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Treatment of subtrochanteric fractures. A comparison of the Gamma nail and the dynamic hip screw: short-term outcome in 58 patients

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Abstract The aim of this non-randomised prospective study was to evaluate the short-term outcome of Gamma nail and dynamic hip screw (DHS) fixation in the treatment of subtrochanteric hip fractures due to low-energy trauma in the elderly. All of the 1,624 femoral hip fractures in 1,511 patients of the Oulu Hospital, aged over 49 years, were prospectively registered from 1991–1999 using special forms. Seventy-three (4.5%) of the fractures were subtrochanteric. After exclusions, 58 patients constituted the final study group. Of these, 43 were treated with Gamma nails and 15 with DHS. Background factors before the fracture, complications, reoperations and functional parameters at 4 months were recorded using standardised forms. Intraoperative and hospital data were collected from patient records. The Seinsheimer fracture types IIIA, IIC and V were the most common fracture patterns when the Seinsheimer classification system was used, and Fielding II and AO 31A3.3, respectively, were the most common types in the Fielding and AO classification system. There were four (9%) intraoperative complications in the Gamma nail group as compared to none in the DHS group. On the other hand, postoperative complications were more common in the DHS group (27%) than in the Gamma nail group (7%). We recognised a correlation between certain fracture types and the likelihood of typical intra- or postoperative complications or difficulties with both devices: In Gamma nailing, difficulty in closed reduction as well as the rate of open reduction and the use of supplementary fixation were most frequent in the Seinsheimer IIC fractures. It is also noticeable that all of the postoperative device failures and fracture displacements of the DHS group occurred in the Seinsheimer type IIIA category. Detailed fracture classification is essential for the choice of the fixation device, and the present study confirms the presumption that, despite the perioperative problems associated with Gamma nailing, this technique may be preferable to plate fixation for specific fracture types with medial cortical comminution, such as Seinsheimer type IIIA.

Résumé Le but de cette étude prospective non randomisée est d'évaluer l'évolution à court terme du traitement par clou Gamma ou par vis DHS des fractures sous-trochantériennes par traumatisme à basse énergie chez le sujet âgé. Parmi les 1,624 fractures de la hanche enregistrées chez 1,511 patients de plus de 49 ans, de janvier 1989 à décembre 1996, 73 (4,5%) étaient des fractures sous-trochantériennes. Le groupe d'étude était de 58 patients dont 43 traités par clou Gamma et 15 avec vis DHS. Les antécédents, les complications et les paramètres fonctionnels à 4 mois étaient notés avec recueil standardisé et les informations sur l'hospitalisation étaient relevées dans les dossiers des patients. Les fractures les plus fréquentes étaient de type Seinsheimer IIIA, IIC, et V ou de type Fielding II et AO 31A3 dans ce dernier système. Il y avait 4 complications opératoires dans le groupe Gamma et aucune dans le groupe DHS tandis que les complications post-opératoires étaient plus fréquentes dans le groupe DHS que dans l'autre. Il existait une corrélation entre certains types de fractures et la survenue de complications avec les 2 matériels utilisés: dans le groupe Gamma la difficulté de réduction et la nécessité d'une fixation complémentaire étaient plus fréquentes avec les fractures de type Seinsheimer IIC; dans le groupe DHS tous les échecs de fixation survenaient pour des fractures de type Seinsheimer IIIA. La classification précise des fractures est essentielle pour le choix du matériel. L'étude présente confirme que l'ostéosynthèse par clou Gamma est préférable lorsqu'il existe une comminution corticale interne comme dans les fractures de type Seinsheimer IIIA.

