Choice of implant for internal fixation of femoral neck fractures

Meta-analysis of 25 randomised trials including 4,925 patients

Martyn J Parker and Chris Blundell

We reviewed all randomised trials comparing different implants for treating intracapsular fractures of the hip and, where possible, the data were combined. 25 randomised trials were identified involving 4,925 patients. Screws appeared to be superior to pins. It was not possible to determine the optimum number or type of screws. No advantage was shown for an implant with a side-plate.

Peterborough District Hospital, Thorpe Road, Peterborough PE3 6DA, U.K. Tel +44 1733-874000. Fax -874001
Submitted 97-06-20. Accepted 97-11-21

25 years ago, Tronzo (1974) identified over 100 different implants for the internal fixation of femoral neck fractures. The determination of which implant is most effective, may be inferred to a limited extent by biomechanical studies and case series of patients.

Biomechanical studies using pull-out strengths of implants and mechanical testing of fractures created on cadaveric bone, have questionable relevance to that which occurs in vivo. Case series of different implants are of limited relevance as selection of fractures, patient characteristics and surgical technique will vary, making comparison of results between different case series infeasible. Therefore the only rational scientific comparison that can be made is use of randomised trials which compare implants. Numerous such studies have been performed, but still no consensus has been reached on the choice of implant. We reviewed all the data from previously performed randomised trials, combining data whenever possible, to determine which is the most effective implant.

Patients and methods

Randomised trials were identified primarily from the Cochrane (1997) database of randomised trials. In addition, abstracts and articles from the last 7 years for the following journals were searched by hand–Journal of Bone and Joint Surgery (American and British), Acta Orthopaedica Scandinavica, Injury, Clinical Orthopaedics, Orthopaedic Clinics of North America and the Journal of Royal College of Surgeons of Edinburgh. A MEDLINE computer search was also performed using the strategy suggested for identification of randomised trials (Dickersin et al. 1994). Articles in all languages were included.

For each randomised trial identified, the average age, sex ratio, proportion of displaced fractures and an assessment of methodology by the scoring system shown in Table 1 was performed. Data were extracted from each study to give an overall complication rate within the follow-up period of each individual study. Complications included were early fracture displacement, non-union, avascular necrosis, breakage of the implant and refracture around the implant, which were combined and termed the fracture-healing complication rate. For uniformity of results, wherever possible the complication rate was expressed as the

Table 1. 9-point assessment of methodology with one point for each criterion satisfied

1. Was there blind randomisation of patients?
2. Were the inclusion and exclusion criteria clearly defined?
3. Were the outcomes of patients who withdrew or were excluded after allocation described and included in order to treat analysis?
4. Were the treatment and control groups adequately described and comparable at entry to at least four admission details given (e.g., age, sex, mobility, function score, mental test score) and no significant difference between groups.
5. Were the care programmes other than trial options identical?
6. Were the outcome measures clearly defined in the text, with a definition of any ambiguous terms encountered?
7. Was the timing of outcome measures appropriate—i.e., a minimum of 1 year follow-up for all surviving patients?
8. Were less than 5% of patients lost to follow-up?
9. Full publication or 'in press' article, as opposed to conference abstract or unpublished data?

