it was 23 (0–25) mm for the uni-axially dynamized 6-hole MSP, and 19 (8–25) mm for the bi-axially dynamized 6-hole MSP. There were no differences in this parameter between the twin hook and the lag screw groups. In 59 of the 60 patients operated upon with an MSP and for whom radiographs were available at 4 and 12 months, no plate slide was revealed during

Table 2 Background, intra- and postoperative parameters in the 102 patients

	Twin hook	Lag screw
Patients (<i>n</i>)	50	52
Female:male	38:12	32:20
Median age (years)	84 (39–96)	81 (44–97)
Intraoperative bleeding (ml)		
Sliding hip screw	200 (150–250)	400 (100–750)
4-hole Medoff sliding plate	200 (75–500)	225 (50–1400)
6-hole Medoff sliding plate	500 (300–1600)	700 (175–1200)
Operating time (min)		
Sliding hip screw	50 (35–105)	67 (37–125)
4-hole Medoff sliding plate	58 (30–85)	51 (28–120)
6-hole Medoff sliding plate	95 (70–130)	105 (58–115)
Length of skin incision (cm)		
Sliding hip screw	14 (13–18)	17 (16–18)
4-hole Medoff sliding plate	16 (11–22)	16 (13–22)
6-hole Medoff sliding plate	18 (16–22)	20 (17–23)
Median hospital stay (days)	13 (5–30)	12 (4–52)
Wound infection	3	0
Thromboembolism	0	2
Mortality at 1 year (<i>n</i>)	14	12
Own home at 1 year/before injury	24/29 ^a	25/33 ^a
Independent walking at 1 year/before injury	13/22 ^a	11/22 ^a
History of pain on weight-bearing after 1 year	1	1

^a Only patients alive after 1 year included. No statistical significant differences between the 2 groups were observed.

Table 3 Postoperative fixation failures (*MSP* Medoff sliding plate)

Fracture type	Fixation	Failure	Secondary procedure	Divergence from intended line of treatment
Jensen-Michaelsen type 5	Twin hook 4-hole MSP	90% medialization and cut-out	No reoperation due to poor general condition	No release of over-distraction Plate slide completed on first postoperative radiograph
Jensen-Michaelsen type 5	Twin hook Uniaxial 6-hole MSP	Penetration	Early reoperation with withdrawal of nail and staged dynamization ^a	No distal enlarging of entry hole of twin hook Erratic locking of twin hook
Seinsheimer	Twin hook	90% medialization	Early reoperation with open reduction and locking of twin hook ^b	No locking of twin hook
Seinsheimer type 5	Twin hook Uniaxial 6-hole MSP	Non-union	No measures since patient asymptomatic	No indication of intraoperative error Plate slide completed on 4-month radiograph
Jensen-Michaelsen type 5	Lag screw 4-hole MSP	Cut-out	No reoperation due to poor general condition	Insufficient distal enlarging of lag screw entry hole
Jensen-Michaelsen type 5	Lag screw 4-hole MSP	75% medialization and non-union	Late Girdlestone procedure	No indication of intraoperative error Plate slide completed on 4-month radiograph
Seinsheimer type 4	Lag screw Uniaxial 6-hole MSP	Penetration	No measure since patient asymptomatic ^a	No release of over-distraction Plate slide almost completed on first postoperative radiograph
Seinsheimer type 5	Lag screw Uniaxial 6-hole MSP	Cut-out Non-union	Early staged dynamization Late hip arthroplasty	Most proximal of cortical plate screws traversed fracture line

^a Fractures that healed within 1 year after the injury.

^b Patient died 4 months after the injury.

this period. One patient, who had a subtrochanteric fracture (Seinsheimer type 5) and a bi-axially dynamized 6-hole MSP with a twin hook, was noted to have 8 mm of plate slide and 50% medial displacement of the femoral shaft, which had occurred in the period between the radiographs taken at 4 months and 12 months following operation. The estimated twin hook or lag screw 'slide' did not differ between the 2 groups. With the 4-hole

MSP, the 'slide' was 4 (0–30) mm and 20 (11–26) mm with the bi-axially dynamized 6-hole MSP.

Postoperative fixation failure occurred in 4 patients in both the twin hook and in the lag screw groups, and all were either in multi-fragmentary intertrochanteric fractures (Jensen and Michaelsen type 5) or subtrochanteric fractures (Seinsheimer type 4 or 5) (Table 3). Of these 8 fractures, 2 finally healed but 1 patient died within 4

Fig. 3A–C Radiographs post-operatively in the anterior (A) and lateral (B) view of an unstable intertrochanteric fracture treated with the twin hook and a 4-hole MSP. The fracture was healed at the 4-month control (C)

months of injury. One year after injury 71 of the 76 patients who were alive had a clinically and radiographically united fracture. (Fig. 3).

Discussion

Intertrochanteric fractures are generally fragility fractures [14] and occur almost exclusively in the elderly. The impact on health is considerable as they often have a poor functional outcome and a high mortality rate, and our study supports these findings [11,12,13,15,25].

The occurrence of superior cut-out or lag screw penetration of the femoral head remains a problem in the internal fixation of trochanteric fractures, and different strategies have been employed to increase the rigidity of fixation in the femoral head. As the cancellous bone of the osteopenic femoral head does not offer a firm grip for a threaded lag screw, resistance to movement is largely determined by its surface area. A larger lag screw head has been shown to increase 'load to failure' in biomechanical testing although impaired inter-fragmentary stress transfer was noted [3]. More cancellous bone is also removed as a larger reamed channel through the neck and head is required. In clinical use no advantages have been documented following the use of these implants [18].