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Introduction

Subtrochanteric fractures are relatively rare, accounting for 10–34% of all hip fractures [7, 14, 27]. They may be very difficult to fix, and the risk of failure has been high regardless of the fixation method [23], especially in high subtrochanteric fractures with loss of the lesser trochanter and the medial buttresses [7, 26]. Various intramedullary and extramedullary devices have been developed in an attempt to address potential complications of device failure, mal- or non-union and deformities. Some decades ago, a sliding-screw plate system came into wider use even in sub-trochanteric fractures because of the successful treatment of stable trochanteric fractures [15]. In unstable per- and sub-trochanteric fractures, however, the system has been reported to involve high failure rates [12, 13, 15].

The Gamma nail was designed to overcome the problems implicit in sliding-screw fixations [15], and it is widely used for the fixation of trochanteric fractures [15]. However, several studies have focused on the relatively high complication rate associated with its use [2, 3, 15, 22, 23, 28]. Therefore, the initial enthusiasm for the Gamma nail may have subsided, and the wide range of indications has been narrowed down to fractures of the subtrochanteric region [23]. Because of their infrequency, few studies have focused on this special entity.

This non-randomised study compares Gamma nail and dynamic hip screw (DHS) fixation in the treatment of subtrochanteric hip fractures derived from low-energy trauma in the elderly.

Materials and methods

All of the 1,624 femoral hip fractures in 1,511 patients of the Oulu University Hospital, aged over 49 years, were prospectively registered from 1991–1999 using special forms [1, 11]. Seventy-three (4.5%) of them were subtrochanteric, defined as a fracture in which the fracture line traversing the femur was mainly within 5 cm of the femur distal to the lower margin of the lesser trochanter [18]. Thirteen were pathological fractures and were excluded, as were two patients with multiple high-energy injuries. Thus, 58 patients constituted the final study group. Of these, 43 were treated with Gamma nails (mean age 76.8 years, range 51–92, 13 males and 30 females; Gamma nail group) and 15 with DHS (mean age 74.1 years, range 60–88, three males and 12 females; DHS group) (Table 1).

The fracture patterns were classified using three different classification systems: Müller's (AO) classification [16], Seinsheimer's classification [25] and Fielding's classification [6] (Table 2).

The patient's functional status was recorded at the time of fracture and at 4 months after treatment using standardised forms with data concerning the place of residence, walking ability and use of walking aids [9, 20, 21]. Function was expressed as a change compared to the situation at the time of fracture (better, same, worse). Reoperations and the

Table 1 Demographic data

	Gamma (n=43)	DHS (n=15)	P value
Age (years)			0.438
Mean	76.8	74.1	
Minimum	50.8	59.6	
Maximum	92.3	87.7	
Sex			0.445
Male	13	3	
Female	30	12	
Marital status			0.248
Unmarried	7	4	
Married	10	1	
Divorced	4	0	
Widow/er	22	10	
Living alone			0.275
No	27	7	
Yes	16	8	

reasons for them as well as mortality were recorded on a separate form for 1 year. Intraoperative and hospital data were collected from patient records.

Operative techniques Low-molecular heparin as thromboembolic prophylaxis and preoperative single-shot antibiotic prophylaxis (1.5 g cefuroxime i.v.) were used in all cases. Gamma nails and dynamic hip screws were inserted by using the previously presented standard techniques in line with the recommendations of the manufacturers of the Gamma nail (Howmedica, London, UK) and the DHS implant (Stratec Medical, Oberdorf, Switzerland). No bone grafts were used. Fifty-one of the operations were performed by orthopaedic surgeons and seven by trained residents assisted by experienced orthopaedic surgeons.

The selection between these two methods was done by the surgeon according to his preference. Standard Gamma nails (220mm, angle 125–135°, width 11–14 mm) were used in 24 and long Gamma nails (320–400 mm) in 19 cases. Two distal locking screws were used in 35 gamma nail fixations, one was used in seven cases, and none were used in one case.

In the DHS fixation, a 6-hole side plate was used in one case, an 8-hole plate in five cases, a 10-hole plate in five cases, a 12-hole plate in two cases and a 14-hole plate in two cases. The plate angle was 135° in all cases.