Table 2. Characteristics of the various studies

	Year	Implants compared	Number patients	Average age (range)	% men	% disp. fractures	Methodology score
Alberts et al.	1989	Nyström nails / Scand screws	133	77 (39–99)	31	65	7
Benterud & Alho	1994	SHS / Olmed screws	203	81 (63–97)	42	100	0
Benterud et al.	1997	Olmed / Ullevaa I/ Tronzo screws	647	78 (32–97)	20	100	1
Christie et al.	1988	SHS / 2 divergent pins	127	69 (26–80)	–	100	6
Dalén & Jacobsson	1985	Thornton nail / Scand screws	94	79	24	–	6
Elmerson et al.	1988	Rydell nail / Gouffon screws	223	– (18–98)	–	74	5
Elmerson et al.	1995	SHS / Hansson pins	222	77	25	61	8
Frandsen & Andersen	1981	SNP / Thornton nail	249	77 (22–96)	22	100	6
Harper & Gregg	1992	ASIF screws / SHS	209	72 (25–93)	24	83	2
Herngren et al.	1992	Uppsala screws / Hansson pins	180	77 (28–96)	37	72	8
Holmberg et al.	1990	Rydell nail / Hansson pins	220	78	25	70	6
Kuokkanen et al.	1991	SHS / Mecron screws	29	66 (21–84)	–	0	6
Lindequist et al.	1989	Hessel pins / Gouffon screws / von Bahr screws	220	77 (32–97)	29	80	7
Madsen et al.	1987	SHS / ASIF screws	103	74 (25–92)	–	100	6
Nordkild et al.	1985	SHS / SNP	49	– (32–86)	33	77	7
Olerud et al.	1991	Uppsala screws / Hansson pins	115	80	16	71	4
Ovesen et al.	1997	SHS / Uppsala screws	316	–	–	80	3
Paus et al.	1986	SHS / von Bahr screws	131	–	18	100	9
Rehnberg & Olerud	1989	von Bahr screws / Uppsala screws	222	80 (55–98)	25	77	9
Sernbo et al.	1990	Rydell nail / Hansson pins	410	77	25	75	8
Sorensen et al.	1992	SHS / Gouffon screws	73	– (52–94)	25	86	7
Sorensen et al.	1996	SHS / Hansson pins / Uppsala screws	150	80 (47–94)	25	67	1
Strömqvist et al.	1984	Rydell nail / Hansson pins	152	78 (52–94)	–	72	7
Svenningsen et al.	1984	SHS / FNP	248	71	30	65	5
Wihlborg	1990	Rydell nail / Gouffon pins	200	77 (46–100)	29	83	4

SHS sliding hip screw, SNP sliding nail plate, FNP fixed nail plate
Scand, Richards, ASIF, Mecron and **Gouffon** screws are all similar, being screws with cancellous threads of about 6.5 mm and a shank of 4–5 mm. **Uppsala** or **Olmed** screws are larger screws with 8 mm threads and a 6 mm shank. **von Bahr** screws have 7.1 mm threads and a 5.5 mm shank. **Ullevaal** screws have a 7 mm shank with 7 mm threads. **Toronzo** (VLF) screws have cancellous threads, but have an additional sliding capacity to allow for collapse at the fracture site. **Nyström** nails are 6.2 mm smooth pins. **Hansson** pins are 6.5 mm in diameter smooth pins with a hook which is extruded from the tip into the subchondral bone. They are used in pairs, as opposed to the **Rydell** four flanged nail, which also has a hook but is used singly. The **Thornton** nail is a four-flanged pin and **Hessell** pins are thin and smooth.

number of complications occurring during the follow-up period, including patients who died during that period, but excluding patients who were lost to follow-up. For each study, odds ratio and 95% confidence limits were calculated and results were expressed graphically on a logarithmic scale. Trials in which comparable implants were used were grouped together and the results pooled.

Results

25 randomised trials were identified and used in the analysis, these studies involved a total of 4,925 patients (Table 2). The study of Ingwersen, Skoglund and Syversen (1992) could not be included as it was only reported as a conference abstract with insufficient data to be of use. One study was reported in 4 conference abstracts (Benterud et al. 1992, Austdal et al. 1993, Benterud and Alho 1995, Benterud et al. 1997) and the most recent report was used. Poulsen et al. (1995) reported results of a study with additional results as a conference abstract (Ovesen et al. 1997), again the more recent report was used.

The fracture-healing complication rate was lower for screws than for pins (Figure 1). This analysis included only those studies which compared 1 pin with a side-plate against 1 screw with a side-plate, or 2 pins against 2 screws or 3 pins against 3 screws. There were no studies comparing a single pin without a plate against a single screw without a plate. There was no difference between 1 pin (the Rydell nail) versus 2 Hansson pins or between a Sliding Hip Screw (SHS) versus multiple screw fixation (Figure 2).