The adjuvant use of cement has also been advocated [21] and increased resistance to cut-out of the lag screw has been demonstrated [3], but the potential disadvantages

are obvious. Adequate cement distribution is difficult to produce and the cement may interfere with the sliding mechanism of the device. The presence of cement in the fracture area, as well as possible heat-induced bone necrosis may increase the risk of non-union, and 'unloading' of the fracture area at the medial cortex has also been noted [3]. An impaired functional outcome has also been reported [1] but as yet remains unexplained. Augmented fixation of the fracture with deposition of an osteoconductive carbonated apatite (Norian SRS) has been tested biomechanically but its clinical role at present remains uncertain [5].

The design of the twin hook is based on the features of the Hansson implant [20], and the decision to assess it clinically was justified by available data on the use of the Hansson implant in combination with a side-plate. In a biomechanical study on an intertrochanteric fracture model [8,9] the Hansson pin combined with a side-plate was shown to resist cyclic loading to a degree comparable to that of a standard SHS. The method was also tested on a small number of patients and no problems attributable to the pin were observed [11].

A rationale for the development and assessment of the twin hook was the potential for increased resistance to nail migration. The axial stress-supporting upward projected surface area of the proximal part of the twin hook with its 2 hooks is approximately the same size as that of the lag screw with the most apical thread included. The shear cylinder area of the lag screw is approximately 5 times greater than these areas. The amount of migration

can only be estimated roughly from measurements on ordinary radiographs, and it was therefore only considered to have occurred when it was greater than 3 mm. Migration appeared to occur more frequently with the lag screw than with the twin hook although the difference was not significant. Theoretically, migration of the lag screw can only occur after fracture of the bone laminae between the threads of the screw head, and the resistance to movement must be reduced after this failure. On the other hand, with the twin hook a gradual impaction of bone must take place over the surface of the hooks during nail migration, and the force required for continued migration should gradually increase.

In biomechanical testing of intertrochanteric fracture models rotational displacement followed by varus tilt and lag screw cut-out has been observed as a typical failure mechanism [8,9,22]. The respective rotational stability produced by the twin hook and the lag screw cannot be determined from our clinical study, but the theoretical advantages of using the twin hook should be stated. Any rotation around the longitudinal axis of the twin hook means that the hooks must have been forced in both directions into intact bone. With the lag screw counter-clockwise rotation may occur without bone impaction and if migration fractures the laminae between the threads the lag screw head will rest in a cavity that offers no resistance to rotation. The bone channel enclosing the lag screw shaft is also enlarged by the introduction of the threaded lag screw head.

Insertion of the twin hook may be performed after the barrel of the side-plate is introduced into its reamed channel, and the plate put into its final position on the lateral aspect of the femoral shaft. The hooks are then extended. This technique allows a small skin incision and little muscle dissection as the plate may be passed under the muscle belly distally with the plate barrel already in its channel. When using a lag screw the plate must be pushed onto the lag screw shaft after it has been inserted and therefore an extended distal dissection is necessary. However, the length of skin incision, intraoperative bleeding and operating time did not differ between the two groups in this study.

The twin hook implant may be withdrawn or removed with the plate still in position. Withdrawal of the nail after femoral head penetration was performed in one patient in our series, and a new nail was inserted with the hooks introduced more distally into the intact cancellous bone of the femoral head. This simple procedure proved to be successful in this case with subsequent uneventful healing of the fracture. With the plate remaining in place withdrawal of the keyed lag screw requires breakage of the bone laminae and re-establishment of purchase by the threads is then not possible. When local irritation is caused by the distal end of the twin hook it may be removed easily while leaving the plate still in place. With the lag screw, concomitant removal of the plate is also required.

As the hook span of the twin hook is larger than the diameter of the lag screw threads, the central positioning of the device is more critical in order to avoid protrusion

from the femoral head. This fact was emphasized in our series as it occurred in 7 patients. Apart from this specific aspect of the use of the twin hook there is extensive evidence to stress the advantages of central positioning of the implant in the femoral head when fixing trochanteric fractures [4,10,16,22].

The dual sliding dynamic capacity of the MSP has been shown to be beneficial in the treatment of unstable intertrochanteric fractures [13,15,23], and the previous observation that the 'slide' of the plate is completed during the first 4 months after operation [12,13,15] was confirmed in our study. For dynamization ('slide') along the femoral shaft to be effective the entry hole for the plate barrel in the lateral femoral cortex must be enlarged distally. The plate must also be fixed to the femoral shaft in an 'extended' position after release of any over-distraction of the injured leg in order to avoid any unnecessary fracture gap and to maintain the plate 'sliding span' postoperatively. The plate must only be fixed to the distal fracture fragment. Plate sliding will be prevented if the bone screws fixing the plate cross the fracture line and engage the proximal fragment. Analysis of the postoperative fixation failures that occurred in our study reveals errors in these respects in 5 of 8 patients. In one subtrochanteric fracture the locking screw was forgotten and this led to extensive medialization, a well-recognized complication both clinically and biomechanically in this fracture [2,7].

The decision to change the design of the ongoing study was made in order to assess the clinical consequences of the specific problems associated with the twin hook. This divergence from our original study protocol must be taken into account when comparisons between the treatment groups are made. However, the standards of a controlled randomized trial, which are not met by a consecutive controlled case series, were not the aims of this study.

From this series no conclusions may be drawn concerning the stabilizing properties of the twin hook compared to the lag screw, but the twin hook appears to achieve adequate fixation. The advantages in intraoperative handling are clear as is the ease of making simple postoperative adjustments. Theoretical benefits from bone impaction with implant movements may reduce the risk of cut-out or penetration of the head or neck of the femur. Further clinical study will be necessary to determine the future role of the twin hook in the arsenal of treatment available for treating trochanteric fractures. The potential for increased resistance to nail migration and to rotation are issues that should be addressed by biomechanical testing.

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