Whenever possible, the patients were mobilised after an X-ray examination on the first postoperative day. Partial weight-bearing (20–30 kg) was allowed as soon as the patient tolerated it, and full weight bearing was normally allowed 6–12 weeks after surgery based on the radiological situation.

Statistical analysis A statistician performed the statistical analysis. The material was processed and analysed using SPSS for Windows 8.0.1 software (SPSS). Chi-square test, nonparametric Mann-Whitney test and Kaplan-Meier survival analysis were used in the evaluation of the

Table 2 Fracture classifications

	Gamma nail (<i>n</i> =43)	DHS (<i>n</i> =5)	<i>P</i> value
Seinsheimer			0.220
I Non-displacement	0	0	
II Two-part fracture			
A Transverse	2	0	
B Spiral fracture, lesser trochanter part of the proximal fragment	5	1	
C Spiral fracture, lesser trochanter part of the distal fragment	9	0	
III Three-part fracture			
A Spiral fracture, with lesser trochanter part of the third fragment	14	6	
B Spiral fracture, with lesser trochanter not part of the third fragment	0	1	
IV Four or more fragments. Greater trochanter not involved	5	2	
V Four or more fragments. Greater trochanter involved	8	5	
Fielding			0.367
I At the level of lesser trochanter	12	3	
II 2.5 cm below lesser trochanter	24	7	
III 5–7 cm below lesser trochanter	7	5	
AO			0.500
31A1.3	1	1	
31A1.2	1	1	
31A1.3	5	3	
31A1.1	9	0	
31A1.2	0	0	
31A1.3	18	8	
32A1	3	0	
32A2	1	0	
32A3	4	1	
32C3	1	1	

significances of the differences. A difference was considered statistically significant when $P < 0.05$.

Results

During the follow-up eight patients were lost in the Gamma nail group (eight deaths) and three in the DHS group (two deaths, one lost to follow-up). There were no statistically significant differences in the fracture patterns between the study groups in any of the classifications (Table 2). Seinsheimer fracture type IIIA was the most common fracture pattern Fielding II and AO 31A3.3 when the Fielding and AO classification systems were used in both groups.

The mean delay, operating time and hospital stay were 1.1 days (range 1–3 days), 93.2 min (range 15–260 min) and 6.1 days (range 1–24 days) in the Gamma nail group and 1.3 days (range 0–4 days), 136.3 min (range 80–220 min) and 7.4 days (range 2–17 days) in the DHS group, respectively. The differences between the groups were not significant.

Difficulties in reduction, as recorded by the operating surgeon, were slightly less common with DHS than with Gamma nail, requiring “open reduction” in two cases. Supplementary fixation was required in five cases (12%) in the Gamma nail group and in four cases (27%) in the DHS group (Table 3). In gamma nailing, difficulties in reduction and extension of operation were most frequent in type IIC

fractures. There were four (9%) intraoperative complications in the Gamma nail group as compared to no intraoperative complications in the DHS group (Table 4). The insertion of distal locking screws was the most hazardous step in Gamma nailing, resulting in four intraoperative femoral shaft fractures. Two of these were treated with a longer Gamma nail and one with Dall-Miles cable fixation, while one required no treatment.

Table 3 Intraoperative data

	Gamma nail (<i>n</i> =43)	DHS (<i>n</i> =15)	Fracture type (Seinsheimer)	<i>P</i> value
Operating time (min)				0.160
Median	93.2	136.3		
Range	15–260	80–220		
Difficulties in closed reduction	9	2		0.154
Of which open reduction	2	0	IIC, IIC	
Deviation from routine operation				
Cerclage wire	3	0	IIC, IIC, IIIA	
Dall-Miles cable	2	0	IIC, V	
Interfragmentary screw	0	4	V, IIIA, IIIA, V	