A few studies included alternative outcome measures such as duration of surgery, operative blood loss, length of hospital stay, mortality, functional assessment and pain at follow-up. Because there was no uniformity in reporting of results, it was not possible to summarise these outcome measures. However, no study reported a significant difference in mortality between implants, and any differences in morbidity tended to be related to the difference in the fracture-healing complication rate. Exceptions to this were

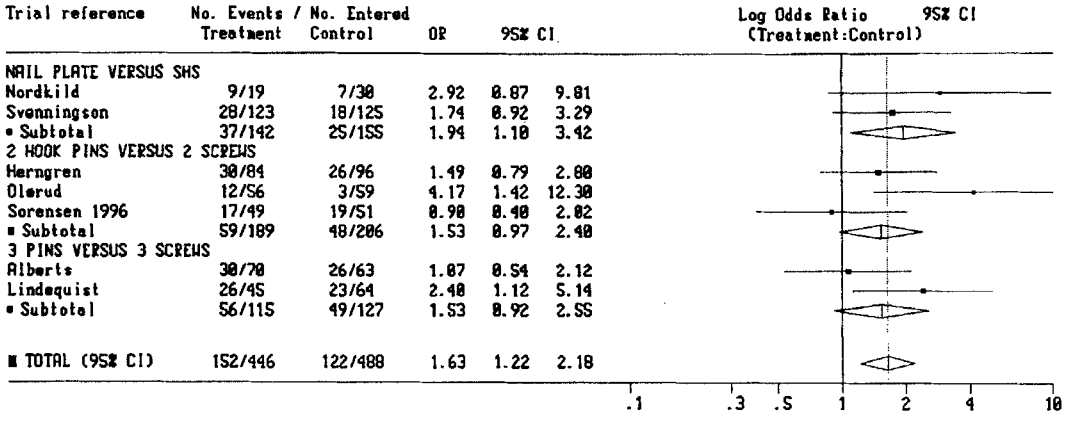

Figure 1. Summary of studies which compared smooth pins (treatment) with screws (control) and graphic representation of odds ratios (OR) and confidence intervals (CI). Results to the left of 1 indicate that the 'treatment' group is superior, while results to the right of 1 indicate the "control" group is superior.

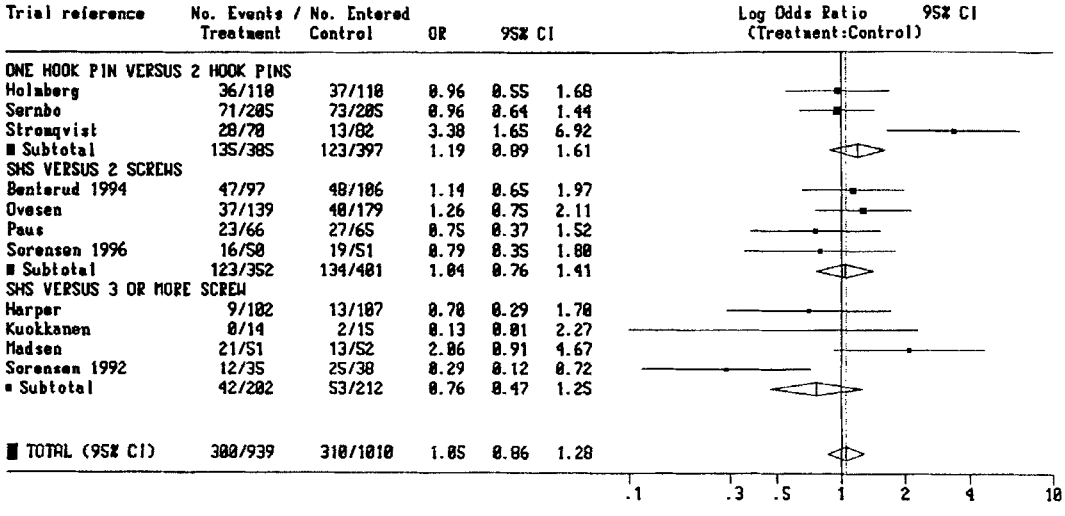

Figure 2. Summary of studies which compared one screw or pin (treatment) with multiple screws or pins (control).

studies which compared a parallel pin or screw method with that of an implant with a side-plate such as the SHS. A longer operation-time (Paus et al. 1986, Madsen et al. 1987, Elmerson et al. 1995, Ovesen et al. 1997) and increased blood loss (Madsen et al. 1987, Kuokkannen et al. 1991, Ovesen et al. 1997) were consistently reported for an implant with a side-plate than for a parallel screw or pin method.

Discussion

The fracture-healing complication rate was used in this study, as it was felt to be the most representative of all the complications related to each implant. Other outcome measures which may be used when comparing implants may be the non-union rate or the reoperation rate. We did not use the reoperation rate, as this included some cases in which the fracture had healed uneventfully, but the implant was removed for minimal symptoms. In addition, there were a few patients who required revision surgery for fixation failure, but were considered unfit for this. Fracture displacement and failure of the fracture to unite were considered together in most studies, since there is no clear distinction between the two terms for such fractures, which are collectively considered to constitute the "non-union rate". Non-union itself accounted for approximately 60% of the fracture-healing complication rate. The analysis shown in Figures 1–3 was also performed, using the non-union rate to produce results, which were comparable to those reported here.

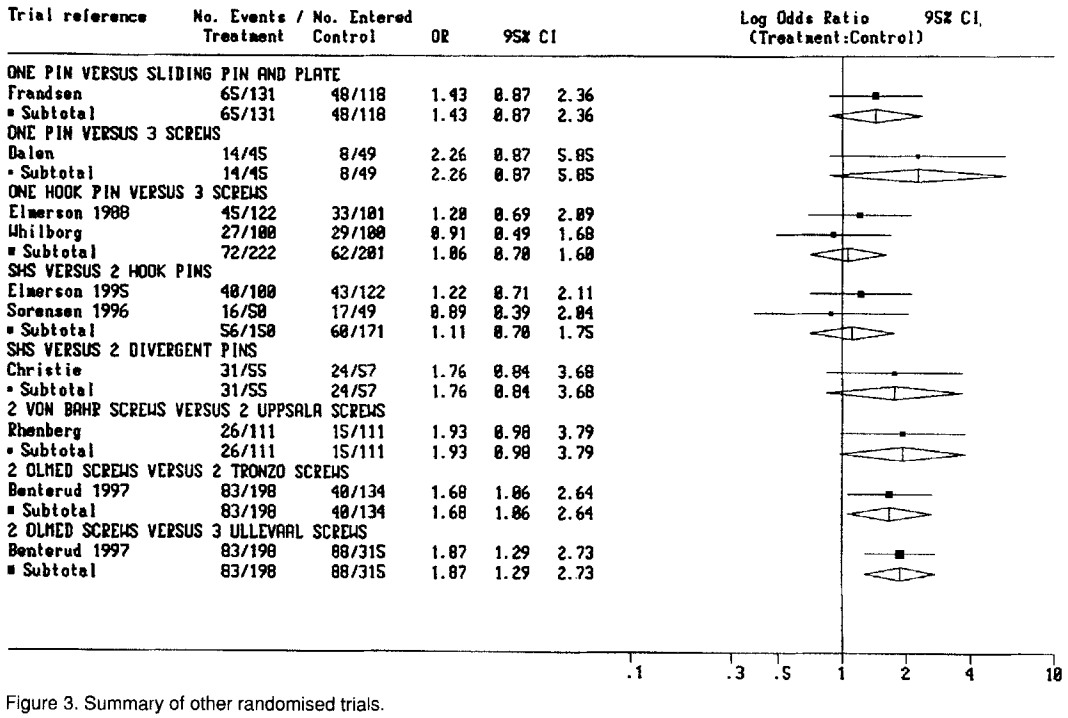

Figure 3. Summary of other randomised trials.

Many of the reported results were only in conference abstract form and this invariably resulted in such studies scoring poorly in the methodology assessment. There is a tendency for some of these studies to be performed for local use only, with a limited presentation of results at a regional meeting. Such a practice should be discouraged, as it means the information gained is not being made readily available for the benefit of all. Because it appeared that studies which had a low methodology score were those reported only as an abstract, without any evidence that such trials had increased biases, no correction factor was attempted based on the methodology assessment.

A screw fixation seemed superior to pins fixation, although individually few of the studies achieved statistical significance. This meta-analysis (Figure 1) was performed using only those studies having an equal number of screws and pins. Further studies which compared pins against screws continued to show this trend in favour of screws (Figure 3). Review of the available results does, however, suggest that the addition of a hook to the pin reduces the complication rate, so that the difference is not statistically significant.

We found no difference in fracture-healing complications for the SHS in comparison with a screw fixation method (Figure 2), nor in studies comparing the SHS with pins (Figure 3). In studies which reported operative details, the SHS was consistently found to have an increased operative blood loss and duration of surgery. The incidence of wound sepsis was reported in only one study (Paus et al. 1986), with 2 cases of infection with the SHS and 1 with parallel screws. A summary of non-randomised trials (Parker and Pryor 1993) indicated a sepsis rate of 2% for the Sliding Hip Screw, as opposed to 1% for a parallel screw or pin method. These benefits, in the absence of any difference in the fracture-healing complication rate, led us to conclude that a parallel screw method is preferable to a SHS fixation.