Table 4 Summary of major intraoperative and postoperative complications

	Gamma nail (n=43)	DHS (n=15)	Fracture type (Seinsheimer)
Fracture of the femoral shaft			
Intraoperative	4	–	IIIA, IIIA, IIIA, V
Postoperative	1	–	IIC
Fixation failure			
Device breakage	–	2	IIIA
Fracture displacement	–	1	IIIA
Other complication			
Deep wound infection	1	–	IIB
Superficial wound infection	1	–	IIC
Haematoma	–	1	IIIA
Reoperation due to complication	4	4	

Postoperative complications were more common in the DHS group (27%) than in the Gamma nail group (7%) (Table 4). One postoperative fracture redisplacement

(femoral medialisation) was treated with DCS fixation, one breakage of the lateral plate with intramedullary Grosse-Kempf fixation and another with a longer plate. All these complications occurred in Seinsheimer type IIIA fractures. In the Gamma nail group, one femoral-shaft fracture appeared 4 months postoperatively after a new injury, which was treated with a longer gamma nail. Bone union was achieved despite complications in all cases in both groups. There were two wound infections in the Gamma nail group. One was successfully treated by revision and the other by extraction of the nail 3 months after the primary operation, when the fracture had healed. No infections were observed in the DHS group.

At 4 months after the fracture, 29% (10/43) of the patients in the Gamma nail group walked alone out of doors, and 20% (7/43) could walk without any aids; the corresponding percentages in the DHS group were 33% (4/15) and 8% (1/15) (Table 5). There was no statistically significant difference in the place of residence (Table 5), walking ability (Table 5) or the use of walking aids (Fig. 1) between the groups at the time of fracture and 4 months (Fig. 2).

Four-month mortality was 18.6% (8/43) in the Gamma nail group and 13.3% (2/15) in the DHS group, and

Table 5 Functional parameters before the fracture and at 4 months after the fracture

	Gamma nail (n=43)		DHS (n=15)	
	Before the fracture	At 4 months	Before the fracture	At 4 months
Residential status				
Own home	28	16	13	12
Sheltered housing	0	0	0	0
Home for the aged	9	3	1	0
Permanent hospital inpatient	6	16	1	0
Nursing home	0	0	0	0
Acute care hospital	0	0	0	0
Died	0	8	0	2
Missing				1
Walking				
Alone out of doors	25	10	13	4
Out of doors only when accompanied	2	1	0	0
Alone indoors	11	11	1	6
Indoors only when accompanied	2	5	1	1
Unable to walk, able to sit	3	6	0	1
Bedbound	0	2	0	0
Walking aids				
Able to walk without aids	27	7	10	1
One stick	3	5	2	4
Two sticks	2	3	2	2
One stick and tripod	0	0	0	0
Two tripods	0	0	0	0
Rollator/walking frame	8	11	1	4
Does not walk	0	2	0	0
Walking ability subjectively compared to prefracture				
Same		6		1
Worse, because of the fracture		18		7
Worse, because of some other reason		11		4

Fig. 1 The changes in the use of walking aids at 4 months in relation to the situation before the fracture showed no significance ($P=0.414$)

mortality at 1 year was 32.6% (14/43) and 20.0% (3/15), respectively, showing no significant differences.

Discussion

The classification of subtrochanteric fractures is very difficult; the actual borderline between trochanteric and subtrochanteric fractures is debatable, and the dividing line between subtrochanteric and femoral diaphyseal fractures is also open to debate [19]. We classified the fracture patterns according to three different classification systems and concluded that they are not comparable, which has been pointed out earlier [5]. In the evaluation of the results, we used Seinsheimer's classification, which has been applied in the majority of studies on subtrochanteric frac-

tures and which, in our opinion, also proved the most practicable system.

The average length of hospital stay, which was about 1 week in both groups, was definitely shorter than those reported in earlier studies, ranging from 10–29 days for DHS and from 13–23 days for Gamma nail [5, 10, 15, 24, 27]. The explanation lies in the manner of elderly care: the catchment area of our hospital has an extensive network of health centre hospitals capable of providing rehabilitation at a very early postoperative phase.