Many of the different screw types have been developed in different areas of the Scandinavian countries. Biases may unintentionally occur from evaluation of an implant developed in a centre to evaluate its effectiveness, even within the confines of a randomised trial. The 3 studies from Uppsala consistently favoured the Uppsala screw against all other implants studied (Rehnberg and Olerud 1989, Olerud et al. 1991, Ovesen et al. 1997). In a report of a multicentre randomised trial, comparing Ullevaal and Olmed screws (Benterud et al. 1992), the incidence of fracture healing problems in Ullevaal Hospital was 12% for Ullevaal screws and 51% for Olmed screws. However, in the other centres the figures were 22% for Ullevaal screws and 28% for Olmed screws.

The overall conclusions from our study are that most studies have had insufficient patient numbers to permit a valid comparison between implants. There-

fore, even with review of the best available evidence and combination of results, the optimum choice of implant for femoral neck fractures is still controversial. The limited evidence available indicates that screws are preferable to smooth pins, although the addition of a hook to the pin may negate these differences. There is insufficient evidence to say whether 1, 2 or more screws should be used, but the use of a supplementary side-plate appears to be unnecessary.

Further studies involving large numbers of patients (at least 400) treated at centres different that which developed the implant are required to determine the optimal type and number of screws. These trials should have appropriate methodology, publish the results in full and make the data available for future meta-analyses.

References

Alberts K A, Jaerveus J, Zyto K. Nail versus screw fixation of femoral neck fractures. A 2-year radiological and clinical prospective study. Ann Chir Gynaecol 1989; 78: 298-303.

Austdal S, Benterud J G, Blikra G, Kuokkannen H, Lindequist S, Lerud P, Raugstad T S, Alho A. Osteosynthesis of displaced femoral neck fractures with multiple screws—a randomised multicentre study. J Bone Joint Surg (Br) (Suppl II)1993; 75:199.

Benterud J, Alho A. Displaced femoral neck fracture treated with HCS or Olmed screws - 225 randomized patients followed for 3 years. Acta Orthop Scand (Suppl 256) 1994; 65: 18.

Benterud J, Alho A. Multiple screw fixation for displaced femoral neck fractures —a multicentre study. J Bone Joint Surg (Br) (Suppl II) 1995; 77: 214.

Benterud J G, Blikra G, Lerud P, Raugstad T S, Austdal S, Lindequist S, Kuokkanen H, Alho A. Multicentric randomized study of screw osteosynthesis of femoral neck fractures. Acta Orthop Scand (Suppl 248) 1992; 63: 85.

Benterud J, Alho A, Raugstad T S,Lerud P. 2-year results of multiple screw fixation in displaced femoral neck fractures: a randomized multicentre study. Poster presentation EFORT meeting, Barcelona, April 1997.

Christie J, Howie C R, Armour P C. Fixation of displaced subcapital femoral fractures. Compression screw fixation versus double divergent pins. J Bone Joint Surg (Br) 1988; 70: 199-201.

Cochrane library. Database of randomised trials and systematic reviews. Oxford Update Software 1997: Issue 1.

Dalén N, Jacobsson B. Factors influencing the incidence of reoperation after femoral neck fractures. Int Orthop 1985; 9: 235-7.

Dickersin K, Schere R, Lefebvre C. Identifying relevant studies for systematic reviews. BMJ 1994; 309: 1286-91.

Elmerson S, Andersson G B, Irstam L, Zetterberg C. Internal fixation of femoral neck fracture. No difference between the Rydell four-flanged nail and Gouffon's pins. Acta Orthop Scand 1988; 59: 372-6.

Elmerson S, Sjostedt A, Zetterberg C. Fixation of femoral neck fracture. A randomized 2-year follow-up study of hook pins and sliding screw plate in 222 patients. Acta Orthop Scand 1995; 66 (6): 507-10.

Frandsen P A, Andersen Jr P E. Treatment of displaced fractures of the femoral neck. Smith-Petersen osteosynthesis versus sliding-nail-plate osteosynthesis. Acta Orthop Scand 1981; 52 (5): 547-52.

Harper W M, Gregg P J. The treatment of intracapsular proximal femoral fractures: A randomized prospective trial (Abstract). J Bone Joint Surg (Br) (Suppl III) 1992; 74: 282.

Herngren B, Mörk-Petersen F, Bauer M. Uppsala screws or Hansson pins for internal fixation of femoral neck fractures? A prospective study of 180 cases. Acta Orthop Scand 1992; 63: 41-6.

Holmberg S, Matthsson P, Dahlborn M, Ersmark H. Fixation of 220 femoral neck fractures. A prospective comparison of the Rydell nail and the LIH hook pins. Acta Orthop Scand 1990; 61: 154-7.

Ingwersen J, Skoglund A, Syversen S. Early loss of fixation of cervical hip fractures. Acta Orthop Scand (Suppl 247) 1992; 63: 6-7.

Kuokkanen H, Korkala O, Antti Poika I, Tolonen J, Lehtimaki M Y, Silvennoinen T. Three cancellous bone screws versus a screw-angle plate in the treatment of Garden I and II fractures of the femoral neck. Acta Orthop Belg 1991; 57: 53-7.

Lindequist S, Malmqvist B, Ullmark G. Fixation of femoral neck fracture. Prospective comparison of von Bahr screws, Gouffon screws, and Hessel pins (published erratum appears in Acta Orthop Scand 1989; 60 (4): 507-8). Acta Orthop Scand 1989; 60: 293-8.

Madsen F, Linde F, Andersen E, Birke H, Hvass I, Poulsen T D. Fixation of displaced femoral neck fractures. A comparison between sliding screw plate and four cancellous bone screws. Acta Orthop Scand 1987; 58: 212-6.

Nordkild P, Sonne Holm S, Jensen J S. Femoral neck fracture: sliding screw plate versus sliding nail plate—a randomized trial. Injury 1985; 16: 449-54.

Olerud C, Rehnberg L, Hellquist E. Internal fixation of femoral neck fractures. Two methods compared. J Bone Joint Surg (Br) 1991; 73: 16-9.

Ovesen O, Poulsen T D, Andersen I. Uppsala screws versus Dynamic Hip Screw for internal fixation of femoral neck fractures. EFORT Conference abstracts, Barcelona, April 1997: 118.

Parker M J, Pryor G A. Hip fracture management. Blackwell Scientific Publications, Oxford 1993: 218.

Paus A, Gjengedal E, Hareide A, Jorgensen J J. Dislocated fractures of the femoral neck treated with von Bahr screws or hip compression screw. Results of a prospective, randomized study. J Oslo City Hosp 1986; 36: 55-61.

Poulsen T D, Ovesen O, Andersen I. Percutaneous osteosynthesis with two screws in treating femoral neck fractures. Orthopedics 1995; 18 (7): 661-4.

Rehnberg L, Olerud C. Fixation of femoral neck fractures. Comparison of the Uppsala and von Bahr screws. Acta Orthop Scand 1989; 60: 579-84.

Sernbo I, Johnell O, Baath L, Nilsson J A. Internal fixation of 410 cervical hip fractures. A randomized comparison of a single nail versus two hook-pins. Acta Orthop Scand 1990; 61: 411-4.

Sorensen J L, Varmarken J E, Bomler J. Internal fixation of femoral neck fractures. Dynamic Hip and Gouffon screws compared in 73 patients. Acta Orthop Scand 1992; 63: 288-92.

Sorensen A I, Scavenius M, Aagaard H, Ronnebech J, Torholm C. Dynamic hip screw versus Hook-pins versus Uppsala screws in treatment of fracture of the cervical neck (Abstract). Acta Orthop Scand (Suppl 267) 1996; 67: 30.

Strömqvist B, Hansson L I, Nilsson L T, Thorngren K G. Two-year follow-up of femoral neck fractures. Comparison of osteosynthesis methods. Acta Orthop Scand 1984; 55: 521-5.

Svenningsen S, Benum P, Nesse O, Furset O I. Internal fixation of femoral neck fractures. Compression screw compared with nail plate fixation. Acta Orthop Scand 1984; 55: 423-9.

Tronzo R G. Hip nails for all occasions. Orthop Clin North Am 1974; 5: 479-91.

Wihlborg O. Fixation of femoral neck fractures. A four-flanged nail versus threaded pins in 200 cases. Acta Orthop Scand 1990; 61: 415-8.