In our study, 43% of the patients in the Gamma nail group and 33% in the DHS group regained their pretrauma walking ability. Previous studies have reported better functional results in both groups. Madsen et al. reported that 69% of the Gamma nail-treated patients, 73% of the cephalic hip screw, and 91% of the DHS/TSP-treated

Fig. 2 The changes in locomotor ability at 4 months in relation to the situation before the fracture were equal for the two groups ($P=0.691$)

patients regained their prefracture walking ability at 6 months after the operation [18], but our follow-up time (4 months) was shorter than in the earlier reports (6 months to 1 year), which prevents comparisons, and the clinical results are naturally not so satisfactory. On the other hand, it has been shown that the main recovery of function in the activities of daily living has been achieved by 4 months after the fracture [4, 9]. Pakuts reported that the early recovery is faster after Gamma nail than after dynamic hip screw fixation, but we did not record the early stage of recovery [17].

Overall, some complications occurred in 16% in the Gamma nail group and in 26% in the DHS group, which matches previously reported complication rates ranging from 8–30% in patients treated with Gamma nail [2, 10, 23, 28] and from 5–17% in patients treated with DHS fixation, respectively [8, 15, 27]. The major complication associated with Gamma nail fixation, fracture of the femoral shaft, occurred in 12% of the patients, which is in line with the earlier reports showing rates ranging from 2–11% [5, 15, 23]. The majority of complications of gamma nail fixation occurred during the operation, whereas those of DHS fixation occurred later during the follow-up, which has also been noted in other studies [5].

It seemed that most intraoperative complications and difficulties occurred in certain types of fractures in both groups. In the Gamma nail group, they were most common in Seinsheimer type IIC and in the DHS fixation group in Seinsheimer type IIIA fractures. These findings are in line with earlier studies [5, 8, 14, 15, 18, 24, 27] and should be considered in the choice between these two fixation methods.

It is concluded that detailed fracture classification is essential for the choice of the fixation device, and this study confirms the presumption that, despite the perioperative problems associated with Gamma nailing, this technique may be preferable to plate fixation for specific fracture types with medial cortical comminution, such as Seinsheimer type IIIA.

References

- Berglund-Röde'n M, Swiersta BA, Wingstrand H, Thorgren KG (1994) Prospective comparison of hip fracture treatment. *Acta Orthop Scand* 65(3):287–294
- Bridle SH, Patel AD, Bircher M, Calvert PT (1991) Fixation of intertrochanteric fractures of the femur. A randomised prospective comparison of the gamma nail and dynamic hip screw. *J Bone Joint Surg [Br]* 73(2):330–334
- Calvert PT (1992) The Gamma nail- a significant advance or a passing fashion? *J Bone Joint Surg [Br]* 74 B:329–331
- Ceder L, Thorgren KG, Wallden B (1980) Prognostic indicators and early home rehabilitation in elderly patients with hip fractures. *Clin Orthop* 152:173–184
- van Doorn R, Stapert JWJL (1999) Indications for the long Gamma nail: do we need a change in the classification system? Dutch experience with the treatment of 328 subtrochanteric fractures with major involvement of the femoral shaft with the long Gamma nail. In: Gahr RH, Leung KS, Rosenwasser MP, Roth W (eds) *The Gamma locking nail. Ten years results and surgical experience*. Einhorn-Press Verlag, Reinbeck, pp 149–157
- Fielding JW, Mangliato HJ (1966) Subtrochanteric fractures. *Surg Gynecol Obstet* 122:555–560
- Guyton JL (1998) Fractures of hip and pelvis. In: Terry Canale S (eds) *Campbell's operative orthopedics*. Mosby, St. Louis, pp 2199–2209
- Haynes RC, Poll RG, Miles AW, Weston RB (1997) An experimental study of the failure modes of the Gamma locking nail and AO dynamic hip screw under static loading: a cadaveric study. *Med Eng Phys* 19(5):446–453
- Heikkinen T, Jalovaara P (2005) Four or twelve months' follow-up in the evaluation of functional outcome after hip fracture surgery? *Scand J Surg* 94(1):59–66
- Hotz TK, Zellweger R, Kach KP (1999) Minimal invasive treatment of proximal femur fractures with the long Gamma nail: indication, technique, results. *J Trauma* 47(5):942–945
- Jalovaara P, Berglund-Röden M, Wingstrand H, Thorgren KG (1992) Treatment of hip fracture in Finland and Sweden. *Acta Orthop Scand* 63(5):531–535
- Jensen JS, Tondenvold E, Mossing N (1978) Unstable trochanteric fractures treated with the sliding screw-plate system. *Acta Orthop Scand* 49(4):392–397
- Kaufer H (1980) Mechanics of the treatment of hip injuries. *Clin Orthop Relat Res* 146:53–61
- Lunsjö K, Ceder L, Tidermark J, Hamberg P, Larsson B-E, Ragnarsson B, Knebel RWC, Allvin I, Hjalmarsson K, Norberg S, Fornander P, Hauggaard A, Stigsson L (1999) Extramedullary fixation of 107 subtrochanteric fractures. A randomized multicenter trial of the Medoff sliding plate versus 3 other screw-plate systems. *Acta Orthop Scand* 70(5):459–466
- Madsen JE, Naess L, Aune AK, Alho A, Ekeland A, Stromsoe K (1998) Dynamic hip screw with trochanteric stabilizing plate in the treatment of unstable proximal femoral fractures: a comparative study with the Gamma nail and compression hip screw. *J Orthop Trauma* 12(4):241–248
- Muller ME, Nazarian S, Koch P, Schatzker J (1990) *The AO classification of long bones*. Springer-Verlag, Berlin Heidelberg New York
- Pakuts AJ (2004) Unstable subtrochanteric fractures-Gamma nail versus dynamic condylar screw. *Int Orthop* 28(1):21–24
- Parker MJ (1996) Trochanteric hip fractures. Fixation failure commoner with femoral medialization, a comparison of 101 cases. *Acta Orthop Scand* 67(4):329–332
- Parker MJ, Pryor GA, Thorgren KG (1997) *Handbook of hip fracture surgery*. Butterworth-Heinemann, pp 7–28
- Parker MJ, Currie CT, Mountain JA, Thorgren KG (1998) Standardised audit for hip fractures in Europe (SAHFE). *Hip Int* 8:10–15
- Partanen J, Jalovaara P (2004) Functional comparison between un-cemented Austin-Moore hemiarthroplasty and osteosynthesis with three screws in displaced femoral neck fractures-a matched-pair study of 168 patients. *Int Orthop* 28(1):28–31
- Radford JP, Needoff M, Webb JK (1993) A prospective randomised comparison of the dynamic hip screw and the gamma locking nail. *J Bone Joint Surg [Br]* 75-B:789–793
- Rantanen J, Aro HT (1998) Intramedullary fixation of high subtrochanteric femoral fractures: a study comparing two implant designs, the gamma nail and the intramedullary hip screw. *J Orthop Trauma* 12(4):249–252
- Ruff ML, Lubbers LM (1986) Treatment of subtrochanteric fractures with a sliding screw-plate system. *J Trauma* 26(1):75–80
- Seinsheimer F (1978) Subtrochanteric fractures of the femur. *J Bone Joint Surg* 60-A:300–306
- Wheeler DL, Croy TJ, Woll TS, Scott MD, Senf DC, Duwelius PJ (1997) Comparison of reconstruction nails for high subtrochanteric femoral fracture fixation. *Clin Orthop* 338:231–239
- Whitelaw GP, Segal D, Sanzone C, Ober NS, Hadley N (1990) Unstable intertrochanteric/subtrochanteric fractures of the femur. *Clin Orthop* 252:238–245
- Williams WW, Parker BC (1992) Complications associated with the use of the Gamma nail. *Injury* 23:291